

AN AUTOMATED STORAGE SYSTEM THEREOF

FIELD OF INVENTION

- 5 The invention relates to a storage system. More particularly, the invention relates to an automated storage and retrieval system for storage and retrieval of containers into or from a grid storage structure.

BACKGROUND OF THE INVENTION

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- For decades, warehouse storage has played an important role in various industries. In order for businesses to thrive, it is essential to maintain a seamless operation within their storage system. As the scale of operations grows, the need for more sophisticated and innovative storage solutions has become increasingly apparent. To address this
- 15 need, some industries have adopted systems that allow for the storage and retrieval of a large number of different products. One known system involves arranging storage containers on rows of shelves arranged in aisles, where each container holds a plurality of products of either identical product type or different product types. However, this system has a relatively low storage density due to the need to provide
- 20 aisle space to access the products.

- In recent years, automated storage and retrieval systems have emerged as a promising solution to the issue of efficient and effective storage. An example of such systems is disclosed in Patent document WO98/049075A and illustrated in **Fig. 1**. This patent
- 25 document describes a storage system that allows containers **4** to be stored in a high-density manner within a grid storage structure **1**, where the containers **4** are stacked vertically on top of one another. The system also features a plurality of automated container handling devices **9** that operate on top of the grid storage structure **1** to lift and lower the containers **4** as required.

As shown in **Fig. 1**, the grid storage structure **1** comprises a plurality of vertical support members **2** arranged in such a way that form a plurality of container storage columns **3**. Each container storage column **3** is defined by a volume space bounded by at least two of the adjacent vertical support members **2**. The volume space of each container storage column **3** is sized only sufficient for receiving a single stack of containers **4** and the vertical support members **2** can prevent the containers **4** from horizontal movement, guide the containers **4** in vertical movement, and support the containers **4** when stacked.

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Located at the upper section of the grid storage structure **1**, there is provided a horizontal rail system **5** comprises a plurality of tracks **6, 7** arranged in a grid pattern. This grid pattern comprises a plurality of rectangular grid spaces **8**, each of which is aligned with a container storage column **3** beneath the corresponding grid space **8**. As previously stated, each container storage column **3** can contain only one stack of containers, meaning that a stack of containers **4** occupies a single grid space **8**.

The plurality of tracks **6, 7** includes a first set of parallel tracks members **6** for guiding movements of the container handling devices **9** laterally in a first direction, a second set of parallel track members **7** for guiding movements of the container handling devices **9** laterally in a second direction, and the first set of parallel track members **6** is arranged at a right angle to the second set of parallel track members **7** to form the grid pattern. This enables the container handling devices **9** to move horizontally across the grid storage structure **1** while remaining above it.

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The main drawback of existing grid storage structure **1** is that the vertical support members **2** take up a considerable amount of space within the grid storage structure **1**, and thereby reducing the overall storage capacity of the system. In today's economy, where land is becoming more scarce and expensive, it is crucial to optimize the

available space to ensure the storage system remains cost effective. On the other hand, reducing the number of vertical support members **2** may introduce another problem where the containers **4** lack proper support and guidance for movements.

- 5 The limitations of the existing grid storage structure **1** emphasize the necessity for an improved design that can increase storage capacity while minimizing the space occupied by the vertical support members **2**. The present invention addresses this need by providing an improved grid storage structure and system thereof that solve the aforementioned problems.

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SUMMARY OF INVENTION

- In one aspect of the invention, there is provided a grid storage structure for storing a plurality of containers in vertical stacks, the grid storage structure comprises a plurality of vertical support members arranged in such a way that form a plurality of container storage columns where the containers can be stacked therewithin; and a horizontal rail system positioned on top of the vertical support members, having a plurality of tracks arranged in a grid pattern that includes a plurality of grid spaces, each grid space is aligned with a container storage column that is positioned beneath the corresponding grid space; characterised in that the grid storage structure further comprises: one or more container supporting structures for supporting the stacks of containers above a lowest point of the grid storage structure, and one or more height adjustable leg support members for supporting the grid storage structure above ground.
- 25 Preferably, the leg support member may comprise a base in contact with the ground; a rod extended vertically from the base to connect with a bottom section of a grid storage structure; a mechanism for adjusting the height of the leg support member; and a stabilizing member for preventing the leg support member from lateral movement.

