



(12) PATENT

(11) 346364

(13) B1

NORWAY

(19) NO

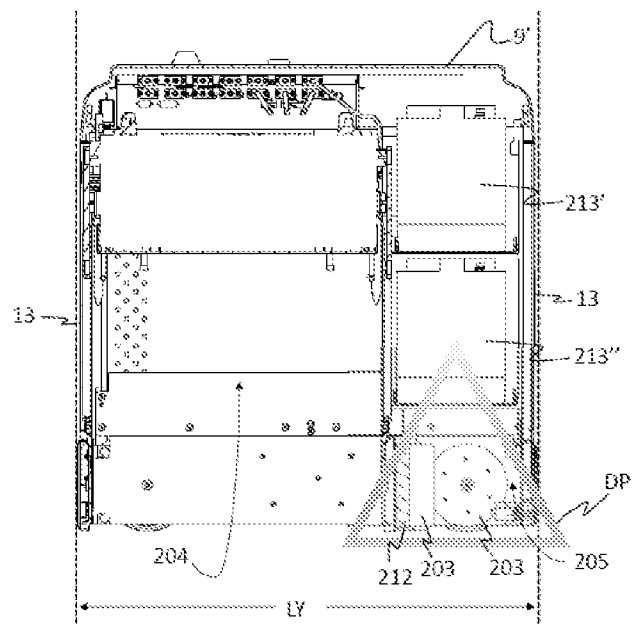
(51) Int Cl.

B65G 1/04 (2006.01)

## Norwegian Industrial Property Office

(21)	Application nr.	20180591	(86)	International Filing Date and Application Number
(22)	Date of Filing	2018.04.25	(85)	Date of Entry into National Phase
(24)	Date of Effect	2018.04.25	(30)	Priority
(41)	Publicly Available	2019.10.28		
(45)	Granted	2022.06.27		
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(54)	Title	<b>Container handling vehicle with first and second sections and battery in second section, and system.</b>		
(56)	References Cited:	US 2016325932 A1, US 2018072546 A1, US 2018029798 A1		
(57)	Abstract			

The present invention provides a container handling vehicle (9') for picking up storage containers (6) from a three-dimensional grid (4) of an underlying storage system (1), comprising a first set of wheels (14) arranged at opposite portions of a vehicle body (13), for moving the vehicle (9') along a first direction (X) on a rail system (8) in the grid (4); a second set of wheels (15) arranged at opposite portions of the vehicle body (13), for moving the vehicle (9') along a second direction (Y) on the rail system (8) in the grid (4), the second direction (Y) being perpendicular to the first direction (X); wherein the vehicle body (13) comprises walls on all sides and forms a quadrilateral footprint, a first section and a second section arranged side-by-side such that a centre point of the first section is arranged off centre relative a centre point of the footprint formed by the vehicle body (13), and wherein a size ratio of a footprint of the first section relative a footprint of the second section is at least 2:1, and wherein the first section is configured to accommodate a storage container, and the second section comprises at least a first battery (213', 213'').



## Technical Field

The present invention relates to the field container handling vehicles for automated storage and retrieval systems and to automated storage and retrieval systems comprising such container handling vehicles.

## 5 Background

The Applicant's already known AutoStore system is a storage system comprising a three-dimensional storage grid structure wherein storage containers/containers are stacked on top of each other to a certain height. Such a prior art system is shown in fig. 1.

10 The storage system is disclosed in detail in for instance NO317366 and WO 2014/090684 A1.

Fig. 1 discloses a framework structure of a typical prior art automated storage and retrieval system 1 and figures 2a and 2b disclose known container handling vehicles of such a system.

15 The framework structure comprises a plurality of upright members/profiles 2 and a plurality of horizontal members 3, which are supported by the upright members 2. The members 2, 3 may typically be made of metal, e.g. extruded aluminium profiles.

20 The framework structure defines a storage grid 4 comprising multiple grid opening/columns 12 arranged in rows. A majority of the grid columns 12 are storage columns 5 in which storage containers 6, also known as containers or bins, are stacked one on top of another to form stacks 7. Each storage container 6 (or container for short) may typically hold a plurality of product items (not shown), and the product items within a storage container 6 may be identical, or may be of  
25 different product types depending on the application. The framework structure guards against horizontal movement of the stacks 7 of storage containers 6, and guides vertical movement of the containers 6, but does normally not otherwise support the storage containers 6 when stacked.

30 The upper horizontal members 3 comprise a rail system 8 arranged in a grid pattern across the top of the grid columns 12, on which rail system 8 a plurality of container handling vehicles 9 are operated to raise storage containers 6 from and lower storage containers 6 into the storage columns 5, and also to transport the storage containers 6 above the storage columns 5. The rail system 8 comprises a first set of parallel rails 10 arranged to guide movement of the container handling vehicles 9 in  
35 a first direction X across the top of the frame structure 1, and a second set of parallel rails 11 arranged perpendicular to the first set of rails 10 to guide movement of the container handling vehicles 9 in a second direction Y, which is perpendicular

to the first direction X, see fig. 3. In this way, the rail system 8 defines an upper end of the storage columns 5, above which the container handling vehicles 9 can move laterally above the storage columns 5, i.e. in a plane, which is parallel to the horizontal X-Y plane.

5 Each container handling vehicle 9 comprises a vehicle body 13 and first and second sets of wheels 22, 23 which enable the lateral movement of the container handling vehicle 9, i.e. the movement in the X and Y directions. In fig. 2, two wheels in each set are visible. The first set of wheels 22 is arranged to engage with two adjacent rails of the first set 10 of rails, and the second set of wheels 23 arranged to engage  
10 with two adjacent rails of the second set 11 of rails. One of the set of wheels 22, 23 can be lifted and lowered, so that the first set of wheels 22 and/or the second set of wheels 23 can be engaged with their respective set of rails 10, 11 at any one time.

Each container handling vehicle 9 also comprises a lifting device 18 (not shown in fig. 1 and 2a, but visible in fig. 2b) for vertical transportation of storage containers  
15 6, e.g. raising a storage container 6 from and lowering a storage container 6 into a storage column 5. The lifting device 18 comprises a lifting frame (not shown in fig. 2a, but similar to the one shown in fig. 2b labelled 17) which is adapted to engage a storage container 6, which lifting frame can be lowered from the vehicle body 13 so that the position of the lifting frame with respect to the vehicle body 13 can be  
20 adjusted in a third direction Z, which is orthogonal the first direction X and the second direction Y.

Conventionally, and for the purpose of this application, Z=1 identifies the uppermost layer of the grid 4, i.e. the layer immediately below the rail system 8 (in the present application, the rail system 8 is termed the top level of the grid), Z=2 is  
25 the second layer below the rail system 8, Z=3 is the third layer etc. In the embodiment disclosed in Fig. 1, Z=8 identifies the lowermost, bottom layer of the grid 4. Consequently, as an example and using the Cartesian coordinate system X, Y, Z indicated in Fig. 1, the storage container identified as 6' in Fig. 1 can be said to occupy grid location or cell X=10, Y=2, Z=3. The container handling vehicles 9  
30 can be said to travel in layer Z=0 and each grid column 12 can be identified by its X and Y coordinates.

Each container handling vehicle 9 comprises a storage compartment or space for receiving and stowing a storage container 6 when transporting the storage container 6 across the grid 4. The storage space may comprise a cavity 21 arranged centrally  
35 within the vehicle body 13, e.g. as is described in WO2014/090684A1, the contents of which are incorporated herein by reference.

Alternatively, the container handling vehicles may have a cantilever construction, as is described in NO317366, the contents of which are also incorporated herein by reference.

The single cell container handling vehicles 9 may have a footprint F, i.e. a horizontal periphery in the X and Y directions (see fig. 4), which is generally equal to the lateral or horizontal extent of a grid column 12, i.e. the periphery/circumference of a grid column 12 in the X and Y directions, e.g. as described in WO2015/193278A1, the contents of which are incorporated herein by reference. Alternatively, the container handling vehicles 9 may have a footprint which is larger than the lateral extent of a grid column 12, e.g. as disclosed in WO2014/090684A1.

The rail system 8 may be a single-track system, as shown in fig. 3. Preferably, the rail system 8 is a double-track system, as shown in fig. 4, thus allowing a container handling vehicle 9 having a footprint F generally corresponding to the lateral extension of a grid column 12 to travel along a row of grid columns in either an X or Y direction even if another container handling vehicle 9 is positioned above a grid column 12 adjacent to that row.

In a storage grid, a majority of the grid columns 12 are storage columns 5, i.e. grid columns where storage containers are stored in stacks. However, a grid normally has at least one grid column 12 which is used not for storing storage containers, but which comprises a location where the container handling vehicles can drop off and/or pick up storage containers so that they can be transported to an access station where the storage containers 6 can be accessed from outside of the grid or transferred out of or into the grid, i.e. a container handling station. Within the art, such a location is normally referred to as a “port” and the grid column in which the port is located may be referred to as a port column.

The grid 4 in fig. 1 comprises two port columns 19 and 20. The first port column 19 may for example be a dedicated drop-off port column where the container handling vehicles 9 can drop off storage containers to be transported to an access or a transfer station (not shown), and the second port 20 column may be a dedicated pick-up port column where the container handling vehicles 9 can pick up storage containers that have been transported to the grid 4 from an access or a transfer station.

When a storage container 6 stored in the grid 4 disclosed in fig. 1 is to be accessed, one of the container handling vehicles 9 is instructed to retrieve the target storage container from its position in the grid 4 and transport it to the drop-off port 19. This operation involves moving the container handling vehicle 9 to a grid location above the storage column 5 in which the target storage container is positioned, retrieving the storage container 6 from the storage column 5 using the container handling vehicle’s lifting device (not shown, being internally arranged in a central cavity of the vehicle, but similar to the lifting device 18 of the second prior art vehicle of fig. 2b), and transporting the storage container to the drop-off port 19. A second prior

art vehicle 9 is shown in fig. 2b to better illustrate the general design of the lifting device. Details of the second vehicle 9 are described in the Norwegian patent NO317366. The lifting devices 18 of both prior art vehicles 9 comprise a set of lifting bands connected close to the corners of a lifting frame 17 (may also be  
5 termed a gripping device) for releasable connection to a storage container. To raise or lower the lifting frame 17 (and optionally a connected storage container 6), the lifting bands are spooled on/off at least one rotating lifting shaft or drum (not shown) arranged in the container handling vehicle. Various designs of the at least one lifting shaft are described in for instance WO2015/193278 A1 and  
10 PCT/EP2017/050195. The lifting frame 17 features container connecting elements for releasably connecting to a storage container, and guiding pins. If the target storage container is located deep within a stack 7, i.e. with one or a plurality of other storage containers positioned above the target storage container, the operation also involves temporarily moving the above-positioned storage containers prior to  
15 lifting the target storage container from the storage column. This step, which is sometimes referred to as “digging” within the art, may be performed with the same container handling vehicle that is subsequently used for transporting the target storage container to the drop-off port 19, or with one or a plurality of other cooperating container handling vehicles. Alternatively, or in addition, the automated  
20 storage and retrieval system may have container handling vehicles specifically dedicated to the task of temporarily removing storage containers from a storage column. Once the target storage container has been removed from the storage column, the temporarily removed storage containers can be repositioned into the original storage column. However, the removed storage containers may alternatively  
25 be relocated to other storage columns.

When a storage container 6 is to be stored in the grid 4, one of the container handling vehicles 9 is instructed to pick up the storage container from the pick-up port 20 and transport it to a grid location above the storage column 5 where it is to be stored. After any storage containers positioned at or above the target position  
30 within the storage column stack have been removed, the container handling vehicle 9 positions the storage container at the desired position. The removed storage containers may then be lowered back into the storage column, or relocated to other storage columns.

For monitoring and controlling the automated storage and retrieval system, e.g.  
35 monitoring and controlling the location of respective storage containers within the grid 4, the content of each storage container 6 and the movement of the container handling vehicles 9 so that a desired storage container can be delivered to the desired location at the desired time without the container handling vehicles 9 colliding with each other, the automated storage and retrieval system comprises a

control system, which typically is computerised and comprises a database for keeping track of the storage containers.

5 The prior art solutions include so-called single cell robots. The single cell robots have its batteries arranged in the upper part of the robot above the space for receiving storage containers. This results in a relatively high center of gravity for the robot and increased challenges with regards to stability if the batteries were to be replaced by larger and heavier batteries.

Consequently, the prior art solution has drawbacks in relation to stability of the robots if the batteries were to be replaced with larger batteries.

10 In view of the above, it is desirable to provide a container handling vehicle, an automated storage and retrieval system comprising said container handling vehicle, that solve or at least mitigate one or more of the aforementioned problems related to the robots.

15 In particular, it is an objective of the present invention to provide a robot with improved operation time without reducing stability of the robot.

### **Summary of the invention**

The invention is defined by the appended claims and in the following:

20 In a first aspect, the present invention provides a container handling vehicle for picking up storage containers from a three-dimensional grid of an underlying storage system, comprising

- a first set of wheels arranged at opposite portions of a vehicle body, for moving the vehicle along a first direction (X) on a rail system in the grid; and
- 25 - a second set of wheels arranged at opposite portions of the vehicle body, for moving the vehicle along a second direction (Y) on the rail system in the grid, the second direction (Y) being perpendicular to the first direction (X); wherein

30 the vehicle body comprises vertical or substantially vertical walls on all sides forming a footprint defined by horizontal peripheries in the X and Y directions of the vehicle body, wherein

- a first section and a second section are arranged side-by-side such that a centre point of the first section is arranged off centre relative a centre point of the footprint of the vehicle body, and

- wherein a size ratio of a footprint of the first section relative a footprint of the second section is at least 2:1, and wherein
- the first section is configured to accommodate a storage container, and
- the second section comprises at least a first battery.

5 The feature of arranging the at least first battery in the second section provides for an improved overall stability of the container handling vehicle in that the center of gravity is lower compared to prior art single cell robots. Normally, the storage containers have a rectangular shape in the X and Y directions and the prior art single cell robots have a rectangular footprint corresponding to the cross-sectional  
10 shape of the storage containers (somewhat larger in X and Y directions due to vehicle walls and wheels). The container handling vehicle according to one embodiment has a substantially quadratic footprint which is more stable than the rectangular footprint of the prior art single cell robots.

15 In an embodiment of the container handling vehicle, the at least first battery is fixed.

In an embodiment of the container handling vehicle, the at least first battery is exchangeable.

20 In an embodiment, the container handling vehicle further comprises a lifting device arranged at an upper level of the first section and wherein the at least first battery is arranged at or below the level of at least parts of the lifting device. This improves the stability of the vehicle due to a lower center of gravity compared to prior art single cell robots having batteries arranged above the lifting device.

25 In an embodiment of the container handling vehicle, the first set of wheels is displaceable in a vertical direction between a first position, wherein the first set of wheels allow movement of the vehicle along the first direction X, and a second position, wherein the second set of wheels allow movement of the vehicle along the second direction Y.

30 In an embodiment of the container handling vehicle, the first section has a rectangular footprint where two of the sides are longer than the two other sides, and wherein the second section is adjacent a long side of the first section.

In an embodiment of the container handling vehicle, the first section accommodates a first, second, third and fourth wheel of the first set of wheels and a first and second wheel of the second set of wheels, and the second section accommodates a third and fourth wheel of the second set of wheels.

35 In an embodiment of the container handling vehicle, the first section accommodates a first and third wheel of the first set of wheels and a first and second wheel of the

second set of wheels, and the second section accommodates a second and a fourth wheel of the first set of wheels and a third and a fourth wheel of the second set of wheels.

5 In an embodiment of the container handling vehicle, the first section comprises four corners, and the rims of the first, second, third and fourth wheels of the first set of wheels and the first and second wheels of the second set of wheels are arranged at the corners of the first section.

10 In an embodiment of the container handling vehicle, the at least one first motor comprises a hub motor for each of the first and fourth wheel of the first set of wheels, and the at least one second motor comprises a hub motor for each of the third and fourth wheel in the second set of wheels. In other words, each of the first and fourth wheel of the first set of wheels, and each of the third and fourth wheel in the second set of wheels, is driven by a separate/dedicated hub motor. In one embodiment, the hub motors are arranged in or extend into the second section.

15 In an embodiment of the container handling vehicle, the first section comprises four corners, and the outer rim of the first, second, third and fourth wheels of the first set of wheels and the first and second wheels of the second set of wheels are arranged at or near each corner of the first section.

20 The wheels may be arranged on an inside of a wall defining the first and second sections, respectively, or on an outside of the wall defining the first and second sections.

25 In an embodiment of the container handling vehicle, the container handling vehicle may further comprise at least a second battery arranged in the second section above or below the first battery. Preferably, the second battery is arranged at a level below the first battery, i.e. such that both batteries are at a level below the upper level of the first section.

30 In an embodiment of the container handling vehicle, the first and fourth wheel of the first set of wheels, and the third and fourth wheel of the second set of wheels, are arranged within a downward projection area from the at least first battery, wherein the downward projection area represents the downward loads of the at least first battery.

