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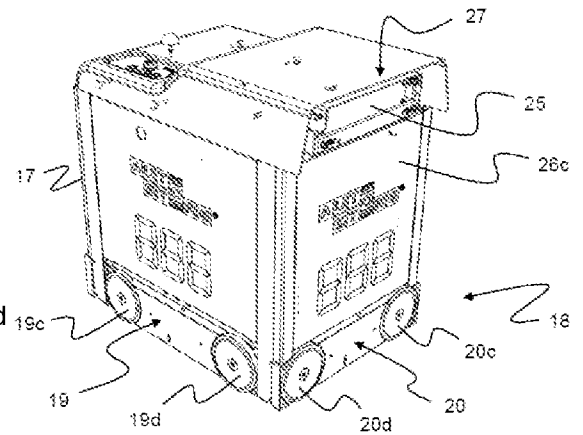
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(73)	Proprietor	Autostore Technology AS, Stokkastrandvegen 85, 5578 NEDRE VATS, Norge		
(72)	Inventor	Ivar Fjeldheim, Bjørnebærveien 9, 5533 HAUGESUND, Norge Ingvar Fagerland, Holeveien 8, 5541 KOLNES, Norge Trond Austrheim, Nedre Teigen 12, 5590 ETNE, Norge		
(74)	Agent or Attorney	ONSAGERS AS, Postboks 1813, Vika, 0123 OSLO, Norge		

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(56)	References Cited:	US 2016325932 A1, JP 2013010633 A, AU 1225970 A, ES 2137021 T3, US 2014217977 A1, US 2015332213 A1, US 2012287532 A1, GB 2539562 A, NO 20160118 A1
(57)	Abstract	

The present invention relates to automated storage and retrieval system comprising: a track system comprising a first set of parallel tracks arranged in a horizontal plane and extending in a first direction, 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, which first and second sets of tracks form a grid pattern in the horizontal plane comprising a plurality of adjacent grid cells, each comprising a grid opening defined by a pair of adjacent tracks of the first set of tracks and a pair of adjacent tracks of the second set of tracks; a plurality of stacks of storage containers arranged in storage columns located beneath the track system, wherein each storage column is located vertically below a grid opening; a plurality of container handling vehicles for lifting and moving storage containers stacked in the stacks, the container handling vehicles being configured to move laterally on the track system above the storage columns to access the storage containers via the grid openings, wherein each of the plurality of container handling vehicles has a footprint with a horizontal extension which is equal to or less than the horizontal extension of a grid cell and comprises: a wheel assembly for guiding the container handling vehicle along the track system and a container-receiving storage space arranged within the footprint of the container handling vehicle for accommodating a storage container. Each container handling vehicle comprises a protruding section which extends horizontally beyond the footprint of the load handling vehicle and, when the load handling vehicle is positioned above a grid cell, into a neighbouring grid cell. The present invention also relates to a container handling vehicle for such an automated storage and retrieval system.



## Technical Field

The present invention relates to an automated storage and retrieval system.

In particular, the present invention relates to an automated storage and retrieval system comprising:

- 5 - a track system comprising a first set of parallel tracks arranged in a horizontal plane and extending in a first direction, 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, which first and second sets of tracks form a grid pattern in the horizontal plane comprising a plurality of adjacent grid cells, each comprising a  
10 grid opening defined by a pair of adjacent tracks of the first set of tracks and a pair of adjacent tracks of the second set of tracks;
- a plurality of stacks of storage containers arranged in storage columns located beneath the track system, wherein each storage column is located vertically below a grid opening;
- 15 - a plurality of container handling vehicles for lifting and moving storage containers stacked in the stacks, the container handling vehicles being configured to move laterally on the track system above the storage columns to access the storage containers via the grid openings, wherein each of the plurality of container handling vehicles has a footprint with a horizontal extension which is equal to or  
20 less than the horizontal extension of a grid cell and comprises:
  - a wheel assembly for guiding the container handling vehicle along the track system; and
  - a container-receiving storage space arranged centrally within the footprint of the container handling vehicle for accommodating a storage container.

25 The present invention also relates to a container handling vehicle for such an automated storage and retrieval system, which vehicle comprises a lower part comprising a wheel assembly for guiding the container handling vehicle along a horizontal track system of the automated storage and retrieval system, and a storage space arranged centrally within the lower part for accommodating a storage container  
30 of the automated storage and retrieval system.

## Background and prior art

WO2016/120075A1, the contents of which are incorporated herein by reference, shows an example of an automated storage and retrieval system of the type identified above. The disclosed container handling vehicles are dimensioned so that they have  
35 a footprint, i.e. a contact area against the track system, which has a horizontal extension that is equal to the horizontal extension of a grid cell.

Within the art, such a container handling vehicle, i.e. a container handling vehicle having a footprint with a horizontal extension corresponding to the horizontal extension of a single grid cell, is sometimes referred to as a “single cell” container handling vehicle.

- 5 Another single cell container handling vehicle is disclosed in WO2015/193278A1, the contents of which are incorporated herein by reference.

The single cell design disclosed in WO2016/120075A1 and WO2015/193278A1 reduces the space required for the container handling vehicles to travel on the track system, thus allowing more vehicles to operate on the track system without interfering  
10 with each other.

However, the single cell design disclosed in WO2016/120075A1 and WO2015/193278A1 makes it difficult for external equipment to interact with the container handling vehicle. In particular, when the vehicle is powered by an on-board battery, the box-shaped single cell design makes it difficult for charging or battery  
15 replacement equipment to access the battery of the vehicle when it needs to be recharged or replaced.

US2016325932 A1 describes a remotely operated vehicle in an automated storage and retrieval system for lifting and transporting storage bins situated within the storage system. The vehicle body is provided with lifting means, driving means, wireless  
20 communication means for the operation of the vehicle.

JP2013010633A relates to an article transport apparatus provided with a carriage device for traveling along a transport path and conveying articles. The system describes a mechanism wherein the regenerative power is stored and utilized.

In view of the above, it is desirable to provide an automated storage and retrieval  
25 system that solves or at least mitigates the aforementioned problem.

### **Summary of the invention**

According to one aspect of the invention, the system is characterised in that each container handling vehicle comprises a protruding section which extends horizontally beyond the footprint of the load handling vehicle and, when the load handling vehicle  
30 is positioned above a grid cell, into a neighbouring grid cell.

According to another aspect of the invention, the container handling vehicle is characterised in that it comprises a protruding section extending horizontally beyond the lower part of the vehicle.

It may be advantageous if the protruding section is arranged at an upper part of the container handling vehicle above the lower part.

5 In a case when the container handling vehicle comprises an on-board battery, it may be advantageous if the protruding section comprises a rechargeable battery or a battery slot for housing a replaceable battery.

10 Positioning the battery in the protruding section is advantageous since it allows charging or battery exchange stations easy access to the battery for charging or battery replacement. In particular, if a battery exchange scheme is used, in which case the protruding section comprises a battery compartment or slot, the protruding character of the protruding section provides advantageous guiding for the battery during a battery exchange operation.

The protruding section may also allow larger batteries to be mounted in the vehicles, thus allowing the vehicles operate longer between recharging or battery replacement.

15 The protruding section may also hold sensors, which may be used to establish the position of the vehicle on the track system, e.g. the alignment of the vehicle vis-à-vis a grid cell, and/or to establish the position of the vehicle vis-à-vis other vehicles on the track system, e.g. when operating the vehicles as a train of vehicles, e.g. as is disclosed in the international patent application PCT/EP2016/077300.

20 When a vehicle is positioned above a grid cell, e.g. to access a container in the storage column located vertically below the grid cell, the protruding section of the vehicle will extend over a neighbouring grid cell. In other words, even though the vehicle has a footprint, i.e. a contact area against the rail system, which does not extend beyond the horizontal extension of one grid cell, it has a vertical projection which occupies more than one grid cell.

25 Normally this would prevent a second vehicle from travelling over the neighbouring grid cell, i.e. the grid cell into which the protruding section of the first vehicle extends. This could be a problem since it could reduce the overall capacity of the automated storage and retrieval system.

30 Therefore, it may be advantageous if the container handling vehicles each comprises a recessed section arranged opposite the protruding section, which recessed section is capable of accommodating the protruding sections of other vehicles when they pass over a neighbouring grid cell. The recessed section may have a shape which is complementary to the shape of the protruding section and may extend across the whole width or length of the container handling vehicle, thus allowing vehicles to pass each other over adjacent grid cells. Then, when the vehicles operate on the track system, the recessed section of each container handling vehicle is capable of  
35 accommodating the protruding sections of other container handling vehicles when

they pass over a neighbouring grid cell, thus allowing container handling vehicles to travel along neighbouring rows of grid cells.

