(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
16 May 2019 (16.05.2019)

WIPO | PCT

(10) **International Publication Number**
WO 2019/094511 A1

(51) **International Patent Classification:**
B65G 1/04 (2006.01) *B65G 1/137* (2006.01)
B65G 1/06 (2006.01) *G06Q 10/08* (2012.01)

(21) **International Application Number:** PCT/US2018/059690

(22) **International Filing Date:** 07 November 2018 (07.11.2018)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
62/582,727 07 November 2017 (07.11.2017) US

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** SYSTEMS AND METHODS FOR STORAGE, RETRIEVAL, AND SORTATION IN SUPPLY CHAIN

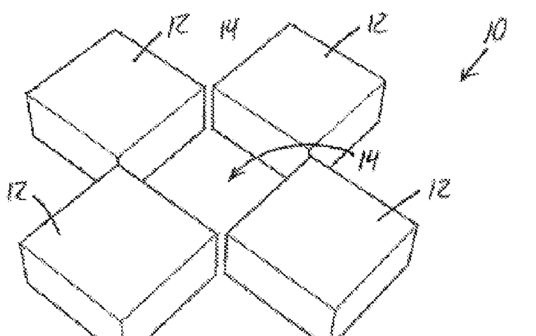

FIG. 1

(57) **Abstract:** A system includes a retrieval vehicle configured to carry an item and a storage apparatus configured to store the item. A control system is configured to control movement of the retrieval vehicle. A first destination container is located in a first location and is configured to receive the item. A transport vehicle is configured to transport the item to the first destination container. The control system is further configured to receive an order request for the item, identify a storage location in the storage apparatus and containing the item, and cause a first retrieval vehicle to retrieve the item and carry the item to a second location. The transport vehicle is configured to receive the item at the second location and deposit the item in the first destination container.

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SYSTEMS AND METHODS FOR STORAGE, RETRIEVAL, AND SORTATION IN SUPPLY CHAIN

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PRIORITY CLAIM

[0002] This application claims priority from U.S. Prov. Pat. Appl. No. 62/582,727 filed November 7, 2017, the entirety of which is hereby incorporated by reference as if fully set forth herein.

BACKGROUND

[0003] Supply chain management is an ever-growing field. The storage and retrieval of products, for ultimate delivery to customers has received a lot of attention with the growth of online retail businesses. Systems exist to more efficiently store and retrieve products, organized into containers, for fulfillment of customer orders. In completion with these systems are systems that sort items for combination to fulfill customer orders. These systems require sequence buffering to retrieve and organize items according to order specifics. Various improvements can be made to these existing systems to make them more efficient, less expensive, *etc*.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Preferred and alternative examples of the present disclosure are described in detail below with reference to the following drawings:

[0005] FIGs. 1A and 1B are diagrams showing advantages of the supply chain management methods and systems according to aspects of the present disclosure.

[0006] FIG. 2 is a diagram of a prior art JWN storage and retrieval system.

[0007] FIG. 3 is another diagram of a prior art storage and retrieval system.

[0008] FIG 4 illustrates features of a robotics sorting systems by Tomkins Robotics.

[0009] FIG. 5 illustrates features of a storage and retrieval system by ATTAbotics.

[0010] FIG. 6 is a diagram of a storage, retrieval, and sorting system according to aspects of the present disclosure.

[0011] FIG. 7 is a chart comparing potential space, output, labor, and ROI gains of a storage, retrieval, and sorting system according to aspects of the present disclosure with prior at systems.

[0012] FIG. 8 is a diagram illustrating an example storage, retrieval, and sorting system according to aspects of the present disclosure.

[0013] FIG. 9 is a flow diagram illustrating processes performed by a storage, retrieval, and sorting system according to aspects of the present disclosure.

[0014] FIG. 10 is another flow chart illustrating an example storage, retrieval, and sorting system according to aspects of the present disclosure.

DETAILED DESCRIPTION

[0015] The present disclosure is directed to eliminating buffer sequencing logic, needed to aggregate product (units) for customer or store replenishment orders, primarily utilized in automated storage and retrieval systems and/or unit distribution systems.

[0016] In one aspect, a storage and retrieval system may be configured to deliver items, such as products, organized into totes or other containers (high-unit volume store or customer orders), to a robotics system, to distribute the totes to the store or customer sort point destinations for packing, and in some cases, then for sorting for shipping by zip code (last mile delivery). By combining both a storage and retrieval system and a sorting system, 'buffer sequencing' logic, typically employed in each of these standalone systems may be eliminated. Buffer sequencing is used to group/organize product upfront, and is generally needed for store or customer orders. Because items retrieved from a storage system or facility are passed to a sorting robotics system directly, according to the present disclosure, items may be immediately diverted to the appropriate final destination (for packing) – either to the store or customer address. As a result, there is no intermediate step of determining which sequence items should be retrieved and sorted in the process of retrieving the correct items and sorting them for packing and/or shipping.

[0017] By skipping any intermediate steps, and directly routing items from storage to sorting for packing/shipping, the need to sequence orders upfront may be greatly reduced or even eliminated. This reduction in sequencing may result in significantly reducing or even eliminating the wait times associated with product aggregation.

[0018] The present disclosure has application in a variety of replenishment and delivery of goods, such as store replenishment and customer order deliveries for e-commerce and retail brick and mortar businesses.

[0019] One key advantage of the present disclosure is the elimination of the need for product (units)/container aggregation, before delivering the products/units/containers/items/articles to the next step (packing, shipping). Typical material handling solutions require buffer sequencing logic to organize or re-sequence product in a logical order, before presenting the product in the correct order needed to pass along next step (e.g. sortation, packing and shipping).

[0020] Prior attempts to curate orders still require material handling solutions to sequence product, before delivering to the next step. For example, an automated storage retrieval system typically sequences product across totes before delivering to a "Goods to Person" station before picking and packing the customer or store order. In another example, a product sorter typically sequences product across totes (containers, pockets) also before delivering to a "Goods to Person" station before picking and packing the customer or store order.

[0021] The disadvantage of these and other prior approaches is that they still require aggregating/organizing product stored across containers, needed for the same store or customer, before passing off the product to the next step. Aggregating/organizing product upstream results in operator wait time, requires un-necessary steps to shift un-used product around, and requires complex programming logic to correctly sequence the product, before delivering the product to the next step for sortation, packing and shipping. This and other issues with prior systems are addressed by eliminating the buffer sequencing logic in material handling solutions that require product aggregation before presenting to the next step, by combining storage and retrieval and sorting in an integrated system.

[0022] Prior art systems perform similar and overlapping tasks. By modifying each system to eliminate sequencing, which is a key part of each system, important aspects of each system may be combined in a new and complementary way. Stated another way, large aspects of prior art systems are redundant, such that combining them in an un-altered form, would not provide maximum efficiency benefits. However, by integrating the retrieval aspect of one prior art system and directly interfacing it with the sorting system of another, a much more efficient system is produced. By changing the fundamentals of operation of both systems, they may be combined to form a more efficient storage, retrieval, and sorting solution.

[0023] As described herein, a new system and omni-facility (of any size), will include a storage & retrieval system and leverage a sortation system/functionality to provide sortation to end sort points (store or customer), to prepare packages for delivery (last mile zip code sorts and delivery).

[0024] In an embodiment, a product retrieval sub-system may interface with a storage system, to retrieve product stored in bins, containers, etc., in the storage sub-system. The retrieval sub-system may perform sorting to organize the retrieved product or items into customer/store orders, before reaching packing and shipping sub-systems. According to aspects of the present disclosure, by integrating the retrieval sub-system and a sorting sub-system, processing time and ultimate product retrieval times may be greatly reduced, by reducing or eliminating the need to sequence or re-sequence orders.

[0025] Briefly, an embodiment may include a storage system, such as an optimized multi-layered grid structure 31 that enables multi-dimension access to bins stored in the grid. Once items or bins are retrieved from the storage facility or grid, the bins/items may be delivered to an induct portion of the system. Here, individual products may be removed and sorted from bins or containers storing multiple different items/types of items. Once all the items for an order have been retrieved and inducted, they may be moved to a packing portion of the system. Here the items may be packed in groups according to order specifics. Next, the packaged items may be moved to a shipping portion of the system, where the items can be organized according to final destination (e.g., zip code, city, state, country, etc.), and ultimately shipped for delivery to a customer, store, or other requestor.

[0026] Robots or other similar equipment may be used to retrieve the bins/containers from the storage facility. In some aspects, those robots may then deliver the retrieved bins to the induct portion of the system. In some cases, different robots, may then deliver the sorted items to the packing portion of the system. In yet some cases, different robots from those may then deliver the packaged items to the shipping portion of the system. In some cases, the retrieval robots or autonomous units may also be responsible for one or more of sorting, delivering to packing, and/or delivery to shipping. In this way, less robots may be required to perform at a similar level of retrieval and sorting output.

[0027] By combing storage and retrieval, and sorting functions, the robots employed by the system (either all-purpose robots, or separate storage and retrieval, and sorting robots), the robots no longer need to wait until all totes/bins/containers with needed product are grouped together before passing off to the next point. One or more embodiments may utilize one or multiple different sizes of robots, or robots of the same size with different components, that are equipped with different carrying capacity. In one aspect, a universal robot may be equipped with different containers or trays. Some robots may be equipped with larger trays or containers, to pick up more product to be stored. In some cases, by eliminating the need for buffer sequencing, the robots are less likely to collide with each other, as the robots no longer have to 'dance' (*e.g.*, idling in the same spot or moving around another robot to avoid collision) while they wait for other robots with needed product to arrive, before being delivered for packing/shipping.

[0028] In some aspects, the storage system may store a universal size of containers, or may store and be configured to store, different sizes, shapes, etc., of containers, to accommodate different product or items. One or more of the containers may include dividers inside the container/tote to physically separate different SKU's (product) – *e.g.* lipsticks would be in a different side, separated from mascara, separated from lip gloss, but all in the same tote.

[0029] In one aspect, there is no need to sequence an order. As the system receives demand (pull requests) for customers or to replenish store inventory, the system system delivers the tote(s)/containers with the necessary product directly to a sorting system, to divert the units to the sort points – either customer address or store location. Once this is done, the system can deliver the package to a shipping sort point, to sort by zip code for the last mile delivery.

[0030] The described systems and methods are flexible enough, modular enough, require smaller footprint, and can yield high outbound through-put, with limited touches, to support any forward deployment (pulls) locations – DMA, Stock Staging locations, traditional DC's or FCs, omni-facilities, store backroom layouts, 3PL's, etc. needed to serve customer and/or store replenishment orders.

[0031] While eliminating the buffer sequence is primarily applicable and advantageous for orders of more than one unit, the system will also function for orders that equal a need of one where the pass-off of the unit for packing and last mile sorting is a new feature.

