

Holder for a Container Connector, Apparatus and Method For Container Coning And/Or Deconing

Field of Invention

- 5 The present invention relates to a holder for container connector, an apparatus and a method for container coning and/or deconing, in particular, to facilitate coning and/or deconing of connectors (e.g. twist-locks or cones) to/from a container having corner fittings and to dispense said connectors to a specific location.

10 Background

- Shipping companies are constantly looking for ways to reduce time a ship spends at a port facility that is involved in berthing operations to increase efficiency of each vessel. For instance, in unloading or loading of containers from/to a vessel, it is important that the entire unloading/loading process is fast. The bottle neck of managing operations in a port is usually associated with the ability to direct a container to or from the vessel. Before containers are loaded or unloaded from the vessel, a coning or deconing operation has to be carried out. The coning and deconing operation adds time to the overall cycle time of container handling, thereby reducing productivity.

- 20 Coning is a process of attaching automatic or semi-automatic twist-locks (TL) or cones (AC) to container corner castings prior to loading onto vessels. Cones are also known as stackers. Deconing is a process of removing twist-locks or cones from container corner castings upon discharge from vessels. In general, twist-locks are used for containers placed above deck, while cones are used for containers placed below deck. No connector may be required to secure the 40 feet in hatch for some vessel designs (particularly for a large vessel).

- 25 Typically, a connector is used to secure between a first container that is stacked on top of a second container. This will ensure that the containers going on board a vessel is safe for journey at sea. These connectors are typically provided in a plurality of bins from the vessel. For semi-automatic twist-locks, during deconing, workers on the vessel will release a lower cone of the connector from a corner casting of the second container manually so that the first container can be lifted by a quay crane to be transported to the wharf. This process of releasing the lower cone is not required for other types of connectors. At the wharf, the workers remove an upper cone of the connector from a corner casting of the first container. During coning, after an upper cone of the connector has been installed to the corner casting of the first container, the first container will be lifted up and stacked on top of the second container. For semi-automatic twist-locks, the workers on the vessel will then secure the lower cone of the connector to the bottom container. This process of securing the lower cone is not required for other types of connectors.

- 40 Coning and deconing are typically executed in one of two ways. One method of deployment is a decentralized concept of deploying a number of workers per quay crane to execute the tasks of coning and deconing under the quay crane. Workers would place a safety cone in front of a Prime Mover (PM) that transports a container during the process to inform the driver not to shift his vehicle and proceed with coning or deconing activities. Once coning (during loading operation) or deconing (during discharging operation) has been completed, the lashing workers will remove the safety cone. Once the lashing workers have moved away from the vehicle, a wharf operations supervisor (WOS) will notify the terminal operating system (TOS) via his WOS computer (WOS PC) that the coning/deconing job has been completed and is safe for the PM to move away. Thereafter, the TOS informs the prime mover driver to proceed to his next location via the PM computer (PMPC) installed inside the PM cabin. TOS in brief is a central system that manages work flow at a port facility.

- 50 The second method is a centralized method of coning and deconing. In this way of operations, workers from the cranes working on the same vessel are pooled and deployed at a bow (deconing operations) or stern (coning operations) of the vessel. Prime Mover drivers receive containers from the quay crane (during discharging) or Yard Crane (during loading) and proceed to the bow or stern of the vessel accordingly. As the PM drivers approach a coning or deconing station, they will be marshalled into one of a plurality of lanes for execution of coning or deconing by a consolidated pool of lashing workers. Once the coning or deconing job is completed, prime mover drivers would be informed of their respective new job locations via the PMPC through communication with TOS

5 A cone or a twist-lock (i.e. a connector) can weigh up to 8kg. Therefore, the coning and/or deconing operation can be quite exhausting for the lashing workers and the worker is prone to hand or finger injury. It is also inefficient as it depends on the ability of the lashing working to install or remove the connector. Typically, it takes about 20 – 40 seconds to install or remove the connectors, thereby increasing the time the ship has to spend in the port. This process is carried out by workers with the container either still carried by a quay crane and hanging in the air, or has landed on a platform, such as trailer.

10 Some improvements have been suggested in recent years to enhance the centralized concept of operations and further reduce the manpower required at the Wharf. For example, International patent publication no. WO/2012/141658. However, a problem remains in that sorting of connectors, for instance, connectors removed from deconing operations or connectors to be provided for coning is still a manually handled process. The efficiency of the prior art in regard to management of workflow for container coning or deconing in a port facility can also be further improved.

15 Summary

The invention is defined in the independent claims. Some optional features of the invention are defined in the dependent claims.

20 Brief Description of the Drawings

In the drawings, the same reference numerals generally relate to the same parts throughout different views, unless otherwise specified. Embodiments of the invention will be better understood and readily apparent to one skilled in the art from the following written description, by way of example only and in conjunction with the drawings, in which:

25 Figure 1 shows a station (an apparatus) for coning or deconing according to an example of the present disclosure.

30 Figure 2 shows a sorting and storing apparatus (in which a sorter is comprised) working together with an equipment control unit as a sub-station used in the station according to an example of the present disclosure.

Figure 3A shows a side view of a storage module of the sorting and storing apparatus according to an example of the present disclosure when a discharging mechanism (in a form of a roller dispenser is inactive.

35 Figure 3B shows a perspective view of a storage module of the sorting and storing apparatus according to an example of the present disclosure when the roller dispenser is active.

Figure 3C shows a perspective view of two storage modules of the sorting and storing apparatus being cascaded according to an example of the present disclosure.

Figure 3D shows an exploded (perspective) view of a container connector holder according to an example of the present disclosure.

40 Figure 3E shows a front view of a holding pin in a holder pocket according to an example of the present disclosure.

Figure 3F shows a perspective view of a holding pin in a holder pocket arranged to move along a guide rail according to an example of the present disclosure.

45 Figure 3G shows the holding pin in Figure 3F in connection with a guide roller holder according to an example of the present disclosure.

Figure 3H shows a perspective view of two holders connected between two of the holding pins depicted in Figure 3G.

Figure 3I shows an example of three holders being arranged between two holding pins for connection to a conveyor mechanism.

50 Figure 3J shows another example of two holders being arranged between two holding pins for connection to a conveyor mechanism.

Figure 4A shows a connector within a holder in a storage module and in an upright orientation (i.e. not tilted) according to an example of the present disclosure.

- Figure 4B shows a connector within a holder in a storage module and being tilted according to an example of the present disclosure.
- Figure 4C shows a top view of a top plate (or support plate) of a holder according to an example of the present disclosure.
- 5 Figure 4D shows different views of a holder pocket for keeping the connector in place and a counterweight within a holder in a storage module according to an example of the present disclosure.
- Figure 4E shows different states of a holder pocket of a holder with respect to a pin as the holder is being tilted according to an example of the present disclosure.
- 10 Figures 5A and 5B show respective upright position and upside-down position of a connector in a desired horizontal orientation according to an example of the present disclosure.
- Figures 5C and 5D show respective upright position and upside-down position of a connector in an undesired horizontal orientation according to an example of the present disclosure.
- Figure 5E shows an orientation unit for re-orientating a connector to a suitable orientation for placing into an empty holder according to an example of the present disclosure.
- 15 Figure 5F shows a visioning unit according to an example of the present disclosure for identifying a type of a connector picked up by the sorter and for identifying an orientation of the picked connector.
- Figure 6A shows a side view of an exemplary interchangeable end effector for coning and/or deconing according to an example of the present disclosure.
- 20 Figure 6B shows a perspective view of the interchangeable end effector of Figure 6A in a working operation.
- Figures 6C shows a perspective view of the exemplary interchangeable end effector of Figure 6A in a disengaged state.
- Figure 6D shows a close-up view of an exemplary casing enclosing a pushing portion of the interchangeable end effector of Figure 6A in a retracted state that is connected to a twisting portion of the interchangeable end effector of Figure 6A.
- 25 Figures 6E and 6F shows two examples of pushing devices in an extended state according to the example in Figure 6D.
- Figure 6G illustrates an example of a twisting portion of the interchangeable end effector of Figure 6A.
- 30 Figures 6H shows an exploded view of a top mating member and a bottom member of the interchangeable end effector of Figure 6A that are operably connected by a locking mechanism.
- Figure 6I shows a universal end effector that can be used with the robotic arm.
- Figures 7A to 7D show how the position and orientation of a twist-lock changes during a coning operation according to an example of the present disclosure.
- 35 Figures 7E to 7H show how the position and orientation of a twist-lock changes during a deconing operation according to an example of the present disclosure.
- Figure 8A shows where a station can be set up near the vessel at the wharf or in the thoroughfare of the yard in a port facility according to an example of the present disclosure.
- 40 Figure 8B shows where a station can be set up under a quay crane in a port facility according to an example of the present disclosure.
- Figure 8C shows where a station can be set up as a part of a quay crane in a port facility according to an example of the present disclosure.
- Figure 8D shows where a station can be set up as a part of a quay crane in a port facility according to an example of the present disclosure.
- 45 Figure 9A to 9D show four different modes of transporting the equipment control unit and/or the sorting and storing apparatus according to an example of the present disclosure.
- Figure 10 shows a station (an apparatus) for coning or deconing according to an example of the present disclosure.

Figure 11A shows an example of indexing data stored in a memory of the sorting and storage device according to an example of the present disclosure.

Figure 11B shows an example of operation information stored in a server according to an example of the present disclosure.

- 5 Figure 12A shows how the station communicates with a server for managing operations in a port facility (i.e. Terminal Operating System).

Figure 12B shows a flow chart of a coning or deconing process according to an example of the present disclosure.

- 10 Figure 13 illustrates how an apparatus according to an example of the present disclosure communicates with a crew device.

Figure 14 shows a corner casting of a top (first) container and a bottom (second) container and how a connector can be connected to these respective corner castings according to an example of the present disclosure.

- 15 Figure 15 illustrates a workflow of a coning and/or deconing operation being performed by an apparatus according to an example of the present disclosure.

Figure 16 illustrates a workflow indicating how a coning/deconing job is being performed by a storing and sorting unit of an apparatus according to an example of the present disclosure.

Figure 17 illustrates a workflow indicating how a coning/deconing job is being performed by an equipment control unit of an apparatus according to an example of the present disclosure.

- 20 Figure 18A illustrates a workflow indicating how a sorter according to an example of the present disclosure prepares a connector for coning and delivers it to a location for retrieving the connector used for coning the container.

Figure 18B is a continuation of the workflow in Figure 18A.

- 25 Figure 19 illustrates how exception handling and/or error handling is carried out by an apparatus according to an example of the present disclosure.

Figure 20 illustrates, according to an example of the present disclosure, a movable platform used to align and/or orientate a vehicle to facilitate the coning or deconing of one or more containers carried by the vehicle.

- 30 Figure 21A illustrates, according to an example of the present disclosure, a movable platform used to align and/or orientate a robotic manipulator (of an equipment control unit) to facilitate the coning or deconing of one or more containers carried by a vehicle.

Figure 21B illustrates, according to another example of the present disclosure, a movable platform used to align and/or orientate a robotic manipulator (of an equipment control unit) to facilitate the coning or deconing of one or more containers carried by a vehicle.

- 35 Figure 21C illustrates a driving mechanism within the movable platform of Figure 21B.

Figure 22A illustrates a skew control unit of a movable platform according to an example of the present disclosure.

Figure 22B illustrates a movable platform for controlling transverse movement according to an example of the present disclosure.

- 40 Figures 23A to 23D illustrate some examples of movable platforms for aligning and/or orientating a vehicle or a robotic manipulator in forward, rearward and/or sideward directions.

Figures 24A to 24B illustrate another example of a dispensing mechanism, in its respective deactivated state and activated state, that is used in a storage module of the sorting and storing apparatus.

- 45 Figure 25A is a side view of a storage module of the sorting and storing apparatus with a pushing dispensing mechanism (or pushing dispenser) according to an example of the present disclosure.

- 50 Figure 25B shows a side view of the storage module of the sorting and storing apparatus when the pushing dispenser is deactivated.

Figure 25C to 2E show side views of the storage module of the sorting and storing apparatus when the pushing dispenser is activated.

- 5 Figure 26A is a side view of a storage module of the sorting and storing apparatus with a dispensing mechanism configured to dispense by magazine motion (or magazine motion dependent dispenser) according to an example of the present disclosure.

- 10 Figure 26B shows a side view of the storage module of the sorting and storing apparatus when the magazine motion dependent dispenser is deactivated.

Figure 26C to 26F show side views of the storage module of the sorting and storing apparatus when the magazine motion dependent dispenser is activated.

- 15 Figures 27A and 27B show a modified holder according to an example of the present disclosure, and the modified holder is pivotally mounted to the conveyor mechanism.

Figure 27C shows a modified guide roller holder that may be used on a guide rail according to an example of the present disclosure.

- 20 Figure 28A shows a side view of a storage module of the sorting and storing apparatus according to an example of the present disclosure when the dispensing mechanism in the form of the roller dispenser is disengaged.

- 25 Figures 28B and 28C show side views of the storage module of the sorting and storing apparatus when the roller dispenser is engaged.

Figure 28D illustrates perspective views and side views of three different holding rods for rigidly connecting two or more holders when used respectively with the roller dispenser, the pushing dispenser and a magazine motion dependent dispenser.

- 30 Figure 29A shows a top view of a modified conveyor mechanism according to an example of the present disclosure.

- 35 Figure 29B shows a perspective view of the conveyor mechanism in Figure 29A.

Figures 29C and 29D show two perspective views (from different angles) of the same holder used with the conveyor mechanism in Figure 29A.

- 40 Figure 29E to 29L show side views of a modified dispensing mechanism according to an example of the present disclosure in operation.

Figure 29M shows a perspective view of a lifter arm of a lifting mechanism of the modified dispensing mechanism according to an example of the present disclosure.

- 45 Figure 29N shows a perspective view of a lifting guide of a lifting mechanism of the modified dispensing mechanism according to an example of the present disclosure.

- 50 Figure 30A illustrates a workflow indicating how a connector may be dispensed from a storage module (e.g. 210 of Figure 2) of an apparatus (e.g. 100 of Figure 1) according to a first example of the present disclosure.

Figure 30B illustrates a workflow indicating how a connector may be dispensed from the storage module (e.g. 210 of Figure 2) of an apparatus (e.g. 100 of Figure 1) according to a second example of the present disclosure.

- 55 Figure 30C illustrates a workflow indicating how a connector may be dispensed from the storage module (e.g. 210 of Figure 2) of an apparatus (e.g. 100 of Figure 1) according to a third example of the present disclosure.

Detailed Description

Implementation of the techniques and examples disclosed herein may be in the form of an apparatus for managing storage and retrieval of twist-locks and cones during a coning and/or deconing operation at a port facility. As used herein, the term "connector" may be considered as a twist-lock or a cone suitable for use during a coning and/or a deconing operation of a container at a port facility. In general, connectors used during the coning operation are provided by the vessel transporting the container and brought manually to a designated area (such as a lashing platform) for performing the coning operation. Similarly, the connectors removed from the container are returned to the vessel prior to the vessel departing the port facility.

"Station" in the present disclosure refers to a holding area of a predetermined size in a port facility for containers to be transported thereto to perform a coning and/or deconing operation. It should be appreciated that in actual implementation, a station is portable and can be set up at any area (e.g. berth area or container stacking area). In one arrangement as shown in Figure 8A, stations 820a and 820b are placed at the stern and bow of a vessel 810 respectively in a wharf area 842. In such arrangement, the station 820a may be configured for a strictly deconing operation and the station 820b may be configured for a strictly coning operation and vehicles 840 are arranged to transport the containers to the respective stations 820a and 820b for deconing or coning. In another arrangement, a station may be placed at a suitable area to perform both coning and deconing operations. In some parts of the present disclosure, the station may be termed as Automated Integrated Wharf Operation Station ("AIWOS").

For example, and referring to Figure 8A, stations 820c and 820d may also be placed at the yard area 844 to perform coning and deconing operations. Containers can be transported to the station by a container transporter (or also known herein as a vehicle) 840 such as prime mover with a trailer, chassis trucks or automated guided vehicles (AGVs) or a movable device with lifting capability (e.g. a straddle carrier). In another example, and referring to Figure 8B, a station 820e can be placed under a quay crane 830. In such an example, a vehicle 840, for example in the form of a prime mover 840a, is being arranged to enter a respective station 820e and wait for the quay crane 830 to place a container to be coned or a container to be deconed on the vehicle 840. The quay crane 830 comprises a spreader 848, a boom 847 and a machinery house 846. The machinery house 846 is an enclosure comprising necessary mechanism, such as motors, gearboxes, wire rope drums, electrical drives, programmable logic controller, and etc., for moving the spreader 848 and the crane 830. The spreader 848 is controlled by the machinery house 846. Optionally, the quay crane 830 may be configured to communicate with the station 820e to align the vehicle 840 for the placement of the container(s) on the vehicle 840 by the spreader 848. An operator can either operate in a cabin (not illustrated in Figures) near the spreader or remotely in a terminal building or other location on the crane 830. In the same example, where the vehicle is in the form of a straddle carrier 840b, the straddle carrier 840b is arranged to place the container to be coned onto a coning platform placed on the ground of the wharf area 842 and move out before the station 820e performs coning. The spreader 840 is arranged to pick up the container only after the station 820e completes the coning operation. In addition, the spreader 848 is arranged to place the container to be deconed onto the coning platform placed on the ground of the wharf area 842, and the straddle carrier 840b is arranged to enter the station 820e to pick up the container only after the station 820e completes the deconing operation. It should be appreciated that the coning platform is portable and can be arranged to be transported into or away from the wharf area 842, if a straddle carrier 840b is not used.

In another example, and referring to Figure 8C, a station 820f can be placed on a fixed seaside platform 850a mounted to a quay crane 830. In such an example, a container to be coned or a container to be deconed is placed on the seaside platform 850a. This means that during deconing operations, the quay crane 830 is arranged to transport the container to be deconed from a vessel 810 to the seaside platform 850a, and to transport the deconed container to the vehicle 840 for commuting to the yard area. During coning operations, the quay crane 830 is arranged to transport the container to be coned from a vehicle 840 to the seaside platform 850a, and to transport the coned container directly to the vessel 810.

In another example, and referring to Figure 8D, a station 820g can be placed on a fixed landside platform 850b mounted to a quay crane 832 having a primary spreader 848 and a secondary spreader 849. The primary spreader 848 handles an operation between the platform

850b and vessel 810, while the secondary spreader 849 handles an operation between the platform 850b and the vehicle 840. In such an example, a container to be coned or a container to be deconed is placed on the landside platform 850b. This means that during deconing operations, the primary spreader 848 is arranged to transport the container to be deconed from a vessel 810 to the landside platform 850b. The secondary spreader is arranged to transport the deconed container to a vehicle 840. The vehicle 840 may be manned or unmanned, such as in the form of a straddle carrier 840d and an automated guided vehicle 840c. During coning operations, the secondary spreader 849 is arranged to transport the container to be coned from the vehicle 840 to the landside platform 850b. The primary spreader 848 is arranged to transport the coned container directly to the vessel 810. It should be appreciated that the use of a secondary spreader allows a cycle time that comprises duration for transporting a container to the station and/or vessel to be more consistent. Customization of the primary spreader and the secondary spreader can be attained more easily.

Optionally, the seaside platform 850a and/or landside platform 850b may comprise a driving mechanism (not illustrated in Figures) for moving along a horizontal beam of a main structure of the quay crane 830 or 832. Optionally, in the event that the secondary spreader 849 is out of operation, the primary spreader 848 may also be configured to handle transportation of a container from the landside platform 850b to the vehicle 840. In another variation, the quay crane 832 having two spreaders may be configured to operate with the seaside platform 850a, instead of the landside platform 850a. Optionally, one or more stations may be permanently mounted on the seaside platform 850a or landside platform 850b.

In the examples of Figures 8C and 8D, the quay crane 830 or 832 is used to lift a bin comprising connectors used to perform coning and/or connector obtained during deconing, as well as a sub-station or a station to the platform 850a and/or 850b. It should be appreciated that a traffic management unit, a vehicle alignment unit, and vehicle number recognition unit (details of which will become apparent in the following description) are not installed in the station because in these examples, the vehicle 840 is not being instructed to enter the station. Although the example of Figure 8A will be much discussed in detail in the following paragraphs, it would be easily understood by a skilled person that similar operations would apply for the examples of Figures 8B to 8D and such similar operations are thus omitted in the present disclosure.

"Crew device" or "Alerting Device" in the present disclosure refers to a mobile device or a typical computing device that can provide for connectivity to the internet and/or intranet to communicate with the station (e.g. receive alerts and/or allow inputs). It can be a desktop, laptop, mobile phone, smart phone, and other equivalent hand-held devices which can be used to communicate with the station. Typically, a crew device uses, for instance, Wireless Local Area Network (WLAN), 2nd to 5th Generation Telecommunication networks and the like for data communication with the apparatus. The crew device may comprise a client application for allowing a crew member to update a status of the station, receive alerts such as predetermined exceptions in the workflow of container coning or deconing, control machinery at the station, and/or check details of supervision jobs being assigned to the crew member. Alternatively, the end user can simply type the hyperlink of a website to arrive at a graphical user interface configured for communicating with the apparatus.

"Cycle time" in the present disclosure refers to the total time where a vehicle carrying a container (or two containers) enters the station, the station performs a coning or deconing operation on the container and the vehicle leaves the station. Coning is a process of attaching twist-locks (TL) or cones (AC) to container corner castings prior to loading onto vessels. Cones are also known as stackers. Deconing is a process of removing twist-locks or cones or stackers from container corner castings upon discharge from vessels. This means that cycle time will increase if a vehicle carrying a container (or two containers) to be coned or a container (or two containers) to be deconed continues to remain in the station for the coning or deconing operation to be completed.

A station (or apparatus) 100 according to an exemplary example of the present disclosure for loading and unloading containers at a port facility is illustrated in Figure 1. The station 100 comprises a station controller 190 for managing coning and/or deconing operations necessary for the loading and unloading of containers at the port facility. The station controller 190 comprises a processor configured to execute instructions in a memory to operate the station as a traffic management unit (e.g. TMS) 160 for controlling movement of one or more vehicles 104 transporting the container (i.e. container transporter) into a lane 170 leading to the station 100, a vehicle number recognition unit 150 for receiving information relating to a vehicle number of the vehicle entering the station and a vehicle alignment unit (e.g. VAU) 140 for aligning the vehicle in the station. The vehicle 104 may be arranged to carry more than one container. One end of the lane 170 is an entry point

172 for receiving a vehicle with a container to be coned and/or deconed. The other end of the lane or road is an exit point 174 for the vehicle to exit. There may be traffic lights 162 for signalling the vehicles to enter the station from the entry point 172 and exit from the exit point 174. The width of the lane can be in a range from 3m to 5.1m for allowing the vehicle 104 to enter for the coning or deconing operations depending on the type of vehicle 104. The lane 170 may be long enough to accommodate more than one vehicle carrying more than one containers respectively. In the present example, the lane 170 is long enough to accommodate one vehicle 104 carrying two small containers (e.g. 20 feet in length) 102a and 102b. In another example, the lane may be long enough to accommodate two vehicles carrying one small container (e.g. 20 feet in length) respectively. In such example, the respective locations of each vehicle carrying the container would have to be determined. Some physical realignment of modules (e.g. equipment control unit and storage and sorting unit) in the station may be required. In another example, the lane may be long enough to accommodate one vehicle carrying one big container (e.g. 40 feet in length). The basic dimensions of containers are largely determined by ISO standards. It should be easily understood that the containers can also be 45 feet, 48 feet or 53 feet in length.

The traffic management unit 160 is configured to manage the flow of vehicles 104 in and out of the lane 170 of the station 100 and the vehicle queue outside station 100 by communicating with the container transporter 104 via vehicle communication infrastructure, in the case of an unmanned vehicle, inform the container transporter 104, or in the case of manned vehicle, alerting the driver via a user interface in the vehicle or a traffic light indicator 162 that the station 100 is ready to receive the container transporter 104 and the vehicle 104 may enter the station 100 from the entry point 172. Examples of vehicle communication infrastructure may be in the form of devices supporting Bluetooth, 3G/4G/5G or WIFI communication, one or more loudspeaker devices, and the like. The vehicle may also be equipped with a transponder or a display unit that comprises a transponder. For instance, the traffic management unit is configured to provide signals to the driver of a prime mover 104 with a trailer, to move the vehicle (with the container) into the station 100. For instance, if the station 100 is currently performing a coning or deconing operation, the traffic management unit 160 is configured to turn a traffic light 162 located at the entry point 172 along the lane 170 to flash the colour red, which means "to stop", in the present example. In another instance, if the station has to stop its operation due to an error and is unable to recover within a predetermined time, the station controller 190 may be configured to communicate with a terminal operating system (TOS). The TOS may then redirect the vehicle 104 presently in the station via a user interface for manned vehicle 104 or issue a new job order to the unmanned vehicle 104 (after cancelling the present job order).

In one arrangement, the vehicle number recognition unit 150 communicates with a vehicle 104 to obtain data relating to the vehicle number via the vehicle communication infrastructure. In another arrangement, the vehicle number recognition unit 150 may be placed outside of the station 100 and apply visual imaging techniques to obtain the vehicle number from a vehicle number plate mounted on the vehicle 104 prior to the vehicle 104 entering the station 100.

The station 100 may be further incorporated with a container identification unit 101 for identifying or verifying an identification number on the container of the vehicle 104. The container recognition unit 101 is configured to cooperate with one or more pan-tilt zoom cameras 120 and one or more laser scanners 130 in the station 100. Other recognition devices (e.g. radiography detector or radiation detector) may be incorporated for improved functionality.

Although it is described in this specific example that the station 100 is equipped with a container identification unit 101 and a vehicle number recognition unit 150, it should be appreciated that the station 100 can be configured without a container identification unit and/or a vehicle number recognition unit. For instance, a container identification unit may be disposed at a location away from the station 100. In one example, the quay crane may be equipped with a visioning unit to check the container number and/or the condition of the container before picking the container up and landing it on the vehicle 104. In such an example, the TOS may arrange for a particular vehicle (of known vehicle number) to transport the container to a designated station 100.

If the station 100 is equipped with a container identification unit 101 and a vehicle number recognition unit 150, the quay cranes that are involved in the unloading of the containers need not be equipped with a visioning unit. It is therefore more economical to equip an imaging unit (e.g. camera) at a coning/deconing station. It would also be more efficient since the container number and vehicle number have to be obtained during a coning operation in order to determine the model

of twist-lock or cone used for the coning operation and/or other specific requirements during coning or deconing. Other specific requirements may comprise any one of the following conditions:

- no coning or deconing required,
- fix connectors only at two diagonal corners of a container.

5 Furthermore, if the obtained container number and/or the obtained vehicle number do not match with the job detail/sequence provided by TOS, it will be easier to manage at the coning/deconing station. Therefore, having the container identification unit 101 in the station 100 is advantageous to automate port operations in a port facility.

10 The vehicle alignment unit 140 is configured for instructing the vehicle 104 that enters the station to align itself at a preferred parking position before the coning and/or deconing operation is performed. In one example, the vehicle alignment unit 140 is configured to communicate with an unmanned vehicle 104 via vehicle communication infrastructure to fine tune the parking position of the vehicle 104 for a more effective coning/deconing operation. In another arrangement, the vehicle alignment unit 140 is configured to provide alignment signals via an alignment light indicator 142 to the driver of a prime mover 104 with a trailer to fine tune the parking position of the vehicle 104 for a more effective coning/deconing operation. In such arrangement, the vehicle alignment unit 140 is configured to provide signals for displaying up/down indicators 142a/142c to a driver of the vehicle 104 to fine tune its parking position by moving the vehicle 104 forward or rearward. In addition, the vehicle alignment unit 140 is configured to provide signals for displaying a stop indicator 142b to indicate to the driver to stop any vehicle movement and park the vehicle. The vehicle alignment unit 140 may include an image processor for detecting positioning of the vehicle 104 through captured images of the vehicle 140 or measurement of the position of the vehicle 104 and for determining the signals to be displayed based on the detected positioning of the vehicle 104.

25 In another arrangement, the vehicle alignment unit 140 may be configured to communicate and control remotely a movable platform that is installed on the ground before the vehicle 104 enters the station 100. The movable platform may extend partially along the lane 170 or throughout the lane 170. In an example, the movable platform may comprise a conveyor belt. Front tires of the vehicle 104 may be positioned on the conveyor belt, and the driver of the prime mover is instructed to put the vehicle in neutral gear. The conveyor belt then guides the vehicle 104 into the station 100 to a preferred parking location and/or orientation that is aligned for coning or deconing of containers carried by the vehicle 104. In another example, the vehicle 104 may be arranged to move onto the movable platform, wherein the movable platform is arranged to move, in a step-wise manner, forward or rearward along a longitudinal axis of the vehicle 104, or sideward along a direction transverse to the longitudinal axis of the vehicle 104 to align the vehicle 104 for coning or deconing or containers carried by the vehicle 104. The movable platform may also be arranged to rotate the vehicle 104.

Figure 20 illustrates an example of the aforementioned movable platform that is suitable for alignment of a vehicle (e.g. 104 of Figure 1) along positions in forward or rearward directions d3 along a longitudinal axis of the vehicle. The alignment process may be controlled by taking in user input or automatically by taking input from a plurality of sensors (e.g. cameras, distance sensors, and the like). In Figure 20, a movable platform 2000 is used to align vehicle (not shown in Figure 20) to facilitate coning or deconing of one or more containers carried by the vehicle. In the present example, the movable platform 2000 comprises a conveyor belt 2030 forming an endless loop for conveying the vehicle residing thereon linearly to positions along a length of the conveyor belt 2030 so as to align the vehicle for coning or deconing. In the present example, the movable platform 2000 comprises a first inclined ramp 2002a and a second inclined ramp 2002b located at two opposite ends of the conveyor belt 2030. When the movable platform 2000 is in use to align the vehicle, the vehicle first moves up the conveyor belt 2030 using the first inclined ramp 2002a. Next, the conveyor belt 2030 is driven to align the vehicle by conveying the vehicle to a desired position for coning or deconing that is along the length of the conveyor belt 2030. After the coning or deconing job has completed at the desired position, the vehicle is moved down from the conveyor belt 2030 using the second inclined ramp 2002b to exit. The conveyor belt 2030 may be controlled to move the vehicle from the desired position to the second inclined ramp 2002b so that the vehicle can move down the second inclined ramp 2002b. In the present example, the conveyor belt 2030 comprises a tensioner 2010 for tensioning the conveyor belt 2030 to ensure the conveyor belt 2030 is sufficiently taut for conveying the vehicle residing thereon, a pair of drive wheels 2006, located at front and rear locations, for driving movement of the conveyor belt 2030 and a plurality of rollers

2008 spaced apart to facilitate movement of the conveyor belt 2030 and to hold the weight of the vehicle that has moved up the conveyor belt 2030. One or both of the drive wheels 2006 may be connected to one or more drivers, such as a motor (not shown in Figure 20), that is configured to drive the forward or rearward movement of the conveyor belt 2030. The one or more drivers may be connected to a transponder (not shown in the Figures) for communicating with a vehicle alignment unit (e.g. 140 of Figure 1) or a respective equipment control unit (e.g. 108a-f of Figure 1) and/or station controller (e.g. 190 of Figure 1) that is or are configured to control the one or more drivers. The transponder may be a wireless transponder configured for wireless data communication. The conveyor belt 2030 may comprise one or more anti-slip rib stops 2004 to prevent the vehicle 104 from slipping or skidding on the conveyor belt 2030. In one example, the whole of the vehicle can be located on the conveyor 2030 that is, in the case that the vehicle has wheels, all the wheels of the vehicle are on the conveyor belt 2030. In another example, there may be a pair of the conveyor belt 2030, wherein each conveyor belt is used to hold one side of the vehicle. For example, left side wheels of the vehicle contact a first conveyor belt 2030, while right side wheels of the vehicle contact a second conveyor belt (not illustrated in Figure 20) that has similar configuration as the first conveyor belt 2030.