5 The recessed section may have a shape which is complementary to the shape of the protruding section. However, the recessed section may have a different shape than the protruding section as long as the recessed section is capable of accommodating the protruding section of another vehicle when it passes a neighbouring grid cell.

10 The recessed section may advantageously extend across the whole width or length of the container handling vehicle in a direction which is orthogonal to the direction in which the protruding section extends, thus allowing two vehicles to completely pass each other on adjacent grid cells.

The protruding section and, if present, also the recessed section may be arranged at the upper part of the container handling vehicle.

15 The wheel assembly 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.

20 The container handling vehicle may comprise a lifting device arranged to transport a storage container vertically between a storage position in a stack and a transport position in the storage space. 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 storage space.

The protruding section may comprise at least one of: a rechargeable battery; a battery slot for housing a replaceable battery; and a sensor for establishing the position of the vehicle on the track system or vis-à-vis other vehicles on the track system.

25 The wheel assembly may comprise wheels which are arranged around the periphery of the storage space.

30 In the following, numerous specific details are introduced by way of example only to provide a thorough understanding of embodiments of the claimed system and method. 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.

### **Brief description of the drawings**

Following drawings are appended to facilitate the understanding of the invention.

Fig. 1 is a side view of an automated storage and retrieval system according to the invention.

- 5 Fig. 2 is a top view of a track system of the automated storage and retrieval system according to Fig. 1.

Fig. 3 shows a grid cell of the track system of Fig. 2.

Fig. 4 is perspective view of a container handling vehicle operating on the automated storage and retrieval system according to Fig. 1.

- 10 Fig. 5 is a first side view of the container handling vehicle according to Fig. 4.

Fig. 6 is a second side view of the container handling vehicle according to Fig. 4.

Fig. 7 is a sectional view of the container handling vehicle from the direction indicated by VII-VII in Fig. 6.

Fig. 8 is a perspective view of a second embodiment of a container handling vehicle.

- 15 Figs. 9 to 11 show container handling vehicles according to Fig. 8 operating over grid cells of an automated storage and retrieval system.

Fig. 12 is a perspective view schematically showing an alternative embodiment of a container handling vehicle according to the invention.

- 20 Fig. 13 is a top view of an alternative track system of an automated storage and retrieval system according to the invention.

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

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

- 25 In the following, embodiments of the invention will be discussed in more detail 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.

An embodiment of a storage structure of an automated storage and retrieval system 1 according to the invention will now be discussed in more detail with reference to Figs. 1 to 3.

5 The storage structure comprises a framework 2 on which a plurality of container handling vehicles 3 are operated (in Fig. 1 only one vehicle 3 is shown).

The framework 2 comprises a plurality of upright members 4 and a plurality of horizontal members 5, which are supported by the upright members 4. The members 4, 5 may typically be made of metal, e.g. extruded aluminium profiles.

10 The framework 2 defines a three-dimensional storage grid comprising storage columns 7 arranged in rows, in which storage columns 7 storage containers 8, also known as bins, are stacked one on top of another to form stacks 9. Each storage container 8 may typically hold a plurality of product items (not shown), and the product items within a storage container 8 may be identical, or may be of different product types depending on the application of the system 1. The framework 2 guards  
15 against horizontal movement of the stacks 9 of storage containers 8, and guides vertical movement of the containers 8, but does normally not otherwise support the storage containers 8 when stacked.

20 The horizontal members 5 comprise a rail or track system 10 arranged in a horizontal plane P above the storage columns 7, on which track system 10 the plurality of container handling vehicles 3 can move laterally above the storage columns 7 to raise storage containers 8 from and lower storage containers 8 into the storage columns 7, and also to transport the storage containers 8 above the storage columns 7.

25 The track system 10 comprises a first set of parallel rails or tracks 11 arranged to guide movement of the container handling vehicles 3 in a first direction X, and a second set of parallel rails or tracks 12 arranged perpendicular to the first set of tracks 11 to guide movement of the container handling vehicles 3 in a second direction Y, which is perpendicular to the first direction X.

30 The track system 10 forms a grid structure or grid pattern 13 in the horizontal plane P (see Figs. 2 and 3). The grid pattern 13 comprises a plurality of rectangular and uniform grid locations or grid cells 14, where each grid cell 14 comprises a grid opening 15 which is delimited by a pair of tracks 11a, 11b of the first set of tracks 11 and a pair of tracks 12a, 12b of the second set of tracks 12. In Fig. 3, the grid cell 14 is indicated by a dashed box and the grid opening 15 is indicated by a hatched area.

35 Consequently, tracks 11a and 11b form pairs of tracks defining parallel rows of grid cells running in the X direction, and tracks 12a and 12b form pairs of tracks defining 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 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.

- 5 In the X and Y directions, neighbouring grid cells are arranged in contact with each other such that there is no space there-between.

One embodiment of a container handling vehicle 3 according to the invention will now be discussed in more detail with additional reference to Figs. 4 to 7.

- 10 Each container handling vehicle 3 comprises a vehicle body 17 and a wheel assembly 18 arranged in a lower section or part 17a (see Fig. 7) of the vehicle body 17 to enable the lateral movement of the container handling vehicle 3, i.e. the movement of the vehicle 3 in the X and Y directions (see Fig. 2).

- 15 The wheel assembly 18 comprises a first set of wheels 19, which is arranged to engage with a pair of tracks 11a, 11b of the first set of tracks 11, and a second set of wheels 20, which is arranged to engage with a pair of tracks 12a, 12b of the second set of tracks 12. At least one of the set of wheels 19, 20 can be lifted and lowered, so that the first set of wheels 19 and/or the second set of wheels 20 can be brought to engage with the respective set of tracks 11, 12 at any one time.

- 20 Each set of wheels 19, 20 comprises four wheels 19a, 19b, 19c, 19d; 20a, 20b, 20c, 20d arranged along the sides of the vehicle (see Figs. 5 to 7). Wheels 19a and 19b are arranged in a first vertical plane, and wheels 19c and 19d are arranged in a second vertical plane which is parallel to the first vertical plane and arranged at a distance from the first vertical plane which corresponds to the distance between rails 11a and 11b (see Fig. 3). Wheels 20a and 20b are arranged in a third vertical plane, which is orthogonal to the vertical planes in which wheels 19a-19d are arranged, and wheels 25 20c and 20d are arranged in a fourth vertical plane which is parallel to the third vertical plane and arranged at a distance from the third vertical plane which corresponds to the distance between rails 12a and 12b.

- 30 At least one of the wheels in each set 19, 20 is motorized in order to propel the vehicle 3 along the track system 10. Advantageously, the at least one motorized wheel in each set comprises a hub motor, i.e. an electric motor that is coupled to, or incorporated into, the hub of a wheel and drives the wheel directly. An example of a container handling vehicle with such a motor is disclosed in WO2016/120075A1, the contents of which are incorporated herein by reference.

- 35 Each container handling vehicle 3 comprises a storage compartment or storage space 24 (see Fig. 7) arranged centrally within the lower part of the vehicle body 17 for receiving and holding a storage container 8 when transporting the storage container

8 across the track system 10. The storage space 24 is arranged within the vehicle body 17 and can be accessed from below, i.e. from an opening (not shown) underneath the container handling vehicle 3.

5 Each container handling vehicle 3 also comprises a lifting device 21 (see Fig. 7) for vertical transportation of a storage container 8, e.g. lifting a storage container 8 from a storage column 7 and bringing it into the storage space 24, and also for lowering a storage container 8 from the storage space 24 into a storage column 7. The lifting device 21 comprises a gripping device 22 which is arranged to releasably engage with a storage container 8. The lifting device 21 also comprises a lifting motor 23 for  
10 lowering and raising the gripping device 22 so that the position of the gripping device 22 with respect to the vehicle body 17 can be adjusted in a third direction Z (see Fig. 1, which is orthogonal the first direction X and the second direction Y.

Conventionally, and also for the purpose of this application, Z=1 identifies the uppermost layer of the storage grid, i.e. the layer immediately below the track system  
15 10, Z=2 the second layer below the track system 10, Z=3 the third layer etc. The container handling vehicles 3 can be said to travel in layer Z=0. Consequently, each storage column can be identified by its X and Y coordinates, and each storage position in the storage grid can be identified by its X, Y and Z coordinates.

The lifting motor 23 is arranged in a second, upper part or section 17b of the vehicle  
20 body 17 (see Fig. 7), which upper part 17b is located above the lower part 7a.

When a storage container 8 stored in the storage grid is to be accessed, one of the container handling vehicles 3 is instructed to retrieve the target storage container 8 from its position in the storage grid and to transport the target storage container 8 to an access station (not shown) where it can be accessed from outside of the storage  
25 grid or transferred out of the storage grid. This operation involves moving the container handling vehicle 3 to the grid cell 14 above the storage column 7 in which the target storage container is positioned and retrieving the storage container from the storage column 7 using the container handling vehicle's lifting device 21. This step involves using the lifting device 21 to lift the storage container from the storage  
30 column 7 through the grid opening 15 of the grid cell 14 and into the storage space 24 of the vehicle 3.