[0032] FIG. 1 illustrates a singular storage cell 10 used within a three-dimensional storage system according to an embodiment of the present invention. Each full cell features four storage units 12, for example in the form of open-top or openable/closeable storage bins capable of holding any variety of goods therein. Each storage unit 12 resides within a respective rectangular volume of space on a respective side of a central void 14 of rectangular volume, whereby the four storage units 12 collectively surround the central void 14 on all four peripheral sides thereof, while leaving the top and bottom of the central void open. These cells are compiled into a space-efficient three-dimensional storage array in an organized manner by which every storage unit resides at an addressable storage location in the array that is directly accessible at all times regardless of the occupied or unoccupied status of every other storage location by its respective storage unit.

[0033] FIG. 2 illustrates a vertical stack 16 in which each layer or level is occupied by a respective full storage cell 10. The stacked storage cells are positioned in alignment with one another, whereby the central voids of all the stacked cells are aligned to create a central upright shaft 18, and each storage location and respective storage unit aligns with a respective storage location and storage unit in each of the other stacked cells. Accordingly, a respective vertical column is formed by the aligned storage locations and storage units on each side of the upright shaft 18. The stack 16 in FIG. 2 is a full-sided stack, in that each of its cells has a full set of four storage locations disposed around its central void, and so the stack features four vertical columns of storage locations and storage units. The hollow upright shaft 18 formed by the aligned voids of the stacked cells passes vertically through the entire stack from the open top of the uppermost cell's central void to the open bottom of the lowermost cell's central void.

[0034] FIG. 3 illustrates placement of a plurality of stacks beside one another to form a three-dimensional collection of storage units, in which the stacks have numbered sequentially from 1 to 9 for reference. Referring back to FIG. 2, the stacked cells and the central voids thereof may be interpreted as occupying five blocks of a square nine-block reference grid in a horizontal reference plane, while the four corner blocks of the nine-block grid are unoccupied by the storage units of the stack. Turning again to FIG. 3, the plurality of stacks fit together in a mating fashion, wherein at least one empty corner of each stack's nine-block reference grid is occupied by a respective vertical column of an adjacent one of the stacks, while the central upright shaft of each stack remains open. It is by way of this central upright shaft 18 that each and every storage location throughout the stack is accessible. So, with continued reference to FIG. 3, in which X and Y directions are marked in a horizontal reference plane, the corner-mated relation of the stacks can result in runs of four directly adjacent vertical columns (i.e., up to four neighbouring vertical columns lacking any empty voids between them) in both the X and Y directions, without defeating the accessibility of any vertical column from the upright shaft of its respective stack. Accordingly, a highly optimized balance is achieved between a space efficient three-dimensional layout of storage locations and readily available access to any and all of the storage locations.

[0035] Of the nine labelled stacks in FIG. 3, stacks 1 through 8 are each full-sided stacks in which each storage cell has a full set of four storage units occupying the four respective storage locations around the cell's central void. Stack 9 on the other hand is a reduced stack from which one vertical column of storage locations and storage units has been omitted, thereby leaving only three vertical columns partially surrounding the respective upright shaft 18 on three sides thereof. Each cell of stack 9 is therefore a reduced cell having only three storage locations, thus being capable of storing a maximum of three storage units in the cell at any given time. The inclusion of reduced stacks in a collection enables building of the storage array to fit within a targeted rectangular grid size in the horizontal reference plane, while occupying the greatest possible number of blocks within this target grid size. The horizontal reference plane in FIG. 3 has been labelled with a target grid size of six by eight, in which the six grid rows have been numbered as 1 through 6 and the eight grid columns labelled as A through H.

[0036] In order to achieve this target grid size, stacks 5 and 7 would both need to also be trimmed to a reduced stack of three columns, like stack 9. To optimize the number of storage locations in this target grid size, a single-column reduced stack 10 could also be added in the top left corner of the Figure. Looking at row 6, it will be seen that in addition to the central shaft 18 of reduced stack 9, by which the storage locations of stack 9 are all accessible, row 6 also contains three additional shafts 20 in grid columns A, C and H. These shafts are defined by unoccupied corners of respective stacks of storage cells. Shafts such as these that reside at the outer perimeter rows and columns of the reference grid and do not define the central shafts of respective stacks are referred to herein as outer shafts. For example, grid row 1 in FIG. 3 features two such outer shafts 20 at grid columns B and G, and would have a third outer shaft at grid column A if optional single-column stack 10 were omitted. As outlined below, these outer shafts provide vertical travel paths by which robotic retrieval vehicles can traverse between gridded track layouts above and below the stacks 16 during return of previously retrieved storage units to the stacks, while keeping central upright shafts of the stacks free for retrieval of other storage units from the stacks.

[0037] FIG. 4 illustrates a completed three-dimensional grid structure 31 employing the stacked storage cell configuration described above with reference to FIGS. 1 to 3. In the completed grid structure 31, a gridded upper track layout 22 resides above the stacks 16, and a matching gridded track layout 24 (FIG. 5) resides beneath the stacks 16. The lower gridded track layout 24 at the bottom of the three-dimensional grid is surrounded on the four sides thereof by delivery stations 30 to which the robotic retrieval vehicles deliver the storage units pulled from the stacks.

[0038] As better shown by the similar three-dimensional grid structure 31 in FIG. 5, which is of smaller grid size and height than that of FIG. 4 and is shown at greater scale with the delivery stations 30 omitted, each track layout features a set of X-direction rails 26 lying in the X-direction of the horizontal reference plane and a set of Y-direction rails 28 perpendicularly crossing the X-direction rails in the Y-direction of the reference plane. The crossing rails 26, 28 define the horizontal reference grid of the storage system, where each grid row is delimited between an adjacent pair of the X-direction rails 26 and each grid column is delimited between an adjacent pair of the Y-direction rails 28. Each intersection point between one of the grid columns and one of the grid rows denotes the position of a respective column of storage cells, a respective central shaft, or a respective outer shaft. In other words, each column of storage cells, each central upright shaft of a stack, and each outer shaft resides at respective Cartesian coordinate point of the reference grid at a respective area bound between two of the X-direction rails and two of the Y-direction rails. The three-dimensional addressing of each storage location and associated storage unit in the completed system is completed by the given vertical level at which the given storage location resides within the respective stack. That is, a three-dimensional address of each storage location is dictated by the grid row, grid column and stack level of storage location in the three-dimensional grid.

[0039] With continued reference to FIG. 5, a respective upright frame member 32 spans vertically between the upper and lower grid layouts 22, 24 at each intersection point between the X-direction and Y-direction rails, thereby cooperating with the rails to define a framework of the three-dimensional grid structure 31 for containing and organizing the three-dimensional array of storage cells within this framework. As a result, the central upright shaft 18 of each stack of storage cells and each outer shaft 20 of the three-dimensional storage array has four vertical frame members 32 spanning the full height of the shaft at the four corners thereof.

[0040] Turning momentarily to FIG. 12, each frame member has a square horizontal cross-section whose four sides lie in the X and Y directions of the horizontal reference grid, and so for each central or outer shaft of the three-dimensional storage array, each of the four frame members at the corners of the shaft has a respective corner edge 32a facing diagonally into this shaft. Respective sets of rack teeth 34a, 34b extend from the frame member 32 at the two sides of the frame member 32 that perpendicularly intersect at this corner edge 32a, the teeth of each set being arranged in series in the vertical Z-direction of the three-dimensional grid. One set of teeth 34a thus face in the X-direction along the X-direction rail 26 at one side of the shaft, while the other set of teeth 34b face in the Y-direction along the Y-direction rail 28 at a perpendicularly adjacent second side of the shaft. Accordingly, each of the frame members at the four corners of each central or outer shaft defines a toothed rack member having two sets of teeth 34a, 34b that face inwardly along respective sides of the shaft toward the opposing corner on the same side of the shaft. The X-direction teeth 34a are spaced a short distance from the X-direction rail 28, and the Y-direction teeth 34b are likewise spaced a short distance from the Y-direction rail 28, whereby a gap 35 exits between each set of the teeth and the respective rail. Each shaft thus has eight sets of rack teeth in total, with two sets at each corner of the shaft. As described in greater detail below, the rack teeth 34a, 34b cooperate with pinion wheels on the robotic retrieval vehicles to enable traversal of same between the upper and lower track layouts through the central and outer shafts of the three-dimensional grid structure 31.

[0041] Each rail and each frame member is assembled from modular pieces so that the three-dimensional grid structure 31 can be expanded at any given time, both in the horizontal X-Y dimensions of the reference grid and the vertical Z-direction to increase the number of storage cell stacks and/or increase the height (i.e. number of levels) within the storage cells stacks. Each rail is thus made of up modular rail pieces each horizontally connectable between two frame members, which are likewise formed of modular frame pieces vertically connectable to one another in end-to-end relation. To expand the horizontal grid of the structure without adding to the height, additional rail pieces are simply added to horizontally expand the grid side. To increase the height of the three-dimensional grid structure 31, the rails of the upper track layout are temporarily removed, and additional frame pieces are added atop the existing frame pieces to increase the frame height to the targeted level, and the upper rails are re-installed at the top of the now-taller frame members.

[0042] FIGS. 6-8 illustrate one of the robotic retrieval vehicles 36 operable to retrieve the storage units from the three-dimensional array to enable pulling one or more products from the retrieved storage unit at one of the delivery stations 30. The retrieval vehicle 36 is also operable to return each retrieved storage unit back to an assigned storage location in the three-dimensional array, for example returning it to the same location from which it was retrieved.

[0043] With reference to FIGS. 7 and 8, the vehicles 36 feature a square frame 38 with four vertical perimeter walls connected end to end at four corners of the frame 38. Of these perimeter walls, one opposing pair of perimeter walls 38a denote two Y-oriented sides of the vehicle that lie in the Y-direction of the reference grid, while the other opposing pair of perimeter walls 38b of the vehicle frame 38 denote two X-oriented sides of the vehicle that lie in the X-direction of the reference grid. A respective X-side wheel carriage 40 is mounted to each of the X-side perimeter walls 38a of the frame 38 in a fixed-height position thereon near the bottom edge of the perimeter wall 38a. A respective Y-side wheel carriage 42 is mounted to each of the Y-side perimeter walls of the frame 38, but in a height-adjustable manner thereon by which the Y-side wheel carriages 42 can be displaced upwardly and downwardly along the respective Y-side perimeter walls. For this purpose, the exterior of each Y-side perimeter wall 38a of the vehicle frame 38 features a pair of vertically upright guide tracks 44 fixed thereto and the Y-side wheel carriage 42 features a pair of slide blocks 46 carried at the inner side of the wheel carriage and slidably mated with the guide tracks for movement of the wheel carriage upwardly and downwardly therealong. These cooperating slide members on the vehicle frame and Y-side wheel carriage are shown in FIG. 8.