Preferably, the height adjusting mechanism can be in the form of the rod having a threaded surface configured to be insertable into a threaded hole located beneath the grid storage structure.

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Preferably, the height adjusting mechanism can be in the form of the rod being formed by a pair of tubes connected in a telescopic manner, one tube has an outer threaded surface, while the other tube has an inner threaded surface, allowing the rod to be extendable or retractable by rotating one or both tubes clockwise or counterclockwise.

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Preferably, the stabilizing member may include a body with a first end connected to either the base or the rod, and a second end anchored to the ground.

Preferably, the container supporting structures can be extended from the vertical support members into their respective container storage columns for the bottommost containers of the stacks to be placed thereon.

Preferably, the grid storage structure may further comprise a plurality of horizontal support members located at a bottom of the grid storage structure, and interconnected with the plurality of vertical support members. In this embodiment, the container supporting structures can be extended from the horizontal support members and/or the vertical support members into their respective container storage columns for the bottommost containers of the stacks to be placed thereon.

One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments described herein are not intended as limitations on the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawing the preferred embodiments from an inspection of which
5 when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

10 **Fig. 1** is a schematic perspective diagram illustrating a prior art storage system.

Fig. 2 is a top plan view diagram illustrating a part of a prior art grid storage structure.

15 **Fig. 3** is a schematic perspective diagram illustrating a storage system of the invention.

Fig. 4 is a side view diagram illustrating a grid structure of the storage system.

20 **Fig. 5** is a top plan view of a part of the grid structure.

Fig. 6 is a schematic perspective diagram illustrating a second embodiment of the storage system.

25 **Fig. 7** is an enlarged top plan view taken from section **A** of **Fig. 9**.

Fig. 8 is a schematic perspective diagram illustrating a container handling device of the storage system operating in a first mode.

Fig. 9 is a see-through view of container handling device.

Fig. 10 is a schematic perspective diagram illustrating the container handling
5 device of the storage system operating in a second mode.

Fig. 11 is a top plan view diagram of the storage system.

Fig. 12 is block diagram illustrating an exemplary process flow for operating
10 the container handling device in the first mode.

Fig. 13 is block diagram illustrating an exemplary process flow for operating
the container handling device in the second mode.

15 **Fig. 14** is a side view diagram illustrating the grid structure supported by a
plurality height adjustable leg support members.

Fig. 15 is a see-through enlarged view taken from section **B** of **Fig. 14**,
20 illustrating the stacks of container supported above ground by one or
more container supporting structures.

Fig. 16 is an enlarged view taken from section **C** of **Fig. 14**, illustrating an
embodiment of the height adjustable leg support member.

25 DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described in greater detail, by way of example, with
reference to the drawings.

Referring to **Figs. 3 to 5**, a storage system as illustrated therein generally comprises a grid storage structure **10**, a horizontal rail system **30** and at least one container handling device **40**. The grid storage structure **10** comprises a plurality of vertical support members **11** arranged in such a way that form a plurality of container storage columns **13**. The vertical support members **11** are preferably made of metal such as steel, aluminium or titanium, but it should be noted that the vertical support members **11** can also be constructed using any other type of material that provides suitable strength, durability, and versatility for the grid storage structure **10**. Each container storage column **13** is preferably defined by a volume space bounded by at least two, preferably four, of the adjacent vertical support members **11**. The volume space of each container storage column **13** is sized to contain or store two or more stacks of first containers **21, 22**.

One or more vertical guide members **14** are provided in each container storage column **13**, configured to prevent the first containers **21, 22** from horizontal movement, to guide the first containers **21, 22** in vertical movement, and to support the first containers **21, 22** when stacked. The vertical guide members **14** are arranged between two adjacent stacks of first containers **21, 22** within a corresponding container storage column **13** to also separate the stacks of first containers **21, 22** apart. Since the vertical guide members **14** are not intended for improving the structure integrity of the grid storage structure **10**, the width of the vertical guide members **14** can be much thinner than the vertical support members **11**. As a result, more space is available within the grid storage structure **10**, allowing a single container storage column **13** to have sufficient space for storing two or more stacks of first containers **21, 22**. The vertical guide members **14** may be made of a variety of materials, such as plastic, metal, or wood, depending on the requirements of the storage system. The vertical guide members **14** can be substantially extended in an upright manner from the top to the bottom of the corresponding container storage column **13**.