If the target storage container is located deep within a stack 9, 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  
35 prior to lifting the target storage container from the storage column 7. 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 access station, or with one or a plurality of other

cooperating container handling vehicles. Alternatively, or in addition, the automated 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 be relocated to other storage columns.

Once the target storage container has been brought into the storage space 24 of the container handling vehicle 3, the vehicle transports the storage container to the access station where it is unloaded. The access station may typically comprise a grid location at the periphery of the storage grid where the storage container can be accessed manually or transported further using a suitable conveyor system.

When a storage container 8 is to be stored in the storage grid, one of the container handling vehicles 3 is instructed to pick up the storage container from a pick-up station (not shown), which may also double as an access station, and transport it to a grid cell above the storage column 7 where it is to be stored. After any storage containers positioned at or above the target position within the storage column stack have been removed, the container handling vehicle 3 positions the storage container at the desired position. The removed storage containers may then be lowered back into the storage column 7, or relocated to other storage columns within the storage grid.

For monitoring and controlling the automated storage and retrieval system so that a desired storage container can be delivered to the desired location at the desired time without the container handling vehicles 3 colliding with each other, the automated storage and retrieval system comprises a control system (not shown), which typically is computerised and comprises a database for monitoring and controlling e.g. the location of the respective storage containers 8 within the storage grid, the content of each storage container 8 and the movement of the container handling vehicles 3.

The container handling vehicles 3 typically communicate with the control system via wireless communication means, e.g. via a WLAN operating under an IEEE 802.11 (WiFi) standard and/or via a mobile telecommunication technology such as 4G or higher.

Each container handling vehicle 3 comprises a battery 25 (see Fig. 4) which provides power to onboard equipment, including the motorised wheels, the lifting motor and onboard control and communications systems.

Each container handling vehicle 3 has a footprint, i.e. a contact area against the track system 10, which has a horizontal extension which is equal to or less than the

horizontal extension of a grid cell 14. In other words, when the vehicle 3 is positioned above a grid cell 14, e.g. for lifting a storage container from or lowering a container into a storage column 7, the footprint of the vehicle 3 will not extend beyond the grid cell into a neighbouring grid cell.

5 The wheels 19a-19d, 20a-20d are arranged around the periphery of the storage space 24, and the footprint 14 of the vehicle 3 is larger than the storage space 24 only enough to accommodate the wheels 19a-19d, 20a-20d. In this way, the footprint 14 of the vehicle 3 takes up the minimum possible amount of space in the X-Y plane. Since the storage space 24 is positioned between the pair of wheels 19a-19d, 20a-20d  
10 on each side of the vehicle 3, the centre of gravity of the vehicle 3 will be located within the footprint 14 also when a storage bin is raised into the storage space 24.

Further, the vehicle 3 comprises generally vertical side walls 26a-26d (see Figs. 5 to 7), which are co-planar to the vertical planes in which the wheels 19a-19d; 20a-20d are arranged. Consequently, the lower part 17a of the container handling vehicle 3  
15 has a generally cuboid shape.

However, the upper part 17b of the vehicle 3 has a protruding section 27 which extends horizontally in the X direction beyond the otherwise generally vertical side wall 26c (e.g. see Figs. 1 and 4). This section 27 houses the battery 25 of the vehicle 3. Positioning the battery in this manner is advantageous since it allows charging or  
20 battery exchange stations easy access to the battery for charging or battery replacement. In particular, if a battery exchange scheme is used, in which case the protruding section 27 comprises a battery compartment or slot 28 (e.g. see Fig. 12), the protruding character of section 27 provides advantageous guiding for the battery 25 during battery exchange operation.

25 The protruding section 27 also allows larger batteries to be mounted in the vehicle and may also be beneficial when operating the vehicles as a train of vehicles, e.g. as is disclosed in the international patent application PCT/EP2016/077300.

Alternatively, or in addition, the protruding section 27 may hold down-looking sensors, which may be used to establish the position of the vehicle on the track system  
30 10, e.g. the alignment of the vehicle vis-à-vis a grid cell 14, or to establish the position of the vehicle vis-à-vis other vehicles on the track system 10, e.g. when operating the vehicles as a train of vehicles.

When the vehicle 3 is positioned above a grid cell 14, e.g. to access a container 8 in the storage column 7 located vertically below the grid cell 14, the protruding section  
35 27 will extend over a neighbouring grid cell. In other words, even though the vehicle 3 has a contact area against the rail system 10 which does not extend beyond the

horizontal extension of one grid cell 14, it has a vertical projection which occupies more than one grid cell.

This will prevent a second vehicle from travelling over the neighbouring grid cell, i.e. the grid cell into which the protruding section 27 of the first vehicle extends. This could be a problem since it could reduce the overall capacity of the automated storage and retrieval system.

Figs. 8 to 11 disclose an alternative embodiment of a container handling vehicle 103 which comprises a recessed section 29 which is arranged in the upper part 17b opposite to the protruding section 27. In other words, the protruding section 27 and the recessed section 29 are arranged at opposite sides of the container handling vehicle 103. The recessed section 29 is capable of accommodating the protruding sections 27 of other vehicles when they pass over a neighbouring grid cell. In particular, the recessed section 29 has a shape which is complementary to the shape of the protruding section 27 and extends across the whole width of the container handling vehicle 103 in the Y direction, thus allowing vehicles 103 to pass each other over adjacent grid cells.

This is illustrated in Figs. 9 to 11, which show a first vehicle 103a moving in to operate over a grid cell while a second vehicle 3b is positioned over a neighbouring grid cell while the protruding section 27a of the first vehicle 103a is accommodated in the recessed section 29b of the second vehicle 103b.

In the disclosed embodiment, the protruding section 27 of each container handling vehicle 103 extends in the X direction and the recessed section 29 extends across the whole width of the vehicle 103 in the Y direction. However, it is understood that the protruding section may alternatively extend in the Y direction and the recessed section extend across the whole width of the vehicle in the X direction.

Each container handling vehicle may alternatively have two protruding sections 27', 27'' extending in two orthogonal directions and two opposite, complementary recessed sections 29', 29'', as is schematically illustrated by the container handling vehicle 203 shown in Fig. 12. This configuration will also allow two vehicles to operate over neighbouring grid cells without the protruding sections 27' and 27'' hindering the movement of other vehicles on the track system.

In the track system 10 shown in Fig. 2, each horizontal member making up the tracks comprises two tracks. Consequently, each horizontal member is capable of accommodating two wheels in parallel. In such a track system, the borders between neighbouring grid cells run along the centre-line of the horizontal members, as is indicated in Fig. 2.

Fig. 13 shows an alternative rail or track system 16 which is made up by elongated members each forming a single track, i.e. a track configured to accommodate only one wheel. In such a track system the borders between neighbouring grid cells run midway between neighbouring elongated members forming the single tracks.

5 In Fig. 9, grid cell 14 comprises a grid 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  
10 grid cell 14N comprising a grid opening 15N.

In Fig. 13, a footprint 30 of a container handling vehicle is schematically illustrated. In this embodiment the footprint 30 is defined by the horizontal extension of the wheels of the vehicle. As is evident from the figure, the footprint 30 has a horizontal extension which is less than the horizontal extension of a grid cell.

15 In Fig. 9, a footprint 30' of a container handling vehicle according to an alternative embodiment is also schematically illustrated. In this case the lower part of the vehicle extends beyond the wheels and the footprint 30' has a horizontal extension which is equal to than the horizontal extension of a grid cell.

In the preceding description, various aspects of an automated storage and retrieval  
20 system according to the invention have been described with reference to the illustrative embodiment. However, this description is not intended to be construed in a limiting sense. Various modifications and variations of the illustrative embodiment, as well as other embodiments of the system, which are apparent to persons skilled in the art, are deemed to lie within the scope of the present invention as defined by the  
25 following claims.