[0044] A respectively drive pulley 48 is supported on the respective Y-side perimeter wall 38a near the top end thereof by way of an out-turned flange reaching outward from the Y-side perimeter wall 38a to position the drive pulley's vertical rotation axis slightly outward from the Y-side perimeter wall 38a. A threaded drive shaft 50 reaches vertically downward from the drive pulley 48 on the rotation axis thereof, and is threadedly engaged with an internally threaded feature (not shown) on the inner side of the Y-side wheel carriage 42, whereby rotation of the drive pulley 48 in one direction displaces the Y-side wheel carriage 42 upwardly along the guide tracks 44, while rotation of the pulley in the opposing direction displaces the Y-side wheel carriage 42 downwardly along the guide tracks 44. The two drive pulleys have a drive belt 52 entrained thereabout across the interior space delimited by the perimeter walls 38a, 38b of the square vehicle frame 38, whereby driven rotation of one of these two drive pulleys 48 by a singular motor (not shown) rotates both drive pulleys in concert with one another to lift and lower the Y-side wheel carriages in unison.

[0045] Each of the wheel carriages 40, 42 at both the X and Y sides of the vehicle carries two rotatably driven wheel units 54 at opposing ends of the carriage so that these two wheel units 54 resides adjacent the two respective corners of the vehicle frame 38 where this side of the vehicle intersects the two perpendicularly neighbouring sides. The wheel units at the X-sides of the vehicle are rotatable about horizontal axes lying in the Y-direction, whereas the wheel units at the Y-sides of the vehicle are rotatable about horizontal axes lying in the X-direction. Each wheel unit is a singular body defining both a conveyance wheel 56 and a respective pinion wheel 58. The pinion wheel resides inboard of the conveyance wheel (i.e. nearer to the frame 38), and features a gear-toothed periphery for mating engagement with the teeth on the rack members 32 of the three-dimensional grid framework.

[0046] Turning momentarily again to FIG. 12, the X and Y-direction rails 26, 28 of the gridded track layouts at the top and bottom of the three-dimensional grid structure 31 each feature a raised tongue 60 running longitudinally of the rail at a topside thereon. The raised tongue 60 resides at a generally central position across the rail, and leaves a respective flat 62 on each side of the tongue 60. FIG. 12 illustrates an internal intersection point of the upper gridded track layout, where the top end of the frame member 32 features an upper cap 64 with a flat majority area 66 that lies flush with the flats 62 of the X and Y direction rails that intersect with this frame member 32. A raised central area 68 of the cap's topside stands upward from the flat remainder 66 thereof in alignment with the tongues 60 of the intersecting rails 26, 28. The rail pieces that surround each central and outer shaft may differ from the other rails pieces in that the flat 62 on the shaft-adjacent side of the tongue 60 is narrower than the other flat 62 on the other side of the tongue in order to leave the aforementioned gap 35 between the rails and the rack teeth at the corners of the shaft. The other rail pieces that don't border a central or outer shaft may instead be symmetric across the tongue 60 with two flats of equal width. Just as the shaft-bordering rail pieces may differ from the other rail pieces that don't border a shaft, any frame member that does not have a corner facing into a shaft may lack the rack-teeth that are found on the shaft-bordering frame members.

[0047] FIG. 13 shows another intersection of the rails and frame members, but at the lower track layout. Here, the bottom end of each frame member 32 features a reduced portion 68' that vertically joins a base 69 at the bottom end of the frame member 32 to the remainder of the frame member above this reduced portion 68'. The horizontal cross-section of the frame member 32 is lesser at this reduced portion 68' than at the base 69 and upper remainder of the frame member, and more specifically is generally equal to the width of each rail tongue 60 in each of its two horizontal dimensions, just like the raised area 68 of the frame member's top cap 64. The height of the reduced portion 68' of the frame member exceeds the wheel height of the retrieval vehicle 36. The flat topside of the base 69 around the reduced portion 68' is flush with the flats 62 of the track rails 26, 28 of the lower track layout.

[0048] Turning back to FIGS. 7 and 8, the drive pulleys 48 and associated motor and threaded shafts 50 thus cooperate with the guide tracks 44 to form a wheel lifting and lowering system operable to raise and lower the Y-side wheel carriages 42 relative to the vehicle frame and the fixed-height X-side wheel carriages 40 so that the Y-side wheel units are raiseable and lowerable relative to the X-side wheel units. In the fully lowered state of the Y-side wheel units, the height-adjustable Y-side wheel units reside at a lower elevation on the vehicle frame 38 than the fixed-height X-side wheel units, whereby the conveyance wheels 56 of the Y-side wheel units are lowered into contact with the flats 62 of a pair of Y-direction rails 28 of the track layout 22/24 for rollable support of the vehicle 36 thereon. Each and every wheel unit is rotatably driven by a respective motor carried by the respective wheel carriage, whereby rotation of the Y-side wheel motors in opposing directions causes displacement of vehicle back and forth in the Y-direction of the track layout. By contrast, in the fully raised state of the Y-side wheel units, the Y-side wheel units reside at a greater elevation on the vehicle frame than the X-side wheel units, whereby the conveyance wheels 56 of the Y-side wheel units are raised out of contact with the flats 62 of the Y-direction rails 28, thereby lowering the X-side wheel units into contact with the flats 62 of two X-direction rails 26 of the track layout for rollable support of the vehicle thereon. Accordingly, rotation of the X-side wheel motors in opposing directions causes displacement of vehicle back and forth in the X-direction of the track layout 22/24. Driving of all four wheels in both the X-side wheel set and Y-side wheel sets is preferable to ensure proper vehicle alignment in the horizontal track conveyance of the vehicle, through driving of each wheel unit separately is not as essential during horizontal track conveyance, as compared to vertical shaft conveyance where independent operation of the wheels in opposite rotational directions at each side is of greater significance in order to maintain proper alignment and balance of the vehicle during rack-and-pinion conveyance of the vehicle through the shaft.

[0049] Referring again to FIG. 12, the flat majority 66 of the topside of the frame member caps 64 at the upper track layout enables rolling motion of the vehicle across the top of each frame member 32 from one rail piece to the next, while the raised central area 68 of the cap 64 cooperates with the rail tongues 60 to maintain alignment of the conveyance wheels 56 on the rails as the vehicle crosses from one rail piece to the next. Likewise, referring to FIG. 13, the flat topside of the base 69 of each frame member 32 forms an extension of the rail flats 62 in order to interconnect the flats of the rail pieces that intersect at this frame member, while the reduced portion 68' of the frame member 32, at frame members that don't reside at outer corners of the grid structure 31, enables the wheel units of the robotic retrieval vehicle 36 to roll past the frame member in the space around the reduced portion 68' between the base 69 and the upper remainder of the frame member. At each wheel unit, the conveyance wheel 54 residing outboard of the respective pinon wheel 56 has a relatively smooth periphery by comparison to the toothed periphery of the pinion wheel, and may have rubber or other suitable grip material of sufficient frictional coefficient to ensure good drive traction between the conveyance wheels and the rails.

[0050] As will be apparent from FIG. 12, placement of the conveyance wheels 54 of the robotic retrieval vehicle in rolling contact with the flats 62 of the rails 26, 28 prevents the robotic retrieval vehicle from dropping down a shaft of the three-dimensional grid structure 31 as the vehicle traverses the upper track layout. However, when traveling through a particular shaft, either downwardly from the upper track layout or upwardly from the lower track layout, is required, the wheel units must be retracted inwardly toward the respective sides of the vehicle frame to reduce the outer perimeter of the vehicle (i.e. reduce both the X and Y track width of the vehicle) to a size that is acceptable within the shaft between the crossing rails.

[0051] Referring again to FIGS. 7 and 8, for this purpose each of the four corners of the square vehicle frame features a respective cam 70 that is operable to selectively control inward/outward movement of both the X-side wheel and corresponding Y-side wheel at this corner of the frame. Each cam 70 is rotatable about a vertical axis 70a by a respective control pulley 72 that is supported on the intersecting perimeter walls of the frame 38 at this corner in a manner rotatable on the same vertical axis as the cam 70. As shown, outwardly reaching support flanges 74 support the control pulley 72 at a location placing its rotational axis outwardly of the frame's perimeter walls 38a, 38b at the respective corner of the frame 38. With reference to FIGS. 9 and 10, in horizontal cross-sectional planes of the cam 70, the cam has two diverging sides 76 reaching outwardly away from the cam's axis in order to widen the cam toward a widened distal face 78 of arcuately convex curvature. Lying across the cam's rotational axis from the distal face 78 of the cam is a narrowed proximal face 79 of arcuately convex curvature of lesser radius than the widened distal face 78. The proximal face resides at a lesser radial distance from the rotational axis of the cam than the opposing distal face.

[0052] Each wheel unit 54 is carried by a respective wheel housing 80 at the respective end of one of the wheel carriage. As best shown in FIGS. 9 and 10, at a distal end of the wheel housing 80 furthest from the wheel carriage 40/42 along the direction of the respective perimeter side 38a/38b of the vehicle frame 38, the wheel housing 80 features an angled end wall 82 that lies at 135-degrees to this perimeter side wall direction. At an intermediate portion of the wheel housing between the wheel carriage 40/42 and the angled distal end wall 82 of the wheel housing 80, a hollow camming block 84, 86 extends inwardly from the wheel housing and closes around the respective cam 70. The camming block 86 carried on the movable Y-side wheel carriage 42 is attached to a topside of the respective wheel housing, whereas the camming block 84 on the stationary X-side wheel carriage 40 is attached to the underside of the respective wheel housing. Accordingly, the camming block 86 of the height adjustable Y-side wheel carriage 42 is above the camming block 84 of the fixed-height X-side wheel carriage 40 to allow the Y-side wheel carriage 42 and attached camming block 86 to move upwardly and downwardly relative to the fixed-height X-side wheel carriage 40. Each camming block 84/86 has a hollow rectangular interior which is longer in a direction parallel to the respective side of the vehicle frame on which the caroming block is carried than in the other direction perpendicular thereto. That is, the hollow interior of the camming block 86 on the Y-side of the vehicle is longer in the Y-direction than in the X-direction, and the hollow interior of the camming block 84 on the X-side of the vehicle is longer in the X-direction than in the Y-direction.