The downward projection area of the at least first battery is preferably larger than the horizontal cross-sectional area of the at least first battery, but may also be substantially equal to the horizontal cross-sectional area of the at least first battery.

35 This result in that the wheels do not have to be arranged directly vertically below the at least first battery but can also be arranged horizontally offset relative the at



least first battery. This will be the case in situations where the at least first battery is not occupying a whole cross-sectional area of the second section.

Preferably, the first and fourth wheel of the first set of wheels, and the third and fourth wheel of the second set of wheels (i.e. the at least four wheels in, or in  
 5 connection with, the second section), are arranged such that at least some of the load(s) from the at least first battery is applied to each of said four wheels in, or in connection with, the second section. Preferable, the mutual relationship between the at least first battery and the four wheels in, or in connection with, the second section is such that a weight from the at least first battery is at least distributed to the four  
 10 wheels arranged in, or close to or in connection with, the second section. The arrangement of the at least first battery and the wheels may be such that the weight is substantially evenly distributed to the four wheels. As such, there is less risk of spinning of the wheels as the ground pressure of the wheels on the rail system is increased. Preferably, a major part of the weight (e.g. more than 80% or more than  
 15 90%), of the at least first battery (and the second battery) is distributed to the four wheels in, or in connection with, the second section.

In an embodiment of the container handling vehicle, the at least four wheels in, or in connection with, the second section are arranged substantially vertically below the at least first battery.

20 In an embodiment of the container handling vehicle, the container handling vehicle further comprises an exchangeable battery arranged in the first section.

The wheels may be arranged with its own motor drive, for example an in-wheel motor drive or hub motor.

25 In an embodiment of the container handling vehicle, the second section comprises an assembly of motors comprising a first motor for driving at least one wheel of the first set of wheels and a second motor for driving at least one motor of the second set of wheels.

30 The footprint of the first section can be equal to the size of an underlying grid cell, and the second section is a protruding section which extends horizontally beyond the footprint of the first section.

A grid cell may be defined as the cross-sectional area, including the rails (when the rails are single-track rails), between opposed rails running in the X direction and opposed rails running in the Y direction.

35 A grid cell opening may be defined as the open cross-sectional area between two opposed rails running in the X direction and two opposed rails running in the Y direction.

The footprint of the second section is less than half the size the footprint of the first section (size ratio less than 1:2 relative the first section). When the container handling vehicle is positioned above a grid cell in a position where it can lift or lower a storage container into or out of the first section, the second section extends into a neighboring grid cell. However, the footprint of the vehicle body is less than 1.5 cells (in the Y-direction) and maximum one grid cell wide in the other direction (X-direction). In other words, the lateral extent of the container handling vehicle in the first direction corresponds to the lateral extent of the tracks in one cell, and maximum 1.5 grid cells in the direction perpendicular to the first direction. Consequently, in an example system for storing and retrieving storage containers, where two of the container handling vehicles described above are operated and are oriented in opposite directions, they occupy three grid cells when travelling in the first direction e.g. in the X-direction, whereas when travelling in the second direction e.g. in the Y-direction, they can travel along neighboring rows of grid cells occupying two grid cells.

The first section may have a footprint defined as a horizontal periphery in the X and Y directions (see fig. 4), which is generally equal to the lateral or horizontal extent of a grid column 12, i.e. the periphery/circumference of a grid column 12 in the X and Y directions.

The second section may have a footprint defined by a horizontal extent of the container handling vehicle in the X and Y directions. The extent in the Y direction is maximum half the horizontal extent in the Y direction of the first section.

The first and second sets of wheels may comprise a first set of wheels for engaging with the first set of tracks to guide movement of the container handling vehicle in the first direction, and a second set of wheels for engaging with the second set of tracks to guide movement of the container handling vehicle in the second direction.

The first section of the container handling vehicle may comprise a cavity for accommodating a storage container and a lifting device arranged to transport a storage container vertically between a storage position in a stack and a transport position inside the cavity. The lifting device may comprise a gripping device being configured to releasably grip a storage container; and a lifting motor being configured to raise and lower the gripping device relative to the first section.

The second section, allows for the use of larger and stronger motors for driving the wheels arranged in the second section than what is possible in the prior art single cell robots. In addition, the second section makes it possible to provide only four of the wheels of the vehicle with larger/stronger motors, instead of providing all 8 wheels with weaker/smaller motors. It is not possible to use larger/stronger motors for the wheels arranged in the first section since the available space is very limited. The use of larger/stronger motors in the first section would either reduce the space

available for receiving storage containers or require an increased footprint of the first section, i.e. the footprint of the first section would cover more than one storage column. The possibility of using larger/stronger motors allows for the provision of container-handling vehicles having an improved acceleration and/or speed. It is  
5 noted that similar to the first section, it is difficult, and maybe even impossible, to provide prior art single cell vehicles with larger/stronger motors without increasing their footprint or decreasing the space available for accommodating a container.

Furthermore, utilizing larger motors on the motors in the second section minimizes, and may in some situations even eliminate, the need for motors on the wheels in the  
10 first section. Thus, it is possible to provide a container handling vehicle with only four wheel motors in total, where each motor is arranged in the second section, and where two of the wheel motors drive wheels running in the X direction and two of the motors drive wheels running in the Y direction. The remaining four wheels is then passive (not motor driven). Alternatively, the remaining four wheels comprises  
15 in-wheel motors.

By having the more powerful wheel motors arranged in the second section, a major part of the load/weight of the overlying battery(ies) will push or force the most powerful drive wheels downwards, thus reducing the risk of wheel spin by increasing the ground pressure of the wheels on the rail system.

20 In other situations, if the wheel motors are strong enough alone and the demand for high speed/acceleration is limited, it may be enough with two wheel motors in the container handling vehicle total. Then the two wheel motors are arranged in the second section, where one motor drives a wheel in the X direction and another motor drives a wheel in the Y direction. Then the remaining six wheels are passive  
25 (not motor driven) or comprises in-wheel motors.

Motors arranged in the second section have a short distance between them. Due to the short distance between the motors, fewer, e.g. one BrushLess Direct Current (BLDC) card, may be required instead of four BLDC cards in the prior art single cell robots. In the prior art solutions, the distance between the motors driving the  
30 wheels in the container handling vehicle is of such an extent that typically four BLDC cards are required. The cost of BLDC cards is quite high. However, as the distance between the motors can be substantially reduced by arranging the motors in the second section, the overall cost for the container handling vehicle can be reduced because fewer BLDC cards (e.g. only one BLDC card) is required.

35 The first section and the second section may be fully separated by physical barriers at the intersection between the first and second sections, such as a wall or plate or similar. Alternatively, the first and second section may be partly separated at the intersection between the first and second section, for example by providing a barrier over at only parts of the intersection. Such a partly separation may be in the form of

a connection plate, beam, rod or similar in a lower part of the vehicle body, to which connection plate, beam, rod or similar at least one set of wheels and battery and possibly motor(s) can be connected.

5 The container handling vehicle further provides more available space for track sensors. Track sensors are usually arranged in the space between wheels for detecting the position of the container handling vehicle by integrating tracking devices tracking the number of crossings passed in X- and Y-directions relative to the tracks laid out as a grid structure. Such method may comprise tracking the position of a remotely operated vehicle following a set route relative to tracks laid out on a frame structure forming a grid, the vehicle having first and second sets of wheels connected to drives for moving the vehicle in corresponding X- and Y-directions on the rail system in the grid, the method comprising receiving information of the number of track crossings to pass between start and stop positions in X- and Y-directions according to the set route; directing sensors attached to the vehicle at the tracks along the route of the vehicle; detecting and monitoring track crossings passed when moving the vehicle in the X- and Y-directions according to the set route; transmitting a signal to a controller, controlling the drives of the wheels of the vehicle, when the number of track crossings passed is close to the total number of track crossings to pass between the start and stop positions in respective X- and Y-directions along the set route.

In an embodiment of the container handling vehicle, each of two pairs of opposed wheels in the first set of wheels and each of two pairs of opposed wheels in the second set of wheels, forms an imaginary rotational axis therebetween, and wherein

- 25 - one of the rotational axes formed by the wheels in the first set of wheels intersects with both rotational axes in the second set of wheels, and
- another of the imaginary rotational axes formed by the wheels in the first set of wheels does not intersect any of the rotational axes in the second set of wheels.

30 In an embodiment of the container handling vehicle, the size of the first section corresponds to a grid cell of a rail system of an underlying storage and retrieval system, and wherein, during use, when the container handling vehicle is in a position to lift or lower a storage container, the second section is horizontally displaced relative the grid cell and extends partly into a neighboring grid cell. I.e. the at least first battery arranged in the second section is arranged outside the grid cell occupied by the first section.

In an embodiment of the container handling vehicle, each of two pairs of opposed wheels in the first set of wheels and each of two pairs of opposed wheels in the second set of wheels, forms imaginary rotational axis therebetween, and wherein

- one of the rotational axes formed by the wheels in the first set of wheels intersects with both rotational axes in the second set of wheels, and
- another of the imaginary rotational axes formed by the wheels in the first set of wheels does not intersect any of the imaginary rotational axes in the second set of wheels.

In an embodiment of the container handling vehicle, the first and second sets of wheels are arranged at or within a lateral extension of the vehicle body.

In a second aspect, the present invention provides an automated storage and retrieval system comprising a three-dimensional grid and at least one container handling vehicle, the grid comprises a rail system, on which the container handling vehicle may move, and a plurality of stacks of storage containers;

- the rail system comprises a first set of parallel tracks arranged in a horizontal plane P and extending in a first direction X, and a second set of parallel tracks arranged in the horizontal plane and extending in a second direction which is orthogonal to the first direction X, wherein the first and second sets of tracks form a grid pattern in the horizontal plane P comprising a plurality of adjacent grid cells 14, each grid cell comprising a grid opening defined by a pair of opposed tracks of the first set of tracks and a pair of opposed tracks of the second set of tracks;

- the plurality of stacks of storage containers are arranged in storage columns located beneath the rail system, wherein each storage column is located vertically below a grid opening;

- the container handling vehicle features a vehicle body comprising substantially vertical walls on all sides forming a footprint defined by horizontal peripheries in the X and Y directions of the vehicle body, and a first section and a second section arranged side-by-side, wherein a centre point of the first section is arranged off centre relative a centre point of the footprint formed by the vehicle body, and

- wherein a size ratio of a footprint of the first section relative a footprint of the second section is at least 2:1;
  - the first section is configured to accommodate a storage container; and
  - the second section comprises at least a first battery for driving at least one wheel of each of the sets of wheels, wherein

a footprint of the first section is substantially equal to a grid cell defined by a cross-sectional area, including width of the tracks, between a pair of opposed tracks of the first set of tracks and a pair of opposed tracks of the second set of tracks, and the second section extends partially into a neighboring grid opening when the first section is positioned over an adjacent grid opening.

In an embodiment of the automated storage and retrieval system, an extent of the footprint FV of the container handling vehicle in the X direction, LX, and Y direction, LY, is:

- LX = 1.0 grid cell in the X direction, and
- $1 < LY < 1.5$  grid cells in the Y direction,

wherein a grid cell is defined as the cross-sectional area, including width of the tracks, between two opposed rails running in the X direction and two opposed rails running in the Y direction.

In an embodiment of the automated storage and retrieval system, the second section extends less than 50 % into the neighboring grid opening, i.e. the footprint FV of the container handling vehicle may extend over one grid opening in the X direction and maximum 1,5 grid openings in the Y direction.

The container handling vehicle in the storage system according to the second aspect may comprise any of the features of the container handling vehicle of the first aspect.

In the following, numerous specific details are introduced by way of example only to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art, however, will recognize that these embodiments can be practiced without one or more of the specific details, or with other components, systems, etc. In other instances, well-known structures or operations are not shown, or are not described in detail, to avoid obscuring aspects of the disclosed embodiments.

In the present disclosure relative terms such as upper, lower, lateral, vertical, X-direction, Y-direction, Z-direction, etc., shall be interpreted using the above mentioned prior art storage system (fig. 1) as reference system. Therefore, the feature lateral in relation to the extension in the X-direction and Y-direction of the vehicle shall be understood to be the extension of the vehicle in the X-direction and Y-direction, e.g. the footprint of the vehicle in the X-direction and Y-direction.

### **Short description of the drawings**

Certain embodiments of the present invention will now be described in detail by way of example only and with reference to the following drawings:

Fig. 1 is a perspective side view of a prior art storage and retrieval system.

Fig. 2a and 2b depict two different prior art container handling vehicles.

Figs. 3 and 4A are top side schematic views of two types of rail systems for use in the storage system in fig. 1.

5            Fig. 4B and 4C are top views of two different track systems of the automated storage and retrieval systems;

Fig. 5A is a perspective side view of a lifting device which can be mounted in a container handling vehicle;

10           Figs. 5B, 5C, 5D show the footprints of the container handling vehicle FV, the first section F1 and the second section F2, where the footprint is shown by the shaded area, respectively;

Fig. 6A is an angled side view from above of a container handling vehicle;

15           Fig. 6B is a top view of a container handling vehicle and illustrates the extension in the X- and Y directions of the container handling vehicle on a rail system;

Fig. 7 is a top view of three container handling vehicles passing each other and operating on a rail system;

Fig. 8A is an angled view from below of an interior of the container handling vehicle with the lifting device in an upper position inside a first section;

20           Fig. 8B is an angled view from below of an interior of the container handling vehicle with the lifting device in a lower position extending downwardly from a first section;

Fig. 9 is a side view of a container handling vehicle with two batteries arranged in a second section;

25           Fig. 10A is a side view of a container handling vehicle where the covers are removed, the container handling vehicle has an exchangeable battery arranged inside a battery receiving unit in an upper portion of the container handling vehicle;

Fig. 10B is another view of Fig. 10A, where it is disclosed a motor assembly comprising a lifting device motor arranged in the second section;

30           Fig. 10C is another view of Fig. 10A, where it is disclosed a first battery and a second battery in the second section;

Fig 10D is a view from below of Fig. 10C;

Fig. 10E shows an example of container handling vehicle with a first battery with a lateral extension in the X and Y direction substantially equal to the lateral extension of an inner cross-sectional area of the second section;

5 Fig. 10F is perspective view of an alternative container handling vehicle of Fig. 10B, where a lifting device motor and gear can be seen in the second section;

Fig. 11A is a side view of two container handling vehicles passing each other in the X direction of a rail system;

Fig. 11B is a top view of Fig. 11A;

10 Fig. 11C is another side view of Fig. 11A, showing a gap between the two container handling vehicles passing each other in the X direction of the rail system;

Figs. 12A-C show differences in the center of gravity of the storage containers inside the storage container cavity relative the center of the footprint of the vehicle body, where Fig. 12A illustrates a prior art single cell robot, Fig. 12B is a prior art central cavity robot, and Fig. 12C shows the container handling vehicle  
15 according to the present invention;

Figs. 13A-C show differences in imaginary lines extending between opposed wheels of the same sets of wheels, and which of said lines which intersect or not intersect imaginary lines between other wheels, where Fig. 13A illustrates a prior art single cell robot, Fig. 13B is a prior art central cavity robot, and Fig. 13C shows  
20 the container handling vehicle according to the present invention;

In the drawings, like reference numbers have been used to indicate like parts, elements or features unless otherwise explicitly stated or implicitly understood from the context.

## 25 **Detailed description of the invention**

In the following, embodiments of the invention will be discussed in more detail by way of example only and with reference to the appended drawings. It should be understood, however, that the drawings are not intended to limit the invention to the subject-matter depicted in the drawings and that features described in one drawing  
30 are not necessarily dependent on presence of other features of the same drawing but can be combined with features from other drawings.

Referring to Figs. 3 to 4C, top views of two different rail systems of the automated storage and retrieval systems are shown.

35 The rail system forms a grid structure or grid pattern in the horizontal plane P., see fig. 1. The grid 4 comprises a plurality of rectangular and uniform grid locations or



grid cells 14 (see Fig. 4B), where each grid cell 14 comprises a grid opening 15 (i.e. the upper end of a storage column 12) which is delimited by a pair of opposed rails 10a, 10b of a first set of tracks and a pair of opposed rails 11a, 11b of a second set of tracks. The rails 10a,10b,11a,11b form a rail system 8 on which the container handling vehicle(s) 9' operate. In Fig. 4B, the grid cell 14 is indicated by a dashed box and the grid opening 15 is indicated by a hatched area.

Consequently, pairs of opposed rails 10a and 10b define parallel rows of grid cells running in the X direction, and pairs of opposed rails 11a and 11b extending perpendicular to rails 10a and 10b define parallel rows of grid cells running in the Y direction.