## CLAIMS

1. An automated storage and retrieval system (1) comprising:
- 5 - a track system (10, 16) comprising a first set of parallel tracks (11) arranged in a horizontal plane (P) and extending in a first direction (X), and a second set of parallel tracks (12) arranged in the horizontal plane (P) and extending in a second direction (Y) which is orthogonal to the first direction (X), which first and second sets of tracks (11, 12) form a grid pattern (13) in the horizontal plane (P) comprising a plurality of adjacent grid cells (14), each comprising a grid opening (15) defined by a pair of adjacent tracks (11a, 11b) of the first set of tracks (11) and a pair of adjacent tracks (12a, 12b) of the second set of tracks (12);
  - 10 - a plurality of stacks (9) of storage containers (8) arranged in storage columns (7) located beneath the track system (10, 16), wherein each storage column (7) is located vertically below a grid opening (15);
  - 15 - a plurality of container handling vehicles (3, 310, 320) for lifting and moving storage containers (8) stacked in the stacks (9), the container handling vehicles (3, 310, 320) being configured to move laterally on the track system (10) above the storage columns (7) to access the storage containers (8) via the grid openings (15), wherein each of the plurality of container handling vehicles (3, 310, 320) has a footprint (30, 30'), defined by the contact area of the vehicle (3, 310, 320) against the track system (10, 16), with a horizontal extension which is equal to or less than the horizontal extension of a grid cell (14) and comprises:
    - 20 - a wheel assembly (18) for guiding the container handling vehicle (3, 310, 320) along the track system (10, 16); and
    - 25 - a container-receiving storage space (24) arranged within the footprint of the container handling vehicle (3, 310, 320) for accommodating a storage container (8);
  - 30 which container handling vehicle comprises a lower part (17a) which comprises the wheel assembly (18) and the container-receiving storage space (24);
- characterised in that** each container handling vehicle (3, 310, 320) comprises:
- 35 - a protruding section (27) which extends horizontally beyond the footprint (30, 30') of the load handling vehicle (3, 103, 203) and, when the load handling vehicle (3, 103, 203) is positioned above a grid cell (14), into a neighbouring grid cell; and
  - an upper part (17b) which is arranged above the lower part (17a), at which upper part (17b) the protruding section (27) is arranged.

2. The system (1) according to claim 1, **characterised in that** the protruding section (27) comprises at least one of: a rechargeable battery; a battery slot (28) for housing a replaceable battery (25); and a sensor for establish the position of the vehicle on the track system (10, 16) or vis-à-vis other vehicles on the track system (10, 16).  
5
3. The system (1) according to any one of the preceding claims, **characterised in that** the wheel assembly (18) comprises a first set of wheels (19) for engaging with the first set of tracks (11) to guide movement of the container handling vehicle (3, 103, 203) in the first direction (X), and a second set of wheels (20) for engaging with the second set of tracks (12) to guide movement of the container handling vehicle (3, 103, 203) in the second direction (Y).  
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4. The system (1) according to any one of the preceding claims, **characterised in that** the container handling vehicle (3, 103, 203) comprises:  
- a lifting device (21) arranged to transport a storage container (8) vertically between a storage position in a stack (9) and a transport position in the storage space (24), the lifting device (21) comprising:  
- a gripping device (22) being configured to releasably grip a storage container (8); and  
- a lifting motor (23) being configured to raise and lower the gripping device (22) relative to the storage space (24).  
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5. The system (1) according to any one of the preceding claims, **characterised in that** each container handling vehicle (103, 203) comprises a recessed section (29) arranged to accommodate the protruding sections (27) of other container handling vehicles (103, 203) when they operate over a neighbouring grid cell.
- 25 6. The system (1) according to claim 6, **characterised in that** the recessed section (29) has a shape which is complementary to the shape of the protruding section (27).
7. The system (1) according to any one of claims 5 and 6, **characterised in that** the recessed section (29) extends across the whole width or length of the container handling vehicle (103, 203) in a direction which is orthogonal to the direction in which the protruding section (27) extends.  
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8. The system (1) according to any one of the preceding claims, **characterised in that** the wheel assembly (18) comprising a first set of wheels (19) for engaging with the first set of tracks (11) to guide movement of the container handling vehicle (3, 103, 203) in the first direction (X), and a second set of wheels (20) for engaging with the second set of tracks (12) to guide movement of the container handling vehicle (3, 103, 203) in the second direction (Y).  
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9. A container handling vehicle (3, 103, 203) for an automated storage and retrieval system (1), the container handling vehicle (3, 103, 203) comprising a lower part (17a) comprising a wheel assembly (18) for guiding the container handling vehicle (3, 103, 203) along a horizontal track system (10, 16) of the automated storage and retrieval system (1), and a storage space (24) arranged centrally within the lower part (17a) for accommodating a storage container (8) of the automated storage and retrieval system (1), **characterised in that** the container handling vehicle (3, 103, 203) comprises an upper part (17b) arranged above the lower part (17a), which upper part (17b) comprises a protruding section (27, 27', 27'') extending horizontally beyond the lower part (17a).
10. The container handling vehicle (103, 203) according to claim 9, **characterised in that** it comprises a recessed section (29, 29', 29'') arranged to accommodate the protruding section (27, 27', 27'') of another container handling vehicle (103, 203) when operating on the track system (10, 16).
11. The container handling vehicle (103, 203) according to claim 10, **characterised in that** the recessed section (29, 29', 29'') has a shape which is complementary to the shape of the protruding section (27, 27', 27'').
12. The container handling vehicle (103, 203) according to any one of claims 10 and 11, **characterised in that** the protruding section (27, 27', 27'') and the recessed section (29, 29', 29'') are arranged at opposite sides of the container handling vehicle (103, 203).
13. The container handling vehicle (103) according to any one of claims 9 to 12, **characterised in that** the protruding section (27, 27', 27'') comprises at least one of: a rechargeable battery (25); a battery slot (28) for housing a replaceable battery (25); and a sensor for establish the position of the vehicle on the track system (10, 16) or vis-à-vis other vehicles on the track system (10, 16).
14. The container handling vehicle (103) according to any one of claims 9 to 13, **characterised in that** the wheel assembly (18) comprises wheels (19a-19d, 20a-20d) which are arranged around the periphery of the storage space (24).

## PATENTKRAV

1. Automatisert lagrings- og opphentingssystem (1),  
som omfatter:
- 5 - et skinneresystem (10, 16) som omfatter et første sett med parallelle skinner (11) som er anbrakt i et horisontalt plan (P) og som strekker seg i en første retning (X), og et andre sett med parallelle skinner (12) som er anbrakt i det horisontale planet (P) og som strekker seg i en andre retning (Y) som er ortogonal på den første retningen (X), der disse første og andre settene med skinner (11, 12) danner et
- 10 gittermønster (13) i det horisontale planet (P) som omfatter et flertall av nabo-gitterceller (14), som hver omfatter en gitteråpning (15) som er definert av et par med naboskinner (11a, 11b) i det første settet med skinner (11) og et par med naboskinner (12a, 12b) i det andre settet med skinner (12),
- et flertall av stabler (9) med lagringsbeholdere (8) som er anbrakt i
- 15 lagringskolonner (7) som er lokalisert under skinneresystemet (10, 16), der hver lagringskolonne (7) er lokalisert vertikalt under en gitteråpning (15),
- et flertall av beholderhåndteringskjøretøyer (3, 319, 320) for å løfte og forflytte lagringsbeholdere (8) som er stablet i stablene (9), der
- 20 beholderhåndteringskjøretøyene (3, 310, 320) er konfigurert for å forflyttes lateralt på skinneresystemet (10) over lagringskolonnene (7) for å komme til lagringsbeholderne (8) via gitteråpningene (15), der hvert av flertallet av beholderhåndteringskjøretøyer (3, 310, 320) har et fotavtrykk (30, 30') som er definert av kontaktområdet til kjøretøyet (3, 310, 320) mot skinneresystemet (10, 16), med en horisontal forlengning som er lik med eller mindre enn den horisontale
- 25 forlengningen av en gittercelle (14) og som omfatter:
- et hjuloppsett (18) for å føre beholderhåndteringskjøretøyet (3, 310, 320) langs skinneresystemet (10, 16), og
- et beholdermottakende lagringsrom (24) som er anbrakt inne i fotavtrykket til beholderhåndteringskjøretøyet (3, 310, 320) for å ha plass til en lagringsbeholder
- 30 (8),  
der dette beholderhåndteringskjøretøyet omfatter en nedre del (17a) som omfatter hjuloppsettet (18) og det beholdermottakende lagringsrommet (24),  
**karakterisert ved at** hvert beholderhåndteringskjøretøy (3, 310, 320) omfatter:

- en utstikkende seksjon (27) som strekker seg horisontalt ut over fotavtrykket (30, 30') til lasthåndteringskjøretøyet (3, 103, 203) og, når lasthåndteringskjøretøyet (3, 103, 203) er posisjonert over en gittercelle (14), inn i en nabogittercelle, og
- 5 - en øvre del (17b) som er anbrakt over den nedre delen (17a), og på denne øvre delen (17b) er den utstikkende seksjonen (27) anbrakt.
2. System (1) ifølge krav 1,
- karakterisert ved at** den utstikkende seksjonen (27) omfatter minst én av: et
- 10 oppladbart batteri, en batterislisse (28) for å huse et utskiftningsbart batteri (25), og en sensor for å etablere posisjonen til kjøretøyet på skinner (10, 16) eller vis-a-vis andre kjøretøyer på skinner (10, 16).
3. System (1) ifølge ethvert av de foregående krav,
- 15 **karakterisert ved at** hjuloppsettet (18) omfatter et første sett med hjul (19) for å engasjeres med det første settet med skinner (11) for å styre forflytningen av beholderhåndteringskjøretøyet (3, 103, 203) i den første retningen (X), og et andre sett med hjul (20) for engasjering med det andre settet med skinner (12) for å styre forflytningen av beholderhåndteringskjøretøyet (3, 103, 203) i den andre retningen
- 20 (Y).
4. System (1) ifølge ethvert av de foregående krav,
- karakterisert ved at** beholderhåndteringskjøretøyet (3, 103, 203) omfatter:
- en løfteinnretning (21) som er anbrakt for å transportere en lagringsbeholder
- 25 (8) vertikalt mellom en lagringsposisjon i en stabel (9) og en transportposisjon i lagringsrommet (24), der løfteinnretningen (21) omfatter:
- en gripeinnretning (22) som er konfigurert for frigjøringsbart å gripe en lagringsbeholder (8), og
  - en løftemotor (23) som er konfigurert for å heve og senke gripeinnretningen
- 30 (22) relativt lagringsrommet (24).
5. System (1) ifølge ethvert av de foregående krav,

**karakterisert ved at** hvert beholderhåndteringskjøretøy (103, 203) omfatter en utspart seksjon (29) som er anbrakt for å ta imot de utstikkende seksjonene (27) til andre beholderhåndteringskjøretøyer (103, 203) når de er i drift over en nabogittercelle.

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6. System (1) ifølge krav 6,

**karakterisert ved at** den utsparte seksjonen (29) har en form som er komplementær med formen på den utstikkende seksjonen (27).

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7. System (1) ifølge ethvert av kravene 5 og 6,

**karakterisert ved at** den utsparte seksjonen (29) strekker seg over hele bredden eller lengden til beholderhåndteringskjøretøyet (103, 203) i en retning som er ortogonal på retningen som den utstikkende seksjonen (27) strekker seg ut i.

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8. System (1) ifølge ethvert av de foregående krav,

**karakterisert ved at** hjuloppsettet (18) omfatter et første sett med hjul (19) for å engasjeres med det første settet med skinner (11) for å styre forflytningen av beholderhåndteringskjøretøyet (3, 103, 203) i den første retningen (X), og et andre sett med hjul (20) for å engasjeres med det andre settet med skinner (12) for å styre forflytningen av beholderhåndteringskjøretøyet (3, 103, 203) i den andre retningen (Y).

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9. Beholderhåndteringskjøretøy (3, 103, 203) for et automatisert lagrings- og opphentingssystem (1), der beholderhåndteringskjøretøyet (3, 103, 203) omfatter en nedre del (17a) som omfatter et hjuloppsett (18) for å styre beholderhåndteringskjøretøyet (3, 103, 203) langs et horisontalt skinneresystem (10, 16) i det automatiserte lagrings- og opphentingssystemet (1), og et lagringsrom (24) som er anbrakt sentralt innenfor den nedre delen (17a) for å ta imot en lagringsbeholder (8) i det automatiserte lagrings- og opphentingssystemet (1),

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**karakterisert ved at** beholderhåndteringskjøretøyet (3, 103, 203) omfatter en øvre del (17b) som er anbrakt over den nedre delen (17a), der denne øvre delen (17b) omfatter en utstikkende seksjon (27, 27', 27'') som strekker seg horisontalt ut over den nedre delen (17a).

10. Beholderhåndteringskjøretøy (103, 203) ifølge krav 9,  
**karakterisert ved at** det omfatter en utspart seksjon (29, 29', 29'') som er anbrakt  
for å ta imot den utstikkende seksjonen (27, 27', 27'') til et annet  
5 beholderhåndteringskjøretøy (103, 203) når det er i drift på skinneret (10, 16).
11. Beholderhåndteringskjøretøy (103, 203) ifølge krav 10,  
**karakterisert ved at** den utsparte seksjonen (29, 29', 29'') har en form som er  
komplementær med formen på den utstikkende seksjonen (27, 27', 27'').  
10
12. Beholderhåndteringskjøretøy (103, 203) ifølge krav 10 og 11,  
**karakterisert ved at** den utstikkende seksjonen (27, 27', 27'') og den utsparte  
seksjonen (29, 29', 29'') er anbrakt på motsatte sider av  
beholderhåndteringskjøretøyet (103, 203).  
15
13. Beholderhåndteringskjøretøy (103) ifølge ethvert av kravene 9 til 12,  
**karakterisert ved at** den utstikkende seksjonen (27, 27', 27'') omfatter minst én  
av: et oppladbart batteri (25), en batterislisse (28) for å huse et utskiftningsbart  
batteri (25), og en sensor for å etablere posisjonen til kjøretøyet på skinneret  
20 (10, 16) eller vis-a-vis andre kjøretøyer på skinneret (10, 16).
14. Beholderhåndteringskjøretøy (103) ifølge ethvert av kravene 9 til 13,  
**karakterisert ved at** hjuloppsettet (18) omfatter hjul (19a-19d, 20a-20d) som er  
anbrakt rundt periferien av lagringsrommet (24).  
25

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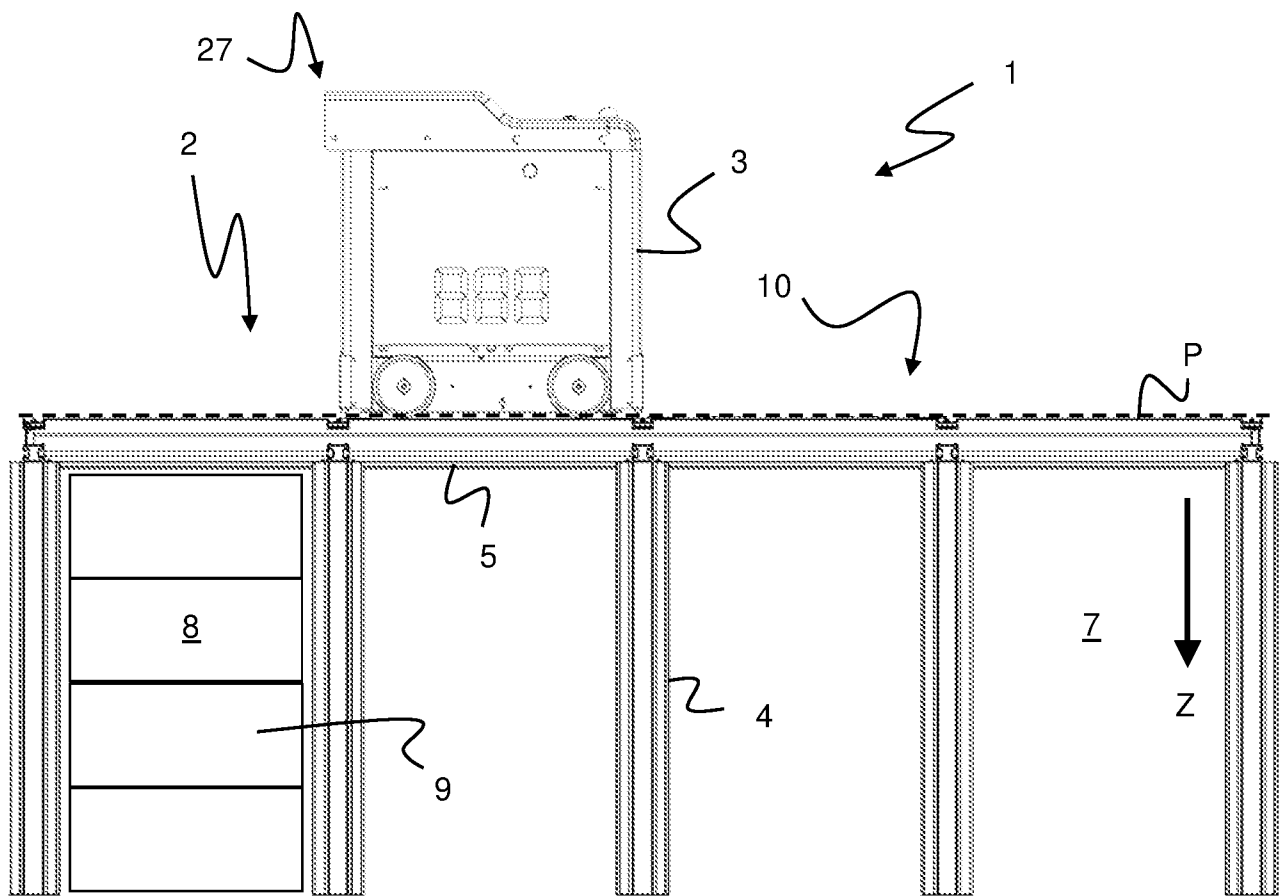