[0053] FIG. 9 shows the cam 70 in an out-turned first position facing its widened distal face 78 outwardly away from the respective corner of the vehicle frame 38, whereby the widened distal face 78 contacts two intersecting sides of the hollow rectangular interior of each caroming block 84, 86 at an outermost corner of this camming block interior that is furthest from the respective corner of the vehicle frame in both the X and Y directions. This position of the cam corresponds to placement of both the X-side and Y-side wheel units into their extended outboard positions situated furthest outward from the vehicle frame 38, as the distal face 78 of the cam 70 abuts against the outer one of the two longer sides of the Y-side camming block's hollow interior and against the outer one of the two long sides of the X-side caroming block's hollow interior. FIG. 10 illustrates rotation of the cam out of the out-turned position of FIG. 9 toward an opposing in-turned position (not shown) in which the distal face 78 of the cam turns toward an opposing innermost corner of the camming block's interior. FIG. 10 shows the cam at an intermediate state half way between these opposing out-turned and in-turned positions, where the contact of the cam's distal face in the interior of the Y-side's camming block 86 has shifted to the inner one of its two longer sides, thereby shifting the Y-side wheel carriage inwardly toward the frame in the X-direction. Continued rotation of the cam to its in-turned position facing 180-degrees opposite the out-turned position of FIG. 9 will shift the distal face of the cam out of contact with the outer one of the X-side camming block's longer interior sides an into contact with the inner one of the X-side camming block's longer interior sides, thereby shifting the X-side wheel carriage inwardly toward the frame in the Y-direction. The angled distal ends 82 of the two wheel housings 80 at each corner of the vehicle enable placement of the wheels at outermost points from the corner of the vehicle frame 38 so as to reach into engagement with the rack teeth 34a, 34b on the rack members 32 of the three-dimensional grid structure 31 without causing interference between retraction of the wheel carriages on the X and Y sides of the vehicle, as shown in FIGS. 9 and 10.

[0054] Turning again to FIGS. 7 and 8, a second drive belt 88 is entrained around the cam control pulleys 74 and an input pulley 90 around the exterior of the vehicle frame. The input pulley 90 is operably driven in opposing directions by a reversible electric motor 92. The input pulley, control pulleys, second drive belt, associated motor 92, and cams 70 therefore form a wheel extension and retraction system for displacing the wheel units inwardly and outwardly at the outer perimeter sides of the vehicle. With reference to FIG. 8, to accommodate inward and outward movement of the X-side wheel carriages 40, each X-side wheel carriage is carried on a pair of linearly displaceable plungers 93a spaced apart from one another along the respective perimeter side wall 38b of the frame 38, and slidable back and forth through a respective bushing on the perimeter wall 38b of the frame 38, thereby accommodating the cam-driven movement of the wheel carriage inwardly and outwardly toward and away from the perimeter frame wall 38b. One X-side plunger 93a is visible in FIGS. 8 and 9. Likewise, each Y-side wheel carriage 42 is carried by a pair of sliding plungers 93b respectively disposed adjacent the opposing ends of the wheel carriage 42, except that the plungers are movably supported not by the respective perimeter frame wall 38a, but rather by a displacement unit 42a incorporating the slide blocks and threaded feature by which the Y-side wheel carriage is vertically displaceable on the guide tracks of the respective perimeter frame wall 38a. This displacement unit 42a is therefore vertically displaceable up and down the perimeter frame wall 38a, carrying the Y-side wheel carriage with it, while the T-side wheel carriage 42 is also horizontally displaceable inwardly and outward toward and away from the displacement unit. One of the Y-side plungers 93b is visible in FIGS. 9 and 10.

[0055] With the robotic retrieval vehicle 36 disposed on the upper track layout 22 of the three-dimensional grid structure 31 at a co-ordinate point overlying the central shaft of one of the stacks of storage cells, the robotic retrieval vehicle 36 is lowerable into the shaft by the following procedure. First, with the Y-side conveyance wheels lowered into contact with the Y-direction rails 28 to support the vehicle thereon, and the X-side conveyance wheels thus raised off the X-direction rails 26, the cams 70 are rotated from the out-turned position of FIG. 9 to an intermediate position opposite that which is shown in FIG. 10, which retracts the X-side wheel carriage 40 and attached X-side wheel units inwardly, thereby withdrawing them inwardly from over the X-direction rails into positions lowerable into the shaft. Now, the raisable/lowerable Y-side wheel carriages 42 are raised upwardly relative to the vehicle frame, whereby the fixed-height X-side wheel carriages 40 are lowered down into the shaft, bringing the respective pinion wheels 58 into engagement with the X-side rack teeth 34a of the rack members 32 at the corners of this shaft. The gap 35 between each set of rack teeth and the neighbouring rail accommodates the outer periphery of the respective conveyance wheel in this gap while the pinion wheel mates with the rack teeth. With the vehicle now supported by engagement of the X-side pinion wheels 58 with the X-side rack teeth 34a of the rack members 32, the cams 70 are rotated from the current intermediate position (not shown) to the in-turned position (not shown), thereby retracting the Y-side conveyance wheels inwardly off the rails of the upper track layout 22. Motorized rotation of the X-side pinion wheels already engaged with the racks is then used to drive the vehicle further downwardly into the shafting, thereby bringing the Y-side pinion wheels into engagement with the respective sets of rack teeth 34b, at which point driven rotation of all the motorized wheel units is then used to drive the vehicle downwardly through the shaft to a targeted level in the stack of storage cells surrounding this shaft. Prior to driving the X-side wheel units, the Y-side wheel carriages 42 may lowered relative to the vehicle frame down into the shaft and toward or into engagement with the Y-side rack teeth 34b of the rack members 32, at which point both the X and Y side wheels can then be driven.

[0056] Similarly, with the robotic retrieval vehicle disposed on the lower track layout 24 of the three-dimensional grid structure 31 at a co-ordinate point underlying the central shaft of one of the stacks of storage cells, the robotic retrieval vehicle is raiseable into the shaft by the following procedure. First, with the X-side conveyance wheels seated on the X-direction rails to support the vehicle thereon, the Y-side wheel carriages 40 and attached y-side wheel units are retracted inwardly by rotating the cams from the out-turned position of FIG. 9 to the intermediate position of FIG. 10. Now, the raisable/lowerable Y-side wheel carriages 42 are raised up in order to lift the retracted Y-side wheel units up into the shaft to place the Y-side pinion wheels into engagement with the Y-side rack teeth 34b of the rack members 32 at the corners of this shaft. With the vehicle now suspended from the rack members by engagement of the Y-side pinion wheels 58 with the Y-side rack teeth 34b of the rack members 32, the X-side wheels are retracted inwardly off the rails by rotating the cam 79 further in the same direction from the intermediate position of FIG. 10 into the in-turned position (not shown). Then, the Y-side wheel units are driven by the respective motors in the required directions to convey the vehicle further upwardly into the shaft, bringing the X-side wheel units into engagement with the X-side rack teeth 34a of the rack members, whereupon all eight wheels are driven to convey the vehicle upwardly through the shaft.

[0057] Turning back to FIG. 6, a completed robotic retrieval vehicle includes the vehicle components of FIGS. 7 and 8, and may include optional cover panels 90 affixed to exterior sides of the wheel carriages. An upper support platform 92 is mounted atop the vehicle frame 38, and features an outer deck surface 94 having a round central opening therein in which a circular turret 96 is operably installed for rotation of the turret 96 about an upright rotation axis passing vertically through the center of the vehicle. The circular turret 96 features a central channel 98 recessed into its otherwise flat topside, which resides flush with the surrounding deck surface 94 to form a flat top of the platform. The channel 98 extends diametrically across the turret through the central rotation axis thereof. An extendable/retractable arm 100 is mounted within the channel 98, and is selectively extendable and retractable by a suitable actuator between an extended position reaching outwardly beyond the outer perimeter of the platform and a retracted position withdrawn fully into the confines of the turret's central channel. Between a motor (not shown) operably driving rotation of the turret about is central rotation axis and the actuator operable to extend and retract the arm 100, the turret is rotatable into any one of four different working positions in which the arm 100 is extendable outwardly from a respective one of the vehicle's four perimeter sides. Each storage unit features a central channel recessed in the underside thereof and shaped to accommodate receipt of the extended arm 100 therein in manner temporary coupling the underside of the storage unit to the arm 100, whereupon retraction of the arm draws the storage bin onto the flat top of the vehicle's upper platform 92 from a targeted storage location situated alongside the central shaft of a storage cell stack in which the robotic vehicle currently resides.

[0058] To retain the retrieved storage unit on the upper platform 92 of the vehicle, the outer perimeter of the platform is surrounded by four raisable/lowerable fences 102 each residing at a respective perimeter side of the vehicle. A respective actuator is operable to raise and lower each fence. Each fence may occupy a raised position by default, in which case a selected fence is only lowered when extension of the arm 100 at the respective side of the vehicle is required. In its raised state, each fence reaches upwardly beyond the platform to block the carried storage unit from sliding off the platform. In its lowered state, each fence aligns its opening with the channel 98 of the turret.

[0059] In one preferred embodiment, the system includes a fleet of robotic storage/retrieval vehicles of the forgoing type. Each vehicle 36 includes suitable receiver by which wireless communication with a wireless computerized control system is possible to control operation of the vehicle fleet. In response to a request for a particular product from the storage system, the controller signals one of the vehicle's to retrieve the product from its known storage location in the three-dimensional array. The vehicles normally occupy the upper track layout 22 by default, where the vehicle uses the X-side and Y-side conveyance wheels to traverse the upper track layout in two dimensions to reach the appropriate central shaft of the stack in which the target storage location resides. The vehicle retracts its wheel units and transitions into the shaft using the above described procedure, and uses the pinion wheels to travel down the shaft to this target storage location, from which the respective storage unit is then retrieved by operation of the turret and associated arm. With the retrieved storage unit safely retained on the upper platform of the vehicle by the perimeter fences, the vehicle continues downwardly through the shaft to the lower track layout 24, where the wheels are once again extended out and the X-side and/or Y-side conveyance wheels are used to traverse the lower track layout in two dimensions to one of the delivery stations 30. Here, the desired product from the storage unit is removed for subsequent handling and delivery, whether by automated or human means. The vehicle then returns to the upper track layout 22 via one of the outer shafts.

[0060] By using only the outer shafts for return of the vehicle to the upper track layout, the central shafts by which storage units are retrieved by downward-travelling vehicles from the upper track layout remain unobstructed by vehicles returning to the upper track layout. During the return of the vehicle to the upper track layout via an outer shaft, the vehicle may carry the same storage unit that it previously delivered to a delivery station back up to the upper track, where the vehicle then travels to a shaft where it descends to a controller-specified storage location where the storage unit is once again placed back into storage. This controller-specified storage location for example may be the same location from which that particular storage unit was previously retrieved.