The movement of the aforementioned movable platform (e.g. 2000 in Figure 20) may be determined from images captured from the pan-tilt zoom cameras 120 and/or data acquired from one or more laser scanners 130 (or in other examples, other scanners such as accelerometer, gyrometer etc.), in the station 100. Fine tuning commands may be sent remotely from the vehicle alignment unit 140 to the movable platform. Such movable platform arrangements are beneficial to the prime mover i.e. the vehicle 104 because such arrangements can reduce the time the prime mover driver needs to align the vehicle 104 at the preferred location. In another example, instead of the movable platform, a container transporter 104 (which is one type of the vehicle 104) may be configured to transport one or more containers on a track (which can be a railway track) that has a predetermined path to the station 100. In this case, the track is already aligned to the station 100 in a manner that one or more containers transported to the station 100 would require little or no alignment for coning or deconing of the transported one or more containers.

In the present example, the station 100 comprises a plurality of equipment control units 108a-108f configured to be placed in line lengthwise along the sides of the lane 170. In other examples, it is possible that the station 100 has only one of the equipment control units 108a-108f or another number of the equipment control units 108a-108f that is different from the number of the plurality of equipment control units 108a-108f. The equipment control units 108a, 108b and 108c are placed in line lengthwise along one side of the lane 170 and the equipment control units 108d, 108e and 108f are placed in line lengthwise along the other side of the lane 170. The equipment control units on each side of the lane may be approximately aligned to one another. Each of the one or more equipment control units 108a-108f comprises a robotic manipulator (not shown in Figure 1) for performing coning or deconing operation.

In one arrangement, each of the equipment control units 108a -108f may be placed on a movable platform. In such arrangement, after entering into the station 100, the vehicle 104 may not be required to align itself at the preferred parking position and orientation for coning or deconing of containers carried by the vehicle 104. Instead, each of the equipment control units 108a -108f may be configured to align itself around the vehicle 104 that is parked in the station 100. The maximum distance the movable platform can move may be set as the reach of the robotic manipulator or at a predetermined distance from an initial set up location. In the event that any of the equipment control units 108a -108f is not able to be aligned to a preferred distance from the vehicle while keeping a safe distance with the adjacent equipment control unit, an alert may be sent to a remote controller. Alternatively, the vehicle alignment unit 140 is configured to instruct the vehicle 104 to make further adjustments to align itself to the preferred parking position. There is an advantage to place the equipment control unit on such movable platform. The movable platform can be guided remotely, for instance, through TOS or the vehicle alignment unit that is communicatively coupled to TOS. With this movable platform, it is easier to deploy the equipment control unit into the station 100. In another arrangement, both the equipment control units 108a – 108f and the vehicle 104 can be aligned relative to each other. This can be done by placing or mounting the equipment control units 108a – 108f and the vehicle 104 to respective movable platforms.

Figure 21A illustrates an example of the movable platform described above that can be used to align movement along positions in forward or rearward directions d3 of a mounting plate 2102 for mounting a robotic manipulator of an equipment control unit (e.g. 108a of Figure 1). The

alignment process may be controlled by taking in user input or automatically by taking input from a plurality of sensors (e.g. cameras, distance sensors, and the like). The reference numerals for elements in Figure 20 are re-used for the same elements found in Figure 21A. In Figure 21A, a movable platform 2100 comprises a conveyor belt 2030 forming an endless loop for conveying the mounting plate 2102 mounted thereon linearly to positions along a length of the conveyor belt 2030 so as to align the robotic manipulator mounted to the mounting plate 2102 for coning or deconing of one or more containers brought to a coning or deconing station. Similar to the movable platform 2000 of Figure 20, the conveyor belt 2030 in Figure 21A comprises a tensioner 2010 for tensioning the conveyor belt 2030 to ensure the conveyor belt 2030 is sufficiently taut for conveying the robotic manipulator residing thereon, a pair of drive wheels 2006 for driving movement of the conveyor belt 2030 and a plurality of rollers 2008 spaced apart to facilitate movement of the conveyor belt 2030 and to hold the weight of the robotic manipulator that is mounted to the conveyor belt 2030. Similarly, one or both of the drive wheels 2006 may be connected to one or more drivers, such as a motor or engine (not shown in Figure 20), that is configured to drive the forward or rearward movement of the conveyor belt 2030. The one or more drivers may be connected to a transponder (not shown in the Figures) for communicating with a vehicle alignment unit (e.g. 140 of Figure 1) or a respective equipment control unit (e.g. 108a-f of Figure 1) and/or station controller (e.g. 190 of Figure 1) that is or are configured to control the one or more drivers. The transponder may be a wireless transponder configured for wireless data communication. Unlike the case in Figure 20, the conveyor belt 2030 of Figure 21A does not require anti-slip rib stops 2004 of Figure 20 since, in the present example, the robotic manipulator is mounted to the conveyor belt 2030 and is not moved up the conveyor belt 2030 like the vehicle described in the example of Figure 20.

Figure 21B illustrates a movable platform 2100a that is an alternative to the movable platform 2100 of Figure 21A. The reference numeral for the mounting plate 2102 in Figure 20 is re-used for a similar mounting plate present in Figure 21A. The movable platform 2100a can be used to align movement of the mounting plate 2102 along positions in forward or rearward directions d3. The movable platform 2100a comprises of a plurality of wheels 2106 that are movable to convey the mounting plate 2102 along one or more tracks 2104. Although it is illustrated in Figure 21B that the mounting plate 2102 is placed on a pair of adjacent tracks 2104, it is appreciated that the mounting plate 2102 can also be arranged to move along a single track 2104. The track or tracks 2104 may be a part of a railway that has a predetermined path leading to a desired location for coning or deconing.

In the example of Figure 21B, there is no requirement to have the conveyor belt 2030 of Figure 20 and its driving mechanisms, as the mounting plate 2102 comprises a driving mechanism of its own. An example of such driving mechanism of the mounting plate 2102 is illustrated in Figure 21C. With reference to Figure 21C, the mounting plate 2102 may have a driving mechanism 2112 comprising a motor and gearbox 2105 for controlling a series of interconnected gears 2108 to move along the track 2104 and a manual recovery member 2114 for disengaging the gear if the driving mechanism 2112 is faulty. The motor and gearbox 2105 drive the gears and the plurality of wheels 2106 to move the mounting plate 2102 forward or rearward on the one or more tracks 2104. Each driving mechanism 2112 may comprise a transponder (not shown in the Figures) for communicating with a vehicle alignment unit (e.g. 140 of Figure 1) or a respective equipment control unit (e.g. 108a-f of Figure 1) or station controller (e.g. 190 of Figure 1) controlling the motor 2105. The transponder may be a wireless transponder configured for wireless data communication.

In another example, the mounting plate 2102 of Figures 21B and 21C may be configured as a platform for carrying one or more containers to be coned or deconed or a vehicle carrying one or more containers to be coned or deconed, and perform the alignment to facilitate the coning or deconing of the one or more containers that is described earlier for the example of Figure 20. In the case that the platform is for carrying one or more containers to be coned or deconed, the one or more containers may be placed on the platform using cranes. In the case that the platform is for carrying a vehicle, two ramps similar to the ramps 2002a and 2002b in Figure 20 may be placed adjacent to the platform to facilitate the vehicle to move up and down the platform like in the example of Figure 20.

It is appreciated that there may be more than one of the mounting plate 2102 present on the one or more tracks 2104 to enable alignment of one or more objects mounted or moved onto the one or more mounting plates 2102. The one or more objects can be one or more robotic manipulators, one or more containers, or one or more vehicles carrying one or more containers.

The movable platforms 2000, 2100, and 2100a of Figures 20, 21A and 21B respectively may be modified to adjust orientation as well.

Figure 22A illustrates an example of a skew control unit 2200 that can be added to the movable platforms 2000, 2100, and 2100a of Figures 20, 21A and 21B respectively to enable them to adjust orientation as well. With reference to Figure 22A, there is present a bottom plate 2201 connected to an top plate 2202 through a shaft 2207 such that the shaft is disposed orthogonally with respect to the bottom plate 2201 and the top plate 2202. The bottom plate 2201 and the top plate 2202 are parallel to each other in the present example. The top plate 2202 is rotatable about a longitudinal axis 2205 of the shaft 2207 in two opposite rotational directions d4. In the present example, the shaft 2207 is fixed to the top plate 2202 but is rotatably coupled to the bottom plate 2201 via an end bearing 2209. A servo motor and gearbox 2213 are connected to the bottom plate 2201, wherein the servo motor is coupled to the gearbox 2213. The servo motor and gearbox 2213 drive a second shaft 2215 extending from the servo motor and gearbox 2213. Separate gears 2211 are provided on the shaft 2207 and the second shaft 2215. The second shaft is not in contact with the top plate 2202. During operation, the servo motor and gearbox 2213 rotates the second shaft 2215 and the gear 2211 arranged on the second shaft 2215 turns a corresponding gear 2211 arranged on the shaft 2207 to rotate the shaft 2207 about the longitudinal axis 2205. As the shaft 2207 is fixed to the top plate 2202, rotation of the shaft 2207 would result in rotation of the top plate 2202 along one of the two opposite rotational directions d4. The direction of rotation of the top plate 2202 is controlled by the direction of rotation of the servo motor. With reference to Figure 20, to enable orientation adjustment, the entire structure of the conveyor belt 2030 can be mounted to the top plate 2202 of the skew control unit 2200 of Figure 22A. With reference to Figure 21A, to enable orientation adjustment, the bottom plate 2201 of the skew control unit 2200 of Figure 22A can be mounted to the mounting plate 2102. Similarly, with reference to Figure 21B, to enable orientation adjustment, the bottom plate 2201 of the skew control unit 2200 of Figure 22A can be mounted to the mounting plate 2102. One or more containers, one or more robotic manipulators, or one or more vehicles carrying one or more containers can be moved or mounted to the top plate 2202 of the skew control unit 2200 and the orientation of the one or more containers, one or more robotic manipulators, or one or more vehicles carrying one or more containers can be adjusted by the skew control unit 2200 to facilitate coning or deconing.

The movable platforms 2000, 2100, and 2100a of Figures 20, 21A and 21B respectively may be modified to adjust both alignment along the directions of movement d3 of the movable platforms 2000, 2100, or 2100a in Figures 20, 21A or 21B respectively, and additionally adjust alignment along transverse directions orthogonal to the directions of movement d3. Figure 22B illustrates an example of a movable platform 2220 that can be configured to work with the movable platforms 2000, 2100, and 2100a of Figures 20, 21A and 21B respectively to enable alignment adjustment along transverse directions d5 orthogonal to the directions of movement d3 of the movable platforms 2000, 2100, or 2100a in Figures 20, 21A or 21B respectively. In the present example, the movable platform 2220 has a similar configuration as the movable platform 2100a of Figure 21B. The movable platform 2220 comprises a mounting plate 2210. The mounting plate 2210 comprises a plurality of wheels 2206 for moving the mounting plate 2210. The plurality of wheels 2206 move along a pair of tracks 2204. The mounting plate 2210 may be configured to be driven by the driving mechanism 2112 of the example of Figure 21C. Instead of moving in the directions of movement d3 of the movable platforms 2000, 2100, or 2100a in Figures 20, 21A or 21B respectively, the pair of tracks 2204 are orientated to enable the mounting plate 2210 to move along directions of movement d5 that is orthogonal to the directions of movement d3 of the movable platforms 2000, 2100, or 2100a in Figures 20, 21A or 21B respectively.

Figures 23A, 23B, and 23C show different combinations of the movable platform 2220 of Figure 22B, the movable platform 2000, 2100, or 2100a in Figures 20, 21A or 21B respectively, and the skew control unit 2200 of Figure 22A. Specifically, Figure 23A shows a combination 2300a comprising the movable platform 2100a of Figure 21B mounted on the top plate 2202 of the skew control unit 2200 of Figure 22A. The bottom plate 2201 of the skew control unit 2200 in the combination 2300a is mounted on the mounting plate 2210 of the movable platform 2220 of Figure 22B. Figure 23B shows a combination 2300b comprising the movable platform 2100 of Figure 21A mounted on the top plate 2202 of the skew control unit 2200 of Figure 22A. The bottom plate 2201 of the skew control unit 2200 in the combination 2300b is mounted on the mounting plate 2210 of the movable platform 2220 of Figure 22B. Figure 23C shows a combination 2300c comprising the movable platform 2000 of Figure 20 mounted on the top plate 2202 of the skew control unit 2200 of

Figure 22B. The bottom plate 2201 of the skew control unit 2200 in the combination 2300c is mounted on the mounting plate 2210 of the movable platform 2220 of Figure 22B.

Figure 23D shows yet another combination 2300d that comprises a modified version 2000a of the movable platform 2000 of Figure 20, wherein the conveyor belt 2030 is mounted on the top plate 2202 of the skew control unit 2200 of Figure 22A. The bottom plate 2201 of the skew control unit 2200 is mounted on the mounting plate 2210 of the movable platform 2220 of Figure 22B. In the modified version 2000a, the inclined ramps 2002a and 2002b are not located on the top plate 2202. This is unlike the case of Figure 23C, wherein the inclined ramps 2002a and 2002b of the movable platform 2000 are mounted on the top plate 2202. The conveyor belt 2030 is configured to be larger than the conveyor belt 2030 of the combination 2300c of Figure 23C. The skew control unit 2200 and the movable platform 2220 are configured to be smaller than those of the combination 2300c. The inclined ramps 2002a and 2002b of the modified version 2000a are arranged on a ground adjacent to the conveyor belt 2030. The inclined ramps 2002a and 2002b of the modified version 2000a are arranged with a height that is substantially at a height of the larger conveyor belt 2030 to enable movement of vehicle up or down the conveyor belt 2030. The various combinations 2300a to 2300d described above enable alignment along directions d3 and d5 that are orthogonal to each other, and/or orientation via rotation of the skew control unit 2200.

The robotic manipulator described above may comprise an end effector. With reference to Figure 1, each of the equipment control units 108b and 108e is configured to install and/or remove connectors from the containers 102a and 102b. In one arrangement, the equipment control unit 108b and 108e may comprise two robotic manipulators to perform the coning or deconing operation at two corner castings (e.g. 110a and 110b) of the containers 102a and 102b simultaneously. In another arrangement, the equipment control unit 108b and 108e may comprise one robotic manipulator to perform the coning or deconing operation at a corner casting of the containers. In the arrangement with one robotic manipulator to perform the coning or deconing operation, the robotic manipulator of the equipment control unit 108b may be configured to install or remove the connector from the corner casting 110a of the container 102a before installing or removing the connector from the corner casting 110b of the container 102b.

"A location for performing a coning or deconing operation" in the present disclosure refers to a preferred parking position of a vehicle with a container to be coned or a container to be deconed before the coning and/or deconing operation is performed. "A location for retrieving a connector used for coning" or "a location for receiving a connector obtained from deconing" in the present disclosure refers to a place at a sorting and storage device for the robotic manipulator to receive a connector to be handled or to return a connector for storing respectively. Details of the sorting and storage device would be discussed later. "A location for a dispensing mechanism to dispense a connector" in the present disclosure refers to a place where a connector is being arranged to drop out of a holder after a tilting action by the dispensing mechanism of the sorting and storage device. Details of the dispensing operation used to discharge a connector from a holder would be discussed later. "A location for loading a connector" in the present disclosure refers to a place where a connector is placed into a holder by the sorting device. In one arrangement, the location for loading a connector is typically opposite of the location for retrieving a connector used for coning and the location for receiving a connector obtained from deconing.

In robotics, an end effector is commonly referred as a device or tool that is connected to one end of a robot arm where handling operations take place. The end effector is typically the part of the robot that interacts with the environment.

Each robotic manipulator in each of the one or more equipment control units 108a-108f has a robotic arm. The robotic arm may be configured to cooperate with one or more end effectors to remove or install the connector from the corner casting of the container.

With reference to Figures 1 and 2, the station controller 190 may be configured to instruct change of an appropriate end effector 254 of a robotic arm 250 to match the type of connector to be handled during coning or deconing after a determination of a change of the end effector is required. The determination of the change of the end effector may be performed by the station controller 190 or a processor residing at each of the one or more equipment control units 108a-108f using information transmitted from TOS. If a change of the end effector is required, the robotic manipulator is configured to:

- retrieve information about a location of a target end effector 254 at the exchange store 270;
- instruct the robot manipulator 250 to disengage an existing end effector mounted on the robotic manipulator 250 at a predetermined location in the exchange store; and
- move to the location of the target end effector to engage the target end effector 254.

Figures 6A and 6B illustrate one example of the robotics present in each of the one or more equipment control units 108a-108f of Figure 1. There is present an end effector 600 that is connected to the end of a robotic arm. End effector 600 comprises a base 604 for matching with one or more tops 602. Each top 602 is configured to handle a specific type of connector during container coning or deconing. This means that the end effector 600 is designed with a view to cooperate with various interchangeable tops 602 to suit different types of connectors to be handled in container handling operations. The tops 602 may be attached to the base 604 by way of magnetic means. For instance, the base 604 of the end effector 600 may have transitory electromagnetic strips. Each top 602 may have permanent magnets. For disengagement of an existing top 602 attached to the base 604 of the end effector 600, the base 604 of the end effector 600 may be configured such that polarities of the transitory electromagnetic strips become the same as the polarities of the permanent magnets of the existing attached top 602. For engagement of the end effector 600 to a target top 602, the base 604 of the end effector 600 may be configured such that polarities of the transitory electromagnetic strips become different from the polarities of the permanent magnets of the target top 602. The engagement and disengagement process between a top 602 and the base 604 of the end effector 600 may be assisted by visioning means (or imaging techniques). There may be visual guides/indicators present in the robotic arm to facilitate the operation of the visioning means (or imaging techniques).

In another arrangement, the top 602 may be attached to the base 604 by an electronically controlled lock. Figure 6H illustrates a top view of an electronic locking mechanism between the base 604 of the end effector 600 and the top 602 to secure the two parts together. The base 604 comprises of an electronically controlled locking mechanism 660 that controls a pair of latches 662 that are configured to engage with a corresponding set of latch strikes 664. Once the latches 662 are fully set into the latch strikes 664, the base 604 and top 602 are fully engaged. Figures 6B and 6C show the top 602 in respective engaged and disengaged configurations with the base 604.

For instance, and referring to Figure 2, after determining that a change of the end effector is required, a robotic manipulator 250 of an equipment control unit (e.g. any one of 108a – 108f of Figure 1) may be configured to retrieve an appropriate end effector 254 from an end effector exchange rack 270. Each robotic manipulator 250 may be equipped with a visioning unit 252 or detection means for measuring and calculating a possibility of collision with a corner casting (not shown in Figure 2). The robotic manipulator may be equipped with an impact sensor (not illustrated in Figures) that is configured to detect an impact of the end effector with an obstacle.

With reference to Figures 6A to 6H, an interchangeable end effector 600 comprises of a top portion 602 and a bottom portion 604 that are configured to be fitted with each other and operatively connected via a locking mechanism 660. The bottom portion 604 is interchanged with a plurality of top portions 602 that are being housed at the end effector exchange rack 270 (of Figure 2). Each top portion 602 has a top mating plate 648 that is configured to fit with a corresponding bottom mating plate 650 of the bottom portion 604. For instance, as shown in Figure 6H, the bottom mating plate 650 further comprises one or more ridges 652 arranged between two opposing ends and are shaped to fit within corresponding one or more recesses 646 of the top mating plate 648. Preferably, four pairs of latch strikes 664 are arranged at four corners of the top mating plate and the bottom mating plate. In the example as shown in Figure 6H, each latch 662 is arranged to be engaged with each respective pair of latch strikes 664. In such arrangement, the locking mechanism 660 is arranged to be disposed between a turning top 642 of a rotation portion 640 and a bottom mating plate 650 of the base 604.

An example of each top 602 may comprise of a clamping portion 610, a pushing portion 620 and/or a twisting portion 630, while the base 604 of the end effector 600 comprises the rotation portion 640. In one example, there can be a top 602 that comprises only the twisting portion 630 and clamping portion 610. In another example, there can be an end effector 602 that comprises only the pushing portion 620 and clamping portion 610.

The clamping portion 610 of the top 602 is configured for clamping to a body of a connector (see 320b of Figure 4A). The clamping portion 610 is configured to have protrusions 612 that will

slide within a groove 612a of a housing 608 of the top 602 such that the clamps of the clamping portion 610 can slide inwards to clamp a connector or slide outwards to release a connector. The clamping portion 610 may be equipped with a sensor (e.g. proximity sensor or infrared sensor) to detect the presence of the connector. This means that if the connector being handled has been dropped during transfer (movement to/from corner casting and to/from storage device respectively), the station controller 190 can be notified of the fault and remote exception handling can be done to address the fault (e.g. another connector is arranged to be retrieved to complete a coning job).

The twisting portion 630 is configured to turn a movable part of some types of connectors while the pushing portion 620 is configured to push another movable part of some types of connectors during installation/removal of a connector to/from the container. Referring to Figures 6D to 6G, the twisting portion 630 has a twisting top 632 that is mounted together with a casing 628 that houses one or more pushing devices (e.g. 620a and 620b). The casing 628 comprises of a pocket 622 for allowing a portion of the connector to sit in. It should be appreciated that a body of a connector (see 320b of Figure 4A) and an upper/lower cone of the connector (see 320c/320a of Figure 4A) remains exposed when the respective lower/upper cone portion of the connector is arranged to sit in the pocket 622 (see Figures 7A to 7H). The pocket 622 allows the lower cone portion of the connector to be rotated to a specific angle during coning or deconing operations to secure or remove the connector from the corner casting respectively. Each pushing device 620a and 620b and the twisting portion 630 are operable through gears and servo motor. Figure 6D shows the pushing devices 620a and 620b in retracted configurations, whereas Figures 6E and 6F show the pushing devices 620a and 620b in extended configurations for pushing a movable part of a connector. The pushing device of each pushing portion 620a and 620b can be configured to move linearly, pivot or to move linearly and pivot upon travelling a maximum linear movement. For instance, the pushing device 620b can move linearly and pivot upon travelling a maximum linear movement. The pushing device 620a can move linearly.

Figure 6G shows the twisting portion 630 before twisting a movable part of a connector. The twisting portion is typically configured to rotate by a maximum of 90° in order to avoid causing excess mechanical strain to the connector. However, any predetermined angles can be envisaged. The twisting portion 630 may be configured to detect if a connector is jammed to the corner casting during coning and deconing by monitoring a torque control parameter of the twisting portion 630. The rotation portion 640 of the base 604 (as illustrated in Figures 6B and 6C) is configured to position the top 602 for more effective installation or removal of a connector. The operation of the twisting portion 630 is similar to the operation of the rotation portion 640. It should be appreciated that the rotational movement of a twisting portion is more restricted than the rotating portion of the base 604 of the end effector 600. The rotational movement is configured in a manner such that a portion of the connector would not over-turn.

Each top 602 may further comprise a manual recovery member 666 for use during repair and recovery. By activating the manual recovery member 666 of a motion unit in the top 602, the top 602 may be released from the base 604. Advantageously, this allows for manual intervention if the robotic arm 600 does not successfully release an attached end effector 602 during change of the end effector 602. Optionally, the clamping portion 610, the twisting portion 630, the pushing portion 620, the rotation portion 640, may each be arranged with a manual recovery member (not shown in figures) to release a connector from itself during repair and recovery. For instance, the clamping portion 610 comprises a manual recovery member 616 to release the clamping action of a connector during repair and recovery. The clamping portion 610, the twisting portion 630, the pushing portion 620, and the rotation portion 640, may each or all of them be electrically powered or pneumatically powered. In a preferred arrangement, all the clamping portion 610, the twisting portion 630, the pushing portion 620, and the rotation portion 640 are electrically powered. The electromechanical propulsion provides fast responses for continuous operations. The electromechanical propulsion also ensures easier troubleshooting and/or repair. Although a change of end effector is described above, it should be appreciated that in another example of a robotic manipulator of the present disclosure, the base 604 of the end effector 600 may be configured to work with a universal top that can handle all types of connectors without need for changing the top 602. In another arrangement, and as illustrated in Figure 6I, the universal end effector 690 can be pre-manufactured as an integral unit. In such an arrangement, the locking means 660, the top mating plate 648 and the bottom mating plate 650 would not be required. The top 602 of the universal end effector 690 is directly mounted or integrated with the base 604 of the universal end effector 690.

In another example, the station controller 190 may be configured to instruct the robotic arm 250 equipped with an appropriate end effector 254 to rotate a twist lock in order to remove a connector (e.g. 320 of Figure 14) from a corner casting (e.g. 110a of Figure 14) during deconing operation. Likewise, the station controller 190 may be configured to instruct the robotic arm 250 equipped with the appropriate end effector 254 to rotate the connector in order to install the connector to a corner casting during coning operation. In such example, a clamping portion of the appropriate end effector 254 is configured to clamp a body (e.g. 320b of Figure 14) of the connector before rotation of the connector is performed by the robotic arm 250 at the corner casting. This means that the appropriate effector does not require a rotating portion 640 and/or a twisting portion 630.

Referring back to Figure 1, the one or more equipment control units 108a-108f may each be configured to terminate coning or deconing and retract a robotic manipulator when a motion sensor (e.g. use of laser scanner 130) installed at the station 100 detects movement of a vehicle 104 carrying one or more containers 102a or 102b being coned or deconed or movement of the one or more containers 102a or 102b on the vehicle 104 that is being coned or deconed during the coning and/or deconing process. The motion sensor may be a sensor that is capable of calculating displacement or acceleration of a fixed point on the container 102a or 102b, or a fixed point on the vehicle 104 using any of known techniques such as, infrared detection, laser detection or gyrometer detection.

The station controller 190 is configured to verify a type of operation to be carried out in the station 100 and its related parameters (i.e. operation information) based on data relating to the vehicle number of the vehicle 104 and/or data relating to the container identification number of the one or more containers 102a and 102b and operation information provided by a central server managing all operations within the port facility to the station controller 190. In the present disclosure, this central server is known as "Terminal Operating System" (TOS) (e.g. 1250 of Figure 12A). The data relating to the vehicle number of the vehicle 104 and/or the data relating to the container identification number of the one or more containers 102a and 102b may be captured by the vehicle number recognition unit 150 and/or container recognition unit 101 respectively. The data is subsequently analysed by the station controller 190 to work out the type of operation. In one arrangement to work out the type of operation, the data captured by the recognition units is compared with operation information retrieved from a memory accessible to the station controller 190. The operation information indicates whether each container has to be coned or deconed. An example of the operation information being stored at the TOS and accessible by the station controller 190 is illustrated in Figure 11B.

With reference to Figure 11B, data of the operation information may be structured according to a list 1200. The list 1200 records:

- vehicle numbers of vehicles in a queue for coning or deconing at the station 100,
- an action (i.e. coning or deconing) to be conducted for each listed vehicle ,
- number of containers each vehicle is transporting,
- the size of each container each vehicle is transporting.
- container number of each container transported by each vehicle,
- type of connectors to be handled for each container, and
- model of the connector to enable selection of the type of an end effector of a robotic manipulator that is compatible with the type of connector to be handled for one action listed in the list.

Figure 11B illustrates 3 example situations as follows.

The first example situation (i.e. first row of the list 1200) is where one or more equipment control units (e.g. 108a – 108f of Figure 1) in a station (e.g. 100 in Figure 1) are configured to perform a coning operation for a vehicle containing two 20-foot containers. The vehicle has a vehicle number "1234". Respective robotic manipulators of the one or more equipment control units each use a "CSAM-DF" type end effector to install twist-locks to the two containers.

The second example situation (i.e. second row of the list 1200) is where one or more equipment control units (e.g. 108a – 108f of Figure 1) in a station (e.g. 100 in Figure 1) are configured to perform a deconing operation for a vehicle containing one 40-foot container. The vehicle has a vehicle number "2345". Respective robotic manipulators of the one or more equipment control units each use a "IS-1T/LF" type end effector to remove cones from the two containers.

The third example situation (i.e. third row of the list 1200) is where there is a detection, for instance, through the plurality of cameras 120 of the container identification unit described with reference to Figure 1, that no connectors are to be handled. For example, there is present a vehicle with a vehicle number "4567". The vehicle is configured to carry two 20-foot containers on its trailer but the vehicle is presently only carrying one 20-foot container. The vehicle enters a station (e.g. 100 in Figure 1) to perform coning for the only container that it carries. Based on the data "1, 20 feet, empty", the station controller 190 is notified that the vehicle is carrying one container at the front of its trailer while the back of its trailer is empty. Thereafter, the station controller 190 communicates with the one or more equipment control units designated to carry out coning action for the single container. The container being coned has an identification number "ABCD7654321" and the connectors for the coning are of "twist-lock" type. Correspondingly, the appropriate end effector for coning the container is of "C5AM-DF" type. In this case, container identification number for the empty container space in the trailer of the vehicle is indicated as "Not applicable". The type of connector to be managed for the empty container space is indicated as "NA" (not applicable) and the model type for the empty container space is indicated as "NA" to indicate that no change of any end effector mounted on robotic manipulators of the one or more equipment control units is required.

The fourth example situation (i.e. fourth row of the list 1200) is where the station is configured to allow two smaller automated guided vehicles 104 to enter the station, wherein each vehicle 104 is arranged to carry a single 20-foot container. For example, there are present two vehicles with respective vehicle number "5678" and "6789". The two vehicles in line are signalled to enter a station (e.g. 1000 in Figure 10) consecutively in order to perform coning for the two containers simultaneously. Based on the data "1, 1, 20 feet, 20 feet", the station controller 190 is notified that two vehicles, each carrying one container, have entered the station 100 for coning operation. Thereafter, the station controller 190 communicates with the respective equipment control units (e.g. 1008a – 1008f of Figure 10) designated to carry out coning action for the two containers. The connectors for the coning operation of a first container having an identification number "BCDE1234567" and a second container having an identification number "WXYZ9876543" are identified to be of "cone" type and "twist-lock" type respectively. Correspondingly, the appropriate end effector for coning the first and the second container is of "IS-1T/LF" type and "C5AM-DF" type respectively. In this case, the robotic manipulators of the equipment control units are equipped with different end effectors. For instance, and referring to Figure 10, the substations 1004a, 1004b, 1004e and 1004f are equipped with end effectors of "IS-1T/LF" type and the substations 1004c, 1004d, 1004g and 1004h are equipped with end effectors of "C5AM-DF" type.

Referring back to Figure 1, the station controller 190 may be configured to instruct one or more devices, including sensors and/or the one or more cameras 120, to verify information such as a number of containers on a vehicle or container transporter 104 and the size of the one or more containers 102a and/or 102b. Thereafter, data of such information can be used to determine location data of corner castings of one or more containers to be coned or deconed. In the example as shown in Figure 1, the station controller 190 can verify job information from the server (i.e. TOS), based on the vehicle number (i.e. PM 1234) obtained through the vehicle recognition number unit 150. The job information may include an operation (i.e. coning or deconing) to be performed on the containers 102a and 102b on the vehicle 104 and the related operation information. In the present example, the related operation information is similar to the operation information 1200 of Figure 11B and shall be denoted by the same reference numeral. The station controller 190 may also be configured to obtain container identifiers of the containers 102a and 102b from the server and verify the container identifiers from the server with container identification numbers of the containers 102a and 102b obtained through the container recognition unit. The operation information 1200 in Figure 12 may, in addition to the data described in Figure 11B, further comprise data on number of robotic manipulators (of the equipment control units 108a - 108f) available to perform the coning or deconing operation and/or which of the robotic manipulators should be used. For the sake of simplicity, the number of equipment control units available at the station 100 and/or the distance between each robotic manipulator and each corner casting are not illustrated in Figure 11B.

Provided that the vehicle 104 is parked and aligned properly with the help of the vehicle alignment unit 140, each robotic manipulator is configured to locate a corner casting using imaging techniques on captured images of surrounding area of the robotic manipulator. Each robotic manipulator may be configured to work with an imaging unit 122 and/or a laser scanner 130 and/or a pan-tilt zoom camera 120 for the purpose of locating corner casting. In the present example, there are several imaging units 122, and/or several cameras 120 (i.e. all blocks indicated with "C" in

Figure 1) and/or several laser scanners 130 (i.e. all blocks indicated with "L" in Figure 1). However, for convenience, only one imaging unit 122 is marked out in Figure 1 and only one laser scanner is marked with the reference numeral 130 in Figure 1.