Fig. 1

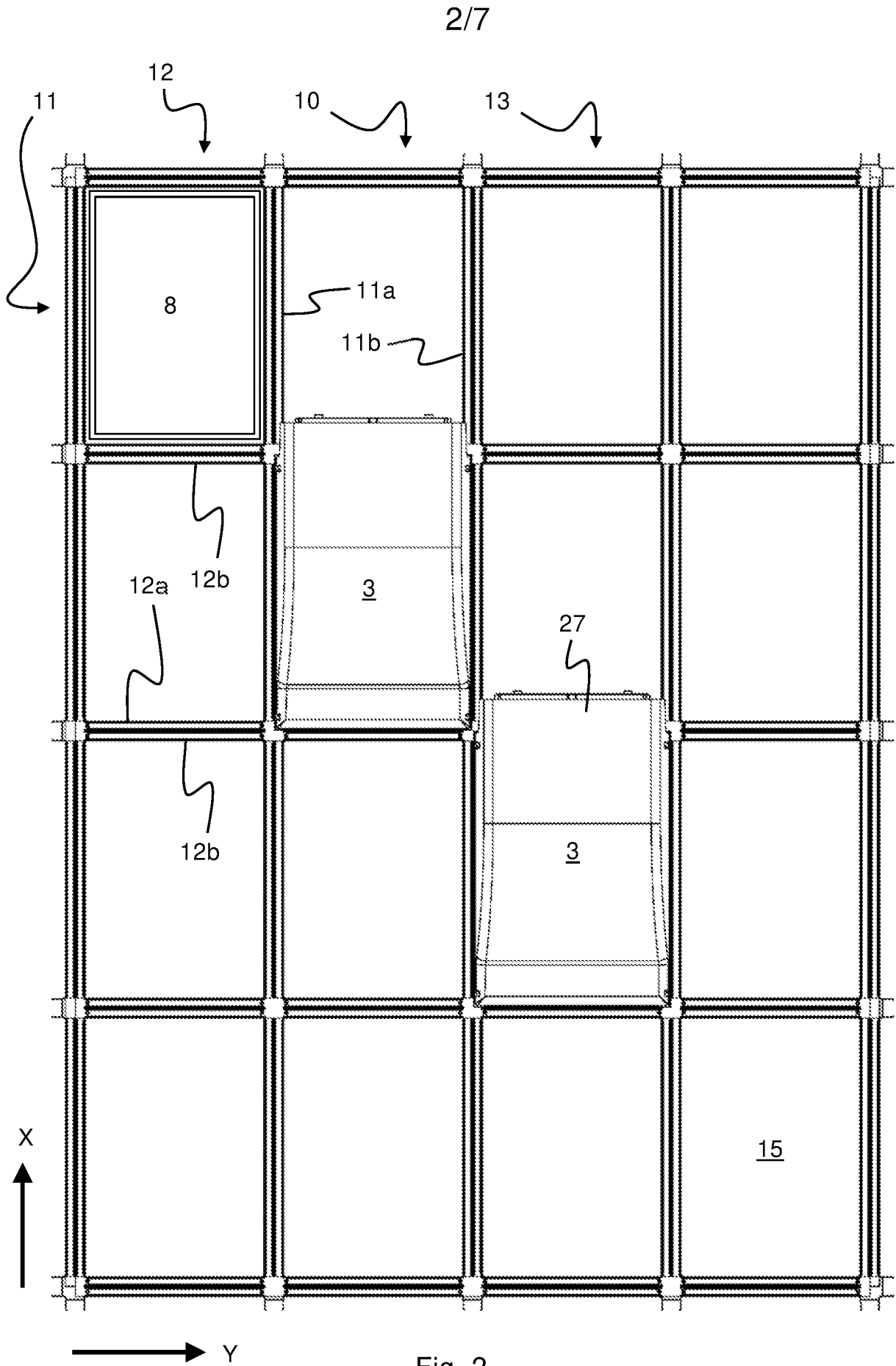


Fig. 2

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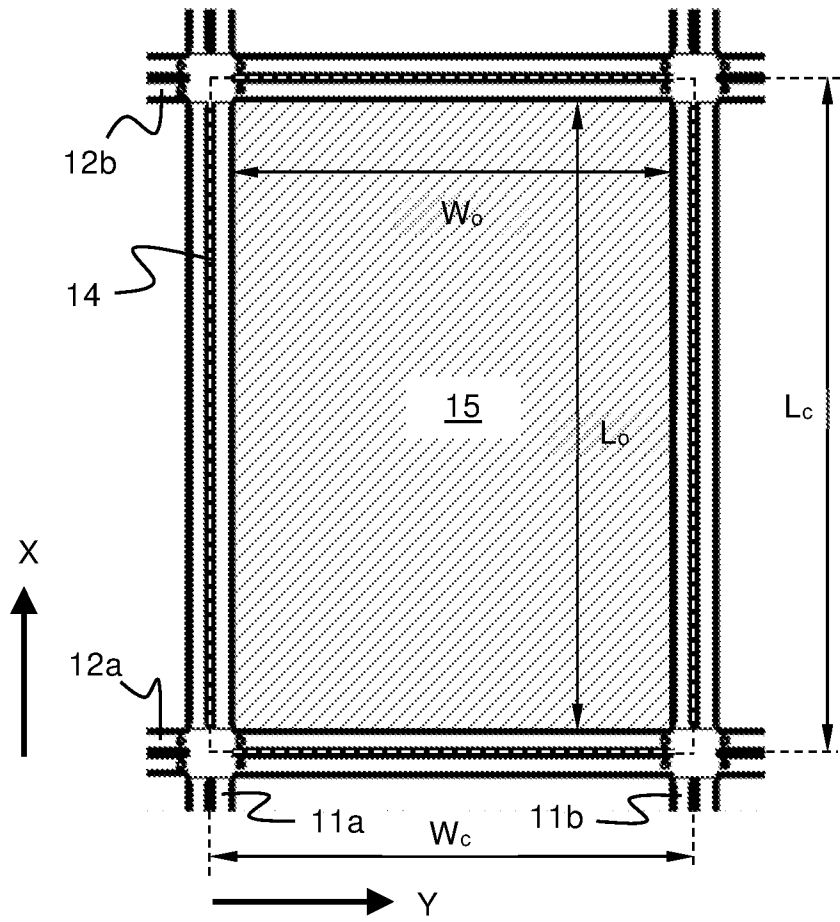