[0061] Referring to FIG. 11A, in addition to the rails 26, 28 and frame members 32, the framework of the three-dimensional grid structure 31 may include connecting bars 108 spanning horizontally between adjacent frame members 32, and may also include connecting panels 110 that reside in vertical planes and likewise span between adjacent frame members to reinforce the three-dimensional framework. These connecting panels may also serve as firebreaks or firewalls to create barriers that prevent or inhibit flames from spreading through the structure from one column of storage locations to the next in the event of a fire. Such connecting panels are installed only at the non-access sides of the storage columns, i.e. at sides thereof not directly neighboured by a central or outer shaft, as the sides of the shafts must be left open to allow the vehicles to access the storage locations in each column. As also shown in FIG. 11A, the lower track layout may be elevated off the ground by support legs 111 attached to the lowermost frame pieces of the modular frame members at the bottom of the bases 69 thereof.

[0062] Turning to FIGS. 11B and 11C, each connection panel 110 of the illustrated embodiment spans approximately two levels of the grid structure 31 in the vertical Z-direction thereof, and features three in-turned flanges 112a, 122b, 112c spanning horizontally across the panel on the interior side thereof that faces into the respective column of storage locations in the grid structure 31. These include an upper flange 112a residing near the top edge of the panel 110 at a short height therebelow, a middle flange 112b residing at a generally central height on the panel 110, and a lower flange 112c residing at or near the bottom edge of the panel 110. Each panel is fastened to two frame members 132 at the inner sides thereof that face into the respective storage column at neighbouring corners thereof, whereby the other sides of these frame members 132 are available for mounting of respective panels for neighbouring columns. During assembly of the framework, a set of three panels are installed together at a same elevation on three sides of a storage column, with the fourth side of the storage column being left unobstructed so as to open into the respective central shaft of the three-dimensional storage array.

[0063] The upper flanges of these three panels form a top shelf for supporting a top one of three storage bins, while the middle flanges and lower flanges of these three panels form middle and lower shelves, respectively, for supporting the other two of these three storage bins. FIG. 11C shows three storage bins in the leftmost column of the figure, which are labelled as upper bin 12a, middle bin 12b, and lower bin 12c. The fact that the upper flange 112a resides a short height below the top edge of each panel 110 leaves a short upper wall area 114 of the panel 110 standing upright from the upper flange 112a in order to block sliding of the upper bin 12a out of the column during insertion of the upper bin back into the storage column by a robotic vehicle. Using the triple-flanged panels 110 of the illustrated embodiment, each set of three panels serves to define three bin-supporting shelves at three respective levels in the three-dimensional grid structure 31, while occupying only slightly more than two levels. It will be appreciated that other embodiments may employ a flanged panel of different height that occupies a greater or lesser number of vertical levels. However, use of multi-flanged panels that define shelving at multiple levels reduces the overall number of individual panels in the completed framework of the finished grid structure 31.

[0064] As the framework of the grid structure 31 includes a respective shelf at each storage location to support the respective storage bin, any given bin can be removed from its storage location by one of the robotic retrieval vehicles without disrupting the bins above and below it in the same storage column. Likewise, this allows a bin to be returned to a prescribed location at any level in the array. It will therefore be appreciated that use of the term `stack` herein to describe the vertically accumulation of storage bins is not used to explicitly mean direct placement of bins in physical contact atop one another, but rather is used to denote the layering of storage bins in vertical levels, while distinguishing a stack of storage cells from individual columns of storage bins.

[0065] That being said, while the illustrated embodiment employs shelving in the framework to enable individual retrieval of a bin from locations other than the uppermost occupied storage location of a column, other embodiments still making use of the unique shaft-access storage cell stacks could alternatively lack any shelving and use direct stacking of bins in physical contact atop one another, for example in the scenario where each column is used to storage the same product (s) in each and every bin in the column. In such an embodiment, retrieval of only the uppermost bin from any column at any given time is sufficient, and each bin could simply be returned back to the top of a given column of storage bins, rather than back to the same storage location from which it was retrieved, as the `top` of the column of bins may have changed in terms of the absolute height in the three-dimensional grid if a second storage bin was removed from that column before return of the first bin back to that column.

[0066] , although the shaft-based access to a stacked-cell three-dimensional storage array has particular advantage in terms of improved balance between space efficiency and individual accessibility when compared to prior art solutions that use either overhead/underneath vehicle grids or aisle-based layouts, use of the presently disclosed storage array is not necessarily limited to applications that specifically provide individual access to any and all storage locations at any time.

[0067] In summary of the disclosed embodiments, a storage system is employed within a grid structure 31 that accommodates storage cells that hold storage bins or other storage units. The structure has a top and bottom level and vertical shafts or voids that the cells are built around. The system comprises a vehicle or robot that manoeuvres around the top and bottom of the grid and vertically through the void or shaft and locates a bin retrieve. The vehicle or robot retrieves a bin from a location within the void or shaft and delivers it to a station at the perimeter of the grid structure 31 at the bottom of the grid. The vehicle or robot, once it has retrieved the bin and completed its task, returns the bin to a designated space within the void or shaft by using the outside of the grid structure 31 to elevate itself to the top of the grid structure 31, where the vehicle or robot then manoeuvres around the top of the grid structure 31 and descends into a void or shaft to store the bin. The grid structure 31 is scalable in three dimensions to a certain desirable height and grid size, and may be constructed of aluminum or steel columns that are interconnected at the top and bottom by aluminum or steel rails, and braced throughout the structure.

[0068] The remotely operated vehicle or robot for picking up storage bins from a storage grid system travels the top grid structure 31 by use of guiding rails and operates in the horizontal X and Y plane, by use of a driving means using four wheels that rotate independently in either direction from each other in the X plane, and four wheels that rotate in either direction independently for the Y plane. The vehicle then retracts four of its wheels on the X side relative to its frame or chassis so as to reduce its track width. In the illustrated embodiment, it achieves this by use of its pulley and cam mechanism, and then by raising its wheels on the Y side of the robot, it lowers its wheels on the X side downwards. In the illustrated embodiment, it achieves this by use a pulley and linear slide mechanism to lower the X side down into the grid or void to engage a gear rack mechanism built into the grid. The vehicle then retracts the wheels on the Y-sides, and using the wheels on the X-side, drives itself downwards until the second set of four wheels on the Y-sides engages the gear rack mechanism. Accordingly, now all eight wheels are engaged on all sides of the void, and said vehicle or robot moves down into the void or vertical plane within the grid structure 31 to an assigned position or bin.

[0069] The vehicle or robot uses a turret mechanism that turns to a predetermined position to pick the bin assigned, it then extends its telescopically extendable arm and engages the bin underneath and pulls the bin onto its turret at the top platform of the robot. The vehicle or robot will lock the bin in place by raising its fences relative to turret position and travel in the vertical Z direction down to the bottom track layout and move in either the X or Y direction by use of the track's guiding rails to an assigned location on the perimeter of the bottom track layout. Here, the bin may be presented in a different plane 90-180 degrees from its original position.

[0070] By use of its four wheels at either the X or Y sides of the robot, it will move towards one of the outer vertical shafts on the perimeter of the structure and raise itself up into the grid by lifting itself into the vertical void, or by assistance of a mechanical lift device or combination of both, whereupon the gear rack mechanism is engaged. It will then drive itself upwards until the second set of four wheels engages the gear rack, by which all eight wheels are then engaged on all sides of the void.

[0071] The vehicle or robot now travels upwards in the Z direction on the outside perimeter of the grid structure 31, and repeats the process of moving in the X and Y direction to its next assigned bin location within the grid structure 31, as prescribed by the computerized wireless controller.

[0072] As shown in FIG. 14, an example of features according to an embodiment of the present invention provides a parcel sorting system. The parcel sorting system includes a parcel sorting device 1400 and a parcel collecting device 1401; the parcel sorting device 1400 is provided thereon with a plurality of parcel checking inlets 1404 and a plurality of parcel outlets 1402, and the parcel collecting device 1401 is located just below the parcel sorting device 1400; the plurality of parcel outlets 1402 on the parcel sorting device 1400 are respectively in communication or connected with the parcel collecting device 1401, the plurality of parcel outlets 1402 are respectively located at the middle or/and edges of the or throughout the parcel sorting device 1400, and the parcel collecting device 1401 is provided thereon with storage devices 1403, with one storage device located at each of positions of the parcel outlets, and an opening diameter of the storage device 1403 is greater than a diameter of the parcel outlet 1402.

[0073] The parcel sorting device 1400 and the parcel collecting device 1401 are embodied in many structures, *e.g.* quadrangle, circle, polygon and so on, and the parcel collecting device 1401 and the parcel sorting device 1400 preferably have substantially the same area.

[0074] In order to improve the parcel sorting efficiency, preferably, each of the parcel checking inlets 1404 is provided with one parcel information acquisition device 200. The parcel checking inlets 1404 are in one-to-one correspondence with the parcel information acquisition devices 200, the parcel information acquisition devices 200 are configured to acquire parcel information of the parcels to be sorted that enter the parcel checking inlets

1404 corresponding to the parcel information acquisition devices 200, and the parcel information contains destinations of the parcels to be sorted.

[0075] A plurality of parcel checking inlets 1404 are provided, with each parcel checking inlet 1404 being provided with a parcel information acquisition device 200, such that the information acquisition and sorting of the plurality of parcels to be sorted may be performed simultaneously at the plurality of parcel checking inlets 1404, so as to significantly increase the parcel information acquisition efficiency, thereby improving the parcel sorting efficiency.

[0076] In the above, there are many manners for the parcel information acquisition devices 200 to acquire the parcel information of the parcels to be sorted. Preferably, the destination information is carried in a destination address information code, the destination address information code is provided on the parcel to be sorted, each of the parcel information acquisition devices 200 includes a scanner, and the scanner is configured to scan the information code for obtaining the destination of the parcel to be sorted. For example, the parcels to be sorted are provided thereon with information codes containing destination information of the parcels to be sorted, and the parcel information acquisition devices 200 obtain the destinations of the parcels to be sorted by scanning the information codes on the parcels to be sorted, wherein the information code may be a bar code, a two-dimensional code, a radio frequency tag etc., and correspondingly, the parcel information acquisition device 200 may be a bar code scanner, a two-dimensional code scanner, a radio frequency identifier, etc., and the mobile transport device 202 may be an auto-navigating small vehicle.

[0077] According to actual demands, in addition to the destination, the parcel information may further contain information about the parcel volume, weight etc., and correspondingly, the parcel information acquisition device 200 may further include a weighing device, a volume scanner, etc.

[0078] While the parcel information is highly-efficiently obtained, in order to improve the efficiency of subsequent sorting, preferably, after the plurality of parcel information acquisition devices 200 simultaneously acquire the parcel information of the respective parcels to be sorted, the control device 201 is used to complete the analytical processing of the obtained parcel information of all the parcels to be sorted, thereby obtaining the destination information of the respective parcels to be sorted. For example, the system further includes a control device 201, the control device 201 is in connection with all the parcel information acquisition devices 200 so as to obtain the parcel information acquired by all the parcel information acquisition devices 200, to obtain the destinations of the respective parcels to be sorted.