Each grid cell 14 has a width  $W_c$  which is typically within the interval of 30 to 150 cm, and a length  $L_c$  which is typically within the interval of 50 to 200 cm. Each grid cell 14 may be rectangular as shown such that  $W_c < L_c$ . Each grid opening 15 has a width  $W_o$  and a length  $L_o$  which is typically 2 to 10 cm less than the width  $W_c$ , and the length  $L_c$ , respectively, of the grid cell 14. This difference between  $W_c$  and  $W_o$  and between  $L_c$  and  $L_o$  corresponds to the width (i.e. the width of a set of tracks) of two opposed rails 10a,10b,11a,11b or, in effect, the width of a double-track rail since the grid cell extends to the midpoint of such a double-track rail (i.e. a double-track rail comprising 10a and 10b or 11a and 11b).

The double-track rail may be profiled to provide two parallel channels for the wheels of the container handling vehicle to run in.

Fig. 3 shows a prior art rail system featuring single-track rails 10, 11. When such a rail system is used, two container-handling vehicles are not allowed to pass each other at adjacent grid cells 14.

Where a single-track rail is used in one of the directions, then the boundary of the grid cell extends to the side of the track on the opposite side of the grid opening to the one being worked (neighboring grid cells will overlap by this track width in a similar way).

The rail system shown in Figs. 4B and 4C, features horizontal double-track rails. Consequently, each rail is capable of accommodating two wheels in parallel. In such a rail system, the borders between neighboring grid cells 14 run along the centre-line of the horizontal rails, as is indicated in Fig. 4B.

In Fig. 4C, grid cell 14, in the middle of the section of the illustrated grid system, comprises a grid opening/grid cell opening 15. To the left (West) of grid cell 14, there is an adjacent grid cell 14W comprising a grid opening 15W. Likewise, to the right (East) of grid cell 14, there is an adjacent grid cell 14E comprising a grid opening 15E. Also, below grid cell 14 (South), there is an adjacent grid cell 14S

comprising a grid opening 15S, and above grid cell 14 (North), there is an adjacent grid cell 14N comprising a grid opening 15N.

In Fig. 4C, a footprint 30 of a prior art container handling vehicle is schematically illustrated. In this embodiment the footprint 30 is defined by the horizontal extent of the wheels of the vehicle. As is evident from the figure, the footprint 30 has a horizontal extent which is less than the horizontal extent of a grid cell.

Fig. 5A is a perspective side view of parts of a lifting device 18 which can be mounted in a container handling vehicle and a container 6 to be lifted by the lifting device. The lifting device comprises a lifting frame 17, which is commonly connected to at least one rotatable lifting shaft via lifting bands, the lifting shaft arranged at an upper level within a cavity of the container handling vehicle. Fig. 5B shows the footprint, i.e. the dashed area in the Figure denoted FV, of an exemplary container handling vehicle 9' according to the invention. The footprint FV is equal to the lateral extent of the container handling vehicle 9' in both directions. The container handling vehicle 9' consists of a first section 204 and a second section 205.

Fig. 5C shows the footprint of the first section 204, i.e. the dashed area in the Figure denoted F1. In the disclosed embodiment, the first section comprises a cavity for accommodating a storage bin 6 and a lifting device 18 as shown in Fig. 5A.

Fig. 5D shows the footprint of the second section 205, i.e. the dashed area in the Figure denoted F2.

Fig. 6A is a perspective side view from above of a container handling vehicle 9'. The container handling vehicle 9' operates on a rail system 8, and is configured to move laterally in the X and Y directions indicated in the Figure. The X direction is perpendicular to the Y direction.

The vehicle 9' comprises a first set of wheels (not shown, see Fig. 8A) arranged at opposite portions of a vehicle body 13, for moving the vehicle 9' along a first direction X on a rail system 8 of a storage system 1, and a second set of wheels (only two of the wheels of the second set of wheels are shown, 202'', 202''') arranged at opposite portions of the vehicle body 13, for moving the vehicle 9' along a second direction Y on the rail system 8. The second direction Y is perpendicular to the first direction X. The first set of wheels is displaceable in a vertical direction Z between a first position and a second position. In the first position, the first set of wheels allow movement of the vehicle 9' along the first direction X, and in the second position, the second set of wheels allow movement of the vehicle 9' along the second direction Y. Structural details of suitable wheel

displacement assemblies for providing displaceable sets of wheels are disclosed in for instance WO2015/193278 A1 and WO2017/153583, the contents of which are incorporated by reference.

5 Fig. 6B is a top view of a container handling vehicle 9' of Fig. 6A and illustrates the extent in the X- and Y directions (LX and LY) of the container handling vehicle 9' on a rail system 8. The line C indicates a center line of the grid cell 14 and grid cell opening 15 in the Y direction. The footprint of the container handling vehicle 9' in the X direction (LX) is substantially equal to the dimension of the grid cell 14 in the X direction and the footprint of the container handling vehicle 9' in the Y direction (line LY) is larger than the dimension of the grid cell 14 in the Y direction such that part of the vehicle body extends into a neighboring cell (in the embodiment shown, this is a neighbouring cell to the left of the cell being worked). This extension of the vehicle body into the neighboring cell is of a size less than half the lateral extent in the Y direction of the grid cell opening in the neighboring cell, meaning that the length LY is more than 1.0 grid cell but less than 1.5 grid cells 14 in the Y direction ( $1.0 < LY < 1.5$  grid cells).

When operating on a rail system 8 as shown in Fig. 6B with rectangular grid cells 14, the footprint of the container handling vehicle 9' is substantially square because the extent of the grid cell 14 is longer in the X direction than in the Y direction and the container handling vehicle occupies more than one grid cell 14 in the Y direction and only one grid cell 14 in the X direction. A substantially square footprint has the advantage that the overall stability of vehicle 9' is improved compared to prior art solutions displaying a more rectangular footprint often in combination with a relatively high center of gravity.

Fig. 7 is a top view of three similar container handling vehicles 9' oriented in the same direction, passing each other and operating on a rail system 8 featuring dual-track rails as discussed above. As shown in the Figure, the container handling vehicles 9' have a footprint corresponding to the dimension of the grid cell 14 in the X direction allowing other container handling vehicles 9' travelling in the Y direction, to pass in neighboring cells (the container handling vehicles 9' occupying two rows of the rail system 8 as they pass by each other) on both sides of the vehicle 9'. However, because the size of the overlap into the neighboring cell is less than half the lateral extent of the grid cell in the Y direction, similar container handling vehicles 9' travelling in the X direction can pass each other occupying three rows.

40 The presence of the second section 205, makes it possible to utilize larger and stronger motors 203, see fig. 8A, for driving the wheels than in the prior art single

cell robot shown in fig. 2A, while at the same time keeping many of the advantages of such a robot.

As disclosed in Fig. 8A, the first section 204 accommodates a first 201', second 201'', third 201''' and fourth 201'''' wheel of the first set of wheels and a first 202' and second 202'' wheel of the second set of wheels, and the second section accommodates a third 202''' and fourth 202'''' wheel of the second set of wheels. This particular wheel arrangement is highly advantageous as it allows for the use of more powerful wheel hub motors 203 for driving the second 201'' and the fourth 201'''' wheel of the first set of wheels as well as the third 202''' fourth 202'''' wheel of the second set of wheels.

Alternatively, the second 201'' and fourth 201'''' wheel of the first set of wheels can be accommodated in the second section (not shown) provided the hub motors of said wheels are also arranged in the second section. To improve stability of the vehicle 9', the rim of the wheels 201', 201'', 202', 202'', 202''', 202'''' are preferably arranged at the corners of the vehicle 9'.

All of the wheels 201', 201'', 201''', 201'''', 202', 202'', 202''', 202'''' are preferably arranged inside the lateral extent LX, LY in the X and Y directions of the vehicle body 13 (see also description in relation to Fig. 9).

The first section 204 and the second section 205 may be fully separated by a physical barrier at the intersection between the first and second sections 204, 205, such as a wall or plate or similar. Alternatively, the first and second sections 204, 205 may be partly separated at the intersection between the first and second section 204, 205, for example by providing a barrier over parts of the intersection.

In Fig. 8A, the first and second section is separated by a wheel connecting element 212 (i.e. a connection plate or beam) to which the second 201'' and the fourth 201'''' wheel of the first set of wheels and their respective hub motors 203 are connected... The wheel connecting element 212 is part of a wheel displacement assembly 214, such that the the second 201'' and the fourth 201'''' wheel of the first set of wheels (together with the the first 201' and the third 201'' wheel of the first set of wheels) may be moved in a vertical direction.

In the disclosed embodiment, the the second 201'' and the fourth 201'''' wheels are accommodated in the first section 204, while the hub motors 203 extend into the second section. In an alternative embodiment, both the second 201'' and the fourth 201'''' wheels, as well as the hub motors, may be accommodated in the second section 205.

- It is noted that having the second 201'' and the fourth 201'''' wheel of the first set of wheels, as well as the third 202''' fourth 202'''' wheel of the second set of wheels, arranged such that their hub motors 203 extend/protrude into the second section 205 allows for the use of more powerful motors than would be the case if the hub motors were arranged such that they would extend into the first section 204. The remaining wheels, i.e. the wheels not featuring a hub motor extending into the second section, may either be passive or motorized, for instance motorized by in-wheel hub motors as disclosed in WO 2016/120075 A1.
- Fig. 8B is a perspective view from below of an interior of the container handling vehicle 9' showing the lifting frame 17 of the lifting device 18 in a lower position extending downwardly from the first section 204. The lifting device 18 may have similar features as the lifting device described in relation to Figs. 2A and 2B.
- Fig. 9 is a side view of a container handling vehicle with hub motors 203 and two batteries 213', 213'' arranged in the second section 205. As is clear from e.g. Fig. 9, the exterior facing side of the wheels may in one aspect be arranged such that they are not extending outside the vehicle body 13 (indicated by the dotted lines on each side of the vehicle 9' in Fig. 9). For example, the exterior facing sides of the wheels in the lateral X and Y directions may be flush with the vehicle body 13. Although not shown in Fig. 9 (but in Figs. 8A and 8B + 6B), the same applies to the wheels in the opposite direction (X), i.e. those wheels may also be arranged such that they are not extending outside the vehicle body 13.
- The vehicle body 13 includes any of the following elements, even if all are present or if some are missing, such as body frame, side cover panels or plates, wheel suspensions, housing for track sensors between the wheels etc. A rotating exterior surface of the wheels may thus be arranged in the same vertical plane as one of the walls in the vehicle body 13. Alternatively, the wheels may be arranged inside the vehicle body 13 such that the rotating exterior surfaces of the wheels can be laterally displaced relative a vertical plane formed by one of the walls in the vehicle body 13. In Fig. 6B, none of the wheels are visible in the top view, indicating that the outermost lateral parts of all wheels are arranged such that they are not extending outside the vehicle body 13.
- The container handling vehicle 9' may be provided with an interface 206 (see Fig. 8A) for charging of the batteries 213', 213'' in the container handling vehicle 9'.

At least four wheels are arranged within a downward projection area DP from the at least first battery 213', 213''. The downward projection area DP may represent the downward loads of the at least first battery 213', 213''.

As shown in Fig. 9, the downward projection area DP of the at least first battery 213', 213'' is preferably larger than the horizontal cross-sectional area of the at least first battery, but may also be substantially equal to the horizontal cross-sectional area of the at least first battery. In other words, because the at least first battery is arranged in the second section the weight of the at least first battery will at least be distributed to the at least four wheels arranged in, or close to the second section, illustrated as the second wheel 201'' and fourth wheel 201''' of the first set of wheels and the third wheel 202''' and the fourth wheel 202'''' of the second set of wheels.

This result in that the wheels do not have to be arranged directly vertically below the at least first battery but can also be arranged horizontally offset relative the at least first battery. This will be the case in situations where the at least first battery is not occupying a whole cross-sectional area of the second section.

Preferably, the at least four wheels are arranged such that at least some of the load(s) from the at least first battery is applied to each of the four wheels.

Preferable, the mutual relationship between the at least first battery and the four wheels is such that a weight from the at least first battery is substantially evenly distributed to the four wheels.

Fig. 10A is a side view of a container handling vehicle where the covers are removed, the container handling vehicle has an exchangeable battery 208 arranged inside a battery receiving unit 209 in an upper portion of the container handling vehicle. It is further disclosed a controller unit 210 which communicates with the overall control system. The controller unit 210 may further accommodate a capacitor power supply (not shown). The capacitor power supply typically has the ability to store enough power to operate any of the electrically driven components of the vehicle 9' if the main power supply malfunctions or is lost. Such situations may e.g. be when the battery 208 is to be exchanged. The battery exchange is typically taking place on two different locations, i.e. the battery to be replaced (the "empty" battery) is dropped off at a different location than where the replacement battery is picked up ("fully charged" battery), therefore the capacitor power supply may be used to move the robot between the two different locations. Alternatively, if the main battery malfunctions, the capacitor power supply can be used to operate the lifting device and/or move the robot to a service area. Furthermore, any regenerated power can be supplied to the capacitor power supply to ensure that the capacitor power supply has sufficient power capacity to perform any of its desired functions.

Fig. 10B is another view of Fig. 10A, where it is disclosed an assembly of motors comprising a lifting device motor 211 arranged in the second section 205. The lifting device motor 211 is connected at one end of a rotatable lifting shaft (not

shown) of a lifting device arranged in the first section. This lifting device motor 211 may replace other lifting device motor(s) (not shown) arranged in the first section or function as an auxiliary motor in addition to any lifting device motors arranged in the first section. Thus, the second section 205 makes it possible to reduce the  
 5 number of lifting device motor(s) in the first section to a minimum (even avoid the use of a lifting device motor in the first section) because the size and lifting capacity of the lifting device motor 211 arranged in the second section 205 is not limited by the available space of the first section. In other words, the lifting device motor 211 in the second section may be the sole lifting device motor of the vehicle,  
 10 such that the available space in a top section of the first section of the vehicle 9' is increased, or the motor 211 may be an auxiliary motor providing an increased lifting capacity to the lifting device.

Fig. 10C is another view of Fig. 10A, where it is disclosed a first battery 213' and a second battery 213'' in the second section 205. The inner cross-sectional area of the  
 15 second section 205 is the cross-sectional area spanning from the intersection (i.e. connection plate 212) between the first and second section to an outer wall of the second section in one lateral direction (e.g. Y direction) and between two opposing walls in the other lateral direction (e.g. X direction). As disclosed, both the first and second battery 213', 213'' are smaller than an inner (horizontal) cross-sectional  
 20 area of the second section 204.

Fig 10D is a view from below of Fig. 10C.

Fig. 10E shows an example of container handling vehicle with a first battery 213' with a lateral extension in the X and Y direction substantially equal to the lateral extension of an inner cross-sectional area of the second section 205.

Fig. 11A is a side view of two container handling vehicles 9' travelling in the X  
 25 direction of the rail system 8 passing each other using a total of three cells in the Y direction of the rail system 8. This particular rail system comprises single track rails in the X direction and double-track rails in the Y direction. The combination of single- and double-track rails may in some instances be the most cost-efficient  
 30 solution, even if a rail system using only double-track rails is optimal regarding the possible travel paths of the container-handling vehicles arranged thereon. Fig. 11B is a top view of Fig. 11A showing a gap G between the vehicle bodies 13 in the Y direction allowing the two vehicles 9' travelling in the X direction to occupy only three rows in the Y direction.

35 Figs. 12A-C are plan views showing differences in the center of gravity of the storage containers inside the storage container cavity relative the center of the footprint of the vehicle body, where Fig. 12 A illustrates a prior art single cell robot, Fig. 12B is a prior art central cavity robot, and Fig. 12C shows the container handling vehicle according to the present invention.

Fig. 12A Single cell and central cavity. The center of gravity of a storage container CGSC is in the center of the cavity which coincides with the center of the footprint of the vehicle body CGV.

5 Fig. 12B Central cavity. The center of gravity of a storage container CGSC is in the center of the cavity which coincides with the center of the footprint of the vehicle body CGV.

Fig. 12C shows the container handling vehicle according to the present invention, where the center of gravity of a storage container CGSC is displaced relative the center of the footprint of the vehicle body CGV.

10 Figs. 13A-C are plan views showing differences in imaginary lines extending between each of two pairs of opposed wheels in the same sets of wheels, and which of said lines which intersect or not intersect imaginary lines between other wheels, where Fig. 13A illustrates a prior art single cell robot, Fig. 13B is a prior art central cavity robot, and Fig. 13C shows the container handling vehicle according to the  
15 present invention.

Fig. 13A Single cell and central cavity. Each imaginary line L1, L2, L3, L4 extending between each of two pairs of opposed wheels in each set of wheels intersects two other imaginary lines L1, L2, L3, L4.

20 Fig. 13B Central cavity. None of the imaginary lines L1, L2, L3, L4 extending between each of two pairs of opposed wheels in each set of wheels intersects another imaginary line L1, L2, L3, L4.

Fig. 13C shows the container handling vehicle according to the present invention where imaginary lines L1, L2 between each of two pairs of opposed wheels in the first set of wheels intersect one imaginary line L3 extending between two wheels in  
25 the second set of wheels, and where one imaginary line L4 between two wheels in the second set of wheels does not intersect any imaginary lines.