Fig. 3

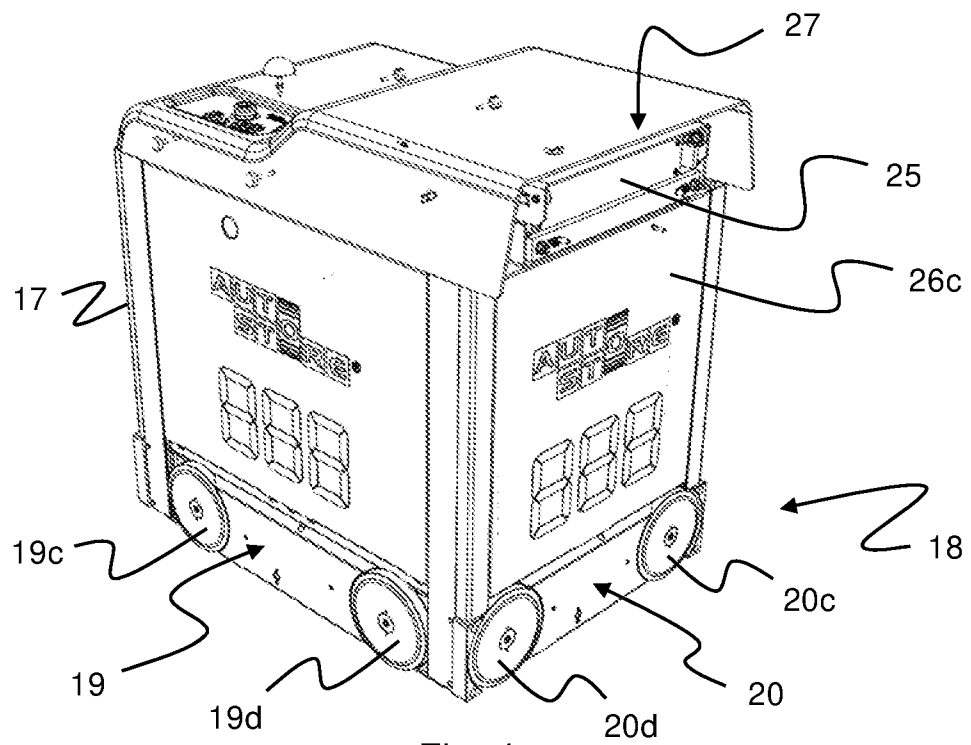


Fig. 4

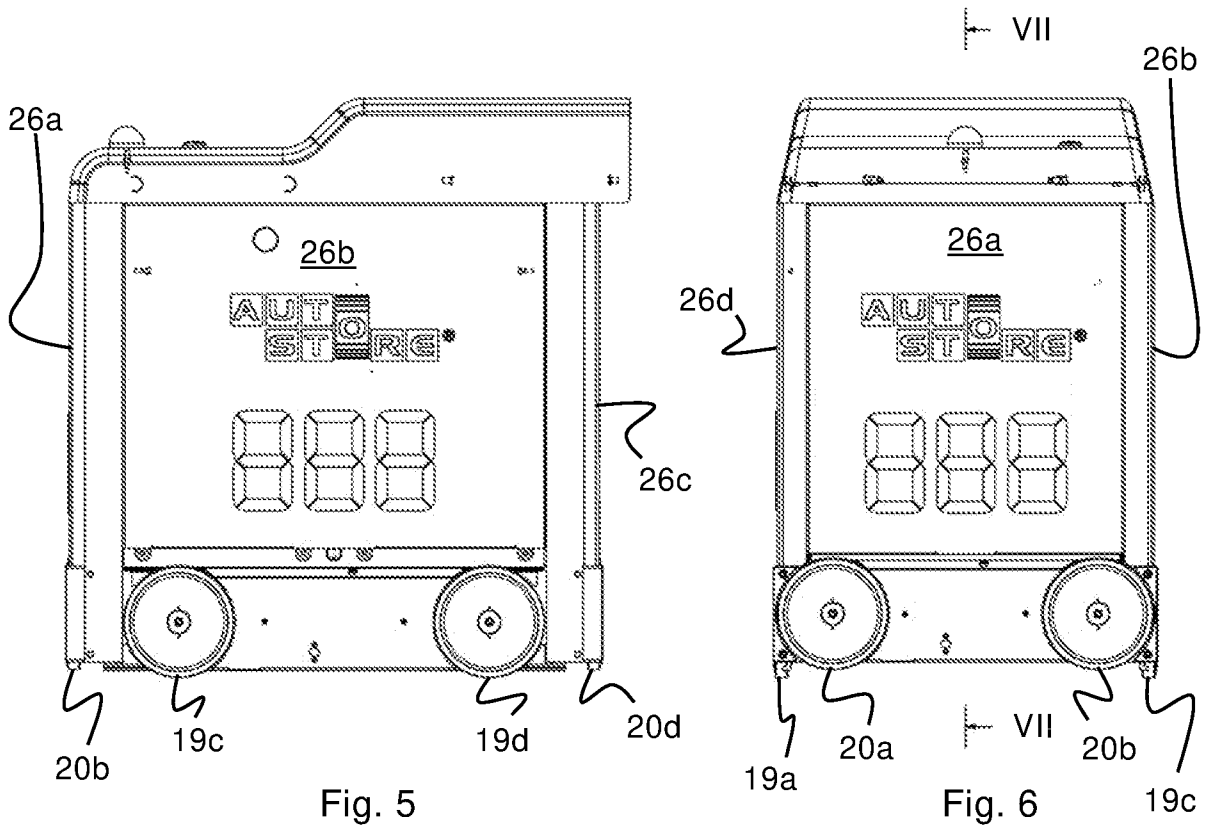


Fig. 5

Fig. 6

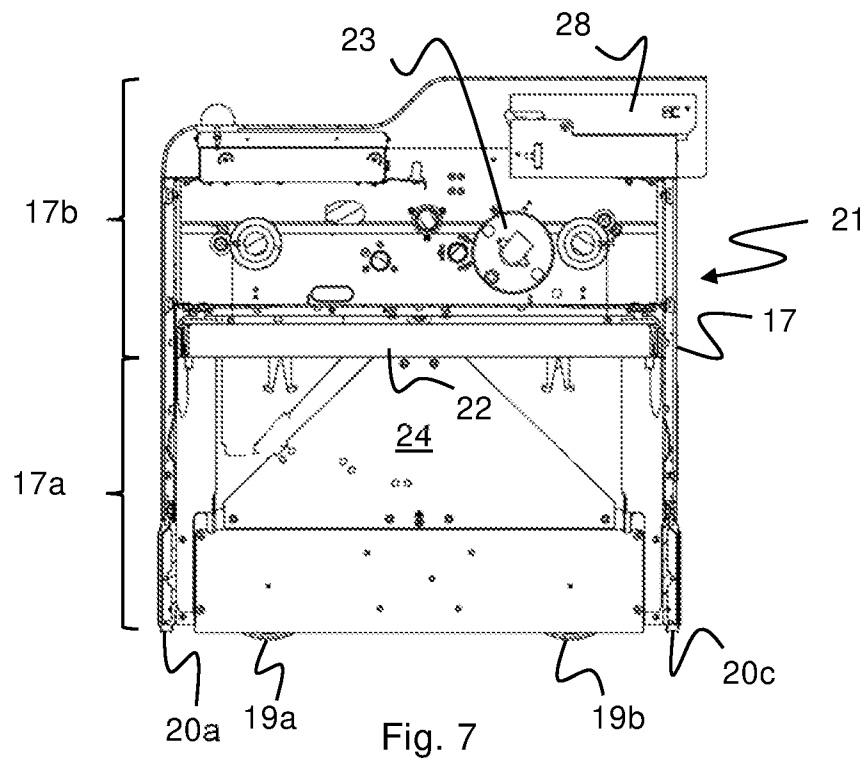


Fig. 7

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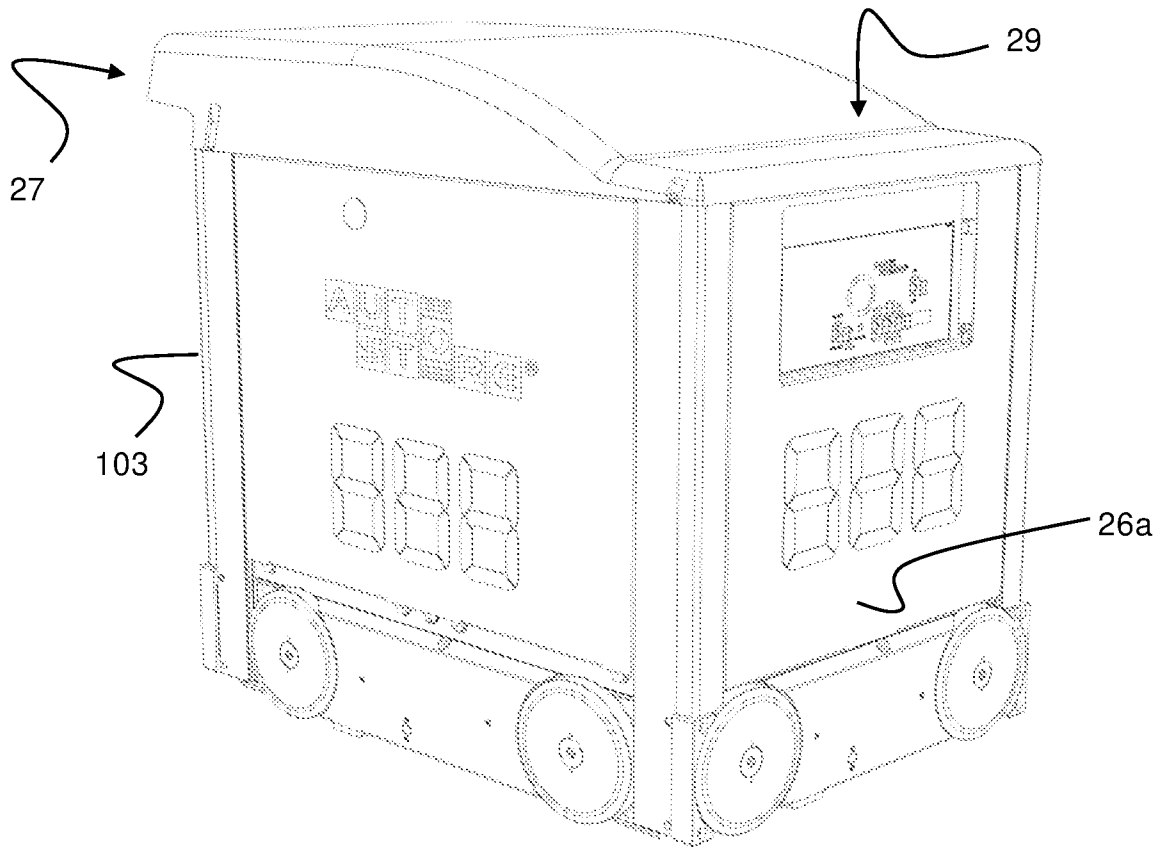