[0079] After obtaining the parcel information, in order to improve the efficiency of the subsequent sorting processes, the system preferably further includes a plurality of mobile transport devices 202, wherein the plurality of mobile transport devices 202 are in connection with the control device 201, the control device 201 is pre-provided with parcel outlets 1402 respectively corresponding to different destinations, the control device 201 is further configured to control, according to the obtained destinations of the parcels to be sorted, at least one of the mobile transport devices 202 to transport the parcels to be sorted to the parcel outlets 1402 corresponding to the destinations of the parcels to be sorted, as shown in FIG. 15.

[0080] In the above, the control device 201 has already obtained the destinations of the respective parcels to be sorted at the respective parcel checking inlets 1404, and the parcel sorting can be completed just by obtaining the transport paths of the respective parcels to be sorted through analysis according to the positions of the parcel outlets 1402 corresponding to the destinations of the respective parcels to be sorted, and then controlling at least one of the mobile transport devices 202 to transport, according to the transport paths, each of the parcels to be sorted to the parcel outlets 1402 corresponding to the destinations of the parcels to be sorted.

[0081] The analysis by the control device 201 on the transport paths of the respective parcels to be sorted is performed simultaneously. After the path analysis is completed, the plurality of mobile transport devices 202 may be simultaneously controlled, to simultaneously complete transporting of the individual parcels to be sorted, thereby significantly improving the parcel sorting efficiency.

[0082] Each of the mobile transport devices 202 is configured to load one parcel to be sorted or a plurality of parcels to be sorted that go to the same destination. Preferably, the mobile transport device 202 is configured to transport one parcel to be sorted one time, and the control device 201 sends a control instruction to the mobile transport device 202 after obtaining the destination of the parcel to be sorted that is going to be transported by the mobile transport device 202, such that the mobile transport device 202 travels to the position of the parcel outlet 1402 corresponding to the destination of the parcel to be sorted.

[0083] In the above, the parcels to be sorted may be manually loaded onto the mobile transport devices 202, and the parcels to be sorted may also be automatically loaded onto the mobile transport devices 202 by intelligently controlling parcel gripping devices or the like through the control device 201. Similarly, the transport of the parcels to be sorted from the parcel outlets 1402 to the parcel collecting device 1401 can be performed manually, and may also be completed by intelligently controlling parcel gripping devices or the like through the control device 201.

[0084] In order to assure that the respective parcels to be sorted that are transported into the parcel collecting device 1401 can be delivered in time, the system preferably further includes a detection device 204 and a transfer device 203, wherein the detection device 204 is configured to detect whether a storage device 1403 is full or not and to transmit to the control device 201 the obtained information regarding whether the storage device 1403 is full or not, and the transfer device 203 is configured to transfer the storage device 1403 which is full according to an instruction from the control device 201. There are many options for the transfer device 203, *e.g.* an intelligent robot; and for another example, the storage device 1403 is mounted on the transfer device 203, and the transfer device 203 is a large-scale auto-navigating vehicle and may move to a position and load and unload the parcels according to the control instruction of the control device 201, as shown in FIGS. 16 and 17.

[0085] Based on the above-mentioned system architecture, the examples of a feature according to an embodiment of the present invention are implemented as follows:

[0086] The respective mobile transport devices, such as a forklift, transport the parcels to be sorted to the respective parcel checking inlets 1404, and the parcel information acquisition devices 200 at the respective parcel checking inlets 1404 acquire the parcel information of the respective parcels and transmit the acquired parcel information to the control device 201. The control device 201 performs simultaneous analysis on the parcel information of the plurality of parcels to be sorted to obtain the destinations of the respective parcels to be sorted and the parcel outlets 1402 corresponding to the respective destinations, and controls the plurality of mobile transport devices 202 to simultaneously transport the respective parcels to be sorted to the corresponding parcel outlets 1402. The parcels to be sorted are delivered from the parcel outlets 1402 into the storage devices 1403 on the parcel collecting device 1401 located below, and then they are moved away from the parcel outlets 1402 according to a control instruction of the control device 201 and wait for further instructions.; The processes above are repeated until all the parcels to be sorted are delivered into the storage devices 1403. In the meantime, the detection device 204 constantly detects whether there is a storage device 203 which is full of parcels, and when there is a storage device 1403 full of parcels, the control device 201 controls the transfer device 203 to transfer the storage device 1403 and placing an empty storage device 1403 at the position where the transferred storage device 1403 was, until sorting of all the parcels to be sorted is completed. This could also be performed by a person.

[0087] The parcel sorting system provided in an example of the present invention can make full use of the area of the parcel sorting device 1400, increasing a plurality of effective parcel outlets 1402 and solving the traditional problem of goods accumulation and thereby greatly increasing checking efficiency, so as to make the whole operation flow of the parcel sorting more systematized and intelligentized. And a "double" structure is creatively adopted, with the parcel sorting device 1400 and the parcel collecting device 1401 being arranged one above the other for sorting parcels, wherein the parcel outlets 1402 on the parcel sorting device 1400 are in communication or positioning with the parcel collecting device 1401, and during parcel sorting, the parcels to be sorted can enter the parcel collecting device 1401 arranged below just by passing through the parcel outlets 1402, thereby completing the sorting. Such a structural design enables that the parcel outlets 1402 can be flexibly arranged on the edges of the parcel sorting device 1400 or at middle positions of the edges, rather than only being provided at the edges of the parcel sorting device 1400 as those in the prior art, where the middle position in the examples of the present invention refers to positions on the parcel sorting device 1400 other than the edges. The utilization ratio of the parcel sorting device 1400 is efficiently improved, the transport path for parcel sorting is shortened, the parcel sorting efficiency is increased, and the design is very ingenious.

[0088] As shown in FIG. 18, an example of the present invention provides a parcel sorting method, which is applied to a parcel sorting system, wherein the parcel sorting system comprises a parcel sorting device and a parcel collecting device; the parcel sorting device is provided with a plurality of parcel checking inlets and a plurality of parcel outlets, and the parcel collecting device is located just below the parcel sorting device; the plurality of parcel outlets on the parcel sorting device are respectively in communication with the parcel collecting device, the plurality of parcel outlets are respectively located at the middle or/and edges of the parcel sorting device, and the parcel collecting device is respectively provided thereon with storage devices, with one storage device located at each of positions the parcel outlets, and an opening diameter of the storage device is greater than a diameter of the parcel outlet; and the method includes:

[0089] step S300: presetting correspondence relationships between the parcel outlets and the parcels to be sorted that go to different destinations; step S301: obtaining the destinations of the parcels to be sorted; step S302: transporting the parcels to be sorted to the parcel outlets corresponding to the destinations of the parcels to be sorted; and step S303: delivering, through the parcel outlets, the parcels to be sorted into the storage devices under the parcel outlets.

[0090] In order to improve the parcel sorting efficiency, preferably, each of the parcel checking inlets is provided with one parcel information acquisition device, the parcel checking inlets are in one-to-one correspondence with the parcel information acquisition devices, and obtaining the destinations of the parcels to be sorted includes: acquiring, by the respective parcel information acquisition devices, the parcel information of the parcels to be sorted that enter the parcel checking inlets corresponding to the parcel information acquisition devices, with the parcel information containing the destinations of the parcels to be sorted.

[0091] There are many manners for the parcel information acquisition devices to acquire the parcel information on the parcels to be sorted. Preferably, the destination information is carried in a destination address information code, the destination address information code is provided on the parcel to be sorted, each of the parcel information acquisition devices includes a scanner, and the scanner is configured to scan the information code for obtaining the destination of the parcel to be sorted. For example, the parcels to be sorted are provided thereon with information codes containing destination information of the parcels to be sorted, and the parcel information acquisition devices obtain the destinations of the parcels to be sorted by scanning the information codes on the parcels to be sorted, wherein the information code may be a bar code, a QR code, an RF Tag etc., and correspondingly, the parcel information acquisition device may be a bar code scanner, a two-dimensional code scanner, a radio frequency identifier, etc., and the mobile transport device may be an auto-navigating small vehicle.

[0092] According to actual demands, in addition to the destination, the parcel information may further contain information about the parcel volume, weight etc., and correspondingly, the parcel information acquisition device may further include a weighing device, a volume scanner, etc.

[0093] While the parcel information is highly-efficiently obtained, in order to improve the efficiency of subsequent sorting, preferably, after the plurality of parcel information acquisition devices simultaneously acquire the parcel information of the respective parcels to be sorted, the control device is used to complete the analytical processing of the obtained parcel information of all the parcels to be sorted, thereby obtaining the destination information of the respective parcels to be sorted. For example, the system further includes a control device and a plurality of mobile transport devices, wherein the correspondence relationships between the parcel outlets and the parcels to be sorted that go to different destinations are preset in the control device, and transporting the parcels to be sorted to the parcel outlets corresponding to the destinations of the parcels to be sorted includes: obtaining, by the control device, the parcel information acquired by all the parcel information acquisition devices to obtain the destinations of the respective parcels to be sorted; and controlling at least one of the mobile transport devices, according to the obtained destinations of the parcels to be sorted, to transport the parcels to be sorted to the parcel outlets corresponding to the destinations of the parcels to be sorted.

[0094] After obtaining the parcel information, in order to improve the efficiency of the subsequent sorting processes, the system preferably further includes a detection device and a transfer device, and the method further includes: obtaining, by the control device, the information detected by the detection device about whether the storage device is full or not, and when obtaining information indicating that the storage device is full, transmitting to the transfer device an instruction for transferring the storage device which is full.

[0095] In the above, the control device has already obtained the destinations of the respective parcels to be sorted at the respective parcel checking inlets, and the parcel sorting can be completed just by obtaining the transport paths of the respective parcels to be sorted through analysis according to the positions of the parcel outlets corresponding to the destinations of the respective parcels to be sorted, and then controlling at least one of the mobile transport devices to transport, according to the transport paths, each of the parcels to be sorted to the parcel outlets corresponding to the destinations of the parcels to be sorted.

[0096] The analysis by the control device on the transport paths of the respective parcels to be sorted is performed simultaneously. After completing the path analysis, the plurality of mobile transport devices may be simultaneously controlled to simultaneously complete transporting of the respective parcels to be sorted, thereby significantly improving the parcel sorting efficiency.

[0097] Each of the mobile transport devices is configured to load one parcel to be sorted or a plurality of parcels to be sorted that go to the same destination. Preferably, the mobile transport device is configured to transport one parcel to be sorted one time, and the control device sends a control instruction to the mobile transport device after obtaining the destination of the parcel to be sorted that is going to be transported by the mobile transport device, such that the mobile transport device travels to the position of the parcel outlet corresponding to the destination of the parcel to be sorted.