The invention has been described with reference to the Figures, however the skilled person will understand that there may be made alterations or modifications to the described embodiments without departing from the scope of the invention as  
30 described in the attached claims.



## Reference numerals

(1) underlying storage system/frame structure	(201''') third wheel first set of wheels
(3) horizontal member	(201''''') fourth wheel first set of wheels
(4) three-dimensional grid, storage grid	(202') first wheel second set of wheels
(5) storage column	(202'') second wheel second set of wheels
(6, 6') storage container/storage bin	(202''') third wheel second set of wheels
(7) stacks	(202''''') fourth wheel second set of wheels
(8) rail system	(203) first motor
(9, 9') container handling vehicle, vehicle	(203) second motor
(10) first set of rails or tracks	(203) motor assembly
(11) second set of rails or tracks	(204) first section
(10, 10b) track in X direction	(205) second section
(11a, 11b) track in Y direction	(206) interface
(12) grid column	(208) battery
(12a, 12b) tracks	(209) battery receiving unit
(13) vehicle body	(210) controller unit
(14) grid cell	(211) lifting device motor
(14E) adjacent grid cell	(212) connection plate
(14N) adjacent grid cell	(213') batteries
(14S) adjacent grid cell	(214) wheel displacement assembly
(14W) adjacent grid cell	(DP) Downward projection
(15) grid opening/grid cell opening	(P) horizontal plane
(15E) grid opening	(X) first direction
(15N) grid opening	(Y) second direction
(15S) grid opening	(Z) vertical direction
	(FV) footprint of container handling vehicle

(15W) grid opening	(F1) footprint first section
(17) lifting frame	(F2) footprint second section
(18) lifting device	(G) Gap
(19) first port column	(L1) imaginary line
(19) drop-off port	(L2) imaginary line
(20) second port	(L3) imaginary line
(20) pick-up port	(L3) imaginary line
(21) cavity	(L4) imaginary line
(22) first set of wheels	(CGSC) center of gravity storage container
(23) second set of wheels	(CGV) center of footprint vehicle body
(30, 30') footprint prior art container handling vehicle	(LX) lateral extension, length X direction
(201') first wheel first set of wheels	(LY) lateral extension, length Y direction
(201'') second wheel first set of wheels	

## Claims

1. A container handling vehicle (9') for picking up storage containers (6) from a three-dimensional grid (4) of an underlying storage system (1), comprising:
  - a first set of wheels (14) arranged at opposite portions of a vehicle body (13), for moving the vehicle (9') along a first direction (X) on a rail system (8) in the grid (4);
  - a second set of wheels (15) arranged at opposite portions of the vehicle body (13), for moving the vehicle (9') along a second direction (Y) on the rail system (8) in the grid (4), the second direction (Y) being perpendicular to the first direction (X); wherein

the vehicle body (13) comprises vertical or substantially vertical walls on all sides forming a footprint defined by horizontal peripheries in the first and second directions (X,Y) of the vehicle body (13),

  - a first section and a second section arranged side-by-side such that a centre point of the first section is arranged off centre relative a centre point of the footprint formed by the vehicle body (13), and
  - wherein a size ratio of a footprint of the first section relative a footprint of the second section is at least 2:1, and wherein
  - the first section is configured to accommodate a storage container, and
  - the second section comprises at least a first battery (213', 213'').
2. The container handling vehicle according to claim 1, wherein the at least first battery (213', 213'') is fixed.
3. The container handling vehicle according to claim 1, wherein the at least first battery (213', 213'') is exchangeable.
4. The container handling vehicle according to any of the preceding claims further comprising a lifting device arranged at an upper level of the first section and wherein the at least first battery is arranged at or below the upper level.
5. The container handling vehicle according to any of the preceding claims wherein the first section has a rectangular footprint where two of the sides are longer than the two other sides, and wherein the second section is adjacent a long side of the first section.
6. The container handling vehicle according to any of the preceding claims, wherein the first section accommodates a first, second, third and fourth

wheel (201', 201'', 201''', 201''''') of the first set of wheels and a first (202') and second (202'') wheel of the second set of wheels, and the second section accommodates a third (202''') and fourth (202''''') wheel of the second set of wheels.

- 5        7. The container handling vehicle according to any of the claims 1-5, wherein the first section accommodates a first (201') and third (201''') wheel of the first set of wheels and a first (202') and second (202'') wheel of the second set of wheels, and the second section accommodates a second (201'') and a fourth (201''''') wheel of the first set of wheels and a third (202''') and a fourth (202''''') wheel of the second set of wheels.
- 10
- 15        8. The container handling vehicle according to claim 6 or claim 7, wherein the first section comprises four corners, and wherein an outer rim of the first (201'), second (201''), third (201''') and fourth (201''''') wheels of the first set of wheels and the first (202') and second (202'') wheels of the second set of wheels are arranged at or near each corner of the first section (204).
- 20        9. The container handling vehicle according to any of the preceding claims, further comprising at least a second battery (213'') arranged in the second section (205) above or below the first battery (213').
- 25        10. The container handling vehicle according to claim 8, wherein the at least four wheels (201'', 201''''', 202'', 202''''') in, or in connection with the second section (205), are arranged such that the weight of the at least first battery is at least distributed to the four wheels (201'', 201''''', 202'', 202''''').
- 30        11. The container handling vehicle according to claims 9 or 10, wherein the at least four wheels (201'', 201''''', 202'', 202''''') in, or in connection with the second section (205), are arranged substantially vertically below the at least first battery (213', 213'').
- 35        12. The container handling vehicle according to any of the preceding claims, comprising an exchangeable battery arranged in the first section (204).
13. The container handling vehicle according to any of the preceding claims, wherein the second section (205) comprises an assembly of motors comprising a first motor (203) for driving the first set of wheels and a second motor (203 for driving the second set of wheels.
14. The container handling vehicle (9') according to any of the preceding claims, wherein the size of the first section (204) corresponds to a grid cell (14) of a rail system (8) of an underlying storage and retrieval system, and wherein, during use, when the container handling vehicle (9') is in a position to lift or

lower a storage container (6), the second section (205) is horizontally displaced relative the grid cell (14) and extends partly into a neighboring grid cell (14).

- 5 15. An automated storage and retrieval system comprising a three-dimensional grid (4) and at least one container handling vehicle (9'), the grid comprises a rail system (8), on which the container handling vehicle may move, and a plurality of stacks of storage containers (7);
- 10 - the rail system (8) comprises a first set of parallel tracks (10) arranged in a horizontal plane (P) and extending in a first direction (X), and a second set of parallel tracks (11) arranged in the horizontal plane (P) and extending in a second direction (Y) which is orthogonal to the first direction (X), wherein the first and second sets of tracks (10,11) form a grid pattern in the horizontal plane (P) comprising a plurality of adjacent grid cells (14), each grid cell comprising a grid opening (15) defined by a pair of opposed tracks (10a,10b) of the first set of tracks (10) and a pair of opposed tracks (10a,10b) of the second set of tracks (11);
- 15 - the plurality of stacks (7) of storage containers (6) are arranged in storage columns (5) located beneath the rail system (8), wherein each storage column (5) is located vertically below a grid opening (15);
- 20 - the container handling vehicle (9') features a vehicle body (13) comprising substantially vertical walls on all sides forming a footprint defined by horizontal peripheries in the first and second directions (X,Y) of the vehicle body (13), and a first section (204) and a second section (205) arranged side-by-side, wherein a centre point of a footprint of the first section is arranged off centre relative a centre point of the footprint formed by the vehicle body (13), and
- 25 - wherein a size ratio of the footprint of the first section relative a footprint of the second section is at least 2:1;
- 30 - the first section (204) is configured to accommodate a storage container (6); and
- 35 - the second section (205) comprises at least a first battery (213', 213'') for driving at least one wheel of each of the sets of wheels, wherein
- 40 the footprint (F1) of the first section (204) is substantially equal to a grid cell (14) defined by a cross-sectional area, including width of the tracks, between a pair of opposed tracks (10a,10b) of the first set of tracks (10) and a pair of

opposed tracks (10a,10b) of the second set of tracks (11), and the second section (205) extends partially into a neighboring grid cell (14) when the first section is positioned over an adjacent grid opening (15).

- 5           16. The automated storage and retrieval system according to claim 15, wherein an extent of the footprint FV of the container handling vehicle (9') in the first direction (X), LX, and second direction (Y), LY, is:
- LX = 1.0 grid cell (14) in the first direction (X), and
  - $1 < LY < 1.5$  grid cells (14) in the second direction (Y),
- 10           wherein a grid cell (14) is defined as the cross-sectional area, including width of the tracks, between the midpoint of two rails running in the first direction (X) and the midpoint of two rails running in the second direction (Y).
- 15           17. The automated storage and retrieval system according to claim 15 or 16, wherein the second section (205) protrudes less than 50% into the neighboring grid cell (14).

## Patentkrav

1. Et containerhåndteringskjøretøy (9') for å plukke opp lagringscontainere (6) fra et tredimensjonalt rutenett (4) i et underliggende lagersystem (1), omfattende:
  - et første hjulsett (14) anordnet på motsatte deler av en kjøretøyskropp (13), for å bevege kjøretøyet (9') langs en første retning (X) på et skinnesystem (8) til rutenettet (4);
  - et andre hjulsett (15) anordnet på motsatte deler av kjøretøyskroppen (13), for å bevege kjøretøyet (9') langs en andre retning (Y) på skinnesystemet (8) til rutenettet (4), den andre retningen (Y) er perpendikulær på den første retningen (X); hvor

kjøretøyskroppen (13) omfatter vertikale eller hovedsakelig vertikale vegger på alle sider som danner et fotavtrykk definert av horisontale periferier i de første og andre retningene (X,Y) av kjøretøyskroppen (13),

  - en første seksjon og en andre seksjon anordnet side-ved-side slik at et senterpunkt av den første seksjonen er anordnet ute av senter relativt et senterpunkt av fotavtrykket dannet av kjøretøyskroppen (13), og
  - hvor et størrelsesforhold av et fotavtrykk til den første seksjonen relativt et fotavtrykk til den andre seksjonen er minst 2:1, og hvor
  - den første seksjonen er konfigurert til å akkommodere en lagringscontainer, og
  - den andre seksjonen omfatter minst et første batteri (213', 213'').
2. Containerhåndteringskjøretøyet ifølge krav 1, hvor det minst første batteriet (213', 213'') er fast montert.
3. Containerhåndteringskjøretøyet ifølge krav 1, hvor det minst første batteriet (213', 213'') er utbyttbart.
4. Containerhåndteringskjøretøyet ifølge hvilke som helst av de foregående kravene videre omfattende en løfteanordning anordnet ved et øvre nivå av den første seksjonen og hvor det minst første batteriet er anordnet ved eller under det øvre nivået.
5. Containerhåndteringskjøretøyet ifølge hvilke som helst av de foregående kravene hvor den første seksjonen har et rektangulært fotavtrykk hvor to av sidene er lengre enn de to andre sidene, og hvor den andre seksjonen er tilliggende en langside av den første seksjonen.

6. Containerhåndteringskjøretøyet ifølge hvilke som helst av de foregående kravene, hvor den første seksjonen akkommoderer et første, andre, tredje og fjerde hjul (201', 201'', 201''', 201''''') i det første hjulsettet og et første (202') og andre (202'') hjul i det andre hjulsettet, og den andre seksjonen akkommoderer et tredje (202''') og fjerde (202''''') hjul i det andre hjulsettet.
7. Containerhåndteringskjøretøyet ifølge hvilke som helst av kravene 1-5, hvor den første seksjonen akkommoderer et første (201') og tredje (201''') hjul i det første hjulsettet og et første (202') og andre (202'') hjul i det andre hjulsettet, og den andre seksjonen akkommoderer et andre (201'') og et fjerde (201''''') hjul i det første hjulsettet og et tredje (202''') og et fjerde (202''''') hjul i det andre hjulsettet.
8. Containerhåndteringskjøretøyet ifølge krav 6 eller krav 7, hvor den første seksjonen omfatter fire hjørner, og hvor en ytre rand av de første (201'), andre (201''), tredje (201''') og fjerde (201''''') hjulene i det første hjulsettet og de første (202') og andre (202'') hjulene i det andre hjulsettet er anordnet ved eller nært hvert hjørne av den første seksjonen (204).
9. Containerhåndteringskjøretøyet ifølge hvilke som helst av de foregående kravene, videre omfattende minst et andre batteri (213'') anordnet i den andre seksjonen (205) over eller under det første batteriet (213').
10. Containerhåndteringskjøretøyet ifølge krav 8, hvor de minst fire hjulene (201'', 201''''', 202''', 202''''') i, eller i forbindelse med den andre seksjonen (205), er anordnet slik at vekten av det minst første batteriet er i det minste distribuert til de fire hjulene (201'', 201''''', 202''', 202''''').
11. Containerhåndteringskjøretøyet ifølge krav 9 eller 10, hvor de minst fire hjulene (201'', 201''''', 202''', 202''''') i, eller i forbindelse med den andre seksjonen (205), er anordnet hovedsakelig vertikalt under det minst første batteriet (213', 213'').
12. Containerhåndteringskjøretøyet ifølge hvilke som helst av de foregående kravene, omfattende et utbyttbart batteri anordnet i den første seksjonen (204).
13. Containerhåndteringskjøretøyet ifølge hvilke som helst av de foregående kravene, hvor den andre seksjonen (205) omfatter en sammenstilling av motorer omfattende en første motor (203) for å drive det første hjulsettet og en andre motor (203 for å drive det andre hjulsettet.
14. Containerhåndteringskjøretøyet (9') ifølge hvilke som helst av de foregående kravene, hvor størrelsen til den første seksjonen (204) korresponderer med en rutenettcelle (14) i et skinnesystem (8) i et underliggende lagrings- og opphentingssystem, og hvor, i bruk, når containerhåndteringskjøretøyet (9') er i



en posisjon til å løfte eller senke en lagringscontainer (6), er den andre seksjonen (205) horisontalt forskjøvet relativt rutenettcellen (14) og strekker seg delvis inn i en nabo-rutenettcelle (14).

15. Et automatisert lagrings- og opphentingssystem omfattende et tredimensjonalt rutenett (4) og minst ett containerhåndteringskjøretøy (9'), rutenettet omfatter et skinneresystem (8), på hvilket containerhåndteringskjøretøyet kan bevege seg, og et flertall stabler med lagringscontainere (7);

- skinneresystemet (8) omfatter et første sett parallelle spor (10) anordnet i et horisontalt plan (P) og forløpende i en første retning (X), og et andre sett parallelle spor (11) anordnet i det horisontale planet (P) og forløpende i en andre retning (Y) som er ortogonal på den første retningen (X), hvor de første og andre sett spor (10,11) danner et rutenettmønster i det horisontale planet (P) omfattende et flertall tiliggende rutenettceller (14), hver rutenettcelle omfatter en rutenettåpning (15) definert av et par motstående spor (10a,10b) av det første settet spor (10) og et par motstående spor (10a,10b) av det andre settet spor (11);
- flertallet av stabler (7) med lagringscontainere (6) er anordnet i lagringskolonner (5) lokalisert under skinneresystemet (8), hvor hver lagringskolonne (5) er lokalisert vertikalt under en rutenettåpning (15);
- containerhåndteringskjøretøyet (9') har en kjøretøyskropp (13) omfattende hovedsakelig vertikale vegger på alle sider som danner et fotavtrykk definert av horisontale periferier i de første og andre retningene (X,Y) til kjøretøyskroppen (13), og en første seksjon (204) og en andre seksjon (205) anordnet side-ved-side, hvor et senterpunkt av et fotavtrykk til den første seksjonen (204) er anordnet ute av senter relativt et senterpunkt av fotavtrykket (FV) til kjøretøyskroppen (13), og
- hvor et størrelsesforhold til fotavtrykket til den første seksjonen relativt et fotavtrykk til den andre seksjonen er minst 2:1;
  - den første seksjonen (204) er konfigurert til å akkommodere en lagringscontainer (6); og
  - den andre seksjonen (205) omfatter minst et første batteri (213', 213'') for å drive minst ett hjul i hvert av hjulsettene, hvor

fotavtrykket (F1) til den første seksjonen (204) er hovedsakelig likt som en rutenettcelle (14) definert av et tverrsnittsareal, inkludert bredden til sporene, mellom et par av motstående spor (10a,10b) av det første settet spor (10) og et par motstående spor (10a,10b) av det andre settet spor (11), og den andre seksjonen (205) strekker seg delvis inn i en nabo-rutenettcelle (14) når den første seksjonen er posisjonert over en tiliggende rutenettåpning (15).