Preferably, the grid storage structure **10** may further comprise a plurality of horizontal support members **12** that are interconnected with the plurality of vertical support members **11**. The horizontal support members **12** can be made of the same or similar materials as the vertical support members **11**. This configuration provides added stability and support to the grid storage structure **10**, allowing for increased load capacity and improved safety. As shown in **Fig. 1**, the horizontal support members **12** are typically located at the top section and/or the bottom section of the grid storage structure **10**. Nevertheless, it should be noted that the specific location of the horizontal support members **12** may vary depending on the intended usage of the grid storage structure **10**. As the volume of each container storage column **13** increases, a corresponding increase in the number of the horizontal support members **12** may be necessary to ensure the structural stability and load-bearing capacity of the grid storage structure **10**. In this embodiment, the vertical guide members **14** are attached to the horizontal support members **12** at respective predetermined positions. Another option is to have the vertical guide members **14** be part of the horizontal support members **12** and protruded from the horizontal support members **12** towards the space within the container storage column **13**.

The horizontal rail system **30** can be a dual rail system positioned at the top section of the grid storage structure **10**, having a plurality of tracks **31**, **32** arranged in a grid pattern. The grid pattern includes a plurality of grid spaces **33**, preferably of a rectangular shape, each of which is aligned with a container storage column **13** beneath or directly beneath the corresponding grid space **33**. Preferably, the plurality of tracks **31**, **32** includes a first set of parallel track members **31** for guiding movements of the container handling devices **40** laterally in a first direction, and a second set of parallel track members **32** for guiding movements of the container handling devices **40** laterally in a second direction. Additionally, the first set of parallel track members **31** is arranged at a right angle to the second set of parallel track members **32**, thereby forming the grid pattern. This arrangement enables the

container handling devices **40** to move horizontally across the grid storage structure **10** while remaining above it. Since each container storage column **13** can contain two or more stacks of containers **21, 22**, the two or more stacks of first containers **21, 22** collectively occupy a substantial footprint of a single grid space **33** as shown in **Fig. 5**. In certain conditions, the stacked first containers **21, 22** may reach above the height of the horizontal rail system **30**, resulting some of the first containers **21, 22** to be stacked or stored above the grid space **33**. Alternatively, the tracks **31, 32** can be an integrated part of or as an additional components that are fixed on top of the horizontal support members **12** that are located at the top section of the grid storage structure **10**.

In the invention, achieving precise accuracy in the dimension of the grid space **33** presents a significant challenge. The accuracy diminishes as the dimension of the grid space **33** increases, mainly due to cumulative errors. To address this challenge, the invention incorporates the use of the horizontal support member **12** positioned at the bottom of the grid storage structure **10**. These bottom horizontal support members **12** serve as guides for the placement of the vertical support members **11** and the horizontal support members **12** at the top of the grid storage structure **10**. By utilizing the bottom horizontal support member **12** as pivot points during the assembly of the grid storage structure **10**, it becomes possible to ensure precision and accuracy in the dimension of the grid space **33**. Furthermore, the first containers **21, 22** are placed on top of the bottom horizontal support members **12**, in contrast to the existing grid storage system where bins are placed directly on the floor. This arrangement guarantees that the placement of first containers **21, 22** are precise and accurate for facilitating smooth container moving operation to be carried out.

The bottom horizontal support members **12** also offer distinct advantages over the conventional grid storage system, where the vertical support members **11** are directly placed on the floor. It is widely recognized that the floor surface in a storage system

can be uneven, requiring time-consuming and costly efforts to level it. When the vertical support members **11** are positioned on uneven floor, there is no clear reference for determining the necessary height adjustments. In contrast, the bottom horizontal support members **12** provide clear reference points, facilitating the introduction of height-adjusting components into the gaps created when laying the bottom horizontal support members **12** on uneven flooring. This allows for precise height adjustments, ensuring stability and alignment in the grid storage structure. By utilizing the bottom horizontal support members **12**, the need for extensive floor leveling procedures is eliminated, leading to improved efficiency and reduced costs.