In one arrangement, an estimated position of a container is first obtained using the laser
 5 scanners 130. Subsequently, the station controller 190 determines and/or predicts each movement trajectory of each robotic manipulator (e.g. 1009a - 1009h of Figure 10) to its designated corner casting on the container to be coned or deconed. If there is a possibility of collision between the robotic manipulator and an obstacle, and the vehicle 104 cannot be aligned to avoid collision, the station controller 190 will flag a fault. Alternatively, the robotic manipulator may proceed with the
 10 coning/deconing job, but use an imaging unit located near an end effector 600 to analyse if the probability of collision is high. It should be appreciated the determination on the probability of collision may be limited by the field of view of the imaging unit. "Collision" used herein refers to a detection of obstacle in the movement path of the robotic manipulator and/or a detection of impact on a part of the robotic manipulator, particularly the end effector.

The imaging unit 122 may comprise one or more cameras and an image processor for
 15 processing and analysing images captured by the one or more cameras. In one arrangement, the imaging unit 122 of the robotic manipulator (represented as the visioning unit 252 of Figure 2) may be placed beside the end effector or on the robotic manipulator to assist in the identification of the location of a corner casting and/or a position of a connector. The imaging unit 122 of the robotic
 20 manipulator can be configured to identify the type of connector on the corner casting to verify that the appropriate connector as identified based on retrieved data of the operation information 1200 is correct and the identification result is used to change the end effector automatically if a wrong type of end effector is currently attached to the robotic manipulator. The imaging unit 122 of the robotic manipulator may also be configured to detect a compartment position storing a target end effector in
 25 an exchange store (e.g. the exchange store 270 of Figure 2).

The plurality of cameras 120 in the station may also be configured to assess the container to be coned or deconed for damages and/or to detect a position of a door of the container. The detected position of the door and any physical condition (e.g. any damage) corresponding to the container is transmitted to the server (i.e. TOS) for monitoring and/or further processing. For
 30 instance, images captured by the plurality of cameras 120 can be compared with a set of reference images, and differences between the captured images and the reference images can be indicative of damages in the container.

Each of the one or more equipment control units 108a-108f is configured to communicate with a respective one of a plurality of storage and sorting devices 106a-106f. Each of the storage
 35 and sorting devices 106a-106f is configured for holding and delivering container connectors to each of the equipment control units 108a-108f respectively for container coning and/or deconing. In the present disclosure, the term "sub-station" is used to refer to a combination of each of the one or more equipment control units 108a-108f and each respective one of the plurality of storage and sorting devices 106a-106f. Details of each of the storage and sorting devices 106a-106f will be
 40 described later.

Figure 10 illustrates an example of a station 1000 similar to the station 100 of Figure 1. Similar to station 100, there is a center lane or road 1070 between two rows of substations. In Figure 10, a vehicle 1020 carrying a container 1022 is parked in the lane 1070. The container 1022 has four corner castings 1025a – 1025d at which coning or deconing is performed. The first row
 45 comprises substations 1004a, 1004b, 1004c and 1004d, placed in line lengthwise along one side of the lane 1070. The second row comprises substations 1004e, 1004f, 1004g and 1004h placed in line lengthwise along the other side of the lane 1234. The substation 1004a comprises of an equipment control unit 1008a having a robotic manipulator 1009a and a storage and sorting device 1006a. Likewise, the substation 1004e comprises of an equipment control unit 1008e having a
 50 robotic manipulator 1009e and a storage and sorting device 1006e. For convenience, not all equipment control units are indicated with reference numerals in Figure 10.

Although Figure 10 shows more than two substations, it should be appreciated that the station 1000 may comprise only two substations (e.g. 1004a and 1004e) residing along the
 55 opposing sides of the lane 1070 to perform coning or deconing of the container 1022 on the vehicle 1020. In the case of only two substations, the substations 1004a and 1004e can be configured to perform coning or deconing on the respective corner castings 1025a and 1025c of the container 1022, before a station controller (similar to the station controller 190 of Figure 1 and not illustrated in

Figure 10) instructs the vehicle 1020 or notify a driver of the vehicle 1020 to move the vehicle forward for the substations 1004a and 1004e to perform coning or deconing on the other two corner castings 1025b and 1025d of the container 1022.

For most optimum efficiency of a station, the station 1000 may comprise eight equipment control units 1008a – 1008h as shown in Figure 10 distributed equally along the two opposing sides of the lane 1070. In the present example, the equipment control units 1008a, 1008b, 1008c and 1008d are placed in line lengthwise along one side of the lane 1070. The equipment control units 1008e, 1008f, 1008g and 1008h are placed in line lengthwise along the other side of the lane 1070. The arrangement of the equipment control units 1008a – 1008h in the present example enables the station 1000 to receive two smaller containers (e.g. of 20 feet each) placed adjacent to each other on a vehicle. Each robotic manipulator of the respective equipment control units 1008a – 1008h is configured to install or remove only one connector. This arrangement reduces cycle time at the port facility.

With eight equipment control units 1008a – 1008h, in the case of one large container (e.g. 40 Feet), the equipment control units in operation at the respective four corners of the container are 1008a, 1008e, 1008d and 1008h. In the case of two small containers (e.g. 20 Feet), all the eight equipment control units 1008a – 1008h are in operation at the respective eight corners of the two containers. Advantageously, all the robotic manipulators of the equipment control units 1008a-1008f may be activated to install or remove connectors from all the corner castings of the two containers simultaneously.

Figures 9A to 9D shows four different modes of transporting a substation 906 (e.g. 1004a or 1004e of Figure 10) or a plurality of substations mounted on a platform in the port for deployment according to an example of the present disclosure. In Figures 9A and 9B, if more substations are to be included to a station to enhance work efficiency or replace a faulty substation, the substation can be transported by a forklift or a quay crane spreader to the station. Each substation can be fitted with an energy source for providing power to the substation. The energy source may be a solar panel or a portable generator or one or more rechargeable batteries. Each substation may be fitted with a retractable shelter 902 for sheltering one or more containers (e.g. 102a and 102b of Figure 1, 1022 of Figure 10) from environmental conditions. The retractable shelter 902 is controlled by a shelter system 103 (illustrated in Figure 1) in communication with the station controller 190. The retractable shelter 902 may be triggered to extend to shelter the one or more containers by receiving a signal from a server (e.g. TOS) or from a station controller (e.g. 190 of Figure 1). In one arrangement, the retractable shelter 902 is configured to operate with a weather sensor (e.g. rain detector, not illustrated in Figures) disposed on an external surface of the retractable shelter device 902 such that the retractable shelter 902 is extended according to an input from the weather sensor. It should be appreciated that the retractable shelter is wide enough to cover an equipment control unit (e.g. 108a of Figure 1) comprising a robotic manipulator 904, an storage and sorting device 200 and an vehicle alignment unit 142 and/or all other units that have to be sheltered and that are required for the completion of a coning and or deconing operation.

40 Storage and sorting device

Figure 2 illustrates a storage and sorting device 200 comprising a storage module 210 and a sorter 220. The storage and sorting device 200 is an example of each of the storage and sorting devices 106a-106f in Figure 1. The storage module 210 may be arranged as a separate module from the sorter 220 and the storage module 210 may operate independently from the operation of the sorter 220. The storage and sorting device 200 may be arranged adjacent to an equipment control unit (e.g. 108a -108f in Figure1) in order to facilitate the retrieval of connectors for coning or the storing of connectors obtained from deconing.

Figure 3A illustrates an example of the storage module 210 of the storage and sorting device 200 in Figure 2. The storage module 210 comprises a conveyor mechanism 300, a dispensing mechanism (also known herein as discharging mechanism) 310, and a memory (not shown in Figure 3) for storing indexing data and instructions to perform coning or deconing. Figure 11A shows an example of the indexing data 1100 being stored at the memory of the storage module 210 of Figure 2. In the present example, the indexing data 1100 stored in the memory of the storage module 210 may comprise:

55 (i) a presence of a connector in each holder,

(ii) a type and a model of the connector that is contained in each holder (i.e. 1100b of Fig. 11A), and

(iii) a position of each holder of the conveyor mechanism (i.e. 1100a of Fig. 11A).

Referring back to Figure 3A, the conveyor mechanism 300 comprises a plurality of holders 330 for holding a plurality of connectors 320. The conveyor mechanism 300 is configured for moving the plurality of holders 330 to a location for retrieving a connector 320 used for coning a container and for moving the plurality of holders 330 to a location for receiving a connector 330 obtained from deconing a container. The conveyor mechanism 300 is configured to coordinate with a robotic manipulator (e.g. 250 of Figure 2) of an equipment control unit (e.g. 108a of Figure 1) used for coning or deconing at a corner casting of a container to be coned or deconed.

In one example, the conveyor mechanism 300 comprises of a tensioner 308 and a pair of roller chains 302, which is driven by an electrical/servo drive motor 312. The drive motor 312 is configured to cooperate with a gearbox 314 to drive the roller chain (or driving chain) 302 through the drive wheel 316. Each of the pair of roller chains 302 is configured to be an endless loop. Each of the pair of roller chains 302 can be arranged to be moved in either a clockwise or a counter-clockwise direction. Each of the pair of roller chains 302 may comprise metal chains, a belt, rollers 304 and the like. The plurality of holders 330 are mounted to the pair of roller chains 302 and they are evenly spaced along the roller chains 302. The tensioner 308 is configured to maintain the tension of each roller chain 302. It should be clear that in actual implementation, the length of each roller chain 302 determines the number of holders per chain (or the capacity of the storage module 210), but the available space within a substation (e.g. 1004a) determines the length of the roller chain 302. Each roller chain 302 drives the movement of the holders 330 mounted to the roller chain 302. The conveyor mechanism 300 comprises one or more sensors to detect the presence of a connector held by a holder at the location for receiving a connector obtained from deconing a container. In the present example, this location is also the location for retrieving a connector used for coning a container. By using one or more sensors located at the location for coning and deconing for monitoring, it ensures each connector will be handled properly between the storage module 210 and an end effector of the robotic manipulator (e.g. 250 of Figure 2) during coning or deconing. Furthermore, each holder may be configured to have a proximity sensor and/or a RFID tag for easy data management of the statuses of each holder. In other arrangements, the location for receiving a connector obtained from deconing a container can be different from the location for retrieving a connector used for coning a container i.e. the two locations are spaced apart.

In the present example, there may be provided an encoder 313 (or controller, processor and the like) for estimating a position of each holder in each roller chain 302. Such encoder 313 may be part of a circuit/system for controlling the electrical/servo drive motor 312. Each holder of each roller chain 302 may be given a unique identifier. Once a holder is moved by the roller chain 302 to a predetermined discharging position, the dispensing mechanism 310 can be activated as required to dispense a connector contained in the holder. In one example, the dispensing mechanism 310 can be activated to interact with each holder that reaches the predetermined discharging position for dispensing connector regardless whether the holder actually contains any connector.

The calculation for estimating the position of each holder may be calculated based on a previously recorded position of the holder, speed of movement of the pair of roller chains 302 in the endless loop, and/or how many steps each of the pair of roller chains 302 have moved passed from a predefined point/position. One step movement can be set as movement of a distance between two holders mounted adjacent to each other in the conveyor mechanism 300. The speed of movement of each of the pair of roller chains 302 is controllable as desired. The number of steps to move a holder to the predetermined discharging position can be determined from the estimated position of the holder in the conveyor mechanism 300.

A sensor 307 can be provided at a designated sensor position for detecting identity of a holder moved by the roller chain 302. The designated sensor position can be arranged so as to detect the holder identity when the holder is entering into the discharging zone and towards the predetermined discharging position in the discharging zone. The sensor 307 may detect each holder through a unique RFID tag assigned to each holder. A holder that is moved in a step movement of the roller chain 302 passed the designated sensor position to the predetermined discharging position is ready for the dispensing mechanism 310 to dispense a connector contained in the holder. In Figure 3A, there is a holder X located at the predetermined discharging position that is ready for the dispensing mechanism 301 to dispense a connector contained therein.

In the present example, the holder has to be tilted by the dispensing mechanism 310 beyond a specific angle in order for the connector to drop from the holder due to gravity. A discharging guide 340 with a sloped sliding surface may be provided. The sloped sliding surface is configured to receive the dispensed connector after it drops from the holder and it is sloped in a direction to guide the dispensed connector towards the output bin 350. Upon contacting the discharging guide 340, the dispensed connector slides over the sloped sliding surface into the output bin 350 by gravity pull.

In one arrangement, and referring to Figures 3B and 3C, the robotic manipulator (e.g. 250 of Figure 2) of the equipment control unit (e.g. 108a of Figure 1) is arranged to receive/retrieve a connector at a predetermined position 326b of the conveyor mechanism 300. The holder of the conveyor mechanism 300 at the predetermined position 326b remains in an upright orientation while the robotic manipulator interacts with the holder at the predetermined position 326b. In such an arrangement, a change in states between presence of a connector in the holder and absence of a connector in the holder would be used to trigger the conveyor mechanism 300 to accept another job. The new job received by the storage module 210 can be any of the following

- a movement operation of the conveyor mechanism 300 to move a holder 330 containing a connector for use in a coning operation to be performed for a vehicle next in queue to the position 326b,
- a movement operation of the conveyor mechanism 300 to move an empty holder 360 for use in a deconing operation to be performed for a vehicle next in queue to the position 326b,
- a no-movement operation of the conveyor mechanism 300 to get ready the robotic manipulator to obtain a connector for a coning operation to be performed for a vehicle next in queue (this operation occurs, for instance, if the holder 330 at the position 326b is an appropriate connector for the coning operation),
- a no-movement operation of the conveyor mechanism 300 to get ready the robotic manipulator to receive a connector obtained from a deconing operation to be performed for a vehicle next in queue (this operation occurs, for instance, if an empty holder 360 is at the position 326b),
- a movement operation of the conveyor mechanism 300 to move a holder to receive a connector picked up from a store (bin) 214 at a location 326a for loading a connector. Details will be discussed later for this operation.
- a movement operation of the conveyor mechanism 300 to move the holder 330 to a discharging position 328b for the dispensing mechanism (or discharging mechanism) 310 to dispense a connector 320 held in the holder 330. Details will be discussed later for this operation.

In the present example, each holder 330 is configured to be mounted to the conveyor mechanism 300 such that a connector 320 held by the holder 330 is maintained in an upright orientation when transported by the conveyor mechanism 300 and the connector 320 remains held by the holder 330 until the holder 330 is tilted by the dispensing mechanism 310 to a specific angle, α between a line of gravity (402 of Figures 4A, 4B and 4E) and a longitudinal axis of the holder 330 (e.g. 404 of Figures 4A, 4B and 4E). The specific angle is for dispensing the connector 320 and can be, for instance, any suitable angles between 55° to 150°, preferably between 55° and 90°, and more preferably between 58° and 76°. Details of the specific angle will be discussed with reference to later Figures. The dispensing mechanism 310 is deemed to be engaged when it tilts a holder to dispense a connector and the dispensing mechanism 310 is deemed to be disengaged when it is not tilting any holder. Each holder of the conveyor mechanism 300 is in upright orientation if the dispensing mechanism 310 is disengaged. Figure 3A shows the dispensing mechanism 310 in disengaged configuration and therefore all the holders 330 and 360 are held in the upright orientation. The term "line of gravity" is defined in the present disclosure as an imaginary vertical line from a center of gravity of the holder to the ground.

With reference to Figures 3A to 3C, the dispensing mechanism 310 is arranged to be disposed substantially equidistant between two magazine belts i.e. the pair of roller chains 302 and at a dispensing end of the conveyor mechanism 300 adjacent to the output bin 350. The output bin 350 is configured to hold a plurality of connectors dispensed from the one or more holders 330 by the dispensing mechanism 310. A discharging guide 340 is disposed between the dispensing end of the conveyor mechanism 300 and the output bin 350 to guide connectors dispensed by the

dispensing mechanism 310 into the output bin 350. The output bin 350 may contain connectors that have to be returned to the vessel owner for use at the next port facility that the vessel travels to. Each holder 330 is pivotally connected to the pair of roller chains 302 by two pins 334, wherein a first pin is connected to one of the pair of roller chains 302 and a second pin is connected to the other one of the pair of roller chains 302. The first pin and the second pin at both sides of the holder 330 hold the weight of the holder 330 and the container connector. It should be noted that the pin 334 remains engaged with the roller chains 302 while the holder 330 is being tilted by the dispensing mechanism 310. The holder 330 is always orientated to an upright orientation after being tilted to dispense a connector because of the design of the holder and the movement of the holder with respect to the pin 334.

In another example, and referring to Figures 3F and 3G, the conveyor mechanism 300 does not comprise of a pair of roller chains 302. Instead of having a pair of roller chains 302, the conveyor mechanism 300 comprises of a guide rail 382 and a roller chain 302. The roller chain 302 is driven by an electrical/servo drive motor (see 312 of Figure 3A) and a tensioner (308 of Figure 3A). In such configuration, one of the two pins 334 of the holder 330 is pivotally connected to a roller chain 302 and the other pin 334 is pivotally connected to a guide roller holder 380 that is placed on the guide rail 382. A first end of the other pin 334 is connected to the guide roller holder 380, and a second end of the other pin (i.e. pin head 335) is being housed in a pin head holder 366 of a holder 330. The roller chain 302 is not illustrated in Figure 3F to provide a better view of the guide roller holder 380. In the present example, the roller chain 302 actively drives the movement of the holder 330 whereas the guide rail 382 passively allows the guide rollers 384 mounted on the holder 330 to wheel over as the holder 330 is moved by the roller chain 302.

The guide rail 382 is configured to be an endless loop, and has a shape and size substantially the same as the roller chain 302 discussed in Figures 3A to 3C. There are two pairs of guide rollers 384 secured at four corners of the guide roller holder 380 by studs 386. The guide roller holder 380 is configured to slide between the two pairs of guide rollers 384 when the holder 330 is driven along the conveyor mechanism 300 by the drive wheel 316 corresponding to the roller chain 302. Therefore, the guide roller holder 380 is configured to move in the same direction as the roller chain 302. Advantageously, the cost for constructing a conveyor mechanism 330 would be reduced because such arrangement will cause a reduction of motor and gearbox size and will eliminate a need for additional drive wheel, which is the case in the example having the pair of roller chains 302. Advantageously, the maintenance will be simpler because it eliminates the need to synchronize the tension between the pair of roller chains 302.

In one example, and referring now to Figure 3D, each holder 330 may be configured with a heavier base (and thus a lighter top) and is pivotally mounted, for instance, pivotally mounted via the first and second pins 334, to the conveyor mechanism 300, in particular, each of the roller chains 302, such that the heavier base would alter orientation of the holder 330 to maintain the holding of the connector 320 in the upright orientation. The holder 330 comprises of a pocket 362 for a portion of the connector 320 to reside in, and has a pin head holder 366 mounted at each of two opposite sides of the holder 330. Each of the two opposite sides of the holder 330 on which the pin head holder 366 resides is not a side of the holder 330 facing other holders 330 mounted to the conveyor mechanism 300. Optionally, the pocket 362 of the holder 330 may be formed by a top plate 406 (or support plate), a base 370 and at least two side walls. Although it is shown in Figure 3D that there are four side walls 361a, 361b, 361c and 361d of the holder 330 with equal dimensions, it is possible to have two side walls facing each other and with reduced dimensions for the holder 330. These two side walls with reduced dimensions should be the side walls without the pin head holder 366. Forming these two side walls with reduced dimensions can help to reduce fabrication cost of the holder 330. For example, with reference to Figure 3D, these two side walls with reduced dimensions can be side walls 361a and 361d. An example of a holder with two side walls having reduced dimensions is illustrated by Figures 27A and 27B. In these Figures, it can be seen that the height of side walls 361a and 361d is smaller than the height of side walls 361b and 361c.

Other than the example of a holder illustrated with reference to Figures 3A-3D that is pivotally mounted to a conveyor mechanism, there can be provided another example where the holder is pivotally mounted to side members of a frame housing that can be mounted to a robotic arm of a robotic manipulator and/or an interchangeable end effector of a robotic manipulator for performing coning/deconing operations. The connection elements pivotally mounting the holder to the side members of the frame housing can be considered as support members or part of a support member for mounting the holder to the robotic manipulator. The robotic manipulator can be

configured to move the holder between locations including a location for retrieving a connector used for coning, a location for receiving a connector obtained from deconing, and a location for a dispensing mechanism to dispense a connector. The robotic manipulator can also be configured to perform the coning/deconing/dispensing actions at such locations. Such end effector of the robotic manipulator may comprise a holder design shown as holder 330 in Figure 4A. The holder 330 can be configured to be pivotable about a horizontal axis 408 parallel to a top plate 406 (or support plate) of the holder 330. The holder 330 can be pivoted as required to dispense a connector contained therein using a dispensing mechanism such as the dispensing mechanism 310 described in the present disclosure. The dispensing mechanism 310 may be incorporated as a part of the end effector and/or the robotic arm of the robotic manipulator or provided as a separate device. In addition, there may be a locking mechanism (not shown in Figure 4A) to prevent pivoting of the holder 330 about the horizontal axis 408 during a coning or deconing operation. Such implementation of the holder 330 on the end effector and/or robotic arm of the robotic manipulator can be implemented to work in an automatic container lashing platform (i.e. a coning/deconing platform) that is used at a port facility. The robotic manipulator can be any one of the robotic manipulators described in the present disclosure.

More specifically, with reference to Figure 4A and 4B, an upper cone 320c of a connector 320 may sit within the pocket 362 of the holder 330 described earlier, while a body 320b of the connector 320 and a lower cone 320a of the connector 320 rest on the top plate 406 (or support plate) of the holder 330. In another example, the lower cone 320a of the connector 320 may sit within the pocket 362, while a body 320b of the connector 320 and the upper cone 320c of the connector 320 rest on the top plate 406 of the holder 330. In both cases, the pocket 362 will ensure the connector 320 resides within the holder 330, unless a sufficient pivotal force acts on the holder 330 to drop the connector 320 from the pocket 362 due to gravitational forces. It should be appreciated that the amount of pivotal force generated is dependent on how much the holder 330 is tilted with respect to the longitudinal axis 404 of the holder 330 when the holder 330 is in an upright orientation.

With reference to Figure 3D, the pin head holder 366 is made up of a centrally located gourd-shaped recess 363. A wall 363a is disposed along a circumference of the gourd-shaped recess 363. A cover 368 having a central through-hole 367 that, for example, may be oblong or circular or oval in shape, is arranged to cover the gourd-shaped recess 363 of the pin head holder 366. Each of the first or second pin 334 has a pin head 335 with lateral projections for contacting the wall 363a. The lateral projections of the pin head 335 project orthogonally away from a longitudinal axis of the pin 334. The wall 363a acts as a guide for the movement of the pin head 335 when the holder 330 is being tilted by the dispensing mechanism 310. The wall 363a guides the holder 330 to return to the upright orientation. An end of each of the pins 334 opposite to the pin head 335 is arranged to slot into the central through-hole 367 of the cover 368. The end of each of the pins 334 is mounted to each of the roller chain 302. Together, the pin head holder 366 and the cover 368 hold the pin 334, which in turn holds the holder 330 at a specific position on the conveyor mechanism 300 even when the holder 330 is tilted by the dispensing mechanism 310. Furthermore, the cover 368 restrict lateral movement of the pin head 335 in a direction along the longitudinal axis of the pin 334 opposite of the pin head 335 of the pin 334 when the holder 330 is being tilted by the dispensing mechanism 310. The size of the through-hole 367 of the cover 368 is made to be larger than a circumference of a shaft body of the pin 334 to enable the pin 334 to slot into the through-hole 367 but smaller than the circumference of the pin head 335 to prevent disengagement of the pin head 335 from the gourd-shaped recess 363. In another arrangement, the wall 363a may be a groove in which the lateral projections of the pin head 335 can be slotted. The holder pin 334 can be considered as a support member to pivotally mount the holder 330 to the roller chain (or driving chain) 302 of the conveyor mechanism 300.

Various changes and modifications to the illustrative holder 330 described in Figures 3D and 3F will be apparent to those skilled in the art. For example, the pocket 362 may be formed as a unitary structure that is configured to have disproportionate weight distribution from the top plate 406 to the base 370. In another example, the pin head holder 366 is integrally formed with the respective side wall or walls (e.g. 361b) on which the pin head holder 366 is to be mounted to the holder 330 and only the pin cover 368 is separately mounted to the pin head holder 366.

In another modification, with reference to Figure 3H, there are two holders 330a and 330b collinearly connected to each other such that they would move in tandem when they pivot about the object they are pivotally mounted to. Reference numerals of the components described earlier are

re-used for the same components found in Figure 3H. In the present example, the two holder 330a and 330b are pivotally mounted to the conveyor mechanism 300. The conveyor mechanism 300 comprises a guide rail 382 and a roller chain 302. The holder 330a has a holder pin 334 (not visible in Figure 3H) connected to a guide roller holder 380 holding guide rollers 384 and the holder 330b has another holder pin 334 connected to a roller chain 302. The guide rollers 384 wheel along the guide rail 382 as the roller chain 302 pulls the holder 330b and the holder 330a to any desired position (e.g. a connector discharging position or connector coning/deconing position) along the conveyor mechanism 300. The holders 330a and 330b are in rigid connection with each other through a holding rod 440 so that they will move in tandem as they pivot about the conveyor mechanism. In this modification, the two holders 330a and 330b can be used to dispense two connectors held by them at one instance. This is unlike the case in which only one holder 330 can be used to dispense one connector in the example of Figure 3F. Each of the holders 330a and 330b has the pin head holder 366 of Figure 3F for holding the holder pin 334 and the cover 368 of Figure 3F covering the pin head holder 366. The holder pins 334 of the holders 330a and 330b are respectively located on opposite sides for attachment to the guide roller holder 380 and the roller chain 302 respectively. Each of the holders 330a and 330b has the base 370.

It should be appreciated that in another example, instead of just two holders 330a and 330b in rigid connection with each other, there can be three or more holders in rigid connection with one another between the guide rollers 384 and the roller chain 302. The number of connectors that can be dispensed in tandem increases with the number of holders rigidly connected to one another. Figure 3I is a perspective view of three holders 330a, 330b, and 330c being collinearly connected between a guide roller holder 380 holding the guide rollers 384 and a roller chain 302. The holders 330a, 330b, and 330c are collinearly connected to one another such that they would move in tandem when they pivot about the object they are pivotally mounted to. In the present example, the holder 330a, 330b and 330c are pivotally mounted to the conveyor mechanism 300 (not illustrated in Figure 3I). Similar to Figure 3H, the conveyor mechanism 300 comprises the guide rail 382 and the roller chain 302. The first holder 330a is rigidly connected to the second holder 330b via a holding rod 440, and the second holder 330b is rigidly connected to the third holder 330c via another holding rod 440. The roller chain 302 and/or guide rail 382 are omitted in Figure 3I for the sake of simplicity. In this example, only each of the holders 330a and 330c has the pin head holder 366 for holding the holder pin 334 and the corresponding cover 368 for covering the pin head holder 366. The holder pins 334 of the holders 330a and 330c are respectively located on opposite side walls for attachment to the guide roller holder 380 and the roller chain 302 respectively. Specifically, the holder pin 334 of the holder 330a is connected to a side wall 361c and the holder pin 334 of the holder 330c is connected to a side wall 361b of the holder 330c. The side walls 361c and 361b are facing opposite directions away from each other.

As the holder 330b resides in the middle of the holders 330a and 330c, it does not have any pin head holder 366 installed on its side walls. In the place of the pin head holders 366, there are the holding rods 440 mounted to the holder 330b. The arrangement of Figure 3I allows concurrent pivotal motion of the three holders 330a, 330b and 330c about the conveyor mechanism, and can speed up collection of dispensed connectors from the holders 330a, 330b and 330c. In one example, the three holders 330a, 330b and 330c may be configured to hold the same type of connector 320 (not illustrated in Figure 3I) and all the connectors may be dispensed into one output bin 350 (not illustrated in Figure 3I). In another example, there may be several output bins 350, each for collecting dispensed connectors from the three holders 330a, 330b, and 330c respectively. In another example, different types of the connector 320 may be contained in each of the three holders 330a, 330b and 330c.

Having multiple holders configured according to the examples of Figures 3H and 3I can facilitate sorting of connectors into respective output bins. The connectors that are removed from containers during a deconing operation and stored in the storage unit 210 of Figure 2 can be sorted with help from the examples of Figures 3H and 3I before returning of the connectors to a vessel for storing the connectors. Since the connectors are sorted, this would speed up subsequent connector sorting process at a next port facility that also employs the apparatus 100 disclosed herein.

Figure 3G illustrates the guide roller holder 380, the guide rollers 384, the guide rail 382, and the holder pin 334 connected to the guide roller holder 380 in greater detail. The pin head 335 of the holder pin 334 for fitting into the pin head holder 366 (not shown in Figure 3G) is shown at the front in Figure 3G and the guide rollers 384 are facing the rear. The guide roller holder 380 has a square shape with four guide rollers 384, wherein each roller 384 is symmetrically spaced apart

from each other and mounted close to a corner of the square shape via a stud 386. The guide rail 382 is placed between the guide rollers 384 such that the guide rail 382 is able to contact at least two of the four rollers 384 and the contacted rollers 384 are able to wheel along the guide rail 382. In the present example, the guide rail 382 is placed such that the guide rail 382 can contact all four rollers 384 and the four rollers 384 are able to wheel along the guide rail 382.

Optionally, the end of the holder pin 334 opposite to the pin head 335 may be rounded to form a ball pivot that is pivotally joined to a receiving portion at the center of the guide roller holder 380. This ball pivot joint to the center of the guide roller holder 380 is herein known as a pivot bearing 397. Due to such arrangement, the holder pin 334 is able to freely pivot about the center of the guide roller holder 380. As opposed to a rigid joint, such arrangement provides some movement allowance to the holder pin 334 when the guide roller 384 moves along the guide rail 382. This ensures smoother movement of the holder (not shown), which the holder pin 334 is mounted to, along the guide rail 382.

It should be appreciated that instead of square shape, the guide roller holder 380 can be any other suitable shape, e.g. triangle, rectangle, circle, oblong and the like and have one or more rollers. With reference to Figure 27C, a guide roller holder 380 shown therein is triangular in shape and comprises three guide rollers 384 secured at three corners of the guide roller holder 380 via studs 386. The guide rail 382 is disposed between the guide rollers 384 such that the guide rail 382 contacts all guide rollers 384 and is located below two of the guide rollers 384 and above the other guide roller 384. Similar to the example of Figure 3G, the holder pin 334 connected to the guide roller holder 380 in Figure 27C is joined to the center of the guide roller holder 380 via a pivot bearing 397. The pivot bearing 397 in Figure 27C has the same advantage as the pivot bearing 397 in Figure 3G.

The holder pin 334 described in examples of the present disclosure may not be formed with a pin head, for example 335 in Figure 3G. With reference to Figure 27A and 27B, such configuration of the holder pin 334 without the pin head is compatible with a holder 330 that does not comprise of a pin head holder 366 shown in Figure 27A. The holder pin 334 assembly including the pin head holder 366 in Figure 27A is the same as that described with reference to Figure 3D. An example of a holder without the pin head holder 366 is the holder 330 illustrated in Figure 27B. In the example shown in Figure 27B, the holder pin 334a is rigidly connected to a side wall 361b of the holder 330. Another holder pin (not visible in Figure 27B) is also rigidly connected to a surface of a side wall 361c that is facing away from the surface of the side wall 361b, which the holder pin 334a is rigidly connected. Similar to the holder 330 of Figure 27A, the holder 330 of Figure 27B has a base 370 and two opposing side walls 361a and 361d with reduced dimensions that do not fully cover the sides that the side walls 361a and 361d are located. Specifically, the side walls 361a and 361d cover just a top portion of the holder 330 where a connector can be received. There is an opening 371 between the top portion covered by each of the side walls 361a and 361d to the base 370. More than one of the holders 330 having the design illustrated by Figure 27B may also be joined together using the holding rods 440 like the examples in Figure 3H and 3I.

The reference numerals for elements in Figures 3A-3I, 4A-4B and 27A-27C are re-used for the same elements found in Figure 3J.