16. Det automatiserte lagrings- og opphentingssystemet ifølge krav 15, hvor en utstrekning av fotavtrykket (FV) til containerhåndteringskjøretøyet (9') i den første retningen (X), LX, og den andre retningen (Y), LY, er:
- LX = 1.0 rutenettcelle (14) i den første retningen (X), og
  - $1 < LY < 1.5$  rutenettceller (14) i den andre retningen (Y),
- hvor en rutenettcelle (14) er definert som tverrsnittsarealet, inkludert bredden til sporene, mellom midtpunktet av to spor om løper i den første retningen (X) og midtpunktet mellom to spor som løper i den andre retningen (Y).
17. Det automatiserte lagrings- og opphentingssystemet ifølge krav 15 eller 16, hvor den andre seksjonen (205) stikker ut mindre enn 50% inn i en nabo-rutenettcelle (14).

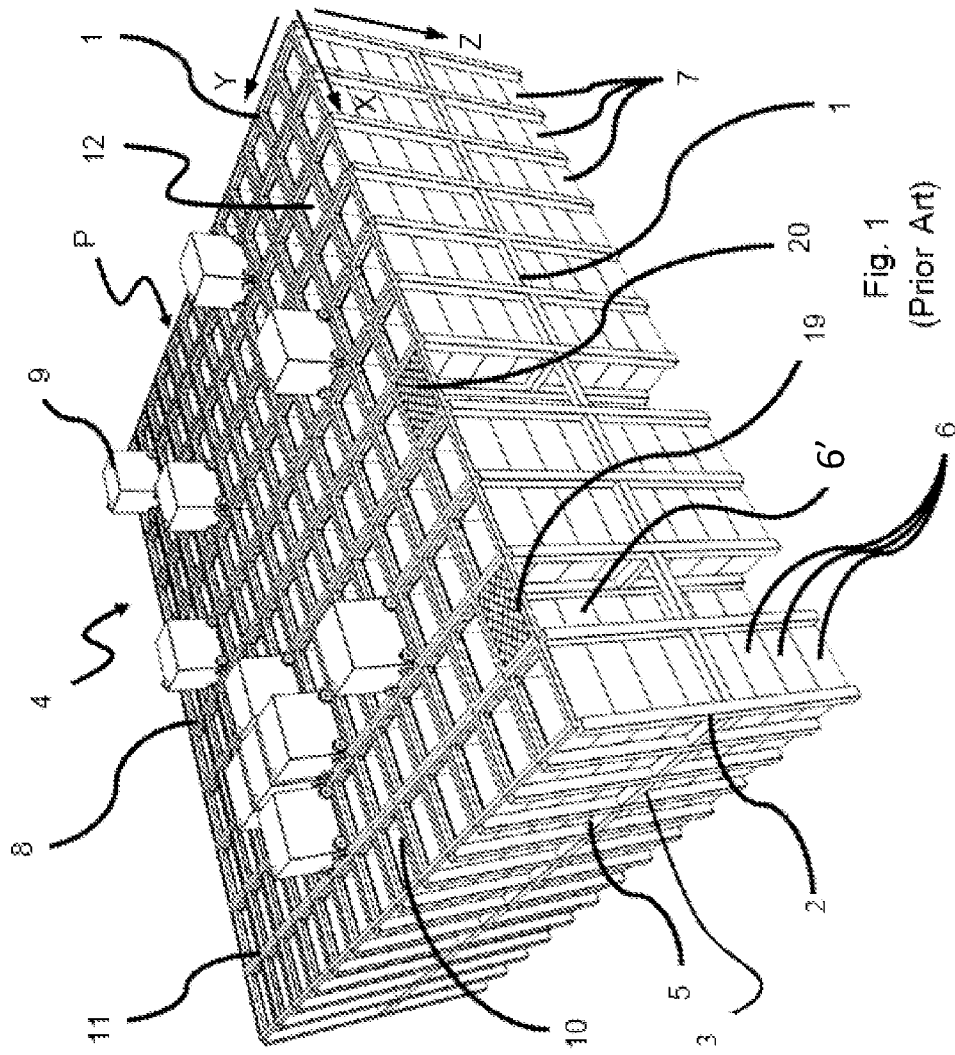


Fig. 1  
(Prior Art)

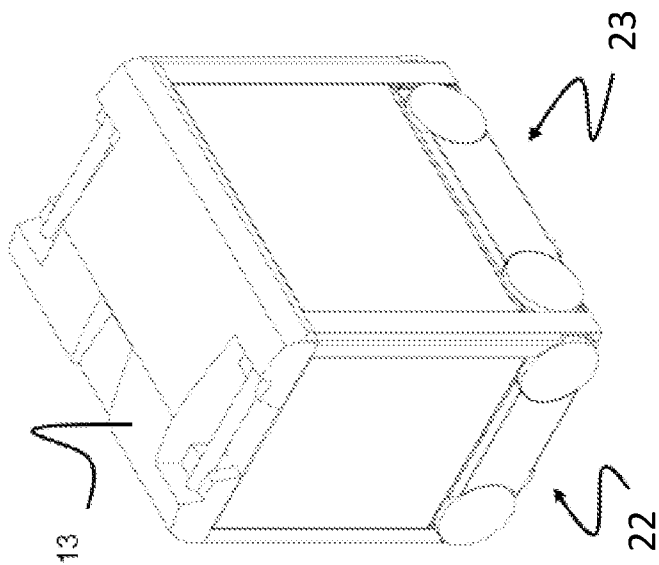


Fig. 2A  
(Prior Art)

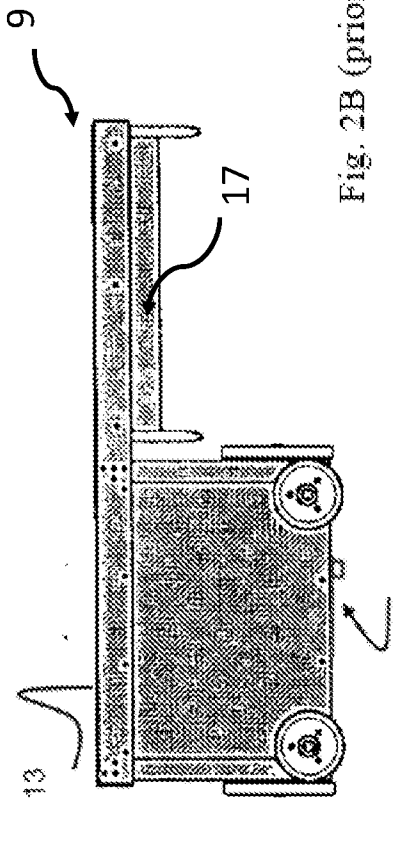


Fig. 2B (prior art)

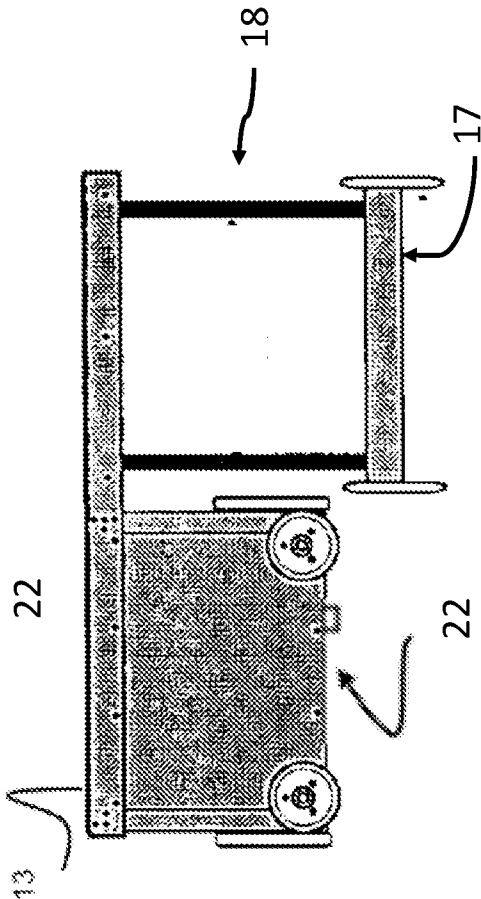


Fig. 2C (prior art)

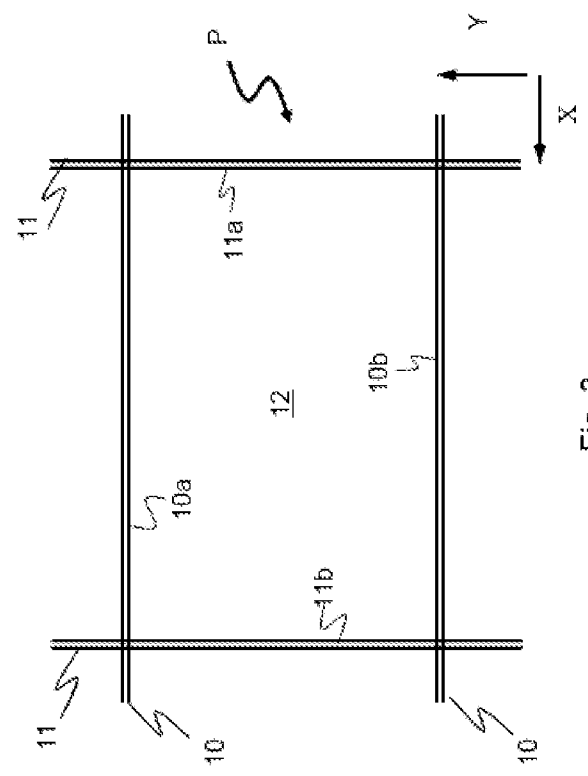


Fig. 3  
(Prior Art)

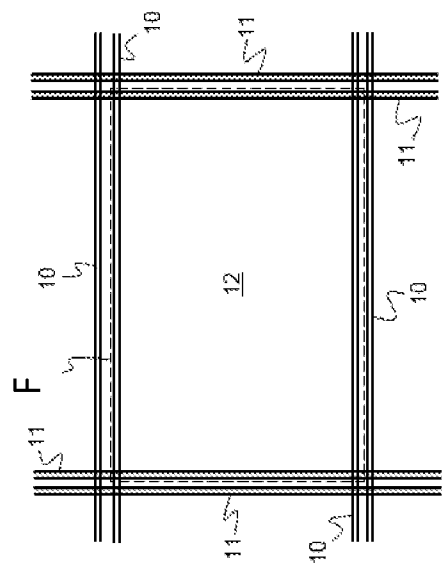


Fig. 4A  
(Prior Art)