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Advantageously, the stacks of containers **21**, **22** can be supported, above the lowest point of the grid storage structure **10**, by a plurality of container supporting structures, and the entire grid storage structure **10** can be supported above ground or floor by a plurality of leg support members **60**, as shown in **Fig. 14**. The grid storage structure **10** comprises a plurality of vertical support members **11** arranged in such a way that form a plurality of container storage columns **13** where the containers **21**, **22** can be stacked therewithin, and a horizontal rail system **30** positioned on top of the vertical support members **11**, having a plurality of tracks **31**, **32** arranged in a grid pattern that includes a plurality of grid spaces **33**, each grid space **33** is aligned with a container storage column **13** that is positioned beneath the corresponding grid space **33**. Preferably, the grid storage structure **10** may further comprise a plurality of horizontal support members **12** located at a bottom of the grid storage structure **10**, and interconnected with the plurality of vertical support members **11**. The container supporting structures can be extended from the vertical support members **11** and/or the horizontal support members **12** into the container storage column **13** for the stacks of containers **21**, **22** to be supported thereon.

Referring to **Fig. 15**, one embodiment of the container supporting structures is illustrated. In this embodiment, edges of the horizontal support members **12** at the

bottom of the grid storage structure **10** are extended into the container storage column **13**, thereby creating flanges where the bottommost containers of the stacks can be sat thereon. Alternatively, the container supporting structures can be extended from one horizontal support member **12** or vertical support member **11** to an opposite horizontal support member **12** or vertical support member **11**. Alternatively, the container supporting structures can be attachments that are attached to the horizontal support members **12** and/or the vertical support members **13** at a height above the lowest point of the grid storage structure **10**. Preferably, the lowest point of the grid storage structure **10** is the point where the leg support members **60** are engaged or connected.

10 Alternatively, if the leg support members **60** are considered as part of the grid storage structure **10**, then the lowest point of the grid storage structure **10** is the ground or floor and the stacks of the containers **21, 22** are supported above the ground or floor.

Conventionally, the stacks of containers **21, 22** are placed on the ground or floor where the load of the containers **21, 22** are directed towards the ground or floor. Prior to the installation of the grid storage structure **10**, the step of refurbishing the floor to achieve an evenness of less than 1cm is necessary. By elevating both the containers **21, 22** and the grid storage structure **10**, this prior step can be eliminated.

20 While it's true that the floor can support a much larger amount of weight, there are several advantages to distribute the load of the containers **21, 22** onto the grid storage structure **10** rather than relying the ground. By keeping the containers **21, 22** off the floor, the risk of forming ground moisture is mitigated as airflow path beneath the grid storage structure **10** is created. In the event of flooding, elevating the containers **21, 22** above ground level helps protect them from water damage and thereby reduces potential losses.

During seismic events, the vibration pattern experienced by the containers **21, 22** placed directly on the floor differs from that of the grid storage structure **10**. When the

containers **21, 22** are loaded onto the grid storage structure **10**, their vibration patterns synchronize with that of the structure. This synchronization reduces wear and tear on the containers **21, 22**, as well as on the grid storage structure **10** itself, thereby enhancing overall durability and longevity. By distributing the load onto the grid storage structure **10**, it also increases the weight of the grid storage structure **10**, which can contribute to greater stability and resistance to seismic forces. The leg support members **60** which support the entire grid storage structure **10** above the ground or floor also assist in damping the seismic forces.

- 10 An example of a leg support member **60**, as depicted in **Fig. 16**, generally comprises a base **63** in contact with the ground **61**, an elongate rod **62** extended vertically from the base **63** to connect with the bottom horizontal support members **12** or a bottom section of the vertical support members **11**, and a stabilizing member **64** for preventing the leg support member **60** from horizontal movements. By way of
- 15 example, the rod **62** has a threaded surface configured to fit into a threaded hole located on the bottom horizontal support members **12** or the vertical support members **11**. This allows the leg support member **60** to be height adjustable by rotating the leg support member **60** in a clockwise or counterclockwise manner. Alternatively, the elongate rod **62** can be formed by a pair of tubes that can extend or retract in a telescopic
- 20 manner. In this configuration, one tube has an outer threaded surface, while the other tube has an inner threaded surface, allowing a length of the rod **62** to be adjustable by rotating one or both tubes clockwise or counterclockwise. The stabilizing member **64** may include a body with a first end connected to either the base **63** or the elongate rod **62**, and a second end connected to the ground **61** via a ground anchor **64**. The second
- 25 end can also be bolted into, embedded in, held by heavy weight on the ground **61**. During the installation of the grid storage structure **10**, the leg support members **60** can be affixed to the grid storage structure **10** in the retracted configuration. As the grid storage structure **10** is placed on uneven ground **61** or floor, the leg support members **60** can then be individually extended in length to reach the ground **61** or

floor. Subsequently, the stabilizing member **64** will then be screwed into the ground **61** or floor.