[0098] In the above, the parcels to be sorted may be manually loaded onto the mobile transport device, and the parcels to be sorted may also be automatically loaded onto the mobile transport devices by intelligently controlling parcel gripping devices or the like through the control device. Similarly, the transport of the parcels to be sorted from the parcel outlets to the parcel collecting device can be performed manually, and may also be completed by intelligently controlling parcel gripping devices or the like through the control device.

[0099] As to the methods provided in the examples of the present invention, the implementation principles and the technical effects produced thereof are the same as those in the preceding examples regarding the systems, and for brief description, as for contents not mentioned in the examples regarding the methods, reference can be made to the corresponding contents in the preceding examples regarding the systems.

[00100] As illustrated in FIG. 19, an embodiment includes a system for use in an order fulfillment center or any other facility that receives orders or listings of articles for an order. The system provides an improvement for sorting orders and packaging the same for fulfillment. The system includes a platform that is elevated proximal to a lower level, which in some embodiments may be a second platform. The platform provides a surface for transport vehicles 202 to traverse to deposit an article to a destination container 208. In operation, a device or conveyor delivers a container of articles proximal a chute 214 or other material handling system. Alternatively, the articles are placed in vehicles 202 by a human picker or by a robotic arm configured to manipulate the articles. The material handling system delivers the container of articles to an article supply location. The container may contain product that is identical or may be disparate product.

[00101] An operator may select an article from the container and image an identifier 216 positioned on the article via the acquisition device 200. Optionally, the acquisition device 200 may automatically interact with identifier 216 for article recognition. The operator may place the article on the vehicle 202, or the system and process may be set up so that such deposition of article onto vehicle 202 is automated. The acquisition device 200 may then communicate the article identifier information to the control device 201.

[00102] The article supply, namely the articles shown in the containers, may be a supply of articles that has identifier 216 on each article. The information acquisition devices 200 obtain the information contained in the identifier 216 of the articles to be sorted by identifying the information codes on the articles to be sorted, wherein the information code may be a bar code, a two-dimensional code, a radio frequency tag etc., and correspondingly, the parcel information acquisition device 200 may be a bar code scanner, a two-dimensional code scanner, a radio frequency identifier, etc.

[00103] The transport vehicle 202 may have a first position in which an article is stowed about the vehicle and a second position in which the article is deposited into a proximal destination container.

[00104] Additionally, the information acquisition device may be configured to image the article and compare against a database of known articles to determine a characteristic, SKU or identity of the article.

[00105] In one or more embodiments, the mobile transport device 202 may be an auto-navigating small vehicle.

[00106] The control system 201 is configured to determine one destination container 208 of a plurality of destination containers to deposit, with the transport vehicle 202, a selected article based on the interaction with the identifier 216. The control system 201 is further configured to direct the transport vehicle to transport the selected article to the destination container and deposit the article by manipulation of the transport car from the first position to the second position for deposit of the selected article in the destination container.

[00107] The system may be embodied in a multiple level arrangement. The multiple level arrangement may include an elevated platform above a lower level, which may be the floor or a second platform. In operation, the control system determines that a destination container needs an article deposited therein. In the multiple level arrangement, the destination container is positioned proximal an opening in the elevated platform. The transport vehicle traverses the elevated platform to the destination container and deposits the article by manipulation of the transport vehicle from the first position to the second position for deposit of the selected article in the destination container.

[00108] As an example, consider a situation at an order fulfillment facility where an order calls for 3 red shirts, 2 blue shirts, and 2 pair of blue jeans to be transported to an end destination retailer. The control system 201 may know that at article supply #1 are the red shirts, article supply #5 has blue shirts, and article supply #13 has blue jeans. The control system 201 directs a respective transport vehicle 202 to each of article supply #1, article supply #5, and article supply #13. The control system 201 also determines or otherwise knows that the destination container for delivery of the order is located at a certain location on the platform. The control system 201 then directs each respective transport vehicle 202 to deposit articles into the destination container until the entire order is filled. At that time, the control system 201 knows that the order is filled and can direct or otherwise instruct removal of the destination container.

[00109] The control system may be further configured to direct the transport vehicle to return to be proximally located at any article supply. The transport vehicle is in the first position upon being proximal at an article supply. The control system may be further configured to direct a plurality of transport vehicles such that the transport vehicles do not collide with one another.

[00110] Disclosed herein is thus a system. The system includes an article supply. The article supply includes a plurality of articles at an order fulfillment center. In operation, the system has a method or material handling system to move and transport containers of articles. The method or material handling system delivers a container of articles to an article supply location. The container may contain product that is identical or may be disparate product. A control system 201 communicates over a network. The network may be a wired or wireless network. The wireless network may be Bluetooth®, WIFI, a specific Radio Frequency, cellular, and the like. The control system 201 may be embodied as a server with a processor and a memory, where the processor executes many instructions provided herein. The control system 201 may be configured to receive an order for a plurality of disparate articles to fulfill an order. The disparate articles may be a plurality of similar articles having different sizes, colors, and the like, such as apparel, or the disparate articles may be largely unrelated. The control system 201 may be configured to determine one destination container of a plurality of destination containers to deposit, with the transport vehicle, a selected article. The control system 201 may be configured to direct the transport vehicle to transport the selected article which is stowed about the vehicle to the destination container and deposit the article by manipulation of the transport vehicle from the first position to the second position for deposit of the selected article in the destination container. The control system 201 may be configured to direct the transport vehicle to transport a disparate article to the destination container and deposit the disparate article by manipulation of the transport vehicle from the first position to the second position for deposit of the selected disparate article in the destination container. The control system 201 may be configured to determine when the order is complete.

[00111] The system may include an information acquisition device 200 that is configured to image the selected article. The control system may then be further configured to determine a characteristic of the selected article by interacting with the selected article with the information acquisition device. This interaction may include optical recognition to determine one or more characteristic of an article, including size, color, deformation or other defect, UPC or other identifying code, and the like.

[00112] The control system may be further configured to determine a characteristic of the selected article by interacting with an identifier 216 of the selected article with the information acquisition device. The identifier may be a UPC or other product code associated with the article.

[00113] The system may further include an elevated platform above a lower level. The transport vehicle traverses the platform. The destination container is positioned proximal a recess in the platform. The transport vehicle traverses the platform, positions the vehicle proximal the recess and then manipulates from the first position to the second position to deposit the article. Each transport vehicle may carry a respective single selected article, and multiple transport vehicles may be traversing the platform at any given time. The control system may be configured to direct the transport vehicle to return to a position proximal an article supply. The transport vehicle is in the first position upon being proximal an article supply. The control system may be configured to direct a plurality of transport vehicles. The control system is further configured to direct the plurality of transport vehicles such that the transport vehicles do not collide with one another.

[00114] A method may also be provided. The method may include receiving an order for a plurality of disparate articles, determining one destination container of a plurality of destination containers to direct the transport vehicle to deposit a selected article, directing the first transport vehicle to transport the selected article to the destination container and deposit the article by manipulation of the first transport vehicle from the first position to the second position for deposit of the selected article in the destination container, directing the second transport vehicle to transport a disparate article to the destination container and deposit the disparate article by manipulation of the second transport vehicle from the first position to the second position for deposit of the selected disparate article in the destination container, and determining when the order has been completed.

[00115] In another example utilizing the same or many of the components discussed in regard to FIG. 19, a control system receives an order for fulfillment. The order, in this example, may include articles from various portions of a warehouse or fulfillment center. The control system batches orders, thus allowing for multiple orders to be fulfilled at once in a time efficient manner.

[00116] The control system may then determine that a plurality of articles to be sorted are located within a first portion of the fulfillment center, and a second plurality of articles to be sorted are located within a second portion of the fulfillment center, and the like. The plurality of articles span the batched orders.

[00117] The control system may then direct a person or an automated machine to pull the plurality of articles associated with the batched orders where the articles are in the first portion of the fulfillment center. Those pulled articles in the first location may then be positioned in a case, bin or other container. Similarly, the pulled articles in the second location may then be positioned into a separate case, bin or other container. The bin or other container is then taken to a conveyor, chute, or the like to transport the pulled articles to a location of article supply. A person may then position an article onto a transport vehicle, or an automated machine may then position the article onto the transport vehicle.

[00118] The information acquisition device may then image the UPC or other identifying code on the article to determine the article identity. The information acquisition device then communicates the article identity to the control system, which is then able to compare the article identity to the database of orders that have been batched, and assign a destination container for depositing the article based on the orders. The control system then does this for each item until the orders are filled.

[00119] The destination container may be positioned below the platform, where a chute may extend from the elevated platform to the destination container in order to guide the article into the destination container.

[00120] In another example utilizing the same or many of the components discussed in regard to FIG. 19, a control system receives an order for store fulfillment. The order, in this example, may include articles from various portions of a warehouse or fulfillment center. The control system batches orders for stores, thus allowing for multiple store orders to be fulfilled at once in a time efficient manner.

[00121] The control system may then determine that a plurality of articles to be sorted are located within a first portion of the fulfillment center, and a second plurality of articles to be sorted are located within a second portion of the fulfillment center, and the like. The plurality of articles span the store orders.

[00122] The control system may then direct a person or an automated machine to pull the plurality of articles associated with the stores orders where the articles are in the first portion of the fulfillment center. Those pulled articles in the first location may then be positioned in a case, bin or other container. Similarly, the pulled articles in the second location may then be positioned into a separate case, bin or other container. The bin or other container is then taken to a conveyor, chute, small vehicle, or the like to transport the pulled articles to a location of article supply. A person may then place an article onto a transport vehicle, or an automated machine may then place the article onto the transport vehicle.

[00123] The information acquisition device may then image the UPC or other identifying code on the article to determine the article identity. The information acquisition device then communicates the article identity to the control system which is then able to compare the article identity to the database of store orders that have been batched, and assign a destination container for depositing the article based on the individual store. The control system then does this for each article until a store order is filled.

[00124] The control system may be further configured to segregate a store order into departments such that all articles for a given store department are assigned to a single destination container. Store departments may include or be defined as women's, men's, shoes, etc.

[00125] The destination container may be positioned below the platform, where a chute may extend from the elevated platform to the destination container in order to guide the article into the destination container.

[00126] In another example utilizing the same or many of the components discussed in regard to FIG. 19, an operation receives returns of articles from a customer. The returns arrive at a returns processing area and are received into the facility. In operation, a method, device or conveyor delivers a container of returned articles proximal a chute or other material handling system or method. The material handling system or method delivers the container of returned articles to an article supply location.

[00127] An operator may then place a single returned article onto a transport vehicle, or an automated machine may then place the article onto the transport vehicle.