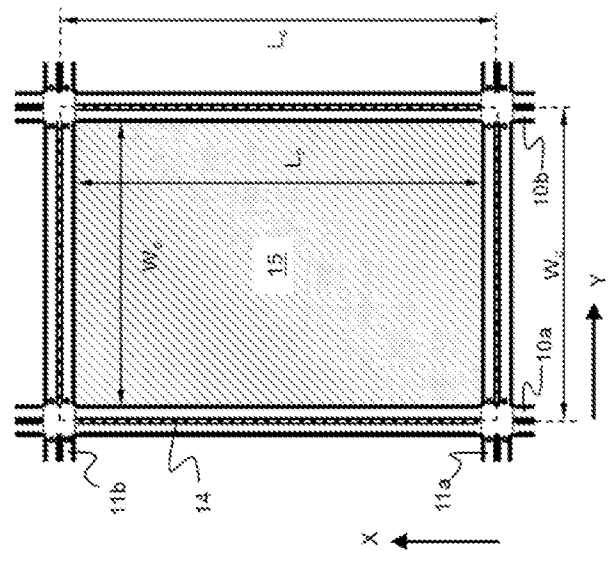


Fig. 4B

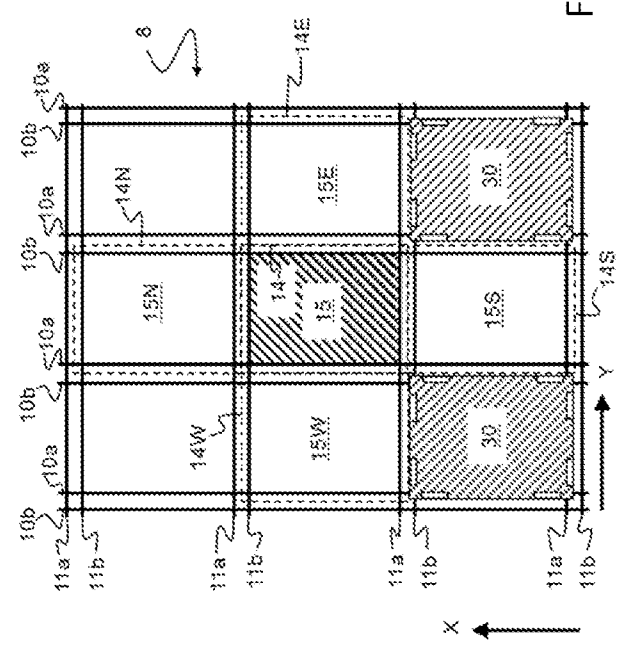


Fig. 4C

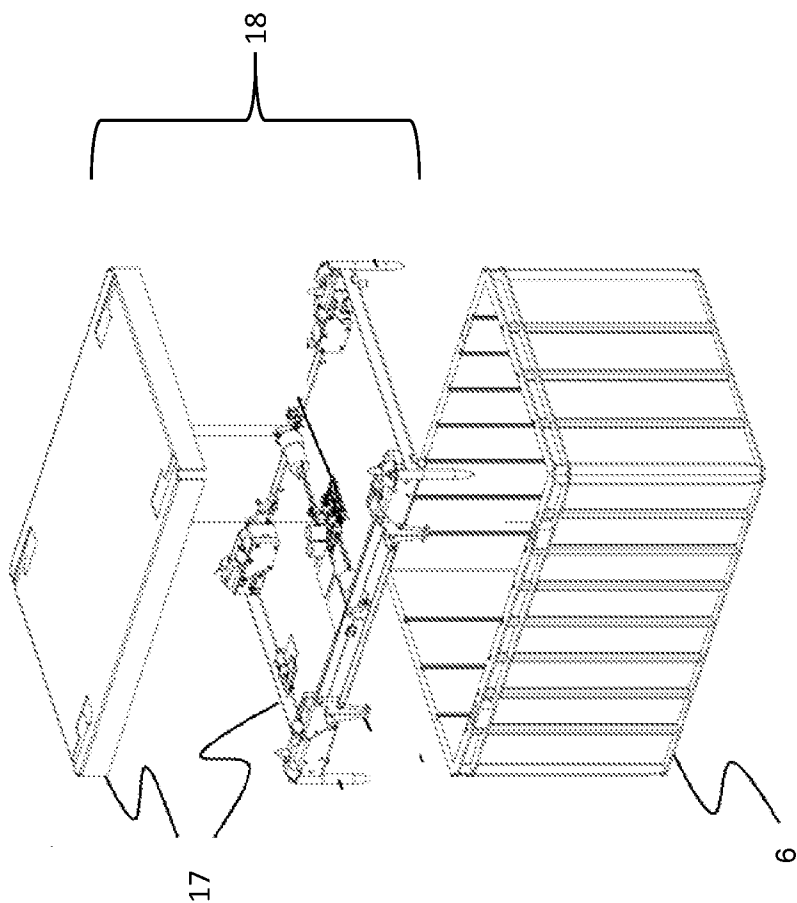
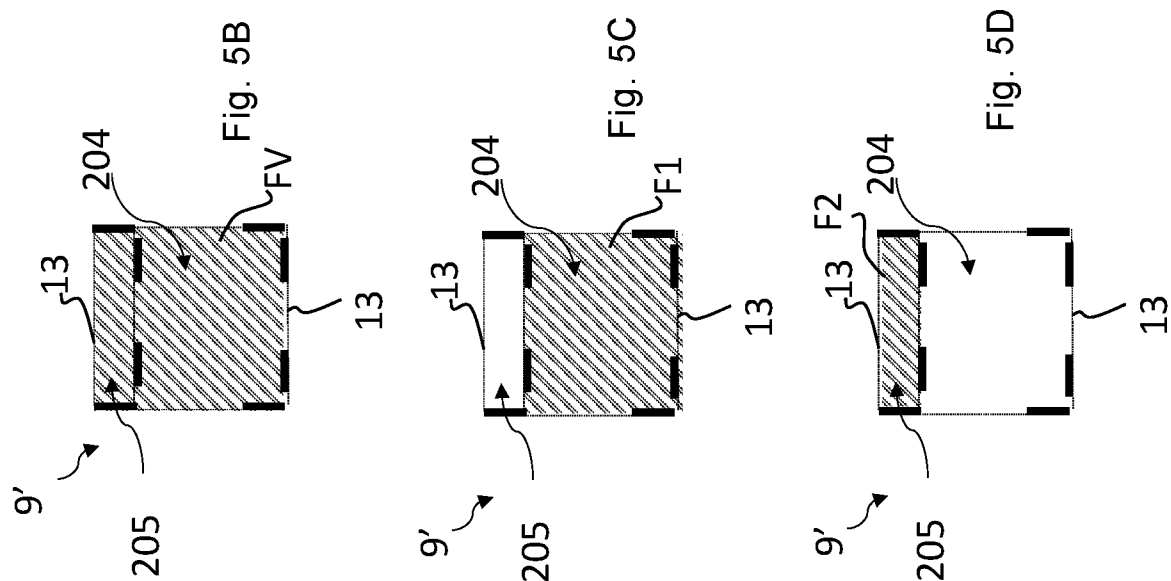
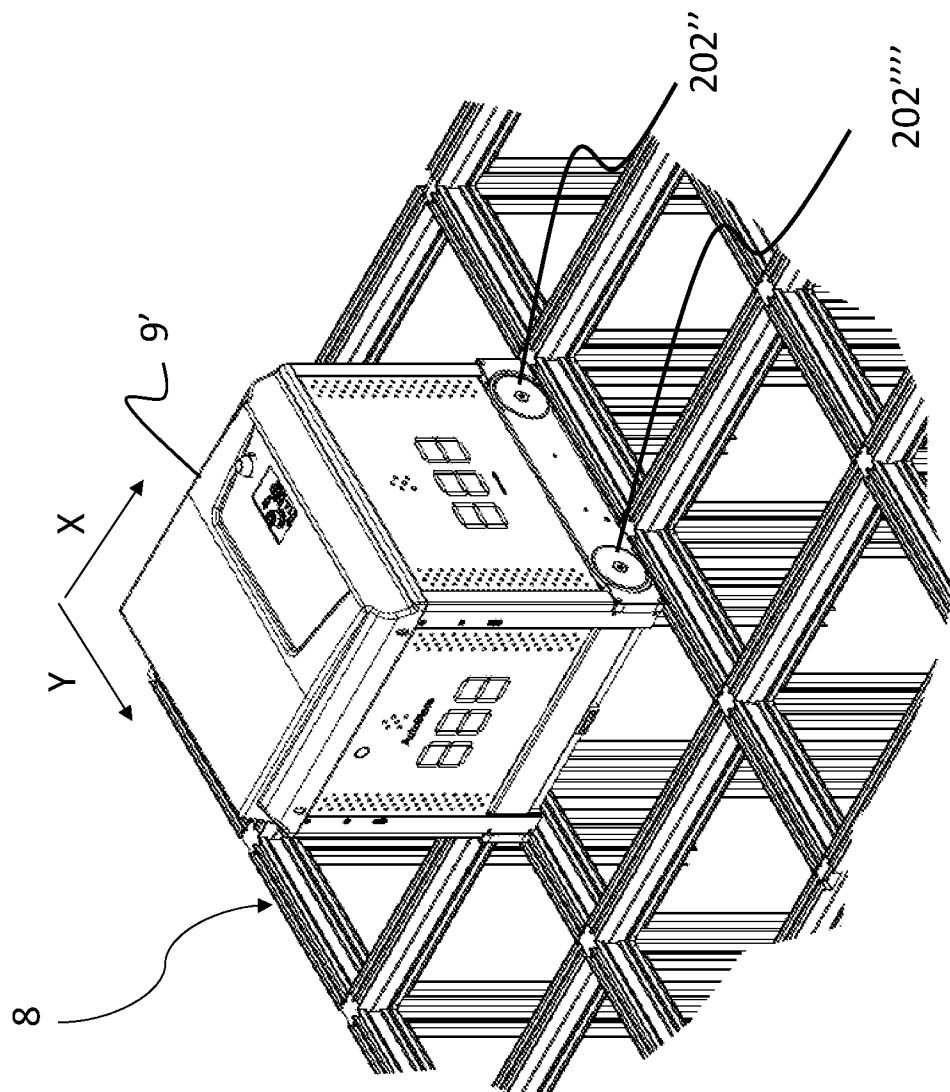
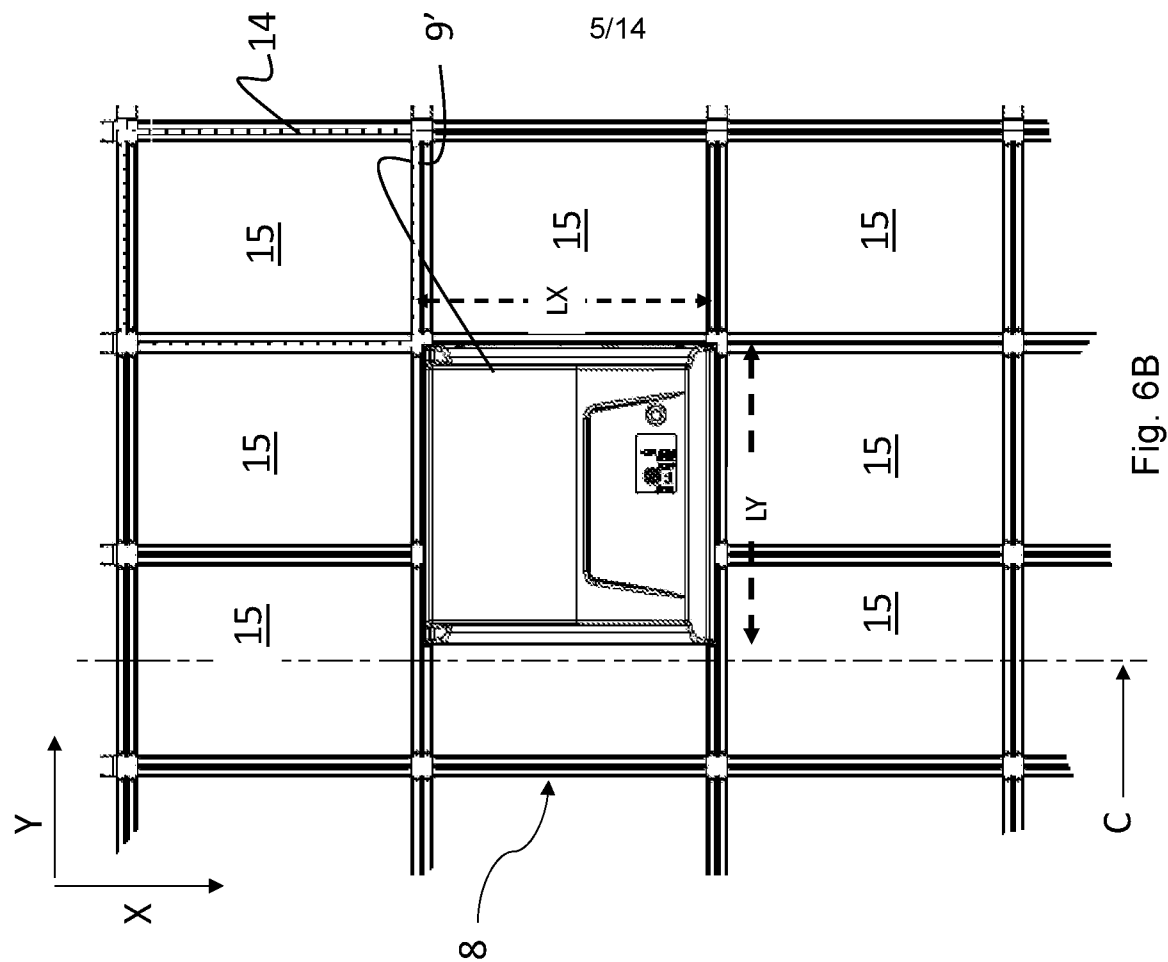
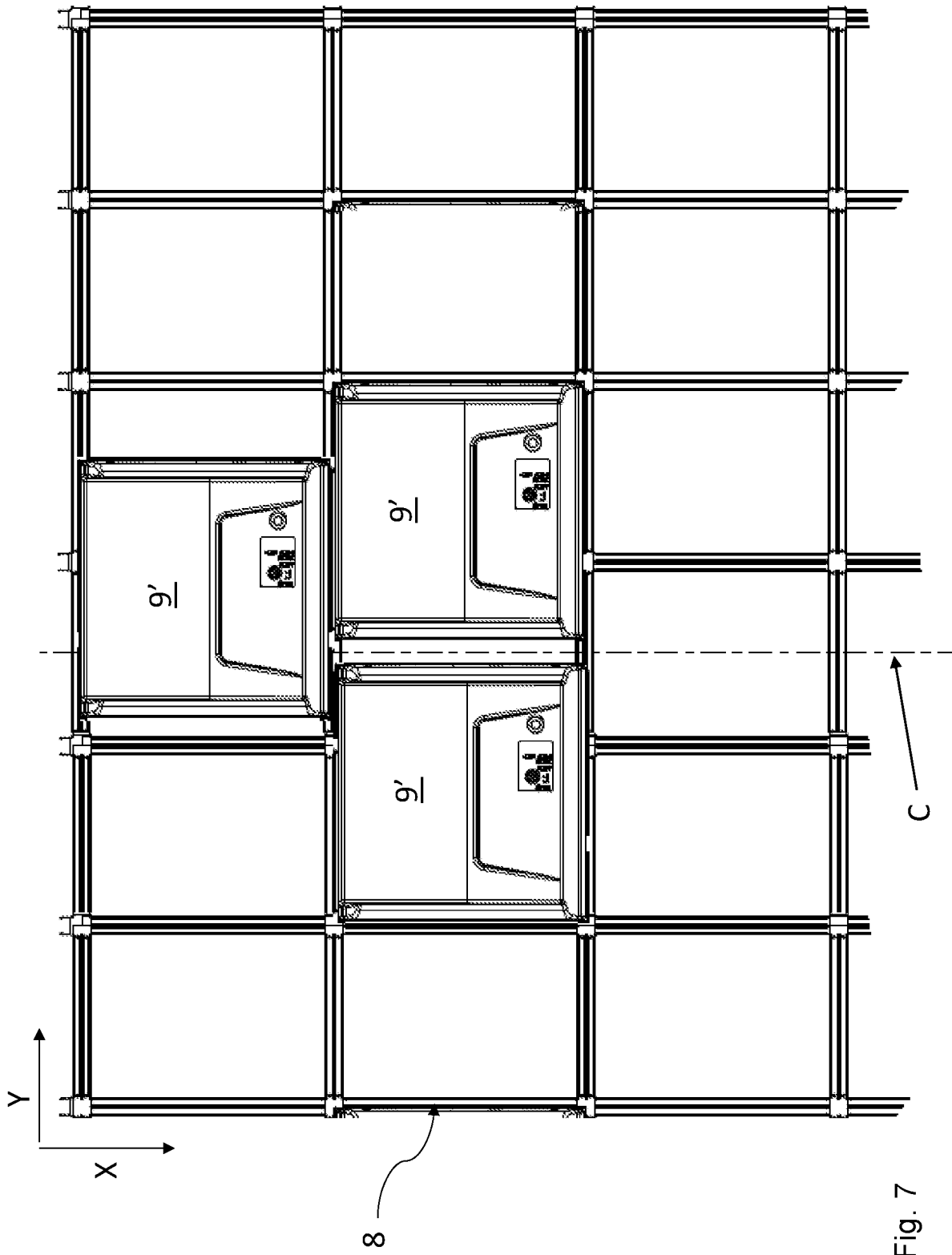