The conveyor mechanism 300 described in earlier examples may be modified to connect to holders 330 in various configurations. Figure 3J illustrates another configuration of the conveyor mechanism 300. With reference to Figure 3J, there is provided a conveyor mechanism 300 comprising a roller chain 302 driven by an electrical/servo motor (not illustrated in Figure 3J) and a pair of guide rails 382. The guide rail 382 is configured to be an endless loop, and has a shape, length and size similar to the roller chain 302. In the present example, the guide rail 382 comprises of a belt. Each roller chain 302 may comprise metal chain, a belt, rollers and the like. There are two holders 330a and 330b formed between the pair of guide rails 382 and the roller chain 302 is connected in the middle between the two holders 330a and 330b. Specifically, each of the holders 330a and 330b is sandwiched between one guide rail 382 on the side and the roller chain 302 in the middle. A holder pin 334 of the holder 330a is pivotally connected to a first guide roller holder 380 that is placed on a first guide rail 382. A holder pin 334 of the holder 330b is pivotally connected to a second guide roller holder 380 that is placed on the second guide rail 382. The holder 330a is rigidly connected to the holder 330b via a holding rod 440. The roller chain 302 is pivotally connected to the holding rod 440 such that the holders 330a and 330b can pivot in tandem about a longitudinal axis of the holding rod 440. The holding rod 440 is moved along with the holders 330a and 330b when the motor moves the roller chain 302. In the present example, the roller chain 302 is made up

of a series of connected pieces, called links. Each link may comprise an opening for the holding rod 440 to slot through to connect the holders 330a and 330b to the roller chain 302.

The guide rollers 384 wheel along the first and second guide rails 382 as the holders 330a and 330b are moved by the movement of the roller chain 302. The dimensions (length and diameter) of the holder pin 334 can be similar to or different from the dimensions of the holder rod 440. In the arrangement of Figure 3J, the holding rod 440 has a thicker diameter than the holder pin 334. A thicker holding rod 440 adds strength to the connection holding the holders 330a and 330b together. Optionally, the roller chain 302 may be connected to the holding rod 440 in a manner such that the roller chain 302 is nearer to one of the holders 330a and 330b. Such arrangement is to facilitate the engagement of the dispensing mechanism 310 to the holding rod 440 for the discharging/dispensing operation of the connectors held by the holders 330a and 330b.

There may be different types of holding rods 440 for engagement with different types of dispensing mechanism 310. Figure 28D illustrates perspective views and side views of three different holding rods for rigidly connecting two or more holders when used with a dispensing mechanism 310 in the form of a roller dispenser, a pushing dispenser and a magazine motion dependent dispenser respectively. Figure 28D will be described in detail later. These terms "roller dispenser", "pushing dispenser" and "magazine motion dependent dispenser" describes different types of the dispensing mechanism 310 proposed in the present disclosure.

Figure 3E further illustrates movement of the holder pin 334 of Figure 3D, in particular the movement of the pin head 335 within the gourd-shaped recess 363. The gourd-shaped recess 363 can have a shape made up of two overlapping circles i.e. a top circle C1 overlapping a lower circle C2 and the lower circle C2 has a diameter larger than the top circle C1. In the present example, the top circle C1 has a circumference that fits the circumference of the pin head 335 and the lower circle C2 has a circumference that is larger than the circumference of the pin head 335. Lateral movement of the shaft body of the pin 334 away from a center of the through-hole 367 is restricted by the size of the through-hole 367. As the pin 334 is moving within the through-hole 367, the pin head 335 may slide along the wall 363a within the gourd-shaped recess 363 of the pin head holder 366. The wall 363a guides the pin head 335 to move along the wall 363a. As an example, when a holder 330 containing a connector and is in an upright orientation, the pin head 335 attached to the holder 330 is at a first position P1, which is only in contact with the circumference of the top circle C1 of the gourd-shaped recess 363. As the holder 330 is being tilted by a dispensing mechanism (e.g. 310 of Figure 3A), the pin head 335 slides along the wall 363a to a second position P2 contacting the circumference of the lower circle C2 and no longer contacting the circumference of the top circle C1. Thereafter, the holder 330 is being tilted further such that the pin head 335 shifts to a third position P3 to contact a bottom most point of the circumference of the lower circle C2. At the third position P3, the connector in the holder 330 falls (dispenses) out of the holder 330 due to gravity. After the connector falls out of holder 330, the dispensing mechanism 310 disengages from the holder 330 and the heavier base of the holder 330 causes the holder 330 to return to its original orientation. As the holder 330 returns to its original orientation, the pin head 335 slides along the wall 363a of the gourd-shaped recess 363 to move from the third position P3 to the second position P2 and subsequently back to the first position P1, which is the upright orientation of the holder 330. There would be some momentum causing the holder 330 to swing when returning to the upright orientation.

Figure 4A shows a close-up cross-sectional view of the connector 320 residing in the holder 330 in an upright orientation (i.e. not tilting). Figure 4B shows a close-up sectional view of the connector 320 residing in the holder 330 just before it is dispensed out from the holder 330. Figure 4C illustrates an example of the physical dimensions of a holder top plate 406 (or support plate). The holder top plate 406 may be designed with different dimensions as long as the top plate 406 is able to support respective bodies of most connectors in the market. Although it is illustrated that the top plate 406 has a rectangular cross section, it should be appreciated that the top plate 406 can also have a cross sectional area that is squarish, circular, and the like that is suitable for holding a portion of the connector 330. The cross sectional area of the holder 330 may not be uniform across the height from the top plate 406 to the base 370. Figure 4D shows different views of the holder 330 with a heavier base. Such heavier base may result in a thicker cross sectional area at the base 370 of the holder 330.

A counter weight 364 can be placed in a base 370 of a holder 330. The counter weight 364 may be positioned at a bottom center of the holder 330 to maintain the holder 330 in an upright orientation in the cases with or without a connector in the holder 330. Alternatively, to provide the

heavier base, the base 370 of the holder 330 can be fabricated with a material that is denser than a material used for remaining portions of the holder 330. The holder 330 may be configured without any locking or clamping mechanism within the holder 330. A container connector (i.e. a twist-lock or a cone) does not need to be locked down to the holder 330, for instance, by turning the twist-lock to lock it to the holder 330. Advantageously, the holder 330 with the heavier base is orientated to be in an upright orientation despite being move around turning corners of the endless loop of the conveyor mechanism (e.g. 300 of Figure 3). The connector 320 held by the holder 330 will not fall out from the conveyor mechanism (e.g. 300 of Figure 3) when moving along the conveyor mechanism (e.g. 300 of Figure 3). The connector 320 only falls out when the dispensing mechanism (e.g. 310 of Figure 3) engages the holder 330.

Turning back to Figure 3B, Figure 3B illustrates holders 330 at positions 328a and 328b being tilted to an orientation for dispensing connectors held in these holders 330. The drawing of connectors in the holders 330 are omitted in Figure 3B for better illustration of the tilting of holders 330. The tilting is caused by the dispensing mechanism 310. The dispensing mechanism 310 is made up of a set of interconnected rollers 310a movable to contact and tilt the bottom surface of the heavier base of the holders 330 to dispense the connectors contained therein. On contact with the bottom surface, the dispensing mechanism 310 moves the holders 330 to pivot about the pin head 335 of the conveyor mechanism 300. Only the holder or holders 330 that have been tilted beyond the specific angle, α will dispense a connector from the holder. The specific angle is an angle between a line of gravity (402 Figure 4A, 4B and 4E) and a longitudinal axis of a holder in upright orientation (e.g. 404 in Figures 4A, 4B and 4E). Without the intervention of the dispensing mechanism 310, connectors held in the holders 330 will remain in an upright orientation and will not be tilted. In this manner, a connector will not be dispensed from any holder 330 unless a dispensing operation is performed by the dispensing mechanism 310.

Figures 28A to 28C illustrates the storage module 210 of Figure 2, movement of the dispensing mechanism 310 of Figures 3A and 3B during a discharging operation, and the conveyor mechanism 300 of Figures 3A and 3B. The conveyor mechanism 300 comprises a plurality of holders 330 mounted thereon. The conveyor mechanism 300 moves the holders 330 to positions along an endless loop that may include a position for coning/deconing of connectors so that each holder 330 may provide/receive a connector 320 during coning/deconing, and a discharging position 328b for commencing discharging of a connector from a holder 330. The dispensing mechanism 310 in Figures 28A to 28C is in a form of a roller dispenser. The dispensing mechanism 310 comprises a plurality of interconnected rollers 310a that will be pushed or extended by a pushing device 311 such that a portion of the plurality of interconnected rollers 310a contacts or engages the base 370 of one or more holders 330 to tilt it or them. Once the one or more holder 330 is tilted beyond a certain angle, a connector 320 in the holder 330 will be dispensed from the holder 330 by gravity. The interconnected rollers 310a are configured in an arc shape and the convex portion of the arc shape is for contacting the one or more holders 330. Such arc shape configuration facilitates tilting of the one or more holders 330 in contact with the interconnected rollers 310a.

In Figure 28A, the dispensing mechanism 310 is in a configuration that is not engaged to a base 370 of any holder 330 to dispense a connector 320 from the holder 330. Figures 28B and 28C illustrates the dispensing mechanism 310 in different stages of engaging the base 370 of holders 330 in order to dispense the connector 320 from one holder 330 moved passed a specific discharging position 328b.

With reference to Figures 3A and 3B, and 28A to 28C, there is shown the discharging position 328b, wherein any holder 330 moved by the conveyor mechanism 300 to the discharging position 328b can interact with the dispensing mechanism 310 to begin discharging a connector held by the holder 330. In Figure 28B, the pushing device 311 is activated to push the plurality of interconnected rollers 310a to contact the holders 330 moved by the conveyor mechanism 300. In the present example, the plurality of interconnected rollers 310a is configured to such that its convex portion contacts three holders A, B and C, each being a movement step away from one another. The holder A is at a position where it will contact the extended interconnected rollers 310a and begin to tilt. However, the position of holder A will not cause the connector 320 held by holder A to drop out of holder A. The holder A has to be moved two further steps by the conveyor mechanism 300 to reach the discharging position 328b. The holder B is at a pre-discharging position 328a that is one movement step away from the discharging position 328b and tilting angle of holder B is more than tilting angle of holder A. As the holders A and B are moved by the conveyor mechanism 300 towards the discharging position 328b, the convex portion of the interconnected rollers 310a brush

and push against the bases of holders A and B to increase tilting angles of the holders A and B. A connector 320 stored in the holder B at the pre-discharging position 328a will still not be dispensed from the holder B because it has not been tilted beyond a pre-specified angle for discharging the connector 320. The holder C is already at the discharging position 328b. The connector 320 held in holder C will begin to discharge the connector 320 as the conveyor mechanism 300 moves the holder C pass the discharging position 328b. As the holder C passes the discharging position 328b, the base of holder C brushes against the convex portion of the interconnected rollers 310a, which tilts the holder C to an angle that will cause the connector 320 in the holder C to drop out by gravity to a discharging guide 340. The dispensed connector 320 from the holder C would be received and guided by a sloped sliding surface of the discharging guide 340 to slide into an output bin 350.

The example of Figure 3C illustrates that the dispensing mechanism 310 is preferably arranged at the location at which the conveyor mechanism 300 receives a connector 320 obtained from deconing a container in such a way that the disposal of the connector 320 removed from a corner casting of the container into the output bin 350 of Figure 3C by the dispensing mechanism is done at a different location from the location at which the conveyor mechanism 300 receives a new connector from the bin 214 of Figure 2, and the disposal will not affect the receiving of the new connector from the bin 214 by the conveyor mechanism 300. It should be appreciated that such preferred arrangement is not limited to the example of Figure 3C, which comprises cascaded conveyor mechanisms 324 and 322. Such preferred arrangement is applicable to examples with single conveyor mechanism 300 or more than two conveyor mechanisms as well.

Figure 4E illustrates different states of a holder 330 during a dispensing operation performed by the dispensing mechanism 310 of Figure 3B to remove a connector 320 from the holder 330. As the dispensing mechanism 310 is configured to tilt the holder 330, the holder 330 is gradually arranged to be orientated into a tilted or inverting configuration for dispensing the connector 320 from an upright orientation. At the upright orientation (best illustrated in Figure 4A), the longitudinal axis of the holder 404 coincides with the line of gravity 402. It is clear from Figure 4E that the pin head holder 366 is rotating about the pin 334 in a clockwise direction as the holder 330 is gradually inverting or tilted to the specific angle, α , as described earlier. The connector 320 (i.e. twist-lock or cone) will gradually lose its contact with a top plate 406 of the holder 330. After tilting to an angle equal or more than the specified angle α , the connector 320 will drop out from the pocket 362 of the holder 330 due to gravitational force. As soon as the dispensing mechanism 310 loses its contact with the bottom surface of the heavier base 370 of the holder 330, the holder 330 will return to the upright orientation, due to a torque created by the counterweight. It should be appreciated that the holder can also be tilted in a reverse direction, i.e. in a counter-clockwise direction.

With reference to Figures 4A and 4B, the connector 320 will drop out of the holder 330 when the center of mass, C_m , 430 of the connector 320 is no longer on any part of the top plate 406. Note that the centre of mass, C_m , 430 shifts as the holder 330 is being tilted, and the line of gravity moves away from the longitudinal axis. Referring to Figures 4B and 4D, the specified angle, α , is the angle between the longitudinal axis 404 and the line of gravity 402, whereas the longitudinal axis 404 is perpendicular to the horizontal base 370 of the holder 330. The specified angle, α , can be derived using the vertical displacement (L) and horizontal displacement (B) from the center of mass of the holder 330 in the upright position.

Using the present example illustrated in Figures 4A and 4B, where the holder top plate 406 is 140mm by 80mm, the connector 320 will be dispensed from the holder 330 when the horizontal displacement (B) is equal to or more than 40mm (i.e. half of the width of the holder 330). The centre of mass of each type of the connector 320 is typically between 10 to 25 mm above the top plate 406. It should be easily envisaged that different values of L and B can be used. In one example, the specified angle can be calculated based on the below formula:

$$\text{Specified angle, } \alpha = \arctan (B/L), \text{ wherein } 0 < \alpha \leq 90^\circ$$

Twist-lock type	L(mm)	B (mm)	Angle (degrees)
1	10	40	75.96
2	25	40	57.99

Table 1: Calculation of Tilting Angle

Although it is described with reference to Figures 3A and 3B, and 28A to 28C that the dispensing mechanism 310 is made up of a set of interconnected rollers 310a movable (e.g. powered by a driver such as motor) to contact and tilt a base 370 of a holder 330, this is just one possible configuration of the dispensing mechanism 310. The dispensing mechanism 310 may also be configured with other suitable mechanical linkage (such as metal chains, belt) and/or motorized means that is controllable by a station controller 190 or a sub-station controller to place a holder 330 in a dispensing orientation (e.g. the orientation in Figure 4B) so that a connector 320 held by the holder 330 can be dispensed from the holder 330.

An example of another type of the dispensing mechanism 310 will now be described. The reference numerals for elements in Figures 3A-3B, and 4A-4B are re-used for the same elements found in Figures 24A and 24B, 25A-25E and 26A-26F. With reference to Figures 24A and 24B, and 25A to 25E, instead of the interconnected rollers 310a of Figures 28A to 28C, the dispensing mechanism 310 is a linear actuator 2405 with an extendable arm 2410. During operation, the extendable arm 2410 has to be extended to push a base of a holder 330 pivotally mounted to the conveyor mechanism of Figure 25A beyond a pre-specified tilting angle to dispense a connector contained in the holder 330. Figure 24A shows the linear actuator 2405 of the dispensing mechanism 310 in a deactivated state, wherein the extendable arm 2410 is retracted. In such deactivated state, the extendable arm 2410 does not push or contact any holder 330. Figure 24B shows the linear actuator 2405 of the dispensing mechanism 310 in an activated state, wherein the extendable arm 2410 is extended. In such activated state, the extendable arm 2410 pushes or contacts a holder 330 so as to tilt the holder 330.

Figure 25A has a similar set up as Figure 3A, and thus the functionality of the same components in Figure 3A will not be discussed. The set up of Figure 25A is similar to Figure 3A except that the dispensing mechanism 310 in Figure 25A employs the linear actuator 2405 shown in Figures 24A and 24B instead of the interconnected rollers 310a. The position of the dispensing mechanism 310 is arranged to be above the tensioner 308 and drive wheel 306 responsible for the holder movement of the conveyor mechanism 300.

Figures 25B to 25E illustrates the set up of Figure 25A in operation. With reference to 25B, it is first assumed that the station controller 190 (the same controlling unit for the set up of Figure 3A) has issued a command of a dispensing operation of a specified holder X. Thus, the specified holder X is arranged to be moved by the conveyor mechanism 300 to a discharging position 328b that is within a discharging zone 2502 and the specified holder X is to remain stationary. The dispensing mechanism 2410 is in the deactivated state in Figure 25B. Figures 25C to 25E illustrates snapshots of the tilting process of the holder X in sequential order. With reference to Figures 25C to 25E, the dispensing mechanism 310 is activated so that the extendable arm 2410 of the actuator 2405 is extended to tilt the specified holder X at the discharging position 328b until a specific angle α , which would dispense the connector 320 held in the holder X to the discharging guide 340. The dispensing mechanism 310 can be configured to activate in a predetermined time duration after an encoder 313 detects that position of the holder X has moved into a predetermined discharging zone 2502 that comprises the discharging position 328b and a sensor 307 positioned to detect identity of any holder entering the predetermined discharging zone 2502 has detected holder X. The discharging guide 340 has a sloped sliding surface for receiving the dispensed connector 320 and for guiding it towards an output bin 350. Specifically, in this example, the extendable arm 2410 is arranged to tilt the holder X at its upper portion as opposed to pushing its base at its lower portion. The upper portion of the holder X is close to a mouth or opening for receiving the connector 320 into the holder X. This is unlike the example of Figures 28A to 28C wherein the interconnected rollers 310a pushes the bases at the lower portions of the holders A to C. Once it is detected that there is an absence of the connector 320 in the tilted holder X, the dispensing mechanism 310 is configured to retract the extendable arm 2410 and assume the deactivated state illustrated by Figure 25B. For example, detection of the absence of the connector 320 in the holder X can be done via one or more sensors (e.g. ultrasonic, infrared and the like) to sense whether the connector 320 is present in the holder X or that the holder X has tilted beyond the angle to dispense the connector 320. Such detection may also be performed by detecting that the extendable arm has extended beyond a pre-determined threshold and/or for a predetermined time that is indicative of certainty that the holder X has been pushed to such tilting angle that will dispense the connector 320 contained therein. After the connector 320 is dispensed from the holder X, the holder X becomes an empty holder 360. The conveyor mechanism 300 may be configured to accept another job, which is to move such empty holder 360 to a location for retrieving a connector for coning from a first source (e.g. 326b of Figure 3C), or a location for receiving a deconed connector (e.g. 326b of Figure 3C), or another location for

loading a connector from a second source (e.g. 326a of Figure 3C). The dispensing mechanism 310 in Figures 25A to 25E can be regarded as a pushing dispenser in the present disclosure.

A modification may be made to the example of Figures 25A to 25E. Instead of the holder X being held stationary at the discharging position 328b, the conveyor mechanism 300 may be configured to continuously move the holder X pass the discharging position 328b. One or more sensors may be used to detect the entry of holder X into the discharging zone 2502 and upon such entry, the dispensing mechanism 310 may be configured such that the extendable arm 2410 is extended at a right time to push the upper portion of holder X to dispense the connector 320 contained therein.

Yet another example of the dispensing mechanism 310 will now be described. Figure 26A has a similar set up as Figure 25A, and thus the functionality of the same components in Figure 25A will not be discussed. The set up of Figure 26A is similar to Figure 25A except that the dispensing mechanism 310 is configured to extend the extendable arm 2410 to contact the base at a lower portion of a holder 330 in a discharging position 328b to tilt the holder 330 to dispense a connector 320 in the holder 330. This is unlike the example of Figure 25A, wherein the extendable arm 2410 is extended to push the upper portion of the holder 330 to tilt the holder 330.

Figures 26B to 26F illustrates the set up of Figure 26A in operation. With reference to Figure 26B, instruction is received to dispense a connector 320 from a holder X. The holder X is then moved by the conveyor mechanism 300 to a discharging position 328b within a discharging zone 2502. The holder X remains stationary in the discharging position 328b. In Figure 26B, the extendable arm 2410 is not yet extended. Thereafter, with reference to Figure 26C, the extendable arm 2410 is extended below the base of the holder X. The dispensing mechanism 310 can be configured to activate when an encoder 313 determines position of the holder X has moved into a predetermined discharging zone 2502 that comprises the discharging position 328b and a sensor 307 positioned to detect identity of any holder entering the predetermined discharging zone 2502 has detected holder X. The extendable arm 2410 is extended such that length of the extendable arm 2410 directly below the base of the holder X is less than half of the length of the base of the holder X. This is to ensure that the holder X can tilt in the tilting process. Once extended, with reference to Figures 26D to 26F, the holder X is moved by the conveyor mechanism 300 pass the discharging position 328b. As the holder X moves pass the discharging position 328b, the bottom of the base of the holder X will come into contact with the extendable arm 2410 that is extended below the holder X. As the extendable arm 2410 is extended to less than half the length of the base, the holder X will pivot about a furthest extended end 2603 of the extendable arm 2410 and tilt until a specific angle α , which would dispense the connector 320 held in the holder X to the discharging guide 340. The discharging guide 340 has a sloped sliding surface for receiving the dispensed connector 320 and for guiding it towards an output bin 350. Once it is detected that there is an absence of the connector 320 in the tilted holder X, the dispensing mechanism 310 is configured to retract the extendable arm 2410 and assume the deactivated state illustrated by Figure 26B. For example, detection of the absence of the connector 320 in the holder X can be done via one or more sensors (e.g. ultrasonic, infrared and the like) to sense whether the connector 320 is present in the holder X or that the holder X has tilted beyond the angle to dispense the connector 320. Such detection may also be performed by detecting that the extendable arm has extended for a predetermined time that is indicative of certainty that the holder X has been pushed to such tilting angle that will dispense the connector 320 contained therein. After the connector 320 is dispensed from the holder X, the holder X becomes an empty holder 360. The conveyor mechanism 300 may be configured to accept another job, which is to move such empty holder 360 to a location for retrieving a connector for coning from a first source (e.g. 326b of Figure 3C), or a location for receiving a connector obtained from deconing (e.g. 326b of Figure 3C), or another location for loading a connector from a second source (e.g. 326a of Figure 3C). The dispensing mechanism 310 in Figures 26A to 26F can be regarded as a magazine motion dependent dispenser in the present disclosure. The term "magazine" refers to the conveyor mechanism 300 in the present example. A modification may be made to the example of Figures 26A to 26F. Instead of the holder X being held stationary at the discharging position 328b, the conveyor mechanism 300 may be configured to continuously move the holder X pass the discharging position 328b. One or more sensors may be used to detect the entry of holder X into the discharging zone 2502 and upon such entry, the dispensing mechanism 310 may be configured such that the extendable arm 2410 is extended at a right time to tilt the holder X to dispense the connector 320 contained therein.

Figure 28D illustrates perspective and side views of 3 types of the holding rod 440 shown in Figures 3H to 3J that is used to join more than one holders 330.

A first type of holding rod 2802 is a simple rod of a suitable length, with circular cross-section or other suitable cross-sectional shapes. This first type of holding rod 2802 can be used, for instance, if the roller dispenser described with reference to Figures 28A to 28C is implemented. In the case of the roller dispenser, the roller dispenser is configured to contact the base of one or more holder 330 joined together by the holding rod 2802. The holding rod 2802 does not have to interact with the roller dispenser and can thus have the simple rod design. The holding rod 2802 can also be used with other types of dispensing mechanism 310 that is configured to directly contact or engage the one or more holder 330 joined together by the holding rod 2802.

A second type of holding rod 2804 comprises a rod of a suitable length, with circular cross-section or other suitable cross-sectional shapes. The holding rod 2804 further comprises a lever 2808 that protrudes upwards from the cylindrical rod when the holders 330 joined by the holding rod 2804 are in an upright orientation (e.g. the orientation of the holder 330 in Figure 4A). This second type of holding rod 2804 can be used, for instance, if the pushing dispenser described with reference to Figures 25A to 25E is implemented. In this case, instead of having the pushing dispenser extend the extendable arm 2410 to push the upper portion of one or more holders 330 to tilt them, the pushing dispenser can be configured to push the lever 2808. By pushing the lever 2808, the more than one holders 330 rigidly connected by the holding rod 2804 will pivot from the upright orientation to a tilting configuration. When the more than one holders 330 are tilted beyond the angle α , the connector 320 held in one or more of the holders 330 would be dispensed. If the roller chain 302 of the conveyor mechanism 300 that is described in earlier examples is to be connected to the holding rod 2804, the roller chain 302 has to be connected nearer to one of the holders that holding rod 2804 is rigidly connected to so as not to obstruct the lever 2808 and the pushing dispenser.

A third type of holding rod 2806 comprises a rod of a suitable length, with circular cross-section or other suitable cross-sectional shapes. The holding rod 2806 further comprises a lever 2810 that protrudes horizontally in a direction away from the dispensing direction of a connector when the holders 330 joined by the holding rod 2806 are in an upright orientation (e.g. the orientation of the holder 330 in Figure 4A). This third type of holding rod 2806 can be used, for instance, if the magazine motion dependent dispenser described with reference to Figures 26A to 26F is implemented. In this case, instead of having the magazine motion dependent dispenser extend the extendable arm 2410 to contact the bases of one or more holders 330 to tilt the moving holders 330, the extendable arm 2410 can be configured to contact the lever 2810. In this case, the extendable arm 2410 has to extend below the lever 2810 such that the length of the extendable arm 2410 directly below the lever 2810 is not longer than the protruding length of the lever 2810. This is to ensure that the holders 330 can tilt in the tilting process. In this way, as the lever 2810 is moved by the conveyor mechanism 300 to contact the extendable arm 2410 below it, the lever 2810 will pivot and, along with the lever 2810, the more than one holders 330 rigidly connected by the holding rod 2806 will also pivot from the upright orientation to a tilting configuration. When the more than one holders 330 are tilted beyond the angle α , the connector 320 held in one or more of the holders 330 would be dispensed. If the roller chain 302 of the conveyor mechanism 300 that is described in earlier examples is to be connected to the holding rod 2806, the roller chain 302 has to be connected nearer to one of the holders that holding rod 2806 is rigidly connected to so as not to obstruct the lever 2810 and the magazine motion dependent dispenser.

For the second type of holding rod 2804 and the third type of holding rod 2806, if the levers 2808 and 2810 are formed in the holding rods of more than two interconnected holders, for example, the connected holders of the example of Figure 3I, it may be configured to have more than one extendable arms 2410 interact with the respective levers 2808 and 2810 to tilt the respective holders 330. In this case, the more than one extendable arms 2410 have to be configured to move in tandem to contact the respective levers 2808 and 2810. In another example, it may be configured to have just one extendable arm 2410 but the arm 2410 that interacts with the respective levers 2808 and 2810 may be configured with a fork design with more than one prongs for contacting each of the respective levers 2808 and 2810 in tandem.

With reference to Figures 29A to 29L, the conveyor mechanism 300 described in earlier examples may be modified to move in a horizontal plane instead of moving in a vertical plane. The reference numerals used in earlier described figures are re-used for the similar components found in Figures 29A to 29D. The modified conveyor mechanism 2900 comprises a movable endless loop. The endless loop comprises a plurality of holders 331 pivotally mounted thereon. The plurality of holders 331 are evenly spaced along the endless loop. Each holder 331 is pivotally mounted to the endless loop of the modified conveyor mechanism 2900 in a similar manner as how the holder 330 described in earlier examples are mounted to the endless loop of the conveyor mechanism 300 in

earlier examples. The horizontal plane refers to the plane that is parallel to a top plate 406 (or support plate) of a holder 331 shown in Figures 29C and 29D. The vertical plane refers to the plane that is perpendicular to the top plate 406 of the holder 331 as shown in Figures 29C to 29D. With reference to Figures 29A and 29B, the conveyor mechanism 2900 further comprises of a tensioner 308, a roller chain (or driving chain) 302 that is driven by an electrical/servo drive motor 312. The roller chain 302 may comprise metal chains, a belt, rollers 304 (illustrated in Figure 29A and not illustrated in Figure 29B) and the like. The drive motor 312 is configured to cooperate with a gearbox 314 to drive the roller chain 302 through the drive wheel 316. The roller chain 302 is configured to be the endless loop, and can be arranged to be moved in either a clockwise or a counter-clockwise direction in the top view. The holder 331 is arranged to be connectable to the roller chain 302 through a holder pin 334. Each holder 331 is pulled by the roller chain 302 to move over a plurality of holder rollers 2906 (best illustrated in Figure 29B) disposed on a pair of tracks 2904. The pair of tracks 2904 is configured to be an endless loop corresponding to the endless loop of the roller chain 302. The pair of tracks 2904 are arranged to be adjacent to the roller chain 302 as shown in Figure 29B. Such modified conveyor mechanism 2900 may be more suitable for implementation where cascading of storage modules is not required. Each holder 331 can be moved by the conveyor mechanism 2900 to a discharging zone 2902 for dispensing a connector contained therein into a discharging guide 340, which guides the dispensed connector into an output bin 350.

With reference to Figures 29C and 29D, the top plate 406 of each holder 331 is hinged such that the top plate 406 is pivotable about a side wall 361A of the holder 331. The top plate 406 and the side wall 361A are hinged to each other by a hinge 2910 which comprises a hinge pin 2905. The top plate 406 has a protruding pin 2915 that extends outwards and this pin 2915 is configured to facilitate pivoting of the top plate 406 about a hinge 2910. The pin 2915 is located away from the hinge 2910 to enable the top plate 406 to tilt about the hinge 2910 when a lifting action by the dispensing mechanism 310 (illustrated by Figures 29E to 29J) is exerted to the pin 2915. In the present example, the pin 2915 is configured to extend from the top plate 406 in a direction parallel to the side wall 361A and is located at a far end away from the hinge 2910. In the present example, a portion of the connector (not shown in Figures 29A to 29J) held by the holder 331 will rest on the top plate 406. How the connector rests on the top plate 406 is shown in Figure 4A. Hence, by lifting the pin 2915 upwards, the top plate 406 can be pivoted about the hinge 2910 to dispense a connector held in the holder 331. In the present example, the top plate 406 is selectively movable to tilt to a tilting angle to dispense a connector resting on the top plate 406 by gravity. This is unlike in earlier examples, wherein the top plate 406 is integral or fixed to the holder 330 and it is the entire holder 330 that is tilted to the tilting angle and not just the top plate 406.

Optionally, the holder 331 may be configured with a heavier base and consequently a lighter top. Such heavier base ensures the holder 331 rests firmly on the pair of tracks 2904 and will not easily tip over the conveyor mechanism 2900. This also ensures that the connector (not shown in Figures 29A to 29J) will sit firmly in the holder 331 and be maintained in an upright orientation (best illustrated in Figure 4A). For instance, to provide such heavier base, a counter weight may be placed in the base 370 of the holder 331. Alternatively, to provide the heavier base, the base 370 of the holder 331 can be fabricated with a material that is denser than a material used for remaining portions of the holder 331. Unlike the holder 330 described in earlier examples, the holder 331 does not require the pin head holder 366 since only a portion of the holder 331 i.e. the top plate 406 of the holder 331 is tilted and not the entire holder 331 is tilted.

In order to perform a discharging operation on the holder 331, modifications to the dispensing mechanism 310 in the form of the pushing dispenser as described with reference to Figures 25A to 25E may be made. With reference to Figures 29E to 29N, the dispensing mechanism 310 can be configured to comprise a lifting mechanism 2970, the actuator 2405 and the extendable arm 2410. Figures 29E to 29L illustrate side views of such modified dispensing mechanism 310 in operation. Figures 29M and 29N illustrate perspective views of the modified dispensing mechanism 310.

The lifting mechanism 2970 comprises two parts, a lifter arm 2980 illustrated by Figure 29M and a lifting guide 2990 illustrated by Figure 29N. The lifter arm 2980 and the lifting guide 2990 are to be mounted to the conveyor mechanism 2900 at a location for dispensing connector from a holder 331 moved by the conveyor mechanism 2900 to such location.

The lifter arm 2980 comprises the extendable arm 2410, wherein a pushing end of the extendable arm 2410 is pivotally connected to a first end of a first limb 2959 of the lifter arm 2980 via a pin 2950a. The first limb 2959 is made up of a first pair of elongate plates and the extendable arm 2410 is disposed between the first pair of elongate plates. The pin 2950a is slotted through the first pair of elongate plates and the extendable arm 2410 and the pin 2950a forms the pivot for the

first limb 2959 to pivot about the extendable arm 2410 when the extendable arm 2410 is extended and retracted.