Figs. 6 & 7 illustrate a second embodiment of the storage system, in which certain
5 container storage columns **13** within the grid storage structure **10** contain two or more
stacks of first containers **21, 22**, while at least one of the remaining container storage
columns **13** contains a single stack of second containers **23**. Preferably, each second
container **23** substantially occupies a single grid space **33**. The second containers **23**
are typically larger than the first containers **21, 22**. By way of example, if each
10 container storage column **13** houses two stacks of first containers **21, 22**, each second
container **23** is then sized to be approximately twice as large as a first container **21,**
22. Similarly, if each container storage column **13** accommodates three stacks of first
containers **21, 22**, each second container **23** then possesses a size approximately three
times that of a first container **21, 22**.

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In a preferred embodiment, grooves may be provided on the second containers **23** to
accommodate the vertical guide members **14** in such a way that the second containers
23 can be guided by the vertical guide members **14**. Alternatively, at least one of the
container storage columns **13** can contain both the first and second containers **21-23**
20 in stacks. In the second embodiment of the storage system, the container handling
device **40** may utilise two or more lifting devices to perform a lifting operation on a
second container **23**.

The second embodiment of the storage system, which features a mixture of the first
25 and second containers **21-23**, provides flexible storage options, enabling
accommodation of different items sizes. Such configuration optimizes space usage
and enhances the efficiency of retrieving and managing the containers **21-23**. The
present of the larger second containers **23** ensures easy access to frequently used item,
eliminating the need to navigate through multiple stacks and thus saving time and

effort. Additionally, this versatile storage solution offers customization possibilities to cater to a variety of needs, effectively accommodating both smaller and bulkier items.

Referring to **Figs. 8 to 9**, an example of a container handling device **40** as illustrated
5 therein comprises a wheel assembly **41, 42** that engages with the tracks **31, 32** of the horizontal rail system **30** for lateral movement, a container receiving cavity, and two or more lifting devices located within the container receiving cavity to carry out a lifting operation. Preferably, the wheel assembly **41, 42** includes a first set of wheels **41** that engage with the first set of parallel track members **31** to move in the first
10 direction and a second set of wheels **42** that engage with the second set of parallel tracks members **32** to move in the second direction. Each of the wheels **41, 42** can be independently coupled with a gear and drive mechanism for driving the container handling device **40** in the first and/or second directions. The first set of wheels **41**, the second set of wheels **42** or both can be displaced by at least one wheel lifting
15 mechanism to engage and disengage the tracks **31, 32**. In one specific embodiment, the second set of wheels **42** can be elevated above the rails or lowered onto the rails using the wheel lifting mechanism, as depicted in **Fig. 9**. The wheel lifting mechanism may comprise a generally T-shaped linkage **52** that connects the second set of wheels **42** and a linkage arm **51** that connects the T-shaped linkage **52** to a wheel lifting motor
20 **50**, which can be controlled or operated electrically by a processor (not shown) of the container handling device **40**. Preferably, the container handling device **40** can have two independently controlled wheel lifting motors **50**, each controls one side of the second set of wheels **42**.

25 Each of the lifting devices includes a gripper device **43, 44** that is connected to at least one winch mechanism via a plurality of strips **45, 46**. The gripper device **43, 44** can include a plurality of grippers **47** arranged around an edge of the gripper device **43, 44** for releasably holding one of the containers **21, 22** from its upper side. Preferably, the at least one winch mechanism includes a spool with rotatable inner side walls to

reduce friction between the spool and the plurality of strips **45, 46** during the winding or unwinding processes to lift or unload the first or second containers **21-23**. The gist of the invention lies in the two or more lifting devices being configured to perform the container lifting operations in two modes. In the first mode as shown in **Fig. 8**, the

5 lifting devices operate independently to lift or unload one or more of the first containers **21, 22**. In the second mode as shown in **Fig. 10**, the lifting devices operate in a synchronized manner to lift or unload one of the second containers. Preferably, the two or more lifting devices in the second mode are coordinated to move uniformly in both direction and speed while lifting or unloading the second container **23**. The

10 lifting operation may include the step of raising one or more containers **21-23** from the container storage column **13** into the container receiving cavity, or lowering the one or more containers **21-23** from container receiving cavity into the container storage column **13**. Once the containers **21, 23** are lifted into the container receiving cavity, they are transported horizontally across the grid storage structure **10** to a

15 designed container storage column **13** for deposition.