Fig. 5A







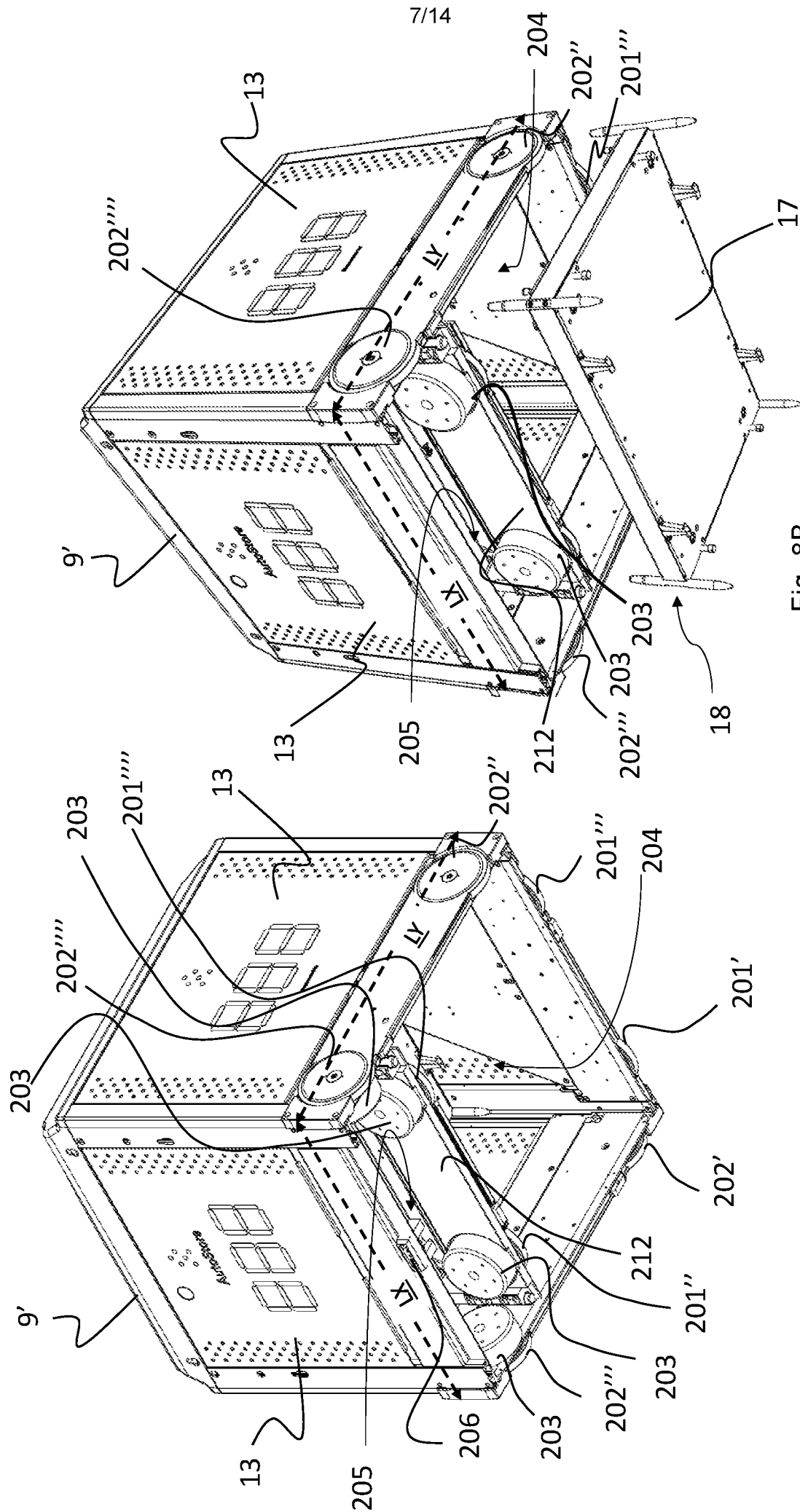


Fig. 8B

Fig. 8A

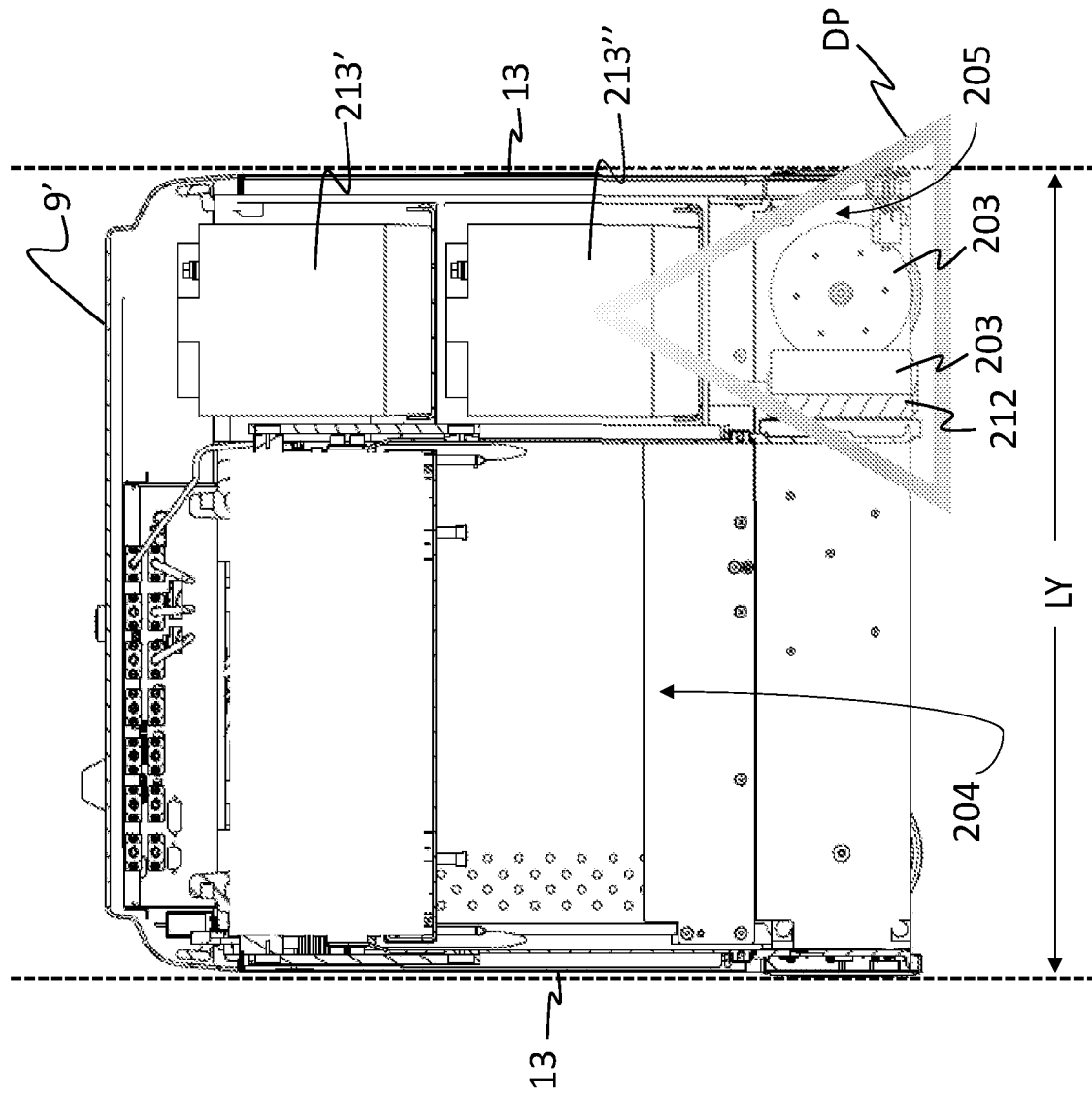


Fig. 9

9/14

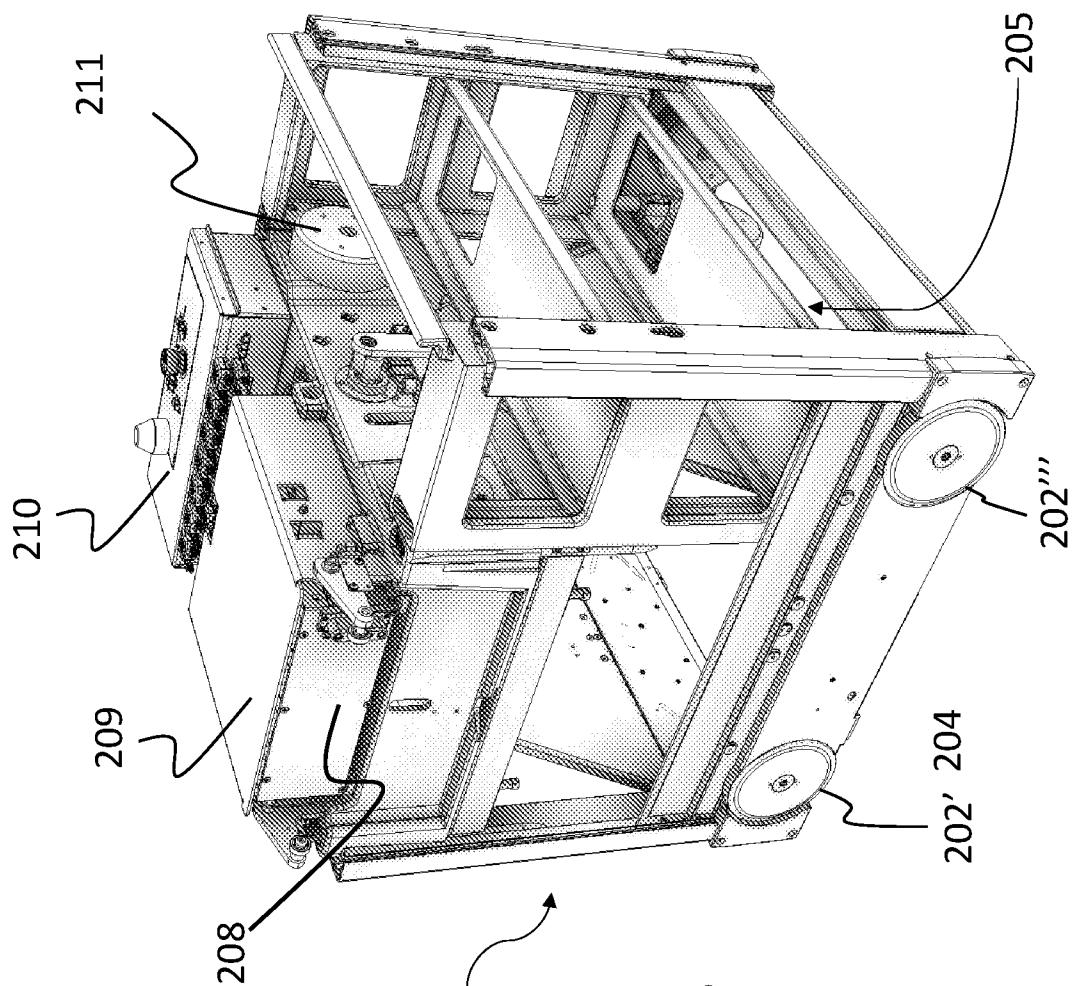


Fig. 10B

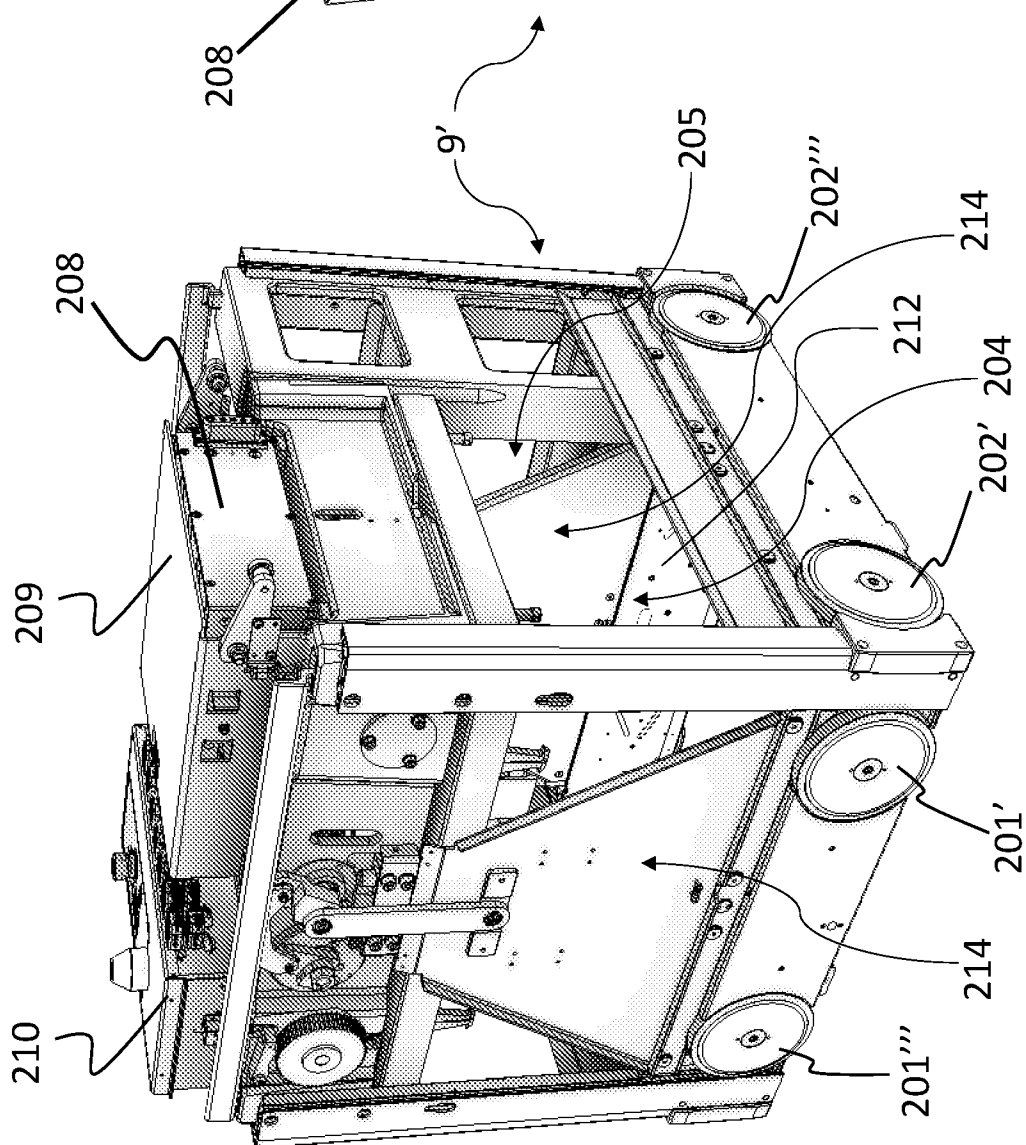
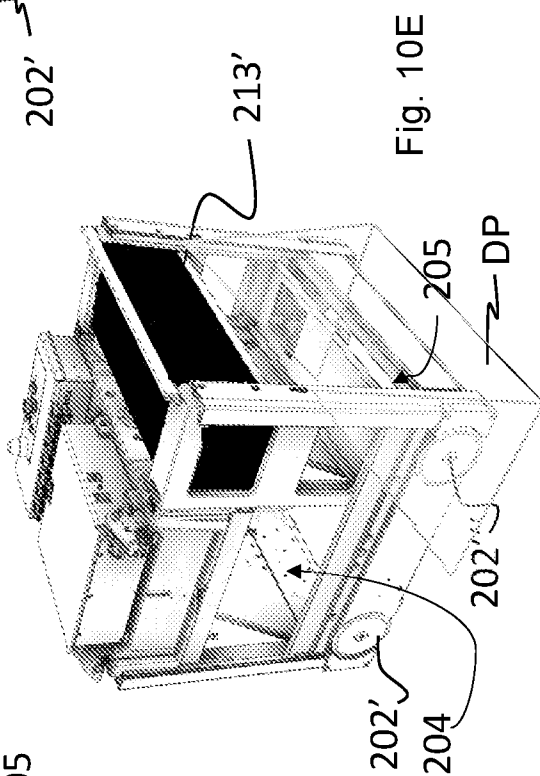
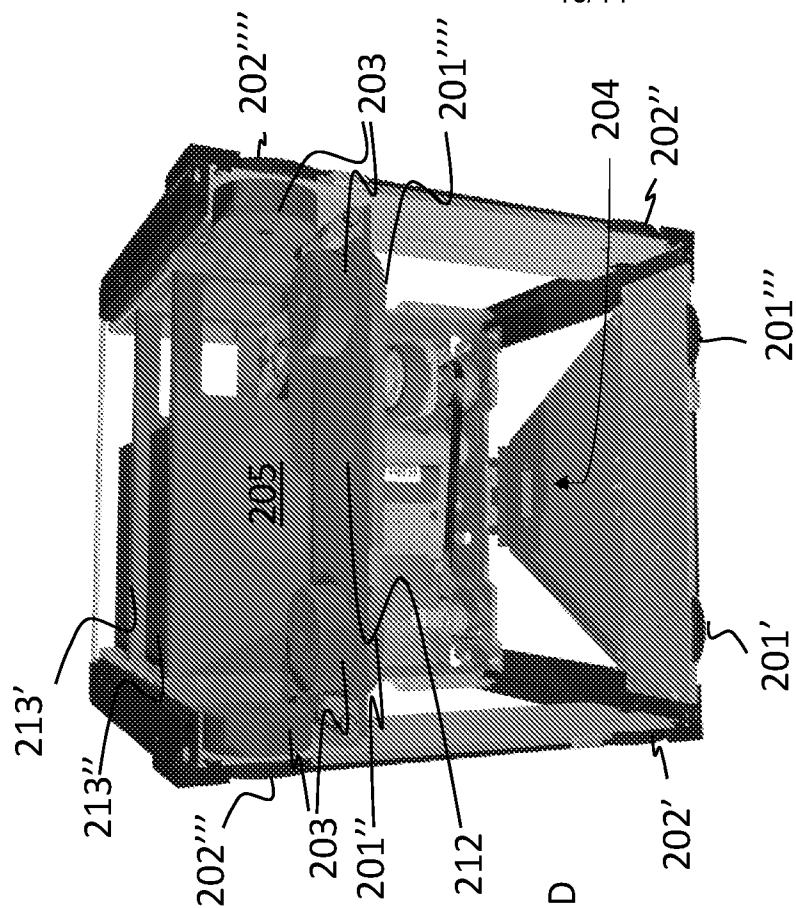
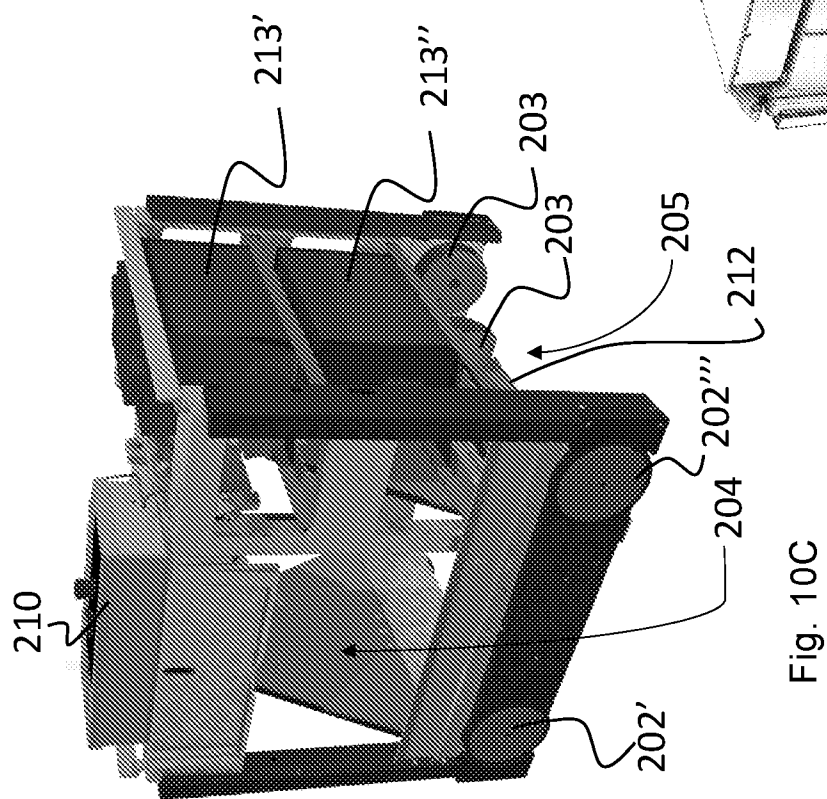