A second end of the first limb 2959 is pivotally connected to a first end of a second limb 2957 via a holding rod 2963. The holding rod 2963 is a guiding member of the lifter arm 2980 and is for guiding the movement of the lifter arm 2980 to lift and tilt the top plate 406 shown in Figures 29C and 29D to dispense a connector resting thereon. The second limb 2957 is made up of a second pair of elongate plates. The holding rod 2963 is slotted through a first end of each of the second pair of plates and the holding rod 2963 forms the pivot for the second limb 2957 to pivot about the first limb 2959 when the extendable arm 2410 is extended and retracted. A second end of each of the second pair of elongate plates of the second limb 2957 is rigidly connected to a first end of a lifting plate 2956 via a fastener 2952. Hence, there is a pair of such lifting plate 2956. A second end of each lifting plate 2956 is configured to form a catch 2961 for receiving the pin 2915 that is extending from the top plate 406 shown in Figures 29C and 29D. A pin 2954 for facilitating pivot movement of the pair of lifting plates 2956 connects the pair of lifting plates 2956 at a position between the catch 2961 and the pin 2952.

The lifting guide 2990 comprises a pair of guiding plates 2460 disposed such that the first limb 2959 and the second limb 2957 are between the pair of guiding plates 2460. Each guiding plate 2460 has a slot 2951. Each slot 2951 is configured to receive opposing ends of the holding rod 2963 when the extendable arm 2410 is extended and retracted. Each guiding plate 2460 is substantially trapezoidal in shape with a right-angle triangular portion at one end and a rectangular portion on an end opposite to the right angle triangular portion. In the present example, a sharp edge of the right-angle triangular portion of the guiding plate 2460 is cut away, leaving a straight side perpendicular to a side of the guiding plate 2460 with longest length. A first straight portion of the slot 2951 is configured to be parallel to the side of the guiding plate 2460 with shorter length. A second arcuate portion of the slot 2951 is shaped as an arc. The first straight portion is disposed close to a side of the guiding plate 2460 with shorter length, wherein such side with shorter length is opposite to the side of the guiding plate 2460 with longest length. The second arcuate portion of the slot 2951 is disposed close to a diagonal side of the triangular portion and stretches along the diagonal side of the triangular portion. The arc shape of the second arcuate portion of the slot 2951 is curved until an end portion of the slot 2951 close to the side of the guiding plate 2460 with longest length. At such end portion, the arc shape becomes straight for a short distance towards the straight side perpendicular to the side of the guiding plate with longest length. At such short distance, the arc shape is parallel to the side of the guiding plate 2460 with longest length.

The lifting guide 2990 further comprises a stopper plate 2953 with a diagonal side parallel to the diagonal sides of the triangular portions of the guiding plates 2460. The diagonal side of the stopper plate 2953 stretches for a length up to about midway of the diagonal sides of the triangular portions of the guiding plates 2460. The stopper plate 2953 is disposed between the pair of guiding plates 2460 when viewed from front and rear views (relative to the side views of Figures 29E to 29L) of the modified dispensing mechanism 310. When viewed from the side views of Figures 29E to 29L, the stopper plate 2953 is disposed adjacent to the pair of guiding plates 2460, and at a position filling in the space of the cutaway sharp edge of the right-angle triangular portion of the guiding plate 2460. The stopper plate 2953 has a pin rest 2971 at end of the diagonal side of the stopper plate 2953, wherein such end is located at about midway of the diagonal sides of the triangular portions of the guiding plates 2460. The pin rest 2971 is configured to engage the pin 2954 when the catch 2961 of one or both of the lifting plates 2956 receives the pin 2915 that extends from the top plate 406 shown in Figures 29C and 29D.

The operation of the modified dispensing mechanism 310 is described as follows with reference to Figures 29E to 29L. The reference numerals of the components of the modified dispensing mechanism 310 in Figures 29M and 29N are marked out in Figures 29E to 29L, where relevant. Figures 29E to 29L illustrates operation of the lifting mechanism 2970 in sequential order from a retracted configuration wherein the extendable arm 2410 is retracted such that a support plate on which a connector rests is not tilted, to an extended configuration wherein the extendable arm 2410 is extended to cause the support plate to tilt to dispense the connector. It is appreciated the returning sequence from extended to retracted would be the reverse of what is illustrated by Figures 29E to 29L.

Figure 29E shows a side view of the lifting mechanism 2970 and a top plate (i.e. the support plate) 406 of a holder (not shown in Figure 29E) that is pivotally mounted to the holder via a hinge pin 2905. The top plate 406 is to be lifted and tilted so that a connector (not shown in Figure 29E) resting on the top plate 406 can be tilted to a tilting angle to dispense or discharge the connector

from the holder by gravity. The lifting mechanism 2970 of Figure 29E is in a deactivated state. Figure 29E illustrates a position of the lifting plates 2956 with the holding rod 2963 slotted in the first straight portion of the slot 2951 of each guiding plate 2460. The positions of the pin 2954, the pin 2952 and the holding rod 2963 are always aligned in a straight line and they are currently aligned with the first straight portion of the slot 2951. The extendable arm 2410 is retracted and the pin rest 2971 is not engaging the pin 2954 in the configuration of the lifting mechanism 2970 in Figure 29E.

Figure 29F illustrates the same configuration of the lifting mechanism 2970 in Figure 29E with the lifting guide 2990 deliberately removed to reveal the lifter arm 2980.

Figure 29G illustrates another configuration of the lifting mechanism 2970 when the extendable arm 2410 has extended until the holding rod 2963 has moved to a transition position in the slot 2951 of each guiding plate 2460, wherein the shape of the slot 2951 is transiting from the first straight portion to the second arcuate portion. The pin 2950a mounting the extendable arm 2410 to the first limb 2959 has moved to a position at the end portion of the second arcuate portion of the slot 2951 that becomes straight for a short distance. At this stage, the catch 2961 of one or both of the lifting plate 2956 has engaged the pin 2915 and the pin 2954 is resting on the pin rest 2971.

Figure 29H illustrates the same configuration of the lifting mechanism 2970 in Figure 29G with the lifting guide 2990 deliberately removed to reveal the lifter arm 2980.

Figure 29I illustrates yet another configuration of the lifting mechanism 2970 when the extendable arm 2410 has extended further until the holding rod 2963 is at about midway of the second arcuate portion of the slot 2951 of each guiding plate 2460. The extendable arm 2410 has also extended until the pin 2950a has moved away from the slot 2951 in a direction towards the holder (not shown in Figure 29I) in the present side view of Figure 29I. The lifting plates 2956 has rotated clockwise due to the pin 2954 abutting against the pin rest 2971 of the stopper plate 2953. Such rotation causes the catch 2961 to lift and pivot the pin 2915 along with the top plate 406 about the hinge pin 2905. The top plate 406 is tilted as a result and a connector resting thereon can be tilted accordingly.

Figure 29J illustrates the same configuration of the lifting mechanism 2970 in Figure 29I with the lifting guide 2990 deliberately removed to reveal the lifter arm 2980.

Figure 29K illustrates a further configuration of the lifting mechanism 2970 when the extendable arm 2410 is extended until the top plate 406 has tilted to the tilting angle or beyond. The holding rod 2963 has been moved to the end portion of the second arcuate portion of the slot 2951 that becomes straight for a short distance. The holding rod 2963 has reached a point, wherein if it is moved further, it would be obstructed by the end portion of the second arcuate portion of the slot 2951. Correspondingly, the pin 2950a that lies together with the holding rod 2963 in the first limb 2959 has reached a point where the pin 2950a should not be moved further in the direction towards the holder (not shown in Figure 29K) in the present side view of Figure 29I. The lifting plates 2956 has rotated about 90 degrees clockwise from the configuration of the lifting plates 2956 of the lifting mechanism 2970 shown in Figures 29G and 29H due to the pin 2954 abutting against the pin rest 2971 of the stopper plate 2953. Such rotation causes the catch 2961 to certainly lift and pivot the pin 2915 along with the top plate 406 about the hinge pin 2905 such that a connector resting on the top plate 406 will be tilted to the tilting angle or beyond and the connector will certainly be dispensed by gravity from the holder.

Figure 29L illustrates the same configuration of the lifting mechanism 2970 in Figure 29K with the lifting guide 2990 deliberately removed to reveal the lifter arm 2980.

Figures 29E to 29N only illustrates one embodiment of the modified dispensing mechanism. It should be appreciated that the modified dispensing mechanism may be configured differently to achieve the purpose of tilting the top plate 406 to dispense a connector resting on the top plate 406. Furthermore, although a pair of guiding plates 2460, a pair of lifting plates 2956, a pair of the second elongate plates of the second limb 2957, a pair of the first elongate plates of the first limb 2959 are described in the above embodiment, it should be appreciated that in other configurations, only one of each of these components may be required. In such configurations, the stopper plate 2953 may be modified to work with just one of each of these components. For instance, the pin 2954 may extend orthogonally from the two major surfaces of one single guiding plate 2460 thereby forming two extended portions of the pin 2954. There may be present two stopper plates 2953 instead of one stopper plate 2953. Each pin rest 2971 of the two stopper plates 2953 is configured to receive the two extended portions of the pin 2954 respectively when the extendable arm 2410 extends until the pin 2954 abuts the respective pin rests 2971. The two stopper plates 2953 may be configured to be spaced apart so that the movement of one single lifting plate 2956 is not affected. It may be configured that the single lifting plate 2956 moves between the two stopper plates 2953.

Referring back to Figures 2, 3A and 3B, the sorting module (or sorter) 220 of the sorting and storing device 200 is configured for identifying a type of connector for each connector 320 in a store (or bin) 214 for storing a plurality of connectors 320. In one example, the store 214 refers to a portable bin comprising one or more unsorted connectors provided by a vessel owner upon berthing at the port facility. Sorting of the connectors are usually required since containers above deck and under hatch uses twist-locks and cones respectively. Having a sorting module 220 in close proximity with the storage module 210 reduces the cycle time of container handling, thereby increasing productivity.

The sorter 220 comprises of a pickup device 212 comprising a visioning unit (e.g. a camera and not illustrated in Figure 2), an orientation device (e.g. a clamp and rotation device that are not illustrated in Figure 2) and an identification device (e.g. a 3D imaging device that is not illustrated in Figure 2). The pickup device 212 can be a robotic arm or any device that can move in three-axes and have a pick up head. In the present example, the pickup device 212 is not to be confused with the robotic manipulator described earlier. The pickup device 212 is used for picking of connectors in the store 214 and for carrying one or more connectors to the identification and orientation station 230. The pickup device 212 is not for coning or deconing. The pickup head can be a gripper for clasping a connector or a magnetic head for picking up a connector via magnetic forces. The visioning unit of the sorter 220 is configured to check if the store 214 contains any connectors. If the visioning unit of the sorter 220 detects that there is a connector in the store 214, the pickup device 212 will retrieve the connector and bring the connector to the identification and orientation station 230. The sorter 220 is configured to identify the type of the retrieved connector and control the pickup device 212 to orientate the connector so as to put the connector into an empty holder, in this case, one of the empty holders 360 shown in Figure 3B. Details of how the connector is orientated will be discussed later.

In one example, and referring to Figure 5F, at the identification and orientation station 230, there is an imaging device or visioning unit 238 configured to acquire a 3-D image of part of the connector brought in by the pickup device 212 in any orientation. Thereafter, the imaging device correlates or compares feature points of the acquired 3-D image with feature points in an array of 3-D reference images of all connectors used for coning/deconing at the port facility to identify the type of the connector brought in by the pickup device 212 and the orientation of the connector when it is picked up. After the orientation of the connector has been identified, if necessary (e.g. if the connector is in upside down orientation), the orientation device will assist the pickup device 212 to re-orientate the connector to a suitable orientation for placing the connector into the empty holder 360 of the conveyor mechanism 300. For instance, and referring to Figures 5A to 5D, a connector 320 may have a top portion (also known as lower cone) 320a, a body 320b, a bottom portion (also known as upper cone) 320c and a wire 320d. If the imaging device 238 determines that the magnetic pickup head has picked up the lower cone 320a of the connector 320, but the wire 320d is facing in an inappropriate orientation, the pickup head can rotate the connector 320 about a longitudinal axis 504 of the connector 320. In one example, the pickup head may rotate the connector 320 such that the wire 320d is rotated from the orientation in Figure 5C to the orientation in Figure 5A. Figure 5A illustrates a connector in an upright position and in a correct horizontal orientation (i.e. the wire 320d is facing an equipment control unit such as any one of 108a – 108f of Figure 1), whereas Figure 5C illustrates a connector in an upright position and in a wrong horizontal orientation (i.e. the wire 320d is facing away from an equipment control unit such as any one of 108a – 108f of Figure 1).

In another example, if the imaging device determines that the pickup head has picked up the upper cone 320c of the connector 320, but the wire 320d is facing correctly in an appropriate orientation, the pickup head would need to rotate the connector 320 about a horizontal axis 503 of the connector 320. In such example, the pickup head may require an orientation device to assist with the rotation of the connector 320 about the horizontal axis 503 such that connector 320 is inverted from Figure 5B (i.e. upside down position) to Figure 5A (upright position). Figure 5B illustrates a connector in an upside down position and in a correct horizontal orientation (i.e. the wire 320d is facing towards an equipment control unit such as any one of 108a – 108f of Figure 1), whereas Figure 5D illustrates a connector in an upside position and in a wrong horizontal orientation (i.e. the wire 320d is facing away from an equipment control unit such as any one of 108a – 108f of Figure 1). The magnetic pick up head may be configured to pick up the connector 320 either by contacting the lower cone 320a or the upper cone 320c. If the magnetic pick up head picks up the connector 320 by contacting any portions other than the lower cone 320a and upper cone 320c, the magnetic pick up head may be configured to lose contact with the connector 320 to drop it and pick up it again.

An example of an orientation device 232 is illustrated in Figure 5E. The orientation device 232 is configured to assist the rotation of the connector 320 along a longitudinal axis 504 in Figure 5B of the connector 320, the longitudinal axis 504 being perpendicular to the horizontal axis 503 in Figure 5B. The horizontal axis 503 of the connector is parallel to the body 320b of the connector 320 and/or a base 370 of a holder 330. When a connector 320 is placed in a holder 330, the longitudinal axis 504 of a connector 320 coincides with the longitudinal axis 404 of the holder 330 in Figure 4A. Likewise, when the connector 320 is placed in the holder 330, the horizontal axis 503 of the connector 320 coincides with a horizontal axis 403 of the holder 330.

In Figure 5E, the orientation unit 232 comprises a clamping unit 234 and a turning unit 236. The clamps 235 of the clamping unit 234 are configured to hold the body 320b of the connector 320 in place or to release the body 320b of the connector 320 after the magnetic pick up head contacts the connector 320 through a movement in a direction d1. The clamping unit 234 is connected to the turning unit 236 such that the clamping unit 234 can be rotated in a direction d2 about a shaft 237 connected to a servo motor and gear box of the turning unit 236. The connector 320 can be rotated by any predetermined angle, but typically is set to 180° in order to invert the connector 320 from the upside down position to the upright position.

A suitable orientation for placing the connector 320 into the empty holder 360 of the conveyor mechanism 300 can be configured to be any predetermined orientation, such as any one of the orientations illustrated in Figure 5A or Figure 5D. Once the predetermined orientation is fixed, there will be no changes to it and all relevant processes described herein will be configured according to the predetermined orientation. For instance, the process of a robotic manipulator described in the present disclosure handling a connector for coning or deconing is facilitated by ensuring that the container connector is placed in the suitable orientation within the holder. This is illustrated with reference to Figures 7A to 7H.

Figures 7A to 7D shows how a connector 320 is being handled by an end effector (e.g. 600 of Figure 6A) during coning. Where applicable, reference will also be made to features of the end effector in Figures 6A to 6I. For instance, the end effector 600 removes the connector 320 (also known herein as twist-lock) from a holder with its clamping portion 610 in an upside down orientation. Then, the end effector 600 gradually turns itself to an upright position during its movement to a corner casting so that the twist-lock 320 can be in an appropriate position as shown in Figure 7C for insertion into a corner casting. After the connector 320 is being coned to the corner casting by turning 90° counter clockwise, the wire 320d will be facing away from the container (i.e. in the orientation as indicated in Figure 7D). In such a manner, the robotic manipulator can operate without pivoting/moving in awkward angles, and the trajectory of the robotic manipulator can be predicted in order to forecast any possibility of collision of the end effector 600 with the container or any other obstacles. Therefore, in this case, no external orientation device is required to invert the orientation of the connector 320 after the connector 320 is being retrieved from the holder 330 during coning.

Figures 7E to 7F shows how a connector 320 is being handled by an end effector (e.g. 600 of Figure 6A) during deconing. Where applicable, reference will also be made to features of the end effector in Figures 6A to 6I. For instance, the end effector 600 unlocks the connector 320 from a corner casting by turning the body 320b of the connector 320 by 90° clockwise (i.e. the orientation in Figure 7F). The end effector 600 is arranged to perform deconing by orientating the end effector 600 in an upside down position. During the movement of the end effector 600 to an empty holder (e.g. 360 in Figure 3C) at the predetermined position (e.g. 326b in Figure 3C), the end effector gradually turns itself to an upright position so that the twist-lock can be in an appropriate position as shown in Figure 7G for placing the connector 320 into the empty holder. In such a manner, the robotic manipulator can operate without pivoting/moving in awkward angles, and the trajectory of the robotic manipulator can be predicted in order to forecast any possibility of collision of the end effector 600 with the container or any other obstacles. Therefore, in this case, no external orientation device is required to invert the orientation of the connector after the connector 320 is removed from the corner casting during deconing.

It should be appreciated from Figure 14 that a connector 320 is used to secure a top container 102a to a bottom container 102b that the top container 102a is to be stacked on. At a vessel, workers will release a lower cone 320a of the connector 320 from the bottom container 102b manually for semi-automatic twist-locks so that the top container 102a can be lifted by a quay crane to be transported to an automated integrated wharf operation station (e.g. 100 of Figure 1). Thereafter, a robotic manipulator at the automated integrated wharf operation station will be activated to perform coning or deconing on an lower cone 320a of the connector based on operation information received from a TOS.

Turning back to Figure 2, in summary, the sorter 220 may be configured for

- picking up one connector (e.g. 320 of Figure 3A) stored in the store 214,
 - identifying type of the picked connector
 - re-orientating the picked connector to a suitable orientation for placing it into one of the plurality of holders of the conveyor mechanism 300 (e.g. 360 of Figure 3B) that is indicated as having no presence of a connector in the indexing data (e.g. 1100 of Figure 11A), and
 - placing the orientated connector with type identified into one of the plurality of holders (e.g. 360 of Figure 3B) that is indicated as having no presence of a connector in the indexing data (e.g. 1100 of Figure 11A).
- 10 The indexing data (e.g. 1100 of Figure 11A) stored in the memory of the sorting and storing device 200 is updated to indicate presence of a connector in the holder containing the placed connector, and the identified type (including model) of the placed connector.
- If the sorter 220 determines, based on the indexing data (e.g. 1100 of Figure 11A), that there is no holder (e.g. 330 of Figure 3A) on the conveyor mechanism 300 available for storing a connector 320, the sorter 220 may be operated to instruct the conveyor mechanism to move one or more holders 330 holding one or more connectors 320 to a designated area and to instruct the dispensing mechanism (e.g. 310 of Figure 3A) to dispense the one or more connectors 320 to the designated area. The designated area may be the bin 214 as illustrated in Figure 2 or a new bin that is being instructed by TOS to replace the bin 214 that is presently used in the station 100 or replace the bin 350 as illustrated in Figure 3A. Note that the bin is usually provided by the vessel that is performing a loading or discharging operation at the port facility. The bin used for collecting the connectors 320 that are dispensed from the holders 330 by the dispensing mechanism 310 can be the same bin that provides connectors 320 for placing into the empty holders 360.
- 25 The indexing data (e.g. 1100 of Figure 11A) may then be updated to indicate no presence of a connector for each holder with a connector dispensed to the bin 214 in Figure 2 or bin 350 in Figure 3A. Although it is indicated in the present example that the sorter 220 is responsible for determining whether there is available holder based on the indexing data (e.g. 1100 of Figure 11A), in another arrangement, it could be the station controller 190 in Figure 1 that is responsible for this determination.
- 30 If a connector 320 being picked up from the bin 214 cannot be identified (e.g. damaged connector), the pickup device 212 may be configured to place the unidentified connector at a holding area 240. Images of the unidentified item may be captured for sending to a central server (e.g. TOS). These images may be transmitted to an electronic device of a relevant personnel whom may take certain action based on the images. When the bin 214 is detected to be empty by the sorter 220 (i.e. in a situation when all connectors in the bin 214 are being sorted) or if the sorter 220 is being notified that a predetermined number of specified connectors that are required for performing coning or deconing operations for the particular vessel is satisfied, the sorter 220 may place all unidentified items back into the bin 214. Thereafter, the sorter 220 may notify, for instance, the station controller 190 of Figure 1 or a processor of the sorting and storing device 200 that all unidentified items are placed back into the bin 214. The station controller 190 of Figure 1 may be configured to notify that new stores (or bins) be brought in to replace empty stores (bins) or to notify additional stores be brought in order to handle with a situation with multiple vessels and multiple bins belonging to different vessels.
- 45 The above-mentioned processor of the sorting and storage device 200 maybe configured for managing the sorter 220 and the storage module 210, and for reporting any notifications (including alarms and fault) and operation statuses of the sorter 220 and the storage module 210. The processor of the sorting and storage device 200 may be further configured to communicate with a processor of an equipment control unit (e.g. any one of 108a-108f of Figure 1 or 1008a-1008h of Figure 10) to facilitate the coning and deconing operation. In another arrangement, a substation (e.g. 1004a or 1004e of Figure 10) may comprise of a substation controller for managing sorting and storing of connectors, and coning and/or deconing operations.
- 50 In one arrangement, the sorting and storing device 200 comprises a plurality of storage modules 210 that are cascaded. Hence, at least two conveyor mechanisms and two corresponding dispensing mechanisms are present since each storage module 210 comprises the conveyor mechanism 300 and the corresponding dispensing mechanism 310. The processor of the sorting and sorting device 200 may be configured to control the operations of the plurality of storage modules 210. Each of the plurality of the storage modules 210 may be configured to work independently of each other to increase productivity and storage capability. The plurality of storage modules 210 can be configured to operate in a staggered or asynchronous manner. For instance, in

Figure 3C, two storage modules 210 are cascaded in the sorting and storing device 200 as "Chain A" 322 and "Chain B" 324. In such arrangement, one of the storage modules 210 (e.g. Chain A 322) may be configured to prepare a holder for a current coning/deconing job, and the other storage module (e.g. Chain B 324) may be configured to prepare a holder for a subsequent coning/deconing job. In another example, Chain A 322 is arranged to perform coning/deconing operations for a first vessel, while Chain B 324 is arranged to perform coning/deconing operations for a second vessel. As an example, with reference to Figure 3C, the discharging guide 340 may have dividing means 342 for channelling connectors from each storage module 210 to a common bin 214 or respective bins for Chain A 322 and Chain B 324. In another example, the discharging guide 340 may be configured to comprise motorised guiding means (not illustrated in any Figures) to change the inclination of the divider 342 so that a dispensed connector can be dispensed into a corresponding bin. Using the example where "Chain A" 322 is arranged to perform coning/deconing operations for a first vessel, while Chain B 324 is arranged to perform coning/deconing operations for a second vessel, the motorised guiding means is configured to dispense a connector stored in "Chain A" 322 to an output bin for "Chain A" 322 and to dispense a connector stored in "Chain B" 324 to an output bin for "Chain B" 324 based on operation information. For instance, the operation information comprises vessel identifiers to identify the first vessel and the second vessel so that Chain A 322 and Chain B 324 can dispense connectors for these vessels accordingly.

The common bin 214 may be compartmentalised to comprise one or more compartments for storing the dispensed connectors 320. In one arrangement, all models of twist-locks may be placed in one compartment, and all models of cones may be placed in another compartment. This may speed up sorting process of the plurality of connectors in the bin 214 at a next port facility (or for ease of accessing an appropriate connector for upcoming coning operations scheduled to the station 100), since containers above deck and under hatch uses twist-locks and cones respectively

Several arrangements for the case in which more than one storage modules 210 are being cascaded will be described as follows. Figure 3C illustrates two cascaded storage modules 322 and 324 arranged to cooperate with only one sorter (e.g. 220 in Figure 2). As mentioned earlier, each storage module 210 comprises the conveyor mechanism 300 in examples shown in Figures 3A-3C and the conveyor mechanism 300 in turn comprises the pair of roller chains 302. The configuration of the conveyor mechanism 300 applies to each of the conveyor mechanism 322 and 324 described below with reference to Figure 3C.

In one arrangement, the conveyor mechanism 322 may be configured to handle all coning jobs, and the conveyor mechanism 324 may be configured to handle all deconing jobs. In another arrangement, the conveyor mechanism 322 can work with the sorter 220 to move one or more connectors from the bin (e.g. 214 of Figure 2) to one or more empty holders 360 of the conveyor mechanism 322 while the conveyor mechanism 324 is used for performing coning or deconing operation. In this arrangement, with reference to Figure 3C, the robotic manipulator of each equipment control unit (e.g. any one of 108a – 108f of Figure 1) is arranged to retrieve a connector 320 used for coning or return a connector 320 obtained from deconing at a position 326b of the conveyor mechanism 322, while the pickup head of the sorter 220 is arranged to store an identified connector into an empty holder 360 at a position 326a of the conveyor mechanism 324. This means the conveyor mechanism 322 and the conveyor mechanism 324 will move the required holder 330 or 360 to the respective locations, 326a or 326b, depending on the operation that the conveyor mechanism 322 or 324 has to coordinate with the respective sorter 220 or the respective robotic manipulator (e.g. 250 of Figure 2) of the equipment control unit (e.g. 108a-108f of Figure 1). This will prevent the pickup head of the sorter 220 from colliding with the robotic manipulator of the equipment control unit, even if there is a drift in any of the conveyor mechanisms 322 or 324 or if the intervals between these movements are not arranged sequentially.

The plurality of storage modules 210 may also be configured to operate simultaneously. For instance, in the example illustrated in Figure 3C, if the connectors held by the holders of "Chain A" 322 and "Chain B" 324 belong to the same vessel, the station controller 190 or the controller of the sub-station (e.g. 1004a-h in Figure 10) or the controller of the storage and sorting device 200 may dispense all connectors stored in the conveyor mechanisms 322 and 324 at once to speed up the return of the connectors to the vessel owner.

It is appreciated that the station controller 190 of Figure 1 may comprise a network unit for communicating with the server (i.e. TOS) to retrieve a list of job instructions periodically or

continuously and instruct the sorting and storing device 200 to perform the list of job instructions until they are completed.

Figure 11A illustrates indexing data 1100 structured in a form of a list. The indexing data 1100 in Figure 11A is described as follows.

- 5 - A connector 1102 stored at a first position of a first roller chain 'A' of a conveyor mechanism is of twist-lock type and its model is C5AM-DF.
- A connector 1104 stored at a twelfth position of the first roller chain 'A' is of cone type and its model is SDL-4.
- The second position of the first roller chain 'A' is indicated as 'Empty'.
- 10 - A connector 1108 stored at a fifth position of a second roller chain 'B' is of twist-lock type and its model is FA8.
- A connector 1110 stored at an eighth position of the second roller chain 'B' is of cone type and its model is IS-1T/LF.

15 It is appreciated that the leftmost column (with the header "Connector") in Figure 11A is provided for the sake of discussion and may not actually be present the actual indexing data 1100.

Advantageously, the sorter 220 of Figure 2 or the station controller 190 of Figure 1 may easily determine, from the indexing data 1100, a type of connector that is stored even in the case when there are different storage modules (e.g. 322 and 324 of Figure 3C) comprising different roller chains such as the first roller chain 'A' and the second roller chain 'B'.

20 Use of the indexing data 1100 is described as follows.

If the sorter 220 of Figure 2 or the station controller 190 of Figure 1 has determined, based on retrieved operation information (e.g. 1200 of Figure 11B), that a deconing operation is to be performed at a location for receiving a connector obtained from deconing, the sorter 220 or the station controller 190 is configured to:

- 25 - identify, based on the retrieved information of the container (i.e. part of the retrieved operation information, a type of a connector to be removed from a container;
- determine a position of a holder on a conveyor mechanism (e.g. 300 of Figure 3A) indicated as having no presence of a connector from the indexing data 1100;
- 30 - instruct the conveyor mechanism to dispense the connector in the holder into the bin (e.g. 214 in Figure 2) through instructing a dispensing mechanism (e.g. 310 of Figure 3A) to tilt the holders if there is no empty holder (e.g. 360 of Figure 3A);
- instruct the conveyor mechanism to move the holder at the determined position to the location for receiving a connector obtained from deconing the container;
- coordinate with a robotic manipulator to place the removed connector into the moved holder based on the determined position; and
- 35 - update the indexing data 1100 to indicate presence of a connector and its type (including its model type) in the holder containing the connector placed by the robotic manipulator, and the identified type of the connector placed by the robotic manipulator.

40 If the sorter 220 of Figure 2 or the station controller 190 has determined, based on the retrieved operation information, that a coning operation is to be performed at a location for retrieving a connector for coning a container, the sorter 220 or the station controller 190 is configured to:

- identify, based on the retrieved information of a container, the type of a connector to be used during coning;
- 45 - determine, based on the indexing data 1100 and the identified type of the connector to be used, a position of a holder on a conveyor mechanism (e.g. 300 of Figure 3A) containing a connector of the type identified to be used during coning;
- instruct the conveyor mechanism to move the holder at the determined position to the location for coning the container;
- coordinate with a robotic manipulator to pick from the location for retrieving a connector for coning the container; and
- 50 - update the indexing data 1100 to indicate no presence of a connector in the holder dispensing the connector.

55 The station 100 of Figure 1 may further comprise a remote diagnostic unit 180 for carrying out exception handling. The remote diagnostic unit 180 shows all the faults and alarms in station 100. It is designed with troubleshooting guides/procedures to allow a remote operator to instruct

devices within the station 100 through a device (e.g. 1050 of Figure 10) that is communicatively coupled to the station 100 to perform simple tasks such as reset the position of the robot manipulator 250 in Figure 2 and/or reset the application of the detection device 252 in Figure 2. The remote diagnostic unit 180 may be used in conjunction with a remote surveillance and supervision device 107. The remote surveillance and supervision device 107 uses the cameras 120 in Figure 1 for surveillance.

The station controller 190 of Figure 1 of the station 100 in Figure 1 may be further configured to operate as a notification unit for receiving one or more signals in an event of a predetermined exception and for sending notification to one or more alerting devices (e.g. 1050 in Figure 10) in data communication with the station controller 190. The predetermined exceptions may comprise any of the following scenarios:

- a connector has dropped before coning or deconing is completed;
- a connector is jammed in a corner casting;
- one of a plurality of robotic manipulators is faulty;
- the indexing data indicates that there is no holder on the conveyor mechanism available for storing a connector;
- a connector cannot be identified due to damage;
- information relating to a vehicle number of a vehicle entering the location for coning or deconing cannot be authenticated; and
- information relating to container number of a container carried by a vehicle for coning or deconing cannot be authenticated.

In another arrangement, the notification may be sent to a remote control center comprising the one or more alerting devices (e.g. 1050 in Figure 10) or alerting device(s) owned by technician(s) for the technician(s) to supervise the coning and/or deconing operations at the port facility. The remote control center may be located anywhere far from the wharf. The remote control center may comprise of an operation dashboard to monitor the operations in all stations. This allows operators at the remote control center or any personnel having one of the alerting devices (e.g. 1050 in Figure 10) to carry out simple diagnosis and basic troubleshooting before the technicians are sent to the station 100 of Figure 1 for detailed repair/troubleshooting.

Each of the one or more alerting devices (e.g. 1050 in Figure 10) may be configured to provide one or more user selectable options to disable a robotic manipulator so that if a notification that the robotic manipulator is faulty is received, the robotic manipulator can be configured to be inoperable via the one or more user selectable options.