Preferably, the container receiving cavity is configured to receive two or more first containers **21, 22** in a side by side manner where at least one of their respective longitudinal sides are adjacent to the another. The winch mechanism are also oriented

20 in such a way that one edge of each strips **45, 46** faces towards the longitudinal side of the first container **21, 22**. Such arrangement ensures that the gripper devices **43, 44**, the first containers **21, 22** or both, can move smoothly within the container receiving cavity with minimal horizontal displacement, thus preventing interference between two or more gripper devices **43, 44**, the lifted first containers **21, 22** or both. While the

25 gripper devices **43, 44** travels within the container storage columns **13**, the vertical guide members **14** can also guide and restrict their horizontal movements. Such arrangement eliminates the need for internal guiding members within the container receiving cavity.

Preferably, the sensor unit **49** disposed at the center of the container handling device **40** to detect the presence of the tracks **31, 32**. The position of the sensor unit **49** is crucial as it positioned at the boundary of each container receiving spaces, thereby allowing the processor to analyze and determine the alignments between at least one
5 of the container receiving spaces and the vertical stacks of the containers **21, 22** within a single grid space **33** or even the single grid space **33** itself.

The arrangement can be best illustrated in **Fig. 11** where the container handling device **40** is situated in a manner that occupies only a portion of a designated single grid
10 space **33** such that at least one of the lifting devices is aligned with a stack of containers **21, 22** within the designated single grid space **33** to perform the first mode of the lifting operation at the designated single grid space **33**. More specifically, the sensor unit **49** is configured to detect the presence of an edge of the tracks **31, 32**, subsequently initiating a signal to the processing unit of the container handling device
15 **40**. This enables the processing unit to analyze and determine whether one or more of the container receiving spaces are aligned with either the single grid space **33** or one of the container stacks within the single grid space **33**. The sensor unit **49** is but not limited to a proximity sensor, a photoelectric sensor, an ultrasonic sensor, a laser sensor, a hall effect sensor, a magnetic sensor, a vision sensor or any combination
20 thereof.

Preferably, the container handling device **40** is positioned to occupy about half of the footprint of the single grid space **33**. This arrangement enables the simultaneous operation of multiple container handling devices **40** within a single grid space **33**.
25 Each container handling device **40** is also sized to substantially occupy the footprint of a single grid space **33** so that one container handling device **40** can move through another container handling device **40** that occupies an adjacent grid space **33** without any obstruction. Nevertheless, it is important to note that the dimensions of the container handling device **40** can vary, and in some cases, it may exceed the size of a

single grid space **33**, depending on the specific application requirements.

Referring to **Fig. 12**, an example of operating the container handling device **40** in the first mode is illustrated. In this example, the container handling device **40** includes a
5 first sensor unit (not shown) disposed at one side of the container handling device **40**, a second sensor unit (not shown) disposed at an opposing side of the container handling device **40**, and the sensor unit **49** disposed at the divider **48**. In step **101**, the container handling device **40** receives a coordinate commands. In step **102**, the container handling device **40** determines whether an instruction from the coordinate
10 command relates to performing the lifting operation at a half grid space position or full grid space position. If it is a half grid space position, then proceed to step **103**, else proceed to step **108**.

In steps **103 & 104**, the load handling device **40** moves to the instructed position. In
15 step **105**, during the movement of the load handling device **40** to the instruction position, the load handling device **40** utilise the pair of the first sensor unit and the sensor unit **49** or the pair of the second sensor unit and the sensor unit **49** to detect the present of the tracks **31, 32**, thereby enabling the load handling device **40** to determine precisely when to stop. In step **106**, the load handling device **40** lower down just the
20 first set of wheels **41** or the second set of wheels **42**. In step **107**, the container handling device **40** then performs the lifting operation via just one of the lifting devices.