Fig. 10A



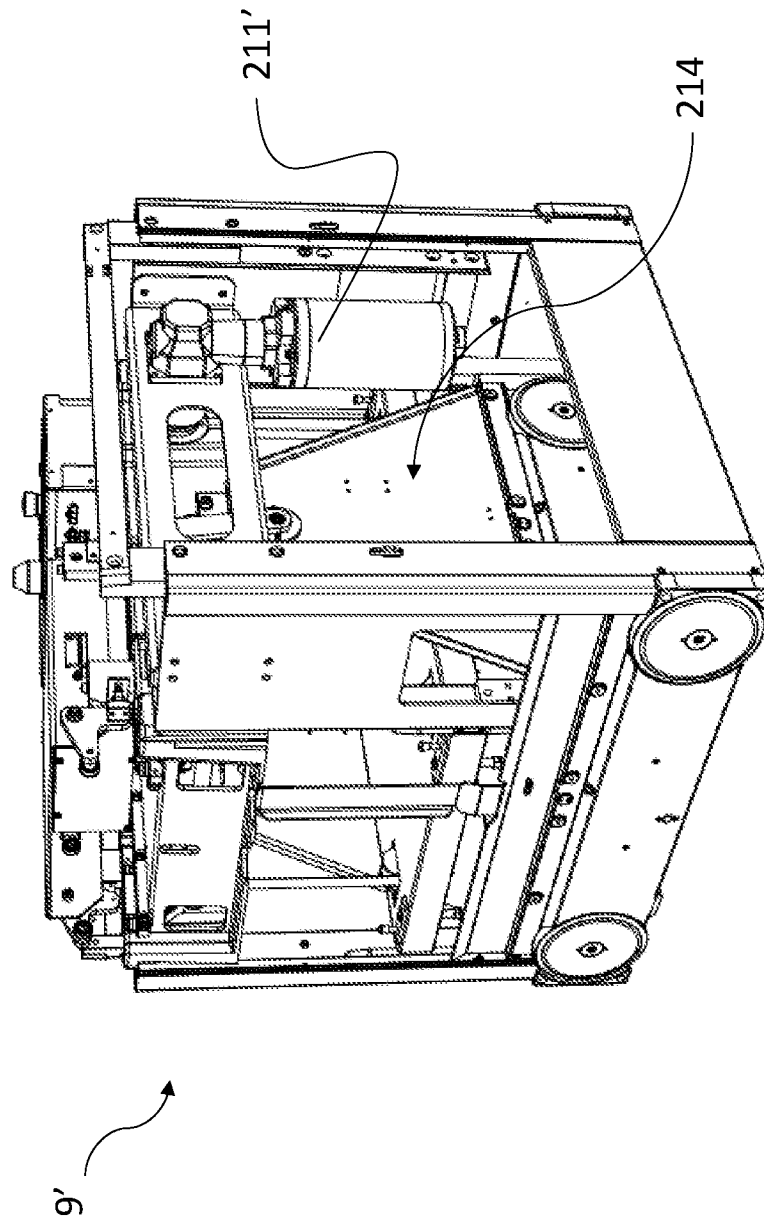


Fig. 10F

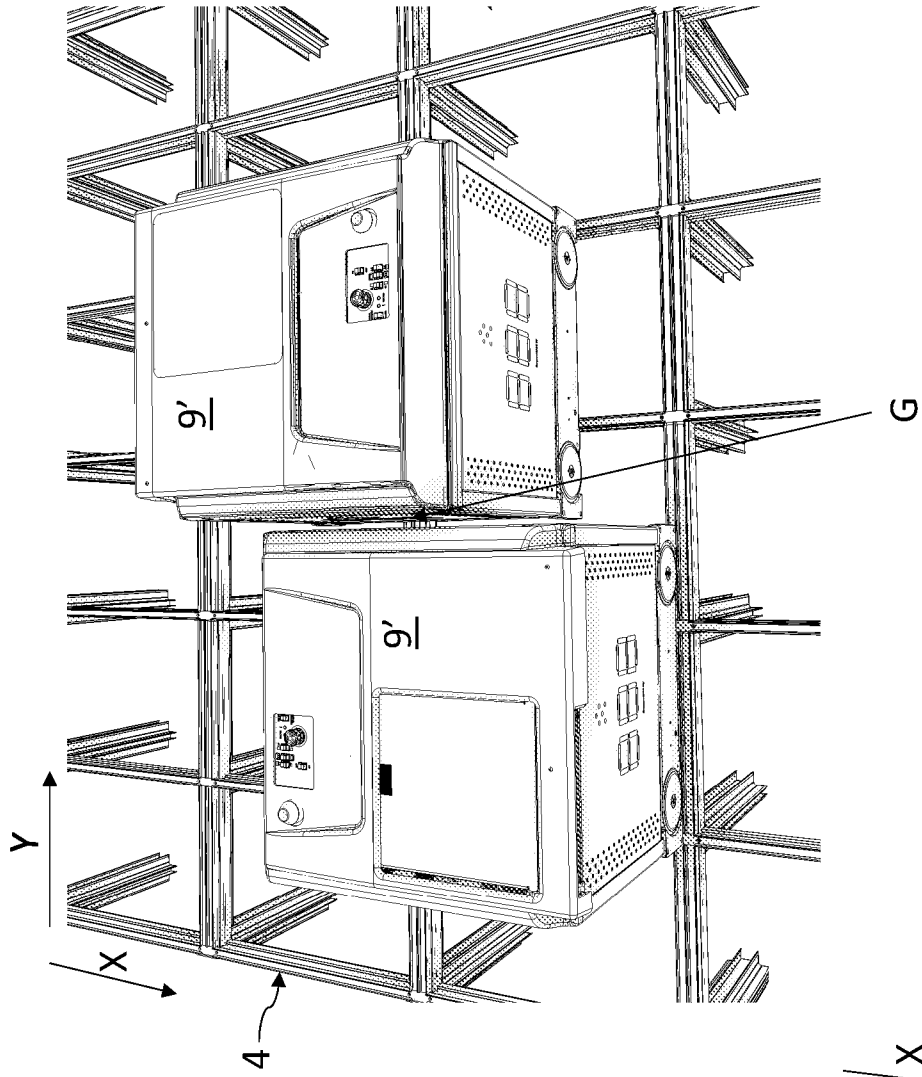


Fig. 11B

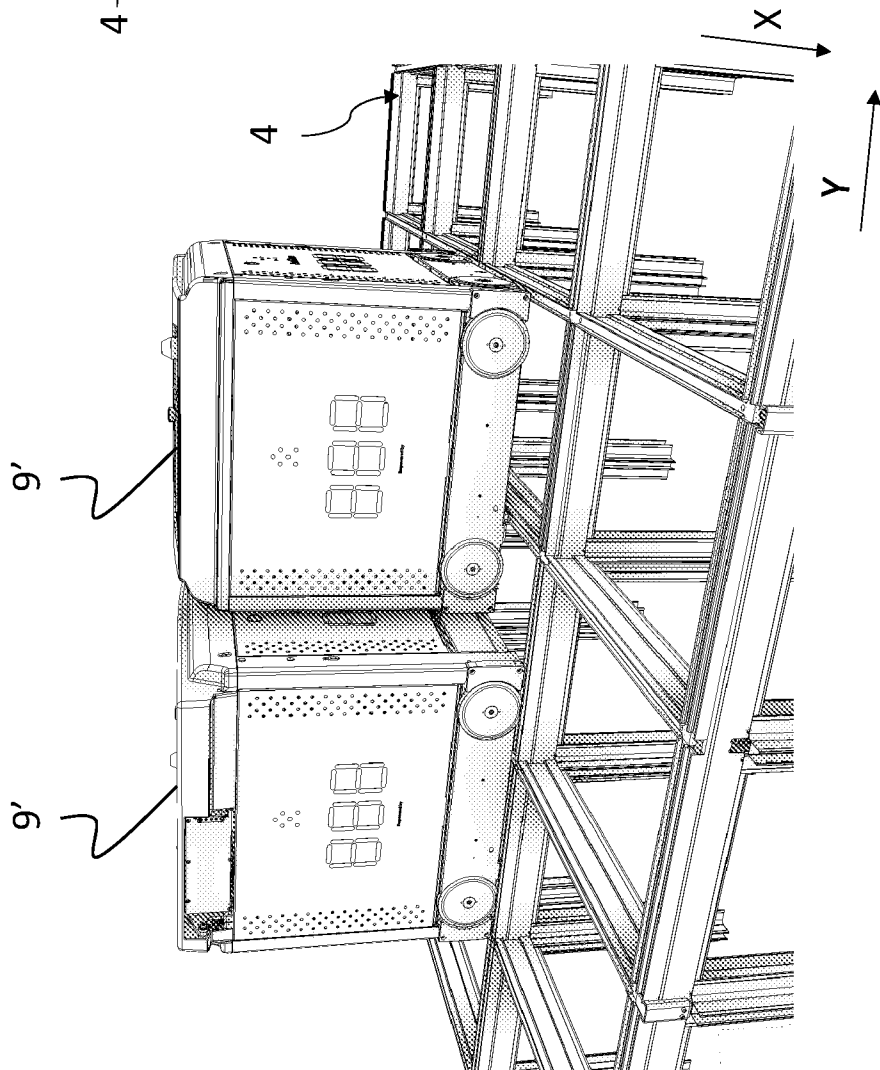


Fig. 11A

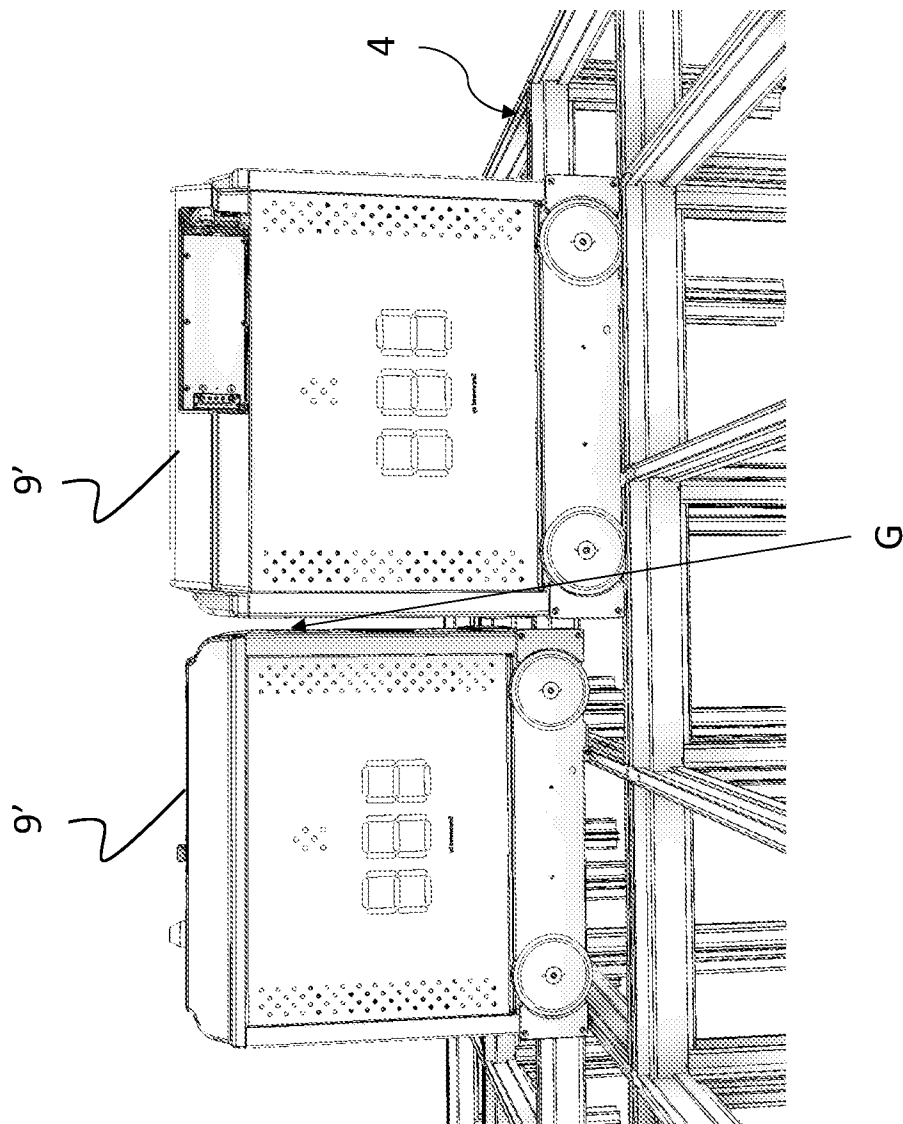


Fig. 11C

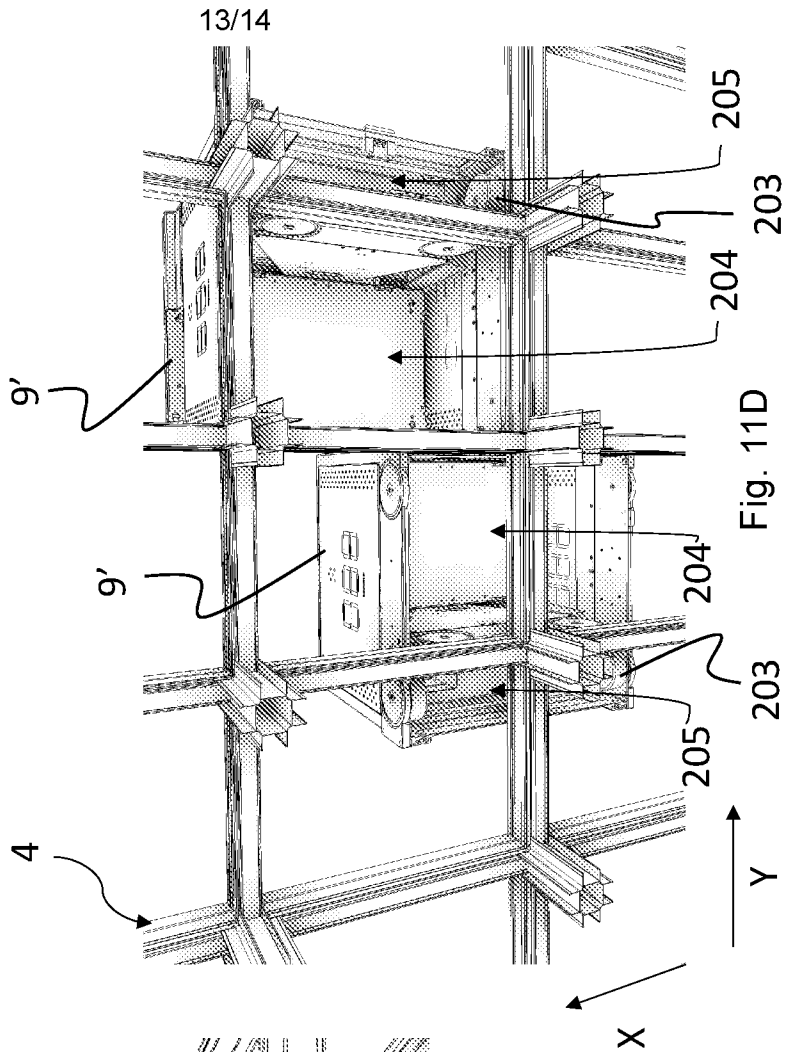


Fig. 11D

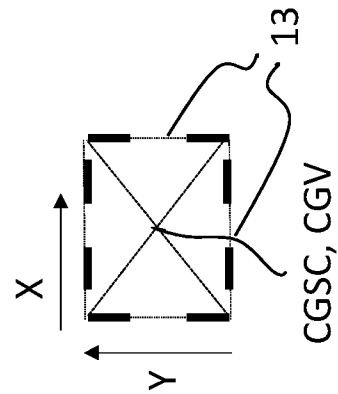


Fig. 12A  
(prior art)

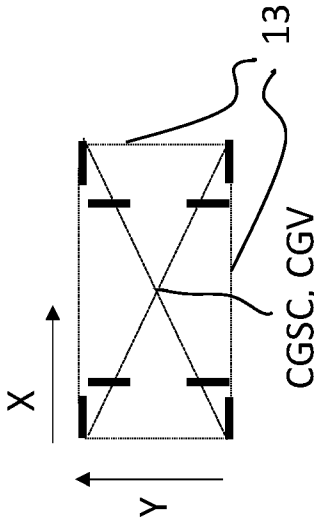


Fig. 12B  
(prior art)

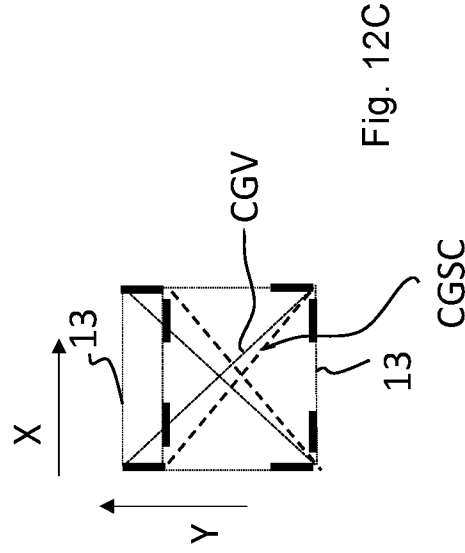


Fig. 12C

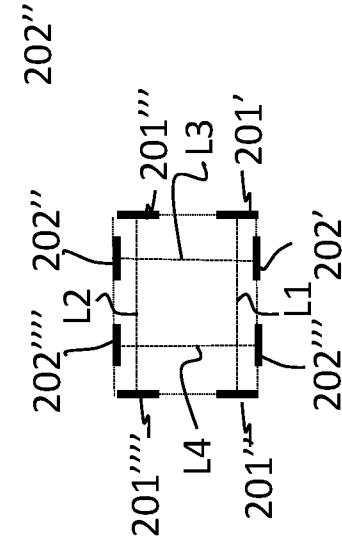


Fig. 13A  
(prior art)

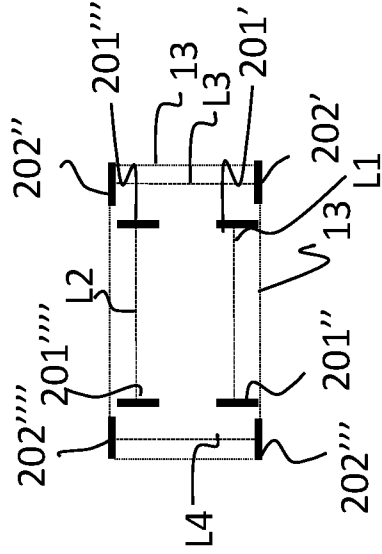


Fig. 13B  
(prior art)

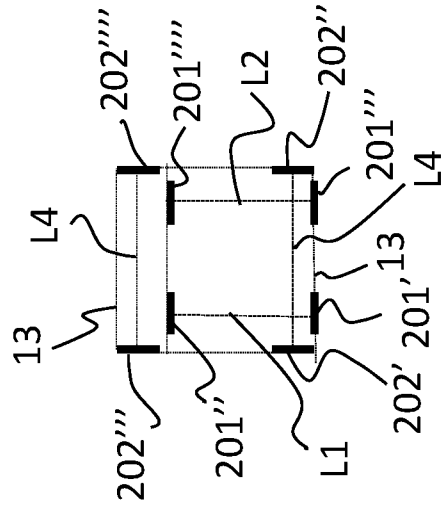


Fig. 13C