In one example, if one substation (e.g. 1004f in Figure 10) is out of order, an operator may configure the station controller 190 of Figure 1 such that the substation that is out of order is skipped. For instance, in the set up as illustrated by Figure 10, if the substation 1004f comprising the equipment control unit 1008f and sorting and storage device 1006f is out of order, the station controller 190 of Figure 1 may be configured to disable the substation 1004f and configure the substation 1004g comprising the equipment control unit 1008g and sorting and storage device 1006g to handle all coning and/or deconing jobs that are previously allocated to the substation 1004f to prevent queue interruption.

In another example, if more than two substations in a station are found to be faulty, the station controller 190 may be configured to send a notification to the one or more alerting devices (e.g. 1050 in Figure 10) to receive user approval to divert an existing queue of vehicles (e.g. 104 in Figure 1) awaiting coning/deconing jobs to other stations handling coning and deconing. The notification may include a service request to a maintenance team to check on the two faulty substations.

Each of the one or more alerting devices (e.g. 1050 in Figure 10) may be further configured to provide one or more user selectable options to re-initiate a coning or deconing operation so that if a notification that a connector has dropped during a coning or deconing operation is received, re-initiation of the coning or deconing operation is selectable via the one or more user selectable options.

In one example, with reference to Figures 1, 2, 3A and 3B, if deconing operation is to be performed at a corner casting of a container to be deconed, and if the connector 320 is determined to be removed but not stored in an empty holder 360 of the sorting and storing device 200, the user may indicate that a deconing operation need not be reinitiated. In this case, it is likely the removed connector 320 has dropped, and can be retrieved later.

In another example, if coning operation is to be performed at a corner casting of a container to be coned, and if the connector 320 is determined to be not installed at a corner casting after coning, a user may reinitiate another coning operation. In this case, it is likely that the connector 320 has dropped. The connector 320 that has dropped can be arranged to be picked up after the whole coning operation is completed in station 100.

Each of the one or more alerting devices (e.g. 1050 in Figure 10) may be further configured to be provided a location of a station (e.g. 100 of Figure 1) so that a user may go to the station for troubleshooting if, for instance, a torque control of the robotic manipulator exceeds a predetermined threshold indicating that a connector is jammed in a corner casting.

Alternatively, each of the one or more alerting devices (e.g. 1050 in Figure 10) may be further configured to provide one or more user selectable options to overwrite location data of a next destination of a vehicle (e.g. 104 in Figure 10) after departing from a station (e.g. 100 in Figure 1). Hence, if one or more of the following conditions occur:

- a notification that a connector is jammed in a corner casting of a container carried by a vehicle (e.g. 104 in Figure 10) is received on the one or more alerting devices (e.g. 1050 in Figure 10),
- a notification that a container carried by the vehicle is found to be damaged is received, and
- a notification that information relating to vehicle number of a vehicle entering the location for coning or deconing cannot be authenticated is received,
- a notification that information relating to container number of a container carried by a vehicle for coning or deconing cannot be authenticated is received.

redirection of the vehicle (e.g. 104 in Figure 10) to, for instance, a service centre is selectable via the one or more user selectable options. Advantageously, the operations at the port facility will not be disrupted as the station (e.g. 100 in Figure 1) can continue to handle coning or deconing operations for other vehicles without any problems.

Each of the one or more alerting devices (e.g. 1050 in Figure 10) may be further configured to provide one or more user inputs to key in a vehicle number or a container number so that if a notification that information relating to a vehicle number or container number of a container or containers on a vehicle entering a location for coning or deconing cannot be authenticated is received, authentication can be provided based on the one or more user inputs. For instance, if a vehicle number of a vehicle (e.g. 104 of Figure 1) or a container number of each of one or more containers carried on the vehicle cannot be identified by the station controller 190 of Figure 1, the user can enter, via the one or more user inputs, the vehicle number or the container number identified by the user through processing of captured images of the vehicle and the one or more containers carried on the vehicle (e.g. images captured by the one or more cameras 120 of Figure 1 at the station 100 of Figure 1) in order to determine what operation is to be performed at a coning or deconing station.

Workflow of Automated Intelligent Wharf Operation Station (AIWOS)

Figure 12A illustrates how the station 100 of Figure 1 and the station 1000 of Figure 10 communicate with a server (i.e. Terminal Operating System (TOS)) 1250 for managing operations in a port facility and one or more alerting devices for remote diagnostics as well as remote surveillance and supervision of the station 100. For instance, a user may access video streams of the coning or deconing operations being performed in the station 100 through the one or more alerting devices. Operation information 1200 or other job details required for completion of the coning and/or deconing jobs scheduled for the station 100 are retrieved from the TOS 1250 and being processed by the station controller 190. The station controller 190 communicates with each of the different modules in the station 100 in order to obtain the progress of completion of each job and/or faults of the parts. The remote surveillance and supervision unit 107 and the container recognition unit 101 communicates with the plurality of pan-zoom cameras 120 in the station 100 to obtain videos and/or images for viewing and/or further image processing. If a job is completed, the information will be passed to the TOS 1250 for real-time updating so that the TOS 1250 is aware of the status of each vehicle 104 and each container (e.g. 102a and 102b of Figure 1) and can schedule upcoming jobs accordingly (e.g. fleet management, manpower allocation). If a fault is reported and a remote controller is unable to resolve the fault, the TOS 1250 may be informed by the station controller 190

and/or the user device of the remote controller. This allows the TOS 1250 to redirect work flow to a suitable area (e.g. service area or another station in operation) for further processing.

Although it is illustrated in Figure 12A that the TOS 1250 only communicates directly with the station controller 190, it should be appreciated that TOS 1250 can also be configured to dispatch operation information directly to the respective processors of each of the different modules such as the sorting and storage device 200 of Figure 2, equipment control unit 108a-108f of Figure 1 or 1008a-1008h in Figure 10, traffic management unit 160 of Figure 1 or a processor for each sub-station 1004a-1004h of Figure 10. This means that the sorting function or the coning and/or deconing function instructed through the station controller 190 can be carried out directly at the processors in the sorting and storage device or the equipment control unit, if these respective processors are configured to communicate with TOS 1250 to retrieve operation information and/or connector compatibility information.

Figure 12B is a flowchart showing steps for dispatching containers to/from a station. When a vessel berths at the port, containers may be required to unload from the vessel and/or containers at the berth may be required to load to the vessel. These activities can be regarded as a vessel operation. The process of such vessel operation begins at a step S1250. At a step S1252, the TOS 1250 described with reference to Figure 12A provides operation information 1200 such as container number, type of job (i.e. coning/deconing) to be performed, type of connectors involved, any special coning/deconing requirements (e.g. no coning or deconing required, fix connectors only at two diagonal corners) to the station controller 190. If there is any fault detected by the station controller 190 and/or the station controller 190 being notified of any fault at a step S1254, the station controller 190 will in turn notify one or more user devices (such as an alerting device 1050 in Figure 10) so that remote surveillance, supervision and/or diagnostic can be carried at a step S1264. For instance, the user device of a remote control room operator is notified and the remote control room operator can rectify the fault remotely. But if the fault is determined, at a step S1266, to be resolved remotely by the control room operator or a remote user, for instance, by keying in a container identification number in the case that the fault is that a container recognition unit (e.g. 101 of Figure 1) fails to identify a container or the resolution of the fault is to simply instruct the robotic manipulator to move to a home position by issuing the instruction to the remote diagnostic unit 107 in the station 100 through the station controller 190, the process goes back to step S1252 to perform the coning or deconing job indicated by the TOS to perform. This arrangement advantageously reduces the need to send someone physically to the station 100 to troubleshoot, and improves the overall efficiency of the vessel operation.

If a fault cannot be rectified remotely by the remote control room operator at a step S1266, the remote control room operator may then deploy a technician to the station 100 to conduct further troubleshooting. The remote control room operator may inform the TOS that the station 100 is out of service directly or indirectly (e.g. via the station controller 190) at a step S1268.

If the fault is determined at a step S1270 to be rectified by the technician, the remote control room operator who is monitoring the progress of the repair and recovery of the station 100 can inform the TOS that the station is back in operation so that new jobs can be scheduled to be carried out by the station 100 (and vehicles can be directed to the station) at a step S1272. In another arrangement, the technician may send a signal through an user interface of his user device or through a station interface to notify the TOS of the recovery. In one example, once the station has recovered from its fault, the station controller 190 ensures that the present coning or deconing job has been completed. The station 100 can then proceed back to step S1252 to handle the next coning or deconing job indicated in the operation information provided by the TOS.

However, if the fault remains unresolved by the technician at a step S1270, the technician can inform the control room operator at a step S1274 and/or the TOS directly through an user interface of his device. It may be possible for the technician to request the TOS to provide a replacement equipment control unit or a storage and sorting device or any required spare parts to the faulty station. The control room operator may also send a signal to the TOS to notify that the station 100 is out of service and all pending jobs should be redirected at a step S1276). In another arrangement, the station controller 190 may be configured to notify the TOS that the station 100 is out of service and will be moved to a standby area or a service center if the station controller 190 receives such request (e.g. from the station interface or a remote device or the station). The TOS may be configured to replace the faulty station with a replacement station in order to complete the vessel operation at a step S1276.

It should be appreciated at the step S1270, if the technician is not able to clear the fault, the technician will check if the fault is arising from the vehicle or equipment control unit. This means that when the equipment control unit is able to return to home position and can function normally, the

vehicle presently in the station may be configured to be redirected to an exception handling area. But if the fault is due to the equipment control unit and/or storage and sorting device, the technician is trained to ensure that the vehicle presently in the station can move out of the station while notifying the TOS that the station is out of service.

5 Under normal operation (i.e. when there are no faults), the station controller 190 may be configured to poll periodically or continuously for status and/or information for each of the units/devices that are communicatively connected to it, for instance, each equipment control unit, each storage and sorting device, the vehicle alignment unit, and so on (S1256). More specifically, the station controller 190 may be configured to monitor the coning/deconing process (of a connector
10 with respect to a corner casting of the container) for each equipment control unit and/or to update the TOS upon completion of a coning/deconing job (S1258). Details of how a station controller can be configured to monitor each coning/deconing operation and/or update the TOS upon completion of such operation will be discussed in detail with reference to Figure 15.

15 If a coning/deconing job is being completed, the station controller will determine if the vessel operation is completed or if there are more jobs being allocated to the station controller to complete at a step S1260. If there are no pending jobs for the vessel operation or new vessel operation allocated to the station controller 190, the station controller 190 will be notified of an end of vessel operation at a step S1262. Subsequently, the station controller 190 may be configured to put the station on a standby mode or to perform a re-initialization process, whereby all connectors are
20 discharged from the holders and/or all robotic manipulators are set to home position.

Figure 15 illustrates a coning/deconing workflow. Specifically, a station controller 190 can be configured to monitor each coning/deconing operation assigned to a station 100 and/or update the TOS described with reference to Figures 12A and 12B upon completion of such operation. At a step S1500, a coning or deconing operation begins. Coning is a process of attaching twist-locks (TL)
25 or cones (AC) to container corner castings prior to loading onto vessels, while deconing is a process of removing twist-locks or cones from container corner castings upon discharge from vessels.

A vehicle 104 (hereinafter, 104 refers to one or more vehicles) is informed by the TOS of a location (e.g. yard for coning operations and quay for deconing operations) to pick up a container at a step S1502 and to transport the picked up container to the station 100 to perform coning or
30 deconing at a step S1504. The vehicle 104 will be queued in line for entry into the station 100. As the vehicle(s) 104 in queue are approaching the station 100, a vehicle number recognition unit (VNRU) 150 of the station 100 communicates with one or more vehicles 104 that are approaching the station 100 to obtain the vehicle number and store them in a memory accessible by a station controller 190 of the station at a step S1506. The station controller 190 may arrange a storage and
35 sorting device 200, based on operation information, to prepare appropriate connectors that are required for the upcoming coning operations in advance or prepare a plurality of empty holders 360 for the upcoming deconing operations in advance to shorten the overall cycle time of container handling. For instance, the TOS can prepare a list of vehicles that are tasked to transport to a specific station and transmit the prepared list to the station controller 190 for advanced preparation.

40 The vehicles in queue will remain stationary, until a traffic management unit (TMU) 160 of the station 100 received a signal that the station 100 is ready for next coning/deconing job. In one arrangement, the station controller 190 may be configured to send a signal to the traffic management unit 160 to indicate that the station 100 is ready for the next coning/deconing job when the station controller 190 detects that the vehicle 104 in the station 100 has successfully exited the
45 station. If it is determined that the station 100 is ready for next coning/deconing job at a step S1508, the traffic management unit 160 will signal one or more vehicles 104 that is next in queue to move into the station 100 at a step S1510.

Each of the one or more vehicles 104 is aligned to a predetermined location for performing a coning or deconing operation by coordinating with signal(s) of a vehicle alignment unit (VAU) 140
50 of the station 100 at a step S1512. In some examples, a movable platform for moving a vehicle carrying one or more containers or a movable platform for moving one or more equipment control units configured for performing coning or deconing for one or more containers is provided to align and/or orientate the vehicle or the one or more equipment control units to facilitate the coning or
55 deconing of one or more containers carried by the vehicle. Container recognition of one or more containers being transported by the one or more vehicles 104 may be performed by a container recognition unit (CRS) 101 simultaneously while the vehicle 104 is aligning itself or may begin container recognition as soon as the vehicle 104 is aligned at the predetermined location at a step S1514. The container recognition unit 101 may be arranged to cooperate with a plurality of pan tilt
60 zoom cameras 120 in the station 100 to obtain a container identifier of each of the containers detected in the station 100.

After obtaining the respective vehicle number(s) and container identifier(s) of the one or more vehicles 104 carrying the one or more containers presently in the station 100, the station controller 190 verifies these details with operation information (e.g. data 1200 of Figure 11B) retrieved from the TOS at a step S1516. If the operation information does not match with the identified vehicle number(s) and/or container identifier(s), a remote operator may be notified, for instance, via an alerting device. In one example, the remote operator may be configured to confirm the identified details with the operation information retrieved from the TOS. If there is truly a difference, the remote operator may send an instruction to the station controller 190 to notify the TOS to update its records, and/or retrieve corresponding information of the container identifier. For instance, it may be that the operation information indicates a vehicle 1234 is carrying two 20-foot containers with identifiers being "ABCD1234567" and "WXYZ9876543", but the identified container identifiers are "ABCD1234567" and "ABCD9876543". In such example, the station controller 190 may send a request to the TOS to retrieve the related operation information of the container "ABCD9876543" so that coning/deconing operation may be performed. At the same time, the station controller 190 may also request the TOS to update its record to indicate that the vehicle 1234 is carrying "ABCD1234567" and "ABCD9876543" and not "WXYZ9876543".

Upon obtaining the operation information of the containers to be coned or the containers to be deconed, the station controller 190 is arranged to instruct its one or more equipment control units (e.g. 108a-f of Figure 1) to coordinate with its one or more storage and sorting devices (e.g. 106a-f of Figure 1) at a step S1518. The respective storage and sorting devices prepares itself in advance for the scheduled coning or deconing job at a step S1520. The process of how the respective storage and sorting device prepares itself for a coning job or a deconing job will be discussed in detail later with reference to Figure 16. Once a storage and sorting device 200 is ready to provide a required connector at a location for retrieving a connector used for coning a container or ready to provide an empty holder at a location for receiving a connector obtained from deconing a container, the respective equipment control units performs the coning or deconing at a step S1522. The process of coning or deconing will be discussed in detail later with reference to Figure 17.

The TOS will be informed of a status (e.g. fault detected, job completed) of the coning or deconing operation of the one or more containers carried by the one or more vehicles in station at a step S1524. If applicable, the TOS may notify the vehicle 104 in station of its next destination (e.g. error handling area, quay, yard) at the step S1524. Once the station 100 is ready for the next coning or deconing job, a signal is being sent to inform the traffic management unit 160 at a step S1526. Each coning or deconing operation ends at a step S1528 and repeats from step S1500 again if there is any pending coning or deconing job allocated to the station 100.

Figure 16 illustrates how a storage and sorting device 200 (e.g. 106a-f in Figure 1) prepares itself in advance before performing a coning or deconing operation (S1522 of Figure 15). The storage and sorting device 200 may be configured to coordinate with an equipment control unit (e.g. 108a-f) to complete deconing at a step S1522 in order to proceed with some steps, such as step S1622, in Figure 16.

The coning or deconing process of a storage and sorting device 200 begins at a step S1600. The storage and sorting device 200 may be configured to receive an instruction to perform coning or deconing from the station controller 190. Upon receipt of such instruction, the storage and sorting device 200 will first determine if deconing is required at a step S1602. If it is determined at the step S1602 that deconing is required, the station controller 190 of an Automated Integrated Wharf Operation Station ("AIWOS") 100 or a controller of the storage and sorting device 200 will determine if the deconing operation is associated with an initial start of a vessel deconing operation at a step S1610.

It is noted that when a vessel berths at a port facility, deconing is typically performed before coning. This allows container(s) on board to be unloaded from the vessel so that container(s) to be shipped by the vessel can be loaded onto the vessel. Specifically, the station 100 may be arranged to perform a plurality of deconing jobs before performing a plurality of coning jobs. In another arrangement, concurrent loading of containers requiring coning and offloading of containers requiring deconing may begin simultaneously on a vessel but using different quay cranes.

Therefore, when the station 100 is to perform a first deconing job for a vessel i.e. YES at S1610, the storage module 210 of the storage and sorting device 200 is initialised at a step S1612. During an initialisation of a storage module, a plurality of connectors are being arranged to be dispensed out of the holders of a conveyor mechanism (e.g. 300 in Figures 3A and 3B) so that there will be sufficient empty holders to store the connectors obtained from the deconing jobs for the vessel. The dispensed connectors are collected and returned to an earlier vessel that has performed coning and/or deconing at the station 100.

The station controller 190 or the controller of the storage and sorting device 200 will monitor if the storage module is faulty (e.g. whether the conveyor mechanism 300 and dispensing mechanism 310 is functioning properly) at a step S1614. If it is determined at the step S1614 that the storage module 210 is faulty, the station controller will be notified of the specific fault at a step S1624. Subsequently, the station controller 190 sends a notification to a remote operator about the specific fault via his alerting device (such as device 1050 in Figure 10), which may be a mobile phone, desktop or any hand-held device at a step S1626. The remote operator may be in a remote control room or in transit (moving around a port facility or out of the port facility). Error handling (or exception handling) process will be invoked at a step S1628. Error handling will be discussed in detail later with reference to Figure 19.

If it is determined that the storage module 210 is functioning at the step S1614, the conveyor mechanism 300 of the storage module 210 is instructed to move to an empty holder 360 to receive and store a connector obtained from deconing of a container at a step S1616. In one example, the conveyor mechanism 300 is configured to move a nearest empty holder 360 to a location (e.g. 326b of Figure 3C) for receiving a connector obtained from deconing. In another arrangement, the conveyor mechanism 300 is configured to move an empty holder having an adjacent holder holding an identical type of connector to the location for receiving a connector obtained from deconing by referring to indexing data stored in a memory that is accessible by the station controller 190 or the controller of the storage and sorting device 200.

In the event that it is determined that there are no empty holders (i.e. storage module 210 is full) at a step S1618, the storage module 210 is arranged to discharge connector(s) that are stored in holder(s) into a bin at a step S1620 in order to provide empty holder(s) for the deconing process. Once there is at least one empty holder available in the conveyor mechanism 300 in Figure 3A and 3B, the station controller 190 or the controller of the storage and sorting device 200 can coordinate with the conveyor mechanism 300 to move the empty holder to a location for receiving a holder obtained from deconing at the step S1616. Subsequently, the station controller 190 is configured to instruct an equipment control unit (e.g. 108a-f of Figure 1) to perform deconing, which is essentially proceeding with step S1522 of Figure 15.

In one example, the dispensing mechanism 310 may be arranged to dispense connectors that would not be used in the upcoming predetermined number of coning jobs based on the operation information retrieved from the TOS and the indexing data stored in a memory accessible by the station controller 190 or the controller of the storage and sorting device 200. The indexing data (e.g. 1100 of Figure 11A) stored in the memory may comprise:

- (i) a presence of a connector in each holder,
- (ii) a type and a model of the connector that is contained in each holder, and
- (iii) a position of each holder of the conveyor mechanism 300.

Once the connector obtained from deconing of a container is stored into an empty holder of the conveyor mechanism 300, the indexing data is updated to indicate presence of a connector in the holder containing the placed connector, and the identified type of the placed connector at a step S1622. The deconing process of the storage and sorting device 200 then ends at a step S1608.

Referring back to the step S1602, if deconing is not required from the received instruction(s) from the station controller 190 or the controller of the storage and sorting device 200, the station controller 190 or the controller of the storage and sorting device 200 will determine at a step S1604 whether a coning process is required. If it is determined at the steps S1602 and S1604 that neither deconing nor coning is required, the conveyor mechanism 300 may remain stationary i.e. at home position and do nothing at a step S1606. In one arrangement, when there is no action required by the station 100 at the step S1606, the conveyor mechanism 300 may coordinate with a sorter 220 of the storage and sorting device 200 to place identified and orientated connector from a bin 214 into empty holders 360 of the conveyor mechanism 300 at a location (e.g. 326a of Figure 3C) for loading connectors into a storage module 210.

If a coning process is determined to be required at the step S1604, the station controller 190 or the controller of the storage and sorting device 200 will determine if the coning operation is associated with an initial start of a vessel coning operation at a step S1630. If the station 100 is to perform a first coning job for the vessel i.e. YES at S1630, the station controller 190 notifies the storage and sorting device 200 the type of connector required for this coning job at a step S1632. Subsequently, the station controller 190 or the controller of the storage and sorting device 200 will check if the sorter 220 is faulty at a step S1634. If it is determined at the step S1634 that the sorter 220 is faulty, the station controller 190 will be notified of the specific fault at the step S1624.

Subsequently, the station controller 190 sends a notification to a remote operator about the specific fault via his alerting device such as the device 1050 in Figure 10, which may be a mobile phone, desktop or any hand-held device at a step S1626. Error handling (or exception handling) process will be subsequently invoked at a step S1628.

5 If the sorter 220 is determined at the step S1634 to be functioning, the station controller 190 will perform identification and orientation, i.e. pick and load connectors for coning onto holders of the conveyor mechanism 300 at a step S1636. The process of identification and orientation of a connector in the bin 214 will be discussed in the following paragraphs with reference to Figures 18A and 18B.

10 With reference to Figures 18A and 18B, the sorter 220 begins the process for preparing a required model and/or type of connector 320 used for a coning job at a step S1800. The station controller 190 or the controller of the storage and sorting device 200 is configured to determine, based on indexing data (e.g. 1100 of Figure 11A) stored in a memory, whether a storage module 210 of the storage and sorting device 200 has a predetermined number of the required connector(s) at a step S1802. For instance, if the predetermined number is set as one, the station controller 190 checks if there is a presence of the required connector 320 in any one of the plurality of the holders 330 in the storage module 210. In another arrangement, if the predetermined number is 10, the station controller 190 checks if there are ten required connectors in one or more storage modules in use for a particular vessel operation. It should be appreciated that a plurality of storage modules may be cascaded for use at each substation (e.g. 1004a-h of Figure 10).

20 If the number of the required connectors is determined to be less than the predetermined number at the step S1802, the station controller 190 or the controller of the storage and sorting device 200 is configured to initialise a search count at a step S1804. The search count is configured to alert a remote operator about a delay in finding a required type of connector and/or its compatible connector to complete a coning job if the search count exceeds a particular threshold.

25 At a step S1806, a pick up device 212 of the sorter 220 picks up an unidentified connector from a bin 214 and places it at an identification and orientation station 230. If the picked connector cannot be identified at the identification and orientation station 230 at a step S1808, the unidentified item will be placed in a holding area 240 at a step S1810 and a new connector will be picked from the bin 214. However, if the picked connector can be identified at the step S1808, the controller will determine if the identified connector is in a desired orientation for placement into an empty holder 360 (e.g. as shown in Figure 5A) at a step S1812. The identified connector is orientated to the required orientation at a step S1814, if it is determined that the identified connector is not in the desired orientation at the step S1812. For example, the identified connector in a non-desirable orientation may be inverted (e.g. Figure 5B) or the wire of the connector is not facing a desired direction (e.g. Figure 5C).

30 Once the identified connector is in an orientation for placement (such as Figure 5A) into an empty holder 360, the station controller 190 or the controller of the storage and sorting device 200 is configured to place the orientated connector in the empty holder 360 of a conveyor mechanism (e.g. 300 in Figure 3A and 3B) of a storage module (e.g. 210 in Figure 2). Prior to storing the orientated connector in the empty holder 360 of the conveyor mechanism, the controller first determines if the storage module is faulty at a step S1816. If the storage module is determined to be operating without fault at the step S1816, the orientated connector is placed into the empty holder 360 of the conveyor mechanism at a step S1826. Once the orientated connector is stored into the empty holder 360 by the pickup head 212 of the sorter 200, the indexing data is updated to indicate presence of a connector in the holder and the type of connector being held in that holder at a step S1828. This is a process to load the holders of the conveyor mechanism 300 with as many connectors beforehand in order to reduce overall cycle time. If the storage module is full i.e. no empty holders 360 in the conveyor mechanism 300, the station controller 190 is arranged to dispense at least one holder that is holding a connector that is not required for the present coning job and/or a connector that is not compatible for use in the present or upcoming jobs.

45 If it is determined at the step S1816 that one or more storage modules 210 is faulty, the station controller 190 will be notified of the specific fault at a step S1818. Subsequently, the station controller 190 sends a notification to a remote operator about the specific fault via his alerting device (such as device 1050 in Figure 10), which may be a mobile phone, desktop or any hand-held device at a step S1820. Error handling (or exception handling) process will be subsequently be invoked at a step S1822. Once the error handling process is completed at the step S1822, the preparation for a required connector used for a coning job also ends, which refers to the step S1608 of Figure 16.

At a step S1830, the station controller 190 is configured, based on the operation information (e.g. data 1200 of Figure 11B) retrieved from the TOS, to determine if there is any required connector for the coning job in any one of the holders 330 (of a storage module). If there are one or more storage modules (e.g. 322 and 324 of Figure 3C) being used to serve a vessel operation in the station 100, the determination is based on the total number of required connectors in the one or more storage modules. It is appreciated that the controller of the storage and sorting device 200 can work together with the station controller 190 or be replaced by the station controller 190 to perform coning or deconing.

If a required connector for the coning job is available, the conveyor mechanism 300 that holds the particular holder storing the connector will be move to a location for retrieving the connector for coning (e.g. 326b) at a step S1832. Once the preparation for the present coning job is completed, the process ends at a step S1824 which corresponds to the step S1636 of Figure 16. If there is no required connector in any holder at the step S1830, the station controller 190 or the controller of the storage and sorting device 200 is configured to check if there are any compatible connectors from the vessel sorted from the bin 214 and/or stored in any one of the holders at a step S1834. This check for compatible connectors is done as a secondary procedure. Hence, the station controller is configured to prioritize the use of a required connector over the use of a compatible connector. However, if compatible connectors are used, the replenishing of the required connector(s) into the holders of the conveyor mechanism 300 for coning can be completed faster and not delay the coning operation.

"A required connector" used herein refers to a specific type and model (i.e. ideal type) of connector indicated by a vessel owner to use during a coning operation for the container to be coned. "A compatible connector" used herein refers to all types of the connector that can be used as direct replacements of the required connector intended for the particular coning operation. In one arrangement, a compatible connector and a required connector uses the same type of end effector. In another arrangement, a compatible connector is suitable for use to secure the containers above-deck or below-deck, but require a change of end effector (by referring to the indexing data 1100 in Figure 11A) in order to perform the coning operation. Note that an effector can be used for different models of connectors.

An example of compatibility data (non-exhaustive) is stored in a memory accessible by the station controller 190 or the controller of the storage and sorting device 200 is illustrated in Table 2 below.

S/N	Type	Model of Connector
1	Twist-lock A	T-2.3C, C8A-DF, TL-GA/L, C5AM-DF
2	Cone A	S-1.47B, C16A
3	Cone B	C12C, IS-1T
4	Cone C	SDL-4, IS-1T/LG

Table 2: Compatibility Data between some models of connectors

Note that there is a slight difference during the removal of type "Cone A" and type "Cone B" from a corner casting of a container because Cone A requires an operating mechanism different from Cone B. The operating mechanism for both "Cone A" and "Cone B" remains the same during the installation onto the corner casting the container. Consequently, "Cone A" and "Cone B" use the same type of end effector. In contrast, "Cone C" requires use of an end effector different from the end effector used for "Cone A" and "Cone B".

In the present disclosure, compatibility between a compatible connector and a required connector is to be understood as the compatible connector is compatible to the required connector if a change of end effector usable to install the required connector is not required to install the compatible connector. Hence, in an arrangement where a compatible connector and a required connector are configured to use the same type of end effector, Cone A will be deemed compatible with Cone B because they do not require use of different end effectors.

However, in another arrangement, the compatibility between a compatible connector and a required connector can be understood as the compatible connector is compatible to the required connector if the compatible connector is suitable for use to secure the container(s) but require a change of end effector in order to perform the coning operation. In this case, if a compatible connector is suitable for use to secure the containers but require a change of end effector in order to perform the coning operation, "Cone C" is considered compatible with "Cone A" and "Cone B".

As an example, and referring to the first row of the operation data 1200 in Figure 11B, the required connector for the coning operation is "C5AM-DF". If it is determined at the step S1830 that no "C5AM-DF" connector is present, the station controller 190 or the controller of the storage and sorting device 200 will be configured to find if there are any compatible models (e.g. T-2.3C, C8A-DF, TL-GA/L). In this arrangement, the vessel operation will not be interrupted and overall cycle time will be reduced.

If there is no required connector and compatible holder in any holder at the step S1834, the search count will be incremented at a step S1836. The search count will also be polled at a step S1838 to determine if it exceeds a threshold. In such arrangement, the sorting may be arranged to stop only if the number of required connector exceeds a minimum limit as determined in step S1802.

If the search count exceeds a threshold, the station controller 190 will be triggered at a step S1840. The station controller 190 is configured to send an alert to a remote operator via his alerting device upon receipt of the triggering signal, so that a technician can be deployed to attend to the bin 214 at S1842. The alerting device may be a mobile phone, desktop or any hand-held device. It should be appreciated that by implementation of a search count, the sorter 200 can be configured to stop searching for a specific model of connector or the compatible models required for completing the coning job. This will reduce a delay (if any) in the cycle time, and notify a technician to conduct preliminary check. For instance, the technician can troubleshoot to identify if there is an image recognition problem with the identification and orientation station and/or to confirm if the bin 214 really does not contain the required connector and/or its compatible connector when the search count exceeds the threshold.

But if the search count does not exceed the threshold at the step S1838, the station controller 190 or the controller of the storage and sorting device 200 is configured to determine if the storage module 210 is full i.e. a situation where there are no empty holders in the conveyor mechanism 300 at a step S1844. If it is determined at the step S1844 that there are empty holders available in the storage module 210, step S1806 will be repeated. This means that more connectors will be picked from the bin 214 for identification and orientation. But if the storage module 210 is determined to be full (i.e. no empty holders), the station controller 190 or the controller of the storage and sorting device 200 is configured to discharge some of the holders stored with connectors that are not required for the coning job and/or upcoming coning jobs at a step S1846 in order to have empty holders to store identified connectors picked from the bin 214. Step S1806 is then repeated i.e. more connectors are picked up from the bin 214.

In summary, from the description above, the station controller 190 is configured to determine the number of the required connector available to complete a coning job, and if it is determined that the storage module 210 is running low on the required connector, the sorter 200 is configured to:

- pick up connectors from a bin and perform identification and orientation.
- initialise a search count,
- increment the search count by one if a required type of connector and its compatible type for coning is absent, and
- sending a notification to alert a remote operator if the search count exceeds a predetermined threshold,

wherein the search count is the number of times the sorter identifies a connector picked from the bin before finding the required connector or its compatible type to complete the coning.

As an example, the remote operator may be alerted if there are more twist-locks than cones in a bin being sorted in an Automated Integrated Wharf Operation Station, AIWOS, (e.g. 100 in Figure 1) to carry out a vessel operation and cones are required to complete the coning. In this example, the remote operator can dispatch a technician to verify the problem. The technician may check if there are required or compatible connectors in unsorted bins that are in the station or in bins in other stations.