In steps **108 & 109**, the load handling device **40** moves to the instructed position. In
25 step **110**, during the movement of the load handling device **40** to the instruction position, the load handling device **40** utilise the pair of the first sensor unit and the second sensor unit to detect the present of the tracks **31, 32**, thereby enabling the load handling device **40** to determine precisely when to stop. In step **111**, the load handling device **40** lower down both the first and second sets of wheels **41, 42**. In step **112**, the

container handling device **40** then performs the lifting operation via one or more of the lifting devices.

Referring to **Fig. 13**, an example of operating the container handling device **40** in the second mode is illustrated. In steps **201** to **203**, when the container handling device **40** receives computer-implemented instructions from a server to retrieve a second container **23** located at a designated grid and level, the container handling device **40** will move to the designated grid. Subsequently, it will instruct the lifting devices to lower their respective gripper devices **43, 44** until they reach the designated level. In steps **204** & **205**, once the gripper devices **43, 44** have reached the second container **23** at the designated level, the grippers **47** on the gripper devices **43, 44** will be activated to securely engage with the second container **23**. In step **206** & **207**, the gripper devices **43, 44**, through the strips **45, 46**, transmit the status of the grippers **47** to the processor of the container handling device **40**. Upon receiving the status of the grippers **47**, the processor of the container handling device **40** will then instruct the lifting devices to lift up the gripper devices **43, 44** together with the engaged second container **23**. In steps **208** to **210**, the processor of the container handling device **40** receives position information from the gripper devices **43, 44**, encoder values from an external encoder, and motor drivers of the lifting devices. In step **211**, the container handling device **40** ensures that the movements of the gripper devices **43, 44** are controlled to synchronously move the gripper devices **43, 44** in the same direction and at the same speed. In step **212**, the processor of the container handling device **40** determines if the second container **23** has reached the designated location.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be

resorted to without departing from the scope of the invention.

CLAIMS

1. A grid storage structure (10) for storing a plurality of containers (21, 22) in vertical stacks, the grid storage structure (10) comprising:
 - 5 a plurality of vertical support members (11) arranged in such a way that form a plurality of container storage columns (13) where the containers (21, 22) can be stacked therewithin; and
 - a horizontal rail system (30) positioned on top of the vertical support members (11), having a plurality of tracks (31, 32) arranged in a grid pattern that includes a plurality
 - 10 of grid spaces (33), each grid space (33) is aligned with a container storage column (13) that is positioned beneath the corresponding grid space (33);characterised in that the grid storage structure (10) further comprises:
 - one or more container supporting structures for supporting the stacks of containers (21, 22) above a lowest point of the grid storage structure (10), and
 - 15 one or more height adjustable leg support members (60) for supporting the grid storage structure (10) above ground (61).
2. The grid storage structure (10) according to claim 1, wherein the leg support member (60) comprises:
 - 20 a base (63) in contact with the ground (61);
 - a rod (62) extended vertically from the base (63) to connect with a bottom section of a grid storage structure (10);
 - a mechanism for adjusting the height of the leg support member (60); and
 - a stabilizing member (64) for preventing the leg support member (60) from lateral
 - 25 movement.
3. The grid storage structure (10) according to claim 2, wherein the height adjusting mechanism is in the form of the rod (62) having a threaded surface configured to be insertable into a threaded hole located beneath the grid storage structure (10).

4. The grid storage structure (10) according to claim 2 or claim 3, wherein the height adjusting mechanism is in the form of the rod (62) being formed by a pair of tubes connected in a telescopic manner, one tube has an outer threaded surface, while the
5 other tube has an inner threaded surface, allowing the rod (62) to be extendable or retractable by rotating one or both tubes clockwise or counterclockwise.
5. The grid storage structure (10) according to any one of claims 2 to 4, wherein the stabilizing member (64) include a body with a first end connected to either the base
10 (63) or the rod (62), and a second end anchored to the ground (61).
6. The grid storage structure (10) according to any one of claims 1 to 5, wherein the container supporting structures are extended from the vertical support members into their respective container storage columns (13) for the bottommost containers of the
15 stacks to be placed thereon.
7. The grid storage structure (10) according to any one of claims 1 to 5, further comprising a plurality of horizontal support members (12) located at a bottom of the grid storage structure (12), and interconnected with the plurality of vertical support
20 members (11).
8. The grid storage structure (10) according to claim 7, wherein the container supporting structures are extended from the horizontal support members (12) and/or the vertical support members (11) into their respective container storage columns (13)
25 for the bottommost containers of the stacks to be placed thereon.