Fig. 8

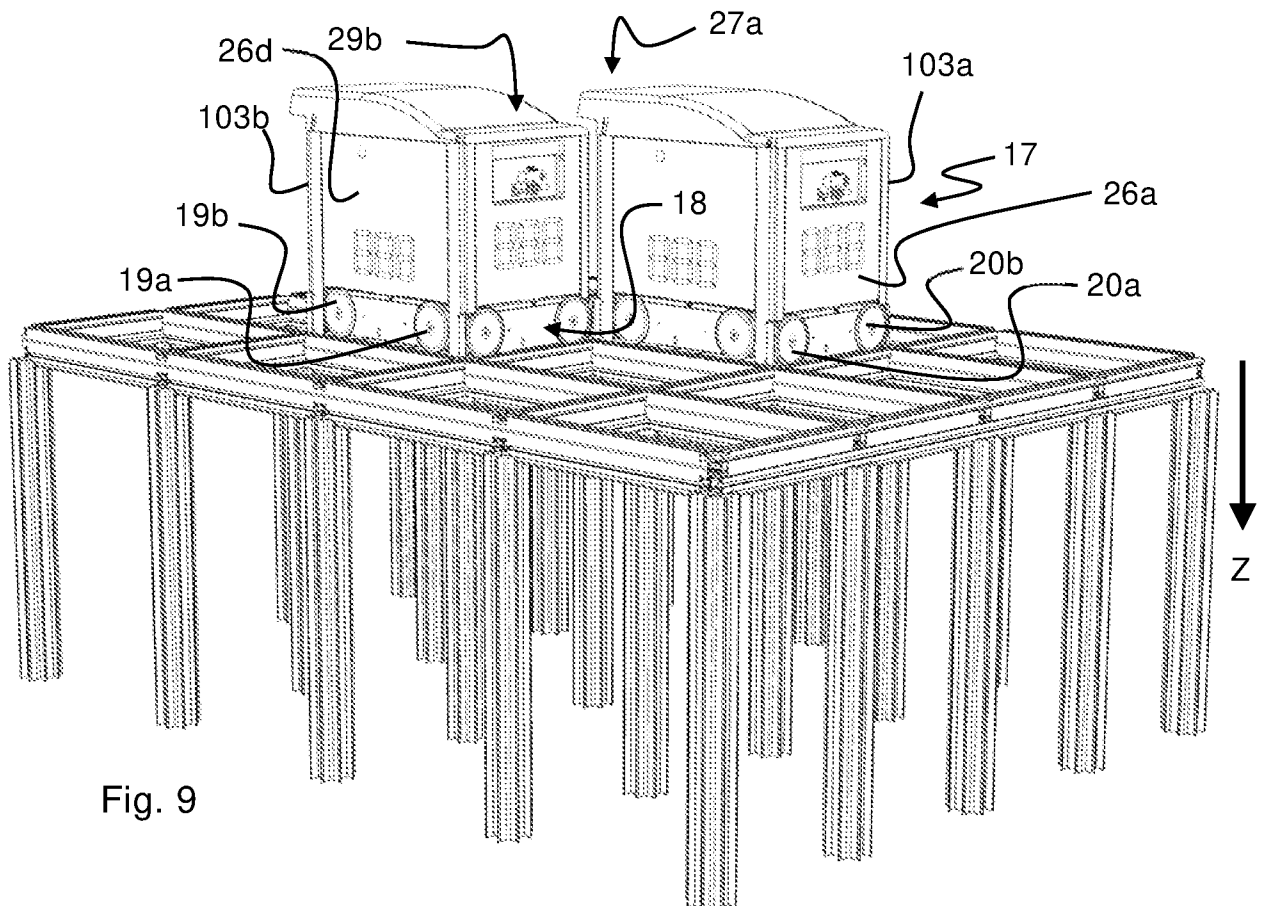


Fig. 9



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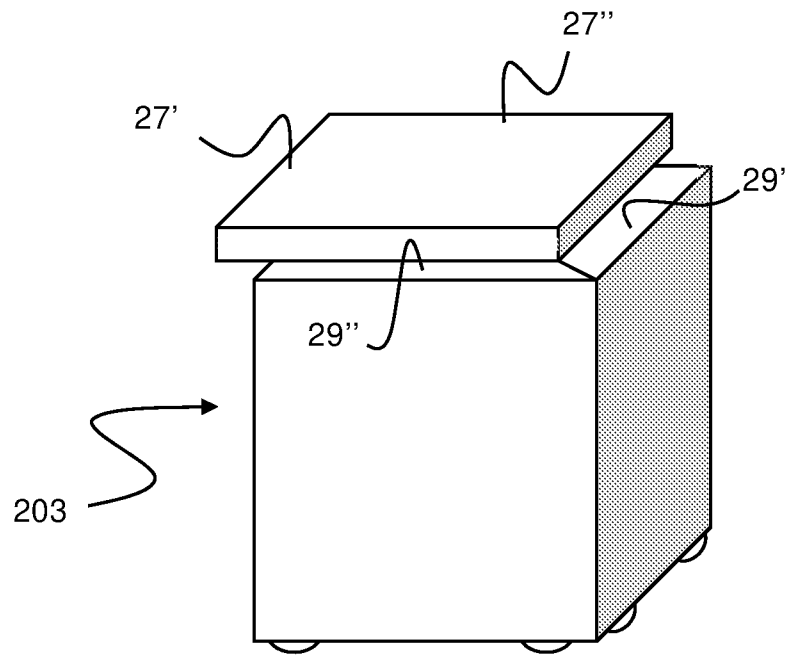


Fig. 12

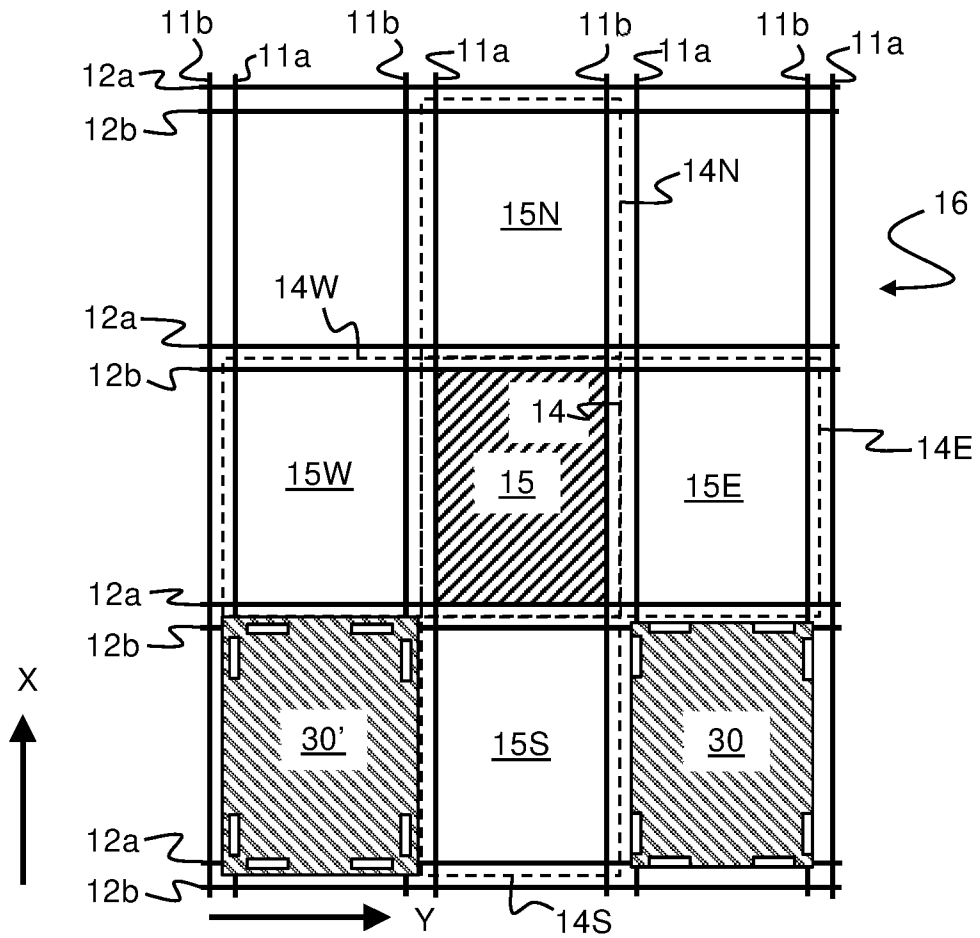


Fig. 13