At step S1846, where holders not storing required connector and/or compatible connector are dispensed by a dispensing mechanism 310, the dispensed connectors may be directed to a particular corner of a bin 214 using a controllable divider (e.g. 342 of Figure 3C). This will reduce the possibility of picking up the same connector during the next iteration of picking, sorting and identifying. Optionally, the identification and orientation station 230 may further comprise a buffer bin (not illustrated in Figures) to store identified connectors that are not required or compatible for the present coning job at step S1808. It should be appreciated that indexing can be carried out at the buffer bin to assist subsequent transfer to a storage module.

If it is indicated that there are required connector and/or compatible connector in the holder, the holder storing the required/compatible connector will be moved to a location for retrieving

- connectors for coning (e.g. 326b) at a step S1832. The preparation for a coning process of a storage and sorting device 200 then ends at a step S1824, which corresponds to the step S1608 of Figure 16. Subsequently, the station controller 190 is configured to instruct an equipment control unit (e.g. 108a-f of Figure 1) to perform coning i.e. the process proceeds with S1522 of Figure 15.
- 5 Once the connector stored into the holder is retrieved to perform coning, the indexing data is updated to indicate absence of a connector in the holder.

- It should be appreciated that a skilled person whom is experienced in day-to-day port operations would understand that there are only two models (i.e. one model for above deck, and one model for below deck) for a vessel loading/unloading operation during new build. However, as the vessel goes into duty and commutes to a number of port facilities, the number of models that are used for above deck or below deck may increase over time. This is largely because wrong (but compatible) models may be used during coning/deconing at some port facilities and/or replacement of damaged connectors may be required. The damaged connectors may be replaced with any available (and compatible) type of connectors in order to complete the vessel operation. A practical problem arises as there is a need for a lashing worker to spend time to find the specified model or compatible model(s) to install to the container before the container can be loaded onto the vessel. Note that the quantity of each distinct type of connector in each bin belonging to a vessel is not known at the start of a vessel operation.
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- In addition, there is a possibility that connectors provided by the vessel owner are insufficient to complete all the coning jobs for the vessel operation. In such a case, the captain of the vessel would be informed if there are not enough required connectors and/or compatible connectors left for coning all the container(s) meant for loading onto vessel. It is usually the decision of the captain to inform the corresponding shipping line on the follow up process. For instance, these affected container(s) would be prevented from loading onto the vessel (due to a lack of required/compatible connectors), and are arranged to be loaded onto a next available vessel travelling to the same destination. Implementation of a search count helps to keep a reasonable number of required connector in a storage module (in advance) for productivity. It also provides a more reliable way to identify a scenario where there are insufficient connectors suitable for completing all coning jobs within a vessel operation so that the vessel captain can be promptly informed about the incapability to complete the vessel operation.
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- Although in the present workflow, the station controller 190 monitors for any faults flagged by the sorter 220 or the storage module 210 of the storage and sorting device 220 before instructions are sent to the sorter 220 or the storage module 210 for execution. However, it should be understood that these steps of monitoring for faults can be arranged in any order or arranged as interrupts such that if a fault is detected, the station controller 190 is notified of the fault.
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- Figure 17 illustrates the coning or deconing process of S1522 in detail. The coning or deconing of a container in a station 100 by a robotic manipulator (e.g. 1009a of Figure 10, 250 of Figure 2) of an equipment control unit (e.g. 1008a of Figure 10) begins at a step S1700. If it is determined at a step S1702 that coning is required of the robotic manipulator, the station controller 190 determines if a corner casting is empty at a step S1710. In one example, this can be performed by analysing images acquired by a visioning unit disposed at an end effector of the robotic manipulator. If it is determined that the corner casting is not empty during a coning process, the station controller will be informed of the specific fault at a step S1726.
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- If it is determined at the step S1702 that coning is not required, the station controller determines if deconing is required at a step S1704. If it is determined at the step S1702 that coning is not required and that deconing is not required by the robotic manipulator at the step S1704, the robotic manipulator will remain stationary (i.e. at home position and do nothing) at a step S1706. For instance, it can be determined at S1706 that there may be specific requirements for a coning or deconing job which do not require manipulation by the robotic manipulator (e.g. no coning or deconing required, fixed connectors only at two diagonal corners of the containers). The coning and/or deconing process for the containers in station then ends at a step S1708.
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- In the event that it is determined at a step S1704 that deconing is required or if it is determined that coning is required at the step S1702 and the corner casting is empty at the step S1710, the station controller 190 determines at a step S1712 to check if the position and orientation of the connector is within a range of the robotic manipulator. It should be appreciated that the container connectors are stored or transported in a desired orientation (as discussed with reference to Figure 7A to 7H). If it is determined that the expected movement of the robotic manipulator is out of range at the step S1712, the station controller will be informed of the specific fault at a step S1726.
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- The station controller 190 is also configured to detect any collision issue at a step S1714. For instance, the station controller 190 may be arranged to calculate a probability of collision and comparing the calculated probability of collision with a predetermined threshold and/or to detect collision of the robotic manipulator by monitoring an impact sensor on the robotic manipulator. The probability of collision may be calculated by determining the location of the container with respect to the robotic manipulator and predicting the movement trajectory of the robotic manipulator. The probability of collision may also be calculated by capturing one or more images when the robotic manipulator is in motion during coning or deconing. The captured images may be compared with a set of reference images to determine if there is an obstacle being captured by a imaging unit located near an end effector of the robotic manipulator. A fault occurs if the calculated probability of collision exceeds the predetermined threshold or the impact sensor detects a collision of the robotic manipulator.
- If no faults are detected at any of the steps S1710, S1712 and S1714, the robotic manipulator of the equipment control unit will coordinate with the storage and sorting device at a step S1716 to:
- retrieve a connector used for coning a container, at a location (of a conveyor mechanism) for retrieving a connector used for coning a container, based on the operation information retrieved from the TOS and indexing information stored in a memory accessible by the storage and sorting device, or
 - place a connector obtained from deconing a container into an identified empty holder, at a location (of a conveyor mechanism) for receiving a connector obtained from deconing a container, based on the operation information retrieved from the TOS and indexing information stored in a memory accessible the storage and sorting device.
- During the coordination between the robotic manipulator (e.g. 250 of Figure 2) of the equipment control unit (e.g. 108a-f in Figure 1) with the storage and sorting device 200, the equipment control unit (e.g. 108a-f in Figure 1) may be further configured to determine the type and/or specific model of the connector to be handled. The equipment control unit (e.g. 108a-f in Figure 1) may be configured to verify with the information provided by the vessel owner to TOS and/or indexing data stored in a memory accessible by the station controller 190.
- It should be appreciated the station controller 190 may have to determine if the robotic manipulator is equipped with the correct end effector at a step S1718. For instance, if it is determined at the step S1718, based on the operation information and/or images captured by visioning unit of the end effector, that an end effector of a twist-lock model type "C5AM-DF" is required, but the present end effector is of a cone model type "IS-1T/LF", the equipment control unit is configured to request the robotic manipulator to retrieve the correct end effector from an effector exchange rack. Although it is indicated in the Figure 17 that the determination of a change in end effector is performed after checking that no faults are detected at any of the steps S1710, S1712 and S1714, the check for an appropriate end effector may actually be made to be performed right before the step S1702 and after S1700 instead. In another example, with reference to Figure 17 and 18B, where a required type of connector, for instance, "C5AM-DF" is determined to be absent at step S1830, and a connector that is compatible with "C5AM-DF" is determined to be present at step S1834, the station controller is configured to check if a change of end effector is required at step S1718 in order to perform coning with the connector that is compatible with "C5AM-DF".
- Referring back to Figure 17, if it is determined that a change of the correct end effector is required at the step S1718, the station controller 190 and/or controller of the equipment control unit will proceed to check if the automated change to the correct end effector is successful at a step S1720. In the event that the change to the correct end effector is not successful at the step S1720, the station controller 190 will be informed of the specific fault at the step S1726.
- If it is determined that the robotic manipulator is equipped with the correct end effector at the step S1720, the robotic manipulator proceeds to carry out coning/deconing at a step S1722. During the coning or deconing operation, the station controller 190 and/or the controller of the equipment control unit (e.g. 108a-f of Figure 1) monitors the coning process of installing the connector onto the container or the deconing process of removing the connector from the container. It should be appreciated that if a change of end effector is determined at the step S1718 to be not required, the step S1720 is skipped. This means that the station controller 190 and/or controller of the equipment control unit is instructed to carry out coning/deconing at the step S1722 and checks if the coning process or the deconing process is successfully completed at a step S1724. Once the present coning or deconing job is completed, the process ends at a step S1708, which means that S1522 of Figure 15 is completed. The station controller 190 will then update the TOS about the

status of the present coning/deconing job and the TOS will transmit the location data of the next destination of the vehicle 104 in the station 100 to the vehicle 104, which is step S1524 of Figure 15.

If the station controller 190 is notified of a specific fault from the equipment control unit (e.g. 108a-f of Figure 1) at the step S1726, for instance, if a corner casting of a container is not empty during deconing process, a robotic manipulator out of range, the calculated probability of collision exceeds the predetermined threshold or if the impact sensor detects a collision, the station controller 190 sends a notification to a remote operator about the specific fault via his alerting device at a step S1728. The alerting device may be in the form of a mobile phone, desktop or any hand-held device. Error handling (or exception handling) process will be invoked at a step S1730. Error handling will be discussed in detail later with reference to Figure 19.

Error Handling

Error handling (otherwise known as exception handling in the present disclosure) may be invoked at a step S1900 if any one of the predetermined errors occur (e.g. step S1728 in Figure 17, step S1828 in Figure 18). It is appreciated that although in the present embodiment, the same error handling process is triggered when the apparatus 100 requires a remote operator to review an error, it can be easily envisaged by a skilled person to have a different error handling process for each flow chart (such as a different error handling process for coning and deconing respectively).

The remote operator may use the remote surveillance system/supervision system 107 via an alerting device 1050 to review the error detected by the station 100 at a step S1902. If it is determined that the error is due to a fault arising from the station 100 at a step S1904, a further determination is required at a step S1918 to check if the fault can be cleared remotely. For instance, the remote operator may attempt to reinitialise the station 100 (e.g. instructing all equipment control units, sorter and storage device to stop all operations and return to their respective home positions). If the detected fault is able to be cleared remotely by intervention of a remote operator at the step S1918, the remote operator may inform the station controller 190 to continue with or repeat the current job at a step S1930. The error handling process then ends at a step S1916.

If the remote operator is unable to remotely clear the detected fault caused by the station 100 at the step S1918, the remote operator will determine whether the vehicle 104 is capable of moving to an exception handling area at a step S1920. In the case of an automated guided vehicle 104, if the unmanned vehicle 104 breaks down, a signal will be transmitted to the station controller 190. In the case of a prime mover 104 that is driven by a human driver, if the prime mover 104 breaks down, the driver can communicate with technicians or interact with an user interface (PMPC) placed in his vehicle. If the vehicle 104 is capable of moving to the exception handling area, the remote operator or the station controller 190 may request the TOS to instruct the vehicle 104 to move to the exception handling area and to indicate that the station 100 is down for operation at a step S1922. Steps 1908 to S1916 are subsequently processed for the vehicle 104 arranged to move to the exception handling area. Details of steps S1908 to S1916 would be discussed in detail in the following paragraph.

Although it is not illustrated in the flow chart in Figure 19, the TOS is configured to re-direct vehicles waiting in queue to enter the faulty station 100 to other operating station(s). In the event that the vehicle 104 is not capable of moving to the exception handling (e.g. the robotic manipulator is stuck to a corner casting, the vehicle breaks down etc.), the remote operator deploys a technician to the faulty station 100 for troubleshooting at a step S1924. If the fault can be successfully cleared by the deployed technician at a step S1926, the error handling process will continue with steps S1930 and S1916. Otherwise, if the detected fault cannot be cleared by the deployed technician, the technician will ensure that it is possible for the vehicle 104 to move out from the station to the exception handling area at a step S1928. Subsequently, the error handling process will proceed to the next step S1922 i.e. the TOS instructs the vehicle 104 to move to the exception handling area. In an example when station controller 190 is instructed to continue with the present coning or deconing job at the step S1930, the station controller 190 may be configured to determine whether the present coning or deconing job is completed partially before instructing a designated equipment control unit (e.g. 1008a-h of Figure 10) to coordinate with its respective storage and sorting device (e.g. 1006a-h of Figure 10) to complete the coning or deconing job. For instance, and referring to Figure 10, if three out of the four corner castings, such as 1025a-c, of a container to be coned 1022 have been installed with the required connector, the station controller 190 is arranged to initiate coning for the remaining corner casting 1025d.

If it is determined that the detected error is not due to a fault by the station 100 at the step S1904, the remote operator informs the station controller 190 and/or the TOS that the vehicle 104 needs to move to an exception handling area to perform the job manually at a step S1908. The

scheduled coning or deconing operation is then completed manually by a technician at the exception handling area at a step S1910. The technician may also inform the remote operator and/or the TOS about the manual job completion at steps S1910 and S1912 respectively. The scheduled coning or deconing operation will be updated by correlating the job status with the container information and vehicle number (e.g. by communication through walkie-talkie or by visual inspection and inputting the required parameters through the alerting device 1050). Once the TOS is informed of the completion of the coning/deconing operation at the step S1912, the TOS informs the vehicle via in-vehicle communication infrastructure to move to the next job location at a step S1914. The error handling process then ends at the step S1916.

Examples of an error not due to a fault by the station 100 may include an instance where a connector is jammed at a corner casting during a deconing operation, and an instance where a possibility of collision between a robotic manipulator and the corner casting is determined to be high.

At a port facility, when coning and deconing operations are completed for a vessel, unused connectors that are held by container holders have to be dispensed and returned to the vessel. As discussed earlier, there are different types of dispensing mechanisms (e.g. the roller dispenser, the pushing dispenser, the magazine motion dependent dispenser and the like) that may be used in the apparatus 100.

Figure 30A illustrates an example of a workflow indicating how a connector 320 may be dispensed from the storage module 210 of the apparatus 100 of Figure 1. The workflow is applicable to the example illustrated by Figures 29A and 29B. In the example illustrated by Figures 29A and 29B, the conveyor mechanism 2900 moves in a horizontal plane that is parallel to a top plate 406 (or support plate) of a holder 331. The top plate 406 is configured to be pivotable about a hinge 2910 formed between the top plate 406 and a side wall 361A of the holder 331. There is provided a protruding pin 2915 extending from the top plate 406 for engagement with the dispensing mechanism 310. When a connector 320 is placed in the holder 331, a portion of the connector 320 will rest on the top plate 406. How the connector 320 rests on the top plate 406 is shown in Figure 4A. When the dispensing mechanism 310 is activated, the pin 2915 is lifted up by the dispensing mechanism 310 and the top plate 406 is tilted accordingly. To dispense the connector 320, the top plate 406 is tilted to a tilting angle that would dispense the connector 320 out of a pocket 362 of the holder 331.

The workflow of the connector (i.e. twistlock (TL) or cone) dispensing (or discharging) process begins at a step S3010. The storage unit 210 is configured to receive an instruction from the station controller 190 or a controller of the storage and sorting device 200 to dispense one or more connectors 320 held by the storage module 210. Upon receipt of such instruction, the storage module 210 of the storage and sorting device 200 is configured to determine which holder 331 is to be subjected to tilting to dispense a connector (e.g. 320 in earlier described figures) held by the holder 331.

There may be a sequence or order to dispense a connector or connectors 320 held in the holder or holders 331. For instance, a first type of connector (e.g. SDL4) may be dispensed before a second type of connector (e.g. C5AM). If there is a sequence or order to follow to dispense the connector or connectors 320, the station controller 190 or the controller of the storage and sorting device 200 is configured to control the conveyor mechanism 2900 to move according to such sequence or order.

It is assumed now that the station controller 190 or the controller of the storage and sorting device 200 issued an instruction to move a specific holder 331 to the discharging zone 2902. The station controller 190 or the controller of the storage and sorting device 200 is configured to determine whether the specific holder 331 is in a discharging zone 2902 based on a position feedback from a motor encoder 313 of the conveyor mechanism 2900 at a step S3012. Such position feedback contains information about position of the specific holder 331 in the conveyor mechanism 2900. The motor encoder 313 generates the position feedback based on a previously recorded position of the holder 331, speed of movement of the pair of roller chains 302 in the endless loop, and/or how many steps each of the pair of roller chains 302 have moved passed/from a predefined point/position. The station controller 190 or the controller of the storage and sorting device 200 makes use of the position feedback to instruct the conveyor mechanism 2900 to move the specific holder 331 to the discharging zone 2902. The position feedback can indicate number of step or steps the conveyor mechanism 2900 requires to move the specific holder 331 to the discharging zone 2902. Step S3012 will loop until the position of the specific holder 331 in the conveyor mechanism is obtained. If no position feedback is received for a period of time after issuance of the instruction to move the specific holder 331 to the discharging zone 2902, it may be indicative of a system error.

- A sensor 307 is positioned to detect whether the specific holder 331 has moved to the discharging zone 2902 at a step S3014. Step S3014 commences after the position feedback is received at step S3012. The sensor 307 scans every holder that has moved to the discharging zone 2902. Only detection of the specific holder 331 will trigger the dispensing mechanism 310 to operate.
- 5 For example, each holder 331 can have a unique identity (e.g. unique RFID tag, barcode, QR code, etc.) and the sensor 307 can detect the identity of each holder as each holder moves into the operating range of the sensor 307. The sensor 307 can provide holder identity information to the encoder 313, which then forwards such information to the station controller 190 or the controller of the storage and sorting device 200, or the sensor 307 can provide such information directly to the station controller 190 or the controller of the storage and sorting device 200. Step S3014 will loop until the specific holder 331 is identified to have moved to the discharging zone 2902. If no holder identity or identity of the specific holder 331 is detected for a period of time after issuance of the instruction to move the specific holder 331 to the discharging zone 2902, it may be indicative of a system error.
- 10 If it is detected at step S3014 that the specific holder 331 has moved into the discharging zone 2902 towards the discharging position within the discharging zone 2902, the conveyor mechanism 2900 is configured to stop movement and remain stationary while the specific holder 331 is at the discharging position. Subsequently, and with reference to Figures 29G to 29J, an extendable arm 2410 of an actuator 2405 of the dispensing mechanism 310 extends at a step S3016 and this causes a lifter plate 2956 to engage the pin 2915 of the top plate 406.
- 20 The extendable arm 2410 extends further at a step S3018 and this cause the lifter plate 2956 to lift the top plate (or support plate) 406 of the holder 331. Such action will tilt the connector 302 supported by the lifted top plate 406. As the extendable arm 2410 continues to extend at a step S3020, the connector 302 will be tilted beyond a tilting angle, α , between a line of gravity (e.g. 402 of Figures 4A, 4B and 4E) and a longitudinal axis of the holder 331 (e.g. 404 of Figures 4A, 4B and 4E). The tilting angle for dispensing the connector 320 and can be, for instance, any suitable angle between 55° to 150°, preferably between 55° and 90°, and more preferably between 58° and 76°. When the connector 320 in the specific holder 331 is tilted beyond the tilting angle, the connector 320 will fall out by way of gravity from a pocket (e.g. 362 in earlier described figures such as Figure 29C) of the holder 331 that received the connector.
- 30 There may be provided a sensor (not sensor 307) to detect an absence of a connector 320 in the specific holder 331. This can be done, for instance, by positioning the sensor at the discharging guide 340 or the output bin 350 to detect whether the dispensed connector 320 has dropped to the discharging guide 340 or the output bin 350. Once the connector 320 is dispensed from the specified holder 331 i.e. absence of the connector 320 is detected, the actuator 2405 of the dispensing mechanism 310 retracts the extendable arm 2410 at a step S3022. Alternatively, a sensor is not used and the dispensing mechanism 310 is configured to automatically retract the extendable arm 2410 after a predetermined time duration from extension of the extendable arm 2410.
- 40 At a step S3024, the station controller 190 or the controller of the storage and sorting device 200 is configured to check if there is any more holder or holders 331 that has a dispensing operation scheduled to dispense the connector or connectors 320 held by the holder or holders 331. If there is other holder or holders 331 that has a dispensing operation scheduled, the station controller 190 or the controller of the storage and sorting device 200 is configured to control the conveyor mechanism 2900 to move the specified holder or holders 331 to the discharging position according to the schedule. In this case, steps S3012 to S3024 are repeated to sequentially move each specified holder 331 to the discharging position. If there is no other holder 331 scheduled for dispensing operation, the work flow ends at a step S3026.
- 50 In contrast to the example discussed with reference to Figure 30A, the following workflow examples relate to the conveyor mechanism 300 of earlier described figures that moves in a vertical plane that is orthogonal to a surface of the top plate 406 (or support plate) of the holder 330.
- Figure 30B illustrates a workflow indicating how a connector (e.g. 320 in earlier described figures) may be dispensed from the storage module 210 of an apparatus 100 of Figure 1. In this example, the dispensing mechanism 310 is the roller dispenser i.e. the dispensing mechanism 310 illustrated by Figures 3A and 3B, and Figures 28A to 28C, or the magazine motion dependent dispenser i.e. the dispensing mechanism 310 illustrated by Figures 26A to 26F. In the workflow example of Figure 30B, the roller dispenser is configured to be dependent on magazine motion to tilt the holders 330.
- 55 The workflow of the connector (i.e. twistlock (TL) or cone) dispensing (or discharging) process begins at a step S3050. The storage unit 210 is configured to receive an instruction from
- 60

the station controller 190 or a controller of the storage and sorting device 200 to dispense one or more connectors 320 held by the storage module 210. Upon receipt of such instruction, the storage module 210 of the storage and sorting device 200 is configured to determine which holder 330 is to be subjected to tilting to dispense a connector 320 held by the holder 330.

5 There may be a sequence or order to dispense a connector or connectors 320 held in the holder or holders 330. For instance, a first type of connector (e.g. SDL4) may be dispensed before a second type of connector (e.g. C5AM). If there is a sequence or order to follow to dispense the connector or connectors 320, the station controller 190 or the controller of the storage and sorting device 200 is configured to control the conveyor mechanism 300 to move according to such sequence or order.

10 It is assumed now that the station controller 190 or the controller of the storage and sorting device 200 issued an instruction to move a specific holder 330 to the discharging zone 2502. The station controller 190 or the controller of the storage and sorting device 200 is configured to determine whether the specific holder 330 is in a discharging zone 2502 based on a position feedback from a motor encoder 313 of the conveyor mechanism 300 at a step S3052. Such position feedback contains information about position of the specific holder 330 in the conveyor mechanism 300. The motor encoder 313 generates the position feedback based on a previously recorded position of the holder 330, speed of movement of the pair of roller chains 302 in the endless loop, and/or how many steps each of the pair of roller chains 302 have moved passed from a predefined point/position. The station controller 190 or the controller of the storage and sorting device 200 makes use of the position feedback to instruct the conveyor mechanism 300 to move the specific holder 330 to the discharging zone 2502. The position feedback can indicate number of step or steps the conveyor mechanism 300 requires to move the specific holder 330 to the discharging zone 2502. Step S3052 will loop until the position of the specific holder 330 in the conveyor mechanism is obtained. If no position feedback is received for a period of time after issuance of the instruction to move the specific holder 330 to the discharging zone 2502, it may be indicative of a system error.

A sensor 307 is positioned to detect whether the specific holder 330 has moved to the discharging zone 2502 at a step S3054. Step S3054 commences after the position feedback is received at step S3052. The sensor 307 scans every holder that has moved to the discharging zone 2502. Only detection of the specific holder 330 will trigger the dispensing mechanism 310 to operate. For example, each holder 330 can have a unique identity (e.g. unique RFID tag, barcode, QR code, etc.) and the sensor 307 can detect the identity of each holder as each holder moves into the operating range of the sensor 307. The sensor 307 can provide holder identity information to the encoder 313, which then forwards such information to the station controller 190 or the controller of the storage and sorting device 200, or the sensor 307 can provide such information directly to the station controller 190 or the controller of the storage and sorting device 200. Step S3054 will loop until the specific holder 330 is identified to have moved to the discharging zone 2502. If no holder identity or identity of the specific holder 330 is detected for a period of time after issuance of the instruction to move the specific holder 330 to the discharging zone 2502, it may be indicative of a system error.

40 If it is detected at step S3054 that the specific holder 330 has moved into the discharging zone 2502 towards the discharging position within the discharging zone 2502, the conveyor mechanism 300 is configured to stop movement and remain stationary while the specific holder 330 is at the discharging position. Subsequently, a pushing device 311 of the dispensing mechanism 310 in the case of roller dispenser or the extendable arm 2410 in the case of magazine motion dependent dispenser extends at a step S3056.

The conveyor mechanism 300 continuously moves the holder 330 at a step S3058 such that the holder 330 contacts the extended set of interconnected rollers 310a or extended extendable arm 2410 and tilts to the tilting angle α , between a line of gravity (e.g. 402 of Figures 4A, 4B and 4E) and a longitudinal axis of the holder 330 (e.g. 404 of Figures 4A, 4B and 4E). This will cause the connector 320 to discharge by gravity from a pocket (e.g. 362 in earlier described figures) of the holder 330 that received the connector 320. The tilting angle for dispensing the connector 320 can be, for instance, any suitable angle between 55° to 150°, preferably between 55° and 90°, and more preferably between 58° and 76°.

55 At a step S3060, a check is done to determine whether a holder adjacent to the specific holder 330 that is a step movement of the conveyor mechanism 300 away from the discharging zone 2502 is scheduled to undergo connector discharging operation. If the adjacent holder is scheduled to undergo such operation, step S3058 is performed again.

60 There may be provided a sensor (not sensor 307) to detect an absence of a connector in the specific holder 330. This can be done, for instance, by positioning the sensor at the discharging

guide 340 or the output bin 350 to detect whether the dispensed connector has dropped to the discharging guide 340 or the output bin 350. Once the connector is dispensed from the specified holder 330 i.e. absence of the connector is detected and when step S3060 determines that no more adjacent holder is in a queue to undergo connector discharging operation, the dispensing mechanism 310 retracts the pushing device 311 or extendable arm 2410 at a step S3062. Alternatively, a sensor is not used and the dispensing mechanism 310 is configured to automatically retract the pushing device 311 or the extendable arm 2410 after a predetermined time duration from extension of the pushing device 311 or the extendable arm 2410 if step S3060 determines that no more adjacent holder is in a queue to undergo connector discharging operation.

At a step S3064, the station controller 190 or the controller of the storage and sorting device 200 is configured to check if there is any more holder or holders 330 that has a dispensing operation scheduled to dispense the connector or connectors 320 held by the holder or holders 330. If there is other holder or holders 330 that has a dispensing operation scheduled, the station controller 190 or the controller of the storage and sorting device 200 is configured to control the conveyor mechanism 300 to move the specified holder or holders 330 to the discharging position according to the schedule. In this case, steps S3052 to S3064 are repeated to sequentially move each specified holder 330 to the discharging position 328b. If there is no other holder 330 scheduled for dispensing operation, the work flow ends at a step S3066.

Figure 30C illustrates a workflow indicating how a connector may be dispensed from the storage module 210 of an apparatus 100 of Figure 1. In this example, the dispensing mechanism 310 is a pushing dispenser i.e. the dispensing mechanism 310 illustrated by Figures 25A to 25E. It should be appreciated that the roller dispenser illustrated by Figures 3A and 3B and 28A to 28C can also be configured to work like a pushing dispenser of the present workflow example that is not dependent on movement of the conveyor mechanism 300 to tilt holders 330.

The workflow of the connector (i.e. twistlock (TL) or cone) dispensing (or discharging) process begins at a step S3070. The storage unit 210 is configured to receive an instruction from the station controller 190 or a controller of the storage and sorting device 200 to dispense one or more connectors 320 held by the storage module 210. Upon receipt of such instruction, the storage module 210 of the storage and sorting device 200 is configured to determine which holder 330 is to be subjected to tilting to dispense a connector 320 held by the holder 330.

There may be a sequence or order to dispense a connector or connectors 320 held in the holder or holders 330. For instance, a first type of connector (e.g. SDL4) may be dispensed before a second type of connector (e.g. C5AM). If there is a sequence or order to follow to dispense the connector or connectors 320, the station controller 190 or the controller of the storage and sorting device 200 is configured to control the conveyor mechanism 300 to move according to such sequence or order.

It is assumed now that the station controller 190 or the controller of the storage and sorting device 200 issued an instruction to move a specific holder 330 to the discharging zone 2502. The station controller 190 or the controller of the storage and sorting device 200 is configured to determine whether the specific holder 330 is in a discharging zone 2502 based on a position feedback from a motor encoder 313 of the conveyor mechanism 300 at a step S3072. Such position feedback contains information about position of the specific holder 330 in the conveyor mechanism 300. The motor encoder 313 generates the position feedback based on a previously recorded position of the holder 330, speed of movement of the pair of roller chains 302 in the endless loop, and/or how many steps each of the pair of roller chains 302 have moved passed from a predefined point/position. The station controller 190 or the controller of the storage and sorting device 200 makes use of the position feedback to instruct the conveyor mechanism 300 to move the specific holder 330 to the discharging zone 2502. The position feedback can indicate number of step or steps the conveyor mechanism 300 requires to move the specific holder 330 to the discharging zone 2502. Step S3072 will loop until the position of the specific holder 330 in the conveyor mechanism is obtained. If no position feedback is received for a period of time after issuance of the instruction to move the specific holder 330 to the discharging zone 2502, it may be indicative of a system error.

A sensor 307 is positioned to detect whether the specific holder 330 has moved to the discharging zone 2502 at a step S3074. Step S3074 commences after the position feedback is received at step S3072. The sensor 307 scans every holder that has moved to the discharging zone 2502. Only detection of the specific holder 330 will trigger the dispensing mechanism 310 to operate. For example, each holder 330 can have a unique identity (e.g. unique RFID tag, barcode, QR code, etc.) and the sensor 307 can detect the identity of each holder as each holder moves into the operating range of the sensor 307. The sensor 307 can provide holder identity information to the encoder 313, which then forwards such information to the station controller 190 or the controller of

the storage and sorting device 200, or the sensor 307 can provide such information directly to the station controller 190 or the controller of the storage and sorting device 200. Step S3074 will loop until the specific holder 330 is identified to have moved to the discharging zone 2502. If no holder identity or identity of the specific holder 330 is detected for a period of time after issuance of the instruction to move the specific holder 330 to the discharging zone 2502, it may be indicative of a system error.

If it is detected at step S3074 that the specific holder 330 has moved into the discharging zone 2502 towards the discharging position within the discharging zone 2502, the conveyor mechanism 300 is configured to stop movement and remain stationary while the specific holder 330 is at the discharging position. Subsequently, the pushing device 311 of the dispensing mechanism 310 in the case of roller dispenser or the extendable arm 2410 in the case of magazine motion dependent dispenser extends at a step S3076. The pushing device 311 or the extendable arm 2410 extends until the extended set of interconnected rollers 310a or the extended extendable arm 2410 tilts the specific holder 330 to the tilting angle α , between a line of gravity (e.g. 402 of Figures 4A, 4B and 4E) and a longitudinal axis of the holder 330. (e.g. 404 of Figures 4A, 4B and 4E). This will cause the connector 320 to discharge by gravity from a pocket (e.g. 362 in earlier described figures) of the holder 330 that received the connector 320. The tilting angle for dispensing the connector 320 can be, for instance, any suitable angle between 55° to 150°, preferably between 55° and 90°, and more preferably between 58° and 76°.

There may be provided a sensor (not sensor 307) to detect an absence of a connector in the specific holder 330. This can be done, for instance, by positioning the sensor at the discharging guide 340 or the output bin 350 to detect whether the dispensed connector has dropped to the discharging guide 340 or the output bin 350. Once the connector is dispensed from the specified holder 330 i.e. absence of the connector is detected, the dispensing mechanism 310 retracts the pushing device 311 or extendable arm 2410 at a step S3078. Alternatively, a sensor is not used and the dispensing mechanism 310 is configured to automatically retract the pushing device 311 or the extendable arm 2410 after a predetermined time duration from extension of the pushing device 311 or the extendable arm 2410.

At a step S3080, the station controller 190 or the controller of the storage and sorting device 200 is configured to check if there is any more holder or holders 330 that has a dispensing operation scheduled to dispense the connector or connectors 320 held by the holder or holders 330. If there is other holder or holders 330 that has a dispensing operation scheduled, the station controller 190 or the controller of the storage and sorting device 200 is configured to control the conveyor mechanism 300 to move the specified holder or holders 330 to the discharging position according to the schedule. In this case, steps S3072 to S3080 are repeated to sequentially move each specified holder 330 to the discharging position 328b. If there is no other holder 330 scheduled for dispensing operation, the work flow ends at a step S3082.

Data communication between server, crew device (or alerting device) and apparatus

Figure 13 illustrates a data communication system 1300 according to an exemplary example of the present disclosure for controlling communication between an apparatus 1302 (e.g. each of 106a-106f in Figure 1 or each of 1006a-1006h in Figure 10 or controller 190 in Figure 1) for moving connectors for container coning and deconing, a server 1304 (i.e. Terminal Operating System 1250 in Figure 12A) for managing operations at a port facility and a crew device 1306 owned by a personnel working at the port facility. It is appreciated that the station controller 190 of Figure 1 may have the elements of the apparatus 1302. Any image processor, controller or processor mentioned in the present disclosure may also have the same elements as the apparatus 1302.

The apparatus 1302 may be an computing device and comprises a number of individual components including, but not limited to, processing unit 1316, a memory 1318 (e.g. a volatile memory such as a Random Access Memory (RAM) for the loading of executable instructions 1320, the executable instructions defining the functionality the apparatus 1302 carries out under control of the processing unit 1316. The apparatus 1302 also comprises a network module 1325 allowing the apparatus to communicate over the communications network 1308 (for example the internet). User interface 1324 is provided for user interaction and may comprise, for example, conventional computing peripheral devices such as display monitors, computer keyboards and the like. The apparatus 102 may also comprise a database 1326. It should also be appreciated that the database 1326 may not be local to the server apparatus 1302. The database 1326 may be a cloud database.

5 The processing unit 1316 is connected to input/output devices such as a computer mouse, keyboard/keypad, a display, headphones or microphones, a video camera and the like (not illustrated in Figure) via Input/Output (I/O) interfaces 1322. The components of the processing unit 1316 typically communicate via an interconnected bus (not illustrated in Figure 1) and in a manner known to the person skilled in the relevant art.

10 The processing unit 1316 may be connected to the network 1308, for instance, the Internet, via a suitable transceiver device (i.e. a network interface) or a suitable wireless transceiver, to enable access to e.g. the Internet or other network systems such as a wired Local Area Network (LAN) or Wide Area Network (WAN). The processing unit 1316 of the apparatus 1302 may also be connected to one or more external wireless communication enabled remote servers 1304 and crew devices 1306 through the respective communication links 1310, 1312, 1314 via the suitable wireless transceiver device e.g. a WiFi transceiver, Bluetooth module, Mobile telecommunication transceiver suitable for Global System for Mobile Communication (GSM), 3G, 3.5G, 4G, 5G telecommunication systems, or the like.

15 The crew device 1306 can be a computing or mobile device, for example, smart phones, tablet devices, and other handheld devices. The one or more crew devices 1306 may be able to communicate through other communications network, such as, wired network, mobile telecommunication networks, but these are omitted from Figure 1 for the sake of clarity. Instead of the system architecture described above for the computing or mobile device 1302, the crew device 20 1306 and/or the apparatus may be a computing or mobile device having the system architecture of the remote server 1304.

The remote server 1304 may comprise a number of individual components including, but not limited to, microprocessor 1328, a memory 1330 (e.g. a volatile memory such as a RAM) for the loading of executable instructions 1332, the executable instructions defining the functionality the remote server 1304 carries out under control of the processor 1328. The remote server 1304 also comprises a network module (not illustrated in Figure) allowing the remote server 1304 to communicate over the communications network 1308. User interface 1336 is provided for user interaction and control that may be in the form of a touch panel display and presence of a keypad as is prevalent in many smart phone and other handheld devices. The remote server 1304 may also 30 comprise a database (not illustrated in Figure), which may not be local to the remote server 1304 but a cloud database. The remote server 1304 may include a number of other Input/Output (I/O) interfaces as well but they may be for connection with headphones or microphones, Subscriber identity module (SIM) card, flash memory card, USB based device, and the like, which are more for mobile device usage.

35 The software and one or more computer programs may include, for example, the client applications and may further include one or more software applications for e.g. instant messaging platform, audio/video playback, internet accessibility, operating the remote server 1304 and crew device 1306 (i.e. operating system), network security, file accessibility, database management, which are applications typically equipped on a desktop or portable (mobile) device. The software and one or more computer programs may be supplied to the user of the remote server 1304 or the crew device 1306 encoded on a data storage medium such as a CD-ROM, on a flash memory carrier or a Hard Disk Drive, and are to be read using a corresponding data storage medium drive for instance, a data storage device (not illustrated in Figure 1). Such application programs may also be downloaded from the network 1308. The application programs are read and controlled in its 45 execution by the processing unit 1316 or microprocessor 1328. Intermediate storage of program data may be accomplished using RAM 1320 or 1330.

Furthermore, one or more of the steps of the computer programs or software may be performed in parallel rather than sequentially. One or more of the computer programs may be stored on any machine or computer readable medium that may be non-transitory in nature. The computer 50 readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a general purpose computer or mobile device. The machine or computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the Wireless LAN (WLAN) system. The computer program when loaded and executed on such a general-purpose computer effectively results in an apparatus that implements the steps of the computing methods in examples herein 55 described.

In summary, examples of the present disclosure may have the following features.

There is provided a holder (e.g. 330 and 360 in Figures 3A, 27A-27C; 331 in Figures 29B-29D) for container connector (e.g. 320 in Figures 3A and 4A-4B), the holder comprising a pocket (e.g. 362 in Figures 3D, 4A-4B, and 29B-29D) configured to receive a connector (e.g. 320 in Figures 3A and 4A-4B) for coning a container (e.g. 102a, 102b in Figure 1); a support plate (e.g. 406 in Figures 3D, 4A-4B, and 29C-29D) on which a portion (e.g. 320b of Figures 4A-4B) of the received connector rests; a support member for mounting the holder to a conveyor mechanism (e.g. 300 in Figures 3A, 25A, 26A, and 28A; 2900 in Figure 29A) for moving the holder between locations including a location for retrieving a connector used for coning (e.g. 326b in Figure 3C), a location for receiving a connector obtained from deconing (e.g. 326b in Figure 3C), and a location for a dispensing mechanism to dispense a connector (e.g. 328b in Figures 3B, 25B-25E, 26B-26F and 28A-28C).

In the present disclosure, the term "support member" can be one or more elements or components used for connecting the container holder to the conveyor mechanism and is configured to allow pivotal movement of the container holder relative to the conveyor mechanism.

The support plate may be selectively pivotable upon activation of a dispensing mechanism (e.g. 310 of Figures 3A-3B, 25A-25E, 26A-26F, and 28A-28C) to tilt the received connector resting on the support plate to a tilting angle (e.g. α in Figures 4B and 4E) that dispenses the received connector from the pocket by gravity, wherein when the holder is mounted to the conveyor mechanism, the connector received in the holder is maintained in an upright orientation (e.g. orientation shown in Figure 4A) that is not tilted to the tilting angle until the dispensing mechanism is activated to cause the support plate to tilt to the tilting angle. The tilting angle may be an angle between a line of gravity (e.g. 402 of Figures 4A, 4B and 4E) and a longitudinal axis of the holder (e.g. 404 of Figures 4A, 4B and 4E).

The holder may be provided with a heavier base (e.g. 370 of Figures 4A-4B, 27A-27B and 29C-29D) to maintain the connector in the upright orientation. For example, a counterweight (e.g. 364 in Figures 4A-4B and 4D) can be placed in the base of the holder. In another example, the base of the holder can be fabricated with a material that is denser than a material used for remaining portions of the holder.

Optionally, the support plate may be integral with or fixed to the holder, the holder is pivotally mounted to the conveyor mechanism via the support member and the holder is configured to pivot about the conveyor mechanism and orientate back to the upright orientation due to gravity acting on the heavier base when the connector is dispensed from the pocket.

The holder may comprise a pin head holder (e.g. 366 in Figures 3D, 3F, 3I, 27A) disposed on a sidewall (e.g. 361b of Figures 3D, 3F, 3I, 27A) of the holder, wherein the support member is a pin (e.g. holder pin 334 of Figures 3D, 3I and 29B) with a pin head (e.g. 335 of Figures 3D and 3I) to be held by the pin head holder, and the pin head holder may comprise a recess (e.g. 363 of Figure 3D), wherein a wall or a groove is disposed along a circumference of the recess and the circumference of the recess is shaped in a manner for guiding the pin head to return the holder to the upright orientation after the holder is tilted.

Optionally, the conveyor mechanism may comprise a rail (e.g. 382 in Figures 3F-3H, 3J and 27C) on which the holder is configured to move along; and a driving chain (e.g. roller chain 302) in Figures 3A-3C, 3H, 3J, 25A, and 26A; 2900 in Figure 29A) for driving movement of the holder along the conveyor mechanism, wherein the support member is mounted to the driving chain and the conveyor mechanism moves the holder along the conveyor mechanism by moving the driving chain, wherein the holder moves along the rail when the driving chain drives the movement of the holder.

Optionally, the conveyor mechanism may comprise at least one driving chain (e.g. 302 in Figures 3A-3C, 3H, 3J, 25A, and 26A; 2900 in Figure 29A) for driving movement of the holder along the conveyor mechanism, wherein the support member is mounted to the driving chain and the conveyor mechanism moves the holder along the conveyor mechanism by moving the driving chain.

The holder (e.g. 330a of Figure 3H, 3I and 3J) and another one or more of the same holder (e.g. 330b of Figures 3H, 3I and 3J) may be configured to rigidly connect to one another via one or more holding rod (e.g. 440 of Figures 3H, 3I, 3J, and 28D) such that, upon activation of the dispensing mechanism, the connected holders are pivotable along with the support plates in tandem to tilt connectors in the connected holders to the tilting angle that dispenses the connectors from the pockets of the connected holders by gravity.

Optionally, the conveyor mechanism may comprise at least one rail (e.g. 382 in Figures 3F-3H, 3J and 27C) on which one or more of the connected holders (e.g. 330a and 330b of Figures 3H, 3I and 3J) is configured to move along; and at least one driving chain (e.g. 302 in Figures 3A-3C, 3H, 3J, 25A, and 26A; 2900 in Figure 29A) for driving movement of one or more of the connected holders along the conveyor mechanism, wherein the support member of one or more of the

connected holders is mounted to the at least one driving chain and the conveyor mechanism moves the connected holders in tandem along the conveyor mechanism by moving the driving chain, wherein the one or more of the connected holders configured to move along the rail moves along the rail when the driving chain drives the movement of the holder.

5 The at least one of the one or more holding rod may comprise a protruding lever (e.g. 2808 and 2810 in Figure 28D) and the dispensing mechanism is configured to contact the protruding lever to cause the connected holders to tilt, and in turn tilt the connected holders along with the respective support plates to the tilting angle to dispense connectors in the connected holders from the respective pockets by gravity.

10 The dispensing mechanism may comprises a set of interconnected rollers (e.g. 310a in Figures 3B and 28A-28C) movable to contact and tilt a bottom surface of the base of the holder, a portion of one or more of the connected holders, or the protruding lever, and in turn tilt the holder or the connected holders along with the respective support plate or plates to the tilting angle to dispense the connector or connectors from the respective pocket or pockets by gravity.

15 Optionally, to tilt the holder or the connected holders along with the respective support plate or plates to the tilting angle, the conveyor mechanism moves the holder or the connected holders so that the bottom surface of the base of the holder or the bottom surface of the base of more than one of the connected holders contact the set of interconnected rollers when the set of interconnected rollers are extended.

20 The dispensing mechanism may comprise a linear actuator (e.g. 2405 of Figures 24A-24B) having an extendable arm (e.g. 2410 of Figures 24A-24B, 25B—25E, 26B-26F, 29E-29M)) to contact and tilt a portion of the holder, a portion of one or more of the connected holders, or the protruding lever, and in turn tilt the holder or the connected holders along with the respective support plate or plates to the tilting angle to dispense the connector or connectors from the respective pocket or pockets by gravity.

25 Optionally, to tilt the holder or the connected holders along with the respective support plate or plates to the tilting angle, the conveyor mechanism moves the holder or the connected holders so that the portion of the holder, the portion of the one or more of the connected holders, or the protruding lever, contacts the extendable arm when the extendable arm is extended.

30 Optionally, the dispensing mechanism comprises a lifting mechanism (e.g. 2956 of Figures 29E-29M) configured to lift and tilt the support plate to the tilting angle to dispense the connector from the pocket by gravity.

The lifting mechanism may comprise a lifter arm (e.g. 2980 in Figures 29B-29M) and a lifting guide (e.g. 2990 in Figures 29B-29M, wherein the lifter arm can be configured to engage the support plate (e.g. 406 in Figures 29B-29M) to lift and tilt the support plate and the lifting guide can be configured to guide the movement of the lifter arm to lift and tilt the support plate.

35 The lifter arm may comprise a catch (e.g. 2961 in Figures 29F and 29M) to engage the support plate to lift and tilt the support plate, and the lifting guide may comprise a slot (e.g. 2951 in Figures 29B-29L) to receive a guiding member (e.g. 2963 in Figures 29B-29L) mounted to the lifter arm. The slot can be configured to form a path for the guiding member to move along. The lifter arm may comprise an extendable arm (e.g. 2410 in Figures 29B-29M), wherein when the extendable arm is extended, the guiding member is moved as guided by the path and the lifter arm can be configured to move as guided by the guiding member.

40 The tilting angle may be between 55° to 150°, or preferably between 55° and 90°, or more preferably between 58° and 76°. The tilting angle can be calculated from the dimensions of the top plate of the holder. In one example, the specified angle can be calculated based on the formula: Tilting angle, $\alpha = \arctan(B/L)$, wherein $0 < \alpha \leq 90^\circ$, where L and B represent respective vertical displacement and horizontal displacement from a center of mass of the holder in the upright position.

45 In one example, the horizontal displacement (B) is equal to or more than a parameter determined from a width of the holder (e.g. half of the width of the top plate of the holder). The centre of mass of each type of the connector 320 is typically between 10 to 25 mm above the top plate of the holder. This means that the vertical displacement can be a dimension between 10 to 25 mm.

50 The dispensing mechanism may be arranged at an end of the conveyor mechanism proximate to the location for retrieving a connector used for coning a container (e.g. 326b of Figure 3C).

55 The conveyor mechanism (e.g. 2900 in Figure 29A) may be configured to move one or more of the holder in a plane that is orthogonal or parallel to a surface of the support plate of the holder.

The conveyor mechanism may be configured to move the holder between the locations that further include a location (e.g. 326a of Figure 3C) for loading a connector to be placed in the holder by a connector sorting device (e.g. 220 of Figure 2).

5 Optionally, the conveyor mechanism comprises a plurality of holders for holding a plurality of container connectors.

The connector sorting device may be configured to pick up a connector stored in a store (e.g. 214 of Figure 2), identify type of the picked connector, orientate the picked connector to an orientation for placement into a holder; and place the orientated connector with type identified into one of the plurality of holders that is indicated as having no presence of a connector in indexing data (e.g. 1100 in Figure 11A) stored in a memory, and the processor is configured to operate the apparatus to update the indexing data in the memory to indicate presence of a connector in the holder containing the placed connector, and the identified type of the placed connector. The indexing data may further indicate a position of each holder on the conveyor mechanism.

10 There is also provided an apparatus (e.g. 210 of Figures 1A and 3A) for container coning and/or deconing, wherein the apparatus comprises one or more of the holder as discussed above; the conveyor mechanism (e.g. 300 in Figures 3A, 25A, 26A, and 28A; 2900 in Figure 29A); the dispensing mechanism (e.g. 310 of Figures 3A-3B, 25A-25E, 26A-26F, and 28A-28C); and a processor (e.g. 190 of Figure 1, 1316 of Figure 13) for executing instructions to operate the apparatus to instruct the conveyor mechanism to move a specific holder (e.g. Holder X in Figures 3A, 25B-25E, 26B-26C, Holder C in Figures 28A-28C) of the one or more holder between the locations including a location for retrieving a connector used for coning (e.g. 326b in Figure 3C), a location for receiving a connector obtained from deconing (e.g. 326b in Figure 3C), and a location for a dispensing mechanism to dispense a connector (e.g. 328b in Figures 3B, 25B-25E, 26B-26F and 28A-28C), and optionally a location for loading a connector to be placed in the specific holder (e.g. 326a of Figure 3C) by a connector sorting device (e.g. 220 of Figure 2); and to instruct the dispensing mechanism to activate and cause the support plate (e.g. 406 in Figures 3D, 4A-4B, and 29C-29D) of the specific holder to pivot and tilt a connector (e.g. 320 in Figures 3A and 4A-4B) resting on the support plate (e.g. 406 in Figures 3D, 4A-4B, and 29C-29D) to the tilting angle (e.g. α in Figures 4B and 4E) that dispenses the connector from the pocket (e.g. 362 in Figures 3D, 4A-4B, and 29B-29D) of the specific holder by gravity, wherein when the specific holder is mounted to the conveyor mechanism, the connector received in the specific holder is maintained in an upright orientation that is not tilted to the tilting angle until the dispensing mechanism is activated to cause the support plate to tilt to the tilting angle.

In one example, the apparatus may comprise a plurality of holders for holding a plurality of connectors, wherein the plurality of holders is pivotally connected to the apparatus, preferably to the conveyor mechanism (e.g. as shown in Figure 3A). In another example, the apparatus may comprise a plurality of connected holders. The connected holders are rigidly connect to one another via one or more holding rod (e.g. 440 of Figures 3H, 3I, 3J, and 28D) such that, upon activation of the dispensing mechanism, the connected holders are pivotable along with the support plates in tandem to tilt connectors in the connected holders to the tilting angle that dispenses the connectors from the pockets of the connected holders by gravity. In another modification, a plurality of connected holders may be pivotally connected to the apparatus, preferably to conveyor mechanism.

The conveyor mechanism may be configured to move one or more of the holder in a plane that is orthogonal or parallel to a surface of the support plate of the holder.

45 The connector sorting device may be configured to pick up a connector stored in a store (e.g. 214 of Figure 2), identify type of the picked connector, orientate the picked connector to an orientation for placement into a holder; and place the orientated connector with type identified into one of the plurality of holders that is indicated as having no presence of a connector in indexing data (e.g. 1100 in Figure 11A) stored in a memory, and the processor is configured to operate the apparatus to update the indexing data in the memory to indicate presence of a connector in the holder containing the placed connector, and the identified type of the placed connector. The indexing data may further indicate a position of each holder on the conveyor mechanism.

50 Optionally, the connector sorting device may be configured to cooperate with the apparatus cascaded to another one or more of the same apparatus.

55 The apparatus may further comprise an encoder (e.g. 313 in Figures 3A, 25A, 26A and 29A) for determining position of the specific holder in the conveyor mechanism and instruct the conveyor mechanism to move the specific holder from the determined position to a discharging zone (e.g. 2502 in Figures 25A-25E, and 26B-26F; 2902 in Figures 29A) comprising a discharging position (e.g. 328b in Figures 3B, 25B-25E, 26B-26F and 28A-28C; and a sensor (e.g. 307 in Figures 3A, 25A, 26A and 29A) for determining whether the specific holder has moved to the discharging zone,

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wherein the dispensing mechanism is configured to, upon activation, tilt the received connector resting on the support plate to the tilting angle that dispenses the received connector from the pocket of the specific holder by gravity at the discharging position. The discharging position may be a location for a dispensing mechanism to dispense a connector. The sensor may be configured to
5 detect identity of each holder moved by the conveyor mechanism. For example, each holder can have a unique identity (e.g. unique RFID tag, barcode, QR code, etc.) and the sensor can detect the identity of each holder as each holder moves into the operating range of the sensor.

Optionally, the apparatus may be operable to instruct the conveyor mechanism to remain stationary at the discharging position to facilitate dispensing of a connector from the pocket of the
10 specific holder by gravity, wherein the dispensing mechanism is configured to, upon activation, contact the specific holder and tilt the specific holder along with the support plate of the specific holder so as to dispense the connector from the pocket of the specific holder by gravity.

Optionally, the apparatus is operable to instruct the conveyor mechanism to remain stationary at the discharging position to facilitate dispensing of a connector from the pocket of the
15 specific holder by gravity, wherein the dispensing mechanism is configured to, upon activation, lift the support plate of the specific holder to tilt the connector resting on the support plate so as to dispense the connector from the pocket of the specific holder by gravity.

Optionally, the apparatus is operable to instruct the conveyor mechanism to continuously move the specific holder pass the discharging position to facilitate dispensing of a connector from
20 the pocket of the specific holder by gravity, wherein the specific holder is tilted along with the support plate of the specific holder when moved by the conveyor mechanism to contact the activated dispensing mechanism.

There is also provided a method for container coning and/or deconing, the method comprising: instructing a conveyor mechanism to move a specific holder (e.g. S1832 of Figure 18B and S1616 of Figure 16) of one or more of the holder as discussed above between the locations
25 including a location for retrieving a connector used for coning, a location for receiving a connector obtained from deconing, and a location for a dispensing mechanism to dispense a connector, and optionally a location for loading a connector to be placed in the specific holder by a connector sorting device; and instructing the dispensing mechanism to activate (e.g. e.g. S1620 of Figure 16, S1846 of Figure 18B, S3016 in Figure 30A, S3056 in Figure 30B and S3076 in Figure 30C) and
30 cause the support plate of the specific holder to pivot and tilt a connector resting on the support plate to the tilting angle that dispenses the received connector from the pocket of the specific holder by gravity (e.g. S3020 of Figure 30A, S3058 of Figure 30B), wherein when the specific holder is mounted to the conveyor mechanism, the connector received in the specific holder is maintained in
35 an upright orientation that is not tilted to the tilting angle until the dispensing mechanism is activated to cause the support plate to tilt to the tilting angle.

For the avoidance of doubt, any feature of one aspect of the present invention may be utilised in any other aspect of the invention. It is noted that the examples given in the description
40 below are intended to clarify the invention and are not intended to limit the invention to those examples per se.

In the specification and claims, unless the context clearly indicates otherwise, the term "comprising" has the non-exclusive meaning of the word, in the sense of "including at least" rather than the exclusive meaning in the sense of "consisting only of". The same applies with
45 corresponding grammatical changes to other forms of the word such as "comprise", "comprises" and so on.

While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention as defined in the
50 appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

Claims

1. A holder for container connector, the holder comprising:
 - 5 a pocket configured to receive a connector for coning a container;
 - a support plate on which a portion of the received connector rests;
 - a support member for mounting the holder to a conveyor mechanism for moving the holder between locations including a location for retrieving a connector used for coning, a location for receiving a connector obtained from deconing, and a location for a dispensing mechanism to dispense a connector,
 - 10 wherein the support plate is selectively pivotable upon activation of a dispensing mechanism to tilt the received connector resting on the support plate to a tilting angle that dispenses the received connector from the pocket by gravity,
 - wherein when the holder is mounted to the conveyor mechanism, the connector received in the holder is maintained in an upright orientation that is not tilted to the tilting angle until the dispensing mechanism is activated to cause the support plate to tilt to the tilting angle.
2. The holder of claim 1, wherein the holder is provided with a heavier base to maintain the connector in the upright orientation.
- 20 3. The holder of claim 2, wherein the support plate is integral with or fixed to the holder, the holder is pivotally mounted to the conveyor mechanism via the support member and the holder is configured to pivot about the conveyor mechanism and orientate back to the upright orientation due to gravity acting on the heavier base when the connector is dispensed from the pocket.
- 25 4. The holder of any one of the preceding claims, wherein the holder comprises:
 - a pin head holder disposed on a sidewall of the holder,
 - the support member is a pin with a pin head to be held by the pin head holder, and the pin head holder comprises a recess,
 - 30 wherein a wall or a groove is disposed along a circumference of the recess and the circumference of the recess is shaped in a manner for guiding the pin head to return the holder to the upright orientation after the holder is tilted.
5. The holder of any one of the preceding claims, wherein the conveyor mechanism comprises:
 - 35 a rail on which the holder is configured to move along; and
 - a driving chain for driving movement of the holder along the conveyor mechanism, wherein the support member is mounted to the driving chain and the conveyor mechanism moves the holder along the conveyor mechanism by moving the driving chain,
 - wherein the holder moves along the rail when the driving chain drives the movement of the holder.
- 40 6. The holder of any one of claims 1 to 4, wherein the conveyor mechanism comprises:
 - at least one driving chain for driving movement of the holder along the conveyor mechanism, wherein the support member is mounted to the driving chain and the conveyor mechanism moves the holder along the conveyor mechanism by moving the driving chain.
- 45 7. The holder of claim 3 or 4, wherein the holder and another one or more of the same holder are configured to rigidly connect to one another via one or more holding rod such that, upon activation of the dispensing mechanism, the connected holders are pivotable along with the support plates in tandem to tilt connectors in the connected holders to the tilting angle that dispenses the connectors from the pockets of the connected holders by gravity.
- 50 8. The holder of claim 7, wherein the conveyor mechanism comprises:
 - at least one rail on which one or more of the connected holders is configured to move along;
 - and
 - 55 at least one driving chain for driving movement of one or more of the connected holders along the conveyor mechanism, wherein the support member of one or more of the connected holders is mounted to the at least one driving chain and the conveyor mechanism moves the connected holders in tandem along the conveyor mechanism by moving the driving chain,
 - wherein the one or more of the connected holders configured to move along the rail moves along the rail when the driving chain drives the movement of the holder.
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9. The holder of claim 7 or 8, wherein at least one of the one or more holding rod comprises a protruding lever and the dispensing mechanism is configured to contact the protruding lever to cause the connected holders to tilt, and in turn tilt the connected holders along with the respective support plates to the tilting angle to dispense connectors in the connected holders from the respective pockets by gravity,
10. The holder of any one of the preceding claims, wherein the dispensing mechanism comprises a set of interconnected rollers movable to contact and tilt a bottom surface of the base of the holder, a portion of one or more of the connected holders, or the protruding lever, and in turn tilt the holder or the connected holders along with the respective support plate or plates to the tilting angle to dispense the connector or connectors from the respective pocket or pockets by gravity.
11. The holder of claim 10, wherein to tilt the holder or the connected holders along with the respective support plate or plates to the tilting angle, the conveyor mechanism moves the holder or the connected holders so that the bottom surface of the base of the holder or the bottom surface of the base of more than one of the connected holders contact the set of interconnected rollers when the set of interconnected rollers are extended.
12. The holder of any one of claims 1 to 9, wherein the dispensing mechanism comprises a linear actuator having an extendable arm to contact and tilt a portion of the holder, a portion of one or more of the connected holders, or the protruding lever, and in turn tilt the holder or the connected holders along with the respective support plate or plates to the tilting angle to dispense the connector or connectors from the respective pocket or pockets by gravity.
13. The holder of claim 12, wherein to tilt the holder or the connected holders along with the respective support plate or plates to the tilting angle, the conveyor mechanism moves the holder or the connected holders so that the portion of the holder, the portion of the one or more of the connected holders, or the protruding lever, contacts the extendable arm when the extendable arm is extended.
14. The holder of any one of claims 1 to 3, wherein the dispensing mechanism comprises a lifting mechanism configured to lift and tilt the support plate to the tilting angle to dispense the connector from the pocket by gravity.
15. The holder of claim 14, wherein the lifting mechanism comprises a lifter arm and a lifting guide, wherein the lifter arm is configured to engage the support plate to lift and tilt the support plate and the lifting guide is configured to guide the movement of the lifter arm to lift and tilt the support plate.
16. The holder of claim 15, wherein the lifter arm comprises a catch to engage the support plate to lift and tilt the support plate; and the lifting guide comprises a slot to receive a guiding member mounted to the lifter arm, wherein the slot is configured to form a path for the guiding member to move along and the lifter arm comprises an extendable arm, wherein when the extendable arm is extended, the guiding member is moved as guided by the path and the lifter arm is configured to move as guided by the guiding member.
17. The holder of any one of the preceding claims, wherein the tilting angle is between 55° to 150°, or preferably between 55° and 90°, or more preferably between 58° and 76°.
18. The holder of any one of the preceding claims, wherein the dispensing mechanism is arranged at an end of the conveyor mechanism proximate to the location for retrieving a connector used for coning and/or the location for receiving a connector obtained from deconing.
19. The holder of any one of the preceding claims, wherein the conveyor mechanism is configured to move one or more of the holder in a plane that is orthogonal or parallel to a surface of the support plate of the holder.

20. The holder of any one of the preceding claims, wherein the conveyor mechanism is configured to move the holder between the locations that further include a location for loading a connector to be placed in the holder by a connector sorting device.
- 5 21. An apparatus for container coning and/or deconing, wherein the apparatus comprises:
 one or more of the holder of any one of claims 1 to 20;
 the conveyor mechanism;
 the dispensing mechanism; and
 a processor for executing instructions to operate the apparatus to:
- 10 instruct the conveyor mechanism to move a specific holder of the one or more holder between the locations including a location for retrieving a connector used for coning, a location for receiving a connector obtained from deconing, and a location for a dispensing mechanism to dispense a connector, and optionally a location for loading a connector to be placed in the specific holder by a connector sorting device; and
- 15 instruct the dispensing mechanism to activate and cause the support plate of the specific holder to pivot and tilt a connector resting on the support plate to the tilting angle that dispenses the connector from the pocket of the specific holder by gravity,
 wherein when the specific holder is mounted to the conveyor mechanism, the connector received in the specific holder is maintained in an upright orientation that is not tilted to the tilting angle until the
- 20 dispensing mechanism is activated to cause the support plate to tilt to the tilting angle.
22. The apparatus of claim 21, wherein the apparatus further comprises:
 an encoder for determining position of the specific holder in the conveyor mechanism and
 instruct the conveyor mechanism to move the specific holder from the determined position to a
- 25 discharging zone comprising a discharging position; and
 a sensor for determining whether the specific holder has moved to the discharging zone, wherein the dispensing mechanism is configured to, upon activation, tilt the received connector resting on the support plate to the tilting angle that dispenses the received connector from the pocket of the specific holder by gravity at the discharging position.
- 30 23. The apparatus of claim 21 or 22, wherein the apparatus is operable to:
 instruct the conveyor mechanism to remain stationary at the discharging position to facilitate dispensing of a connector from the pocket of the specific holder by gravity, wherein the dispensing mechanism is configured to, upon activation, contact the specific holder and tilt the specific holder
- 35 along with the support plate of the specific holder so as to dispense the connector from the pocket of the specific holder by gravity.
24. The apparatus of claim 21 or 22, wherein the apparatus is operable to:
 instruct the conveyor mechanism to remain stationary at the discharging position to facilitate
- 40 dispensing of a connector from the pocket of the specific holder by gravity, wherein the dispensing mechanism is configured to, upon activation, lift the support plate of the specific holder to tilt the connector resting on the support plate so as to dispense the connector from the pocket of the specific holder by gravity.
- 45 25. The apparatus of claim 21 or 22, wherein the apparatus is operable to:
 instruct the conveyor mechanism to continuously move the specific holder pass the discharging position to facilitate dispensing of a connector from the pocket of the specific holder by gravity, wherein the specific holder is tilted along with the support plate of the specific holder when
- 50 moved by the conveyor mechanism to contact the activated dispensing mechanism.
26. A method for container coning and/or deconing, the method comprising:
 instructing a conveyor mechanism to move a specific holder of one or more of the holder of any one of claims 1 to 20 between the locations including a location for retrieving a
- 55 connector used for coning, a location for receiving a connector obtained from deconing, and a location for a dispensing mechanism to dispense a connector, and optionally a location for loading a connector to be placed in the specific holder by a connector sorting device; and

- instructing the dispensing mechanism to activate and cause the support plate of the specific holder to pivot and tilt a connector resting on the support plate to the tilting angle that dispenses the received connector from the pocket of the specific holder by gravity, wherein when the specific holder is mounted to the conveyor mechanism, the connector received in the specific holder is maintained in an upright orientation that is not tilted to the tilting angle until the dispensing mechanism is activated to cause the support plate to tilt to the tilting angle.
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