[00128] The information acquisition device may then image the UPC or other identifying code on the article to determine the article identity. The information acquisition device then communicates the article identity to the control system is then able to compare the article identity to the database of the articles in the article master database, and assign a destination container for depositing the article based on the article identity or SKU. The control system then does this for each article until all returned articles have been transported and deposited into destination containers. The control system can be configured to transport and deposit identical or similar articles into a single destination container.

[00129] The destination container may be positioned below the platform, where a chute may extend from the elevated platform to the destination container in order to guide the article into the destination container.

[00130] In another example utilizing the same or many of the components discussed in regard to FIG. 19, a control system receives an order for fulfillment. The order, in this example, may include articles from various portions of a warehouse or fulfillment center. The control system batches orders, thus allowing for multiple orders to be fulfilled at once in a time efficient manner.

[00131] The control system may then determine that a plurality of articles to be sorted are located within a first portion of the fulfillment center, and a second plurality of articles to be sorted are located within a second portion of the fulfillment center, and the like. The plurality of articles span the batched orders.

[00132] The control system may then direct a person or an automated machine to pull the plurality of articles associated with the batched orders where the articles are in the first portion of the fulfillment center. Those pulled articles in the first location may then be positioned in a case, bin or other container. Similarly, the pulled articles in the second location may then be positioned into a separate case, bin or other container. The bin or other container is then taken to a conveyor, chute, or the like to transport the pulled articles to a location of article supply. A person may then position an article onto a transport vehicle, or an automated machine may then position the article onto the transport vehicle.

[00133] The information acquisition device may then image the UPC or other identifying code on the article to determine the article identity. The information acquisition device then communicates the article identity to the control system, which is then able to compare the article identity to the database of orders that have been batched, and assign a destination container for depositing the article based on the orders. The control system then does this for each item until the orders are filled.

[00134] The destination container may be positioned on the same platform or surface as the transport vehicle and the transport vehicle may deposit directly into the destination container.

[00135] More specifically, and referring to FIG. 20, a system according to one embodiment of the invention for storing, retrieving, and sorting items includes a storage grid structure 31, an intake area 2000, a picker area 2010 having a predetermined number of picker stations, a multi-unit sorting area 2020, a packing area 2030, and an a parcel shipping sorting output area 2040. In certain preferred embodiments sorting area 2020 is a multi-unit sorting area, and output area 2040 is a parcel shipping sorting area. The system further includes at least one processing device 2050 that monitors and controls several of the operations of the system. The at least one processing device 2050 may or may not be at the same site at which the system is located. Operation of the illustrated system, according to an embodiment and for customer or store orders that comprise two or more items, proceeds as follows.

[00136] Intake workers, either human or electromechanical, stationed in the intake area 2000 receive an inbound product/item having associated identifier, such as, in an embodiment, a scannable barcode. Once the item is scanned, it is placed into a robotic retrieval vehicle 36 (previously described with reference to Figs 6-8, but not separately shown in Figure 20) and, in an embodiment, based on the item identifier is stored in the storage grid structure 31 in a location corresponding with the item identifier. Upon the at least one processing device 2050 receiving an order for the item, the at least one processing device, using the item identifier, issues a "pick request" causing a robotic retrieval vehicle 36 to retrieve the item from its storage location and transport the item to a human or electromechanical picker stationed in the picker area 2010.

[00137] In the picker area 2010, the item is once again scanned, either automatically or by a picker, to indicate to the at least one processing device 2050 that the item has arrived at the picker area, is being loaded onto a mobile transport device 202 (previously described with reference at least to Figs 15, 16 and 19, but not separately shown in Figure 20) in the sorting area 2020. The scanning of the item may also enable the at least one processing device 2050 to indicate to the mobile transport device 202 a specific destination container 208 in the sorting area 2020 into which the item should be placed. In an embodiment, the destination container 208 containing the item is manually or electromechanically placed on a system of conveyor belts 2060 that function to carry the destination container to the packing area 2030.

[00138] Upon arriving at the packing area 2030, the item is packaged and a shipping label is placed on the item, either manually or electromechanically. The packaged item is then placed onto another mobile transport device 202 to be carried to the output area 2040 for placement of the item in a bin 2070 for pickup and delivery to the ordering party. In the packing area 2030, the item may again be scanned to enable the at least one processing device 2050 to indicate to the mobile transport device 202 a specific bin in the output area 2040 into which the package (containing the item(s) already packed) item should be placed.

[00139] In an embodiment, the at least one processing device 2050, by monitoring the placement of items by mobile transport devices 202 into destination containers 208, is able to determine at any given time how many destination containers are open (*i.e.*, not filled by an item). In turn, the at least one processing device 2050 uses this determination of the number of open containers to determine the rate at which the at least one processing device makes pick requests. More specifically, the rate at which the at least one processing device 2050 makes pick requests is directly proportional to the number of open destination containers 208.

[00140] In an embodiment, the at least one processing device 2050 monitors the rate at which the robotic retrieval vehicles 36 deliver items to the picker area 2010 in response to a pick request, as well as the amount of time required for the items to be removed from the retrieval vehicles and be placed into a destination container 208 (collectively, "monitored data"). Combining this monitored data with the known number of picker stations in the picker area and the known number of destination containers 208 in the sorting area 2020, the at least one processing device 2050 may determine the rate at which the at least one processing device makes pick requests. More specifically, the rate at which the at least one processing device 2050 makes pick requests is directly proportional to the monitored data, the known number of picker stations in the picker area and the known number of destination containers 208 in the sorting area 2020. Consequently, should the rate at which the pickers are removing items from the retrieval vehicles 36 and placing them on mobile transport devices 202 fall behind the rate at which items are being placed in destination containers 208, the at least one processing device 2050 will correspondingly increase the number of pick requests, including directing more retrieval vehicles 36 to other pick stations up to the total number of pick stations. Conversely, should the rate at which the pickers are removing items from the retrieval vehicles 36 and placing them on mobile transport devices 202 exceed the rate at which items are being placed in destination containers 208, the at least one processing device 2050 will correspondingly decrease the number of pick requests.

[00141] Conditional language used herein, such as, among others, "can," "could," "might," "may," "e.g." and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or steps are included or are to be performed in any particular embodiment. The terms “comprising,” “including,” “having” and the like are synonymous and are used inclusively, in an open-ended fashion, and do not exclude additional elements, features, acts, operations and so forth. Also, the term “or” is used in its inclusive sense (and not in its exclusive sense) so that when used, for example, to connect a list of elements, the term “or” means one, some or all of the elements in the list.

[00142] While certain example embodiments have been described, these embodiments have been presented by way of example only and are not intended to limit the scope of the present disclosure. Thus, nothing in the foregoing description is intended to imply that any particular feature, characteristic, step, module or block is necessary or indispensable. Indeed, the novel methods and systems described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the disclosure. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the disclosure.

[00143] The embodiments of the disclosure in which an exclusive property or privilege is claimed are defined as follows:

CLAIMS

What is claimed is:

1. A system for storing, retrieving, and sorting items comprising:

at least one storage vehicle configured to carry at least one of the items;

a storage apparatus configured to store the at least one storage vehicle;

a control system configured to control movement of the at least one storage vehicle;

at least one first destination container located in a first location and configured to receive at least one of the items;

at least one transport vehicle of a first set of transport vehicles configured to transport at least one of the items to the at least one first destination container,

wherein:

the control system is further configured to receive an order request for a first item of the items, identify a first storage vehicle stored by the storage apparatus and containing the first item, and cause the first storage vehicle to carry the first item to a second location different from the first location, and

a first transport vehicle of the first set of transport vehicles is configured to receive the first item at the second location and deposit the first item in the at least one first destination container.

2. The system of claim 1, further comprising:

at least one second destination container located in a third location different from the first and second locations and configured to receive the first item; and

at least one transport vehicle of a second set of transport vehicles configured to transport the first item to the at least one second destination container.

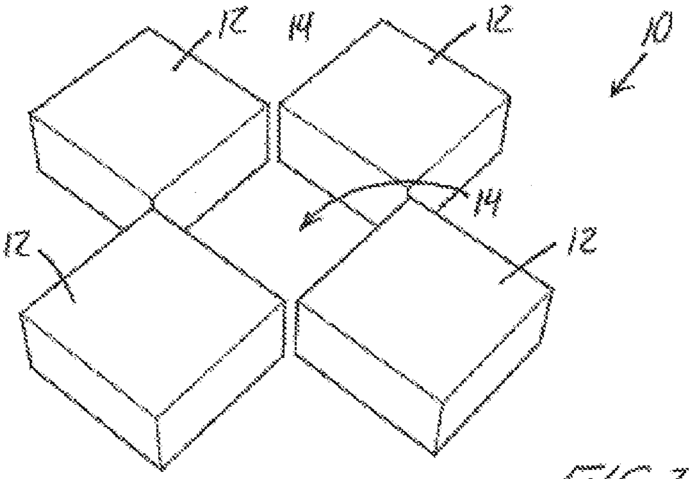


FIG. 1

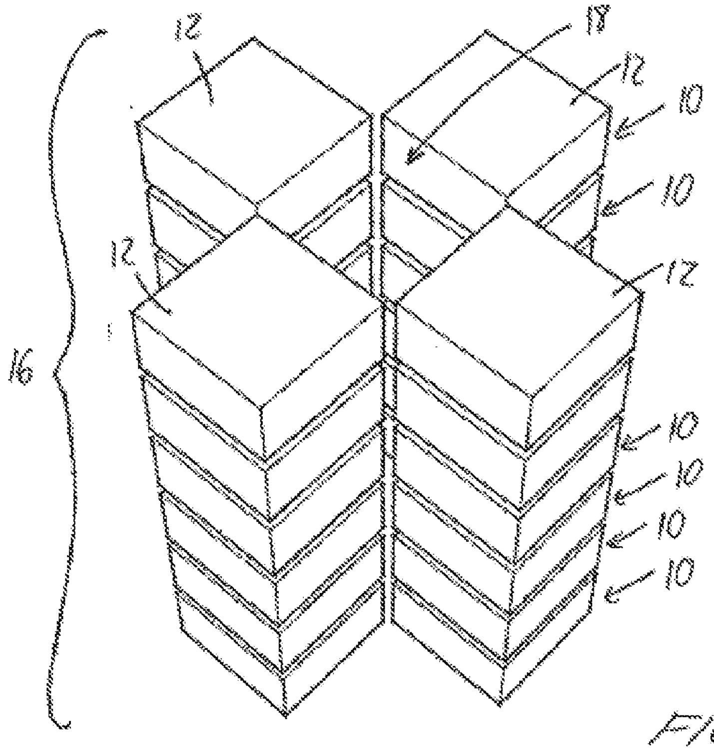


FIG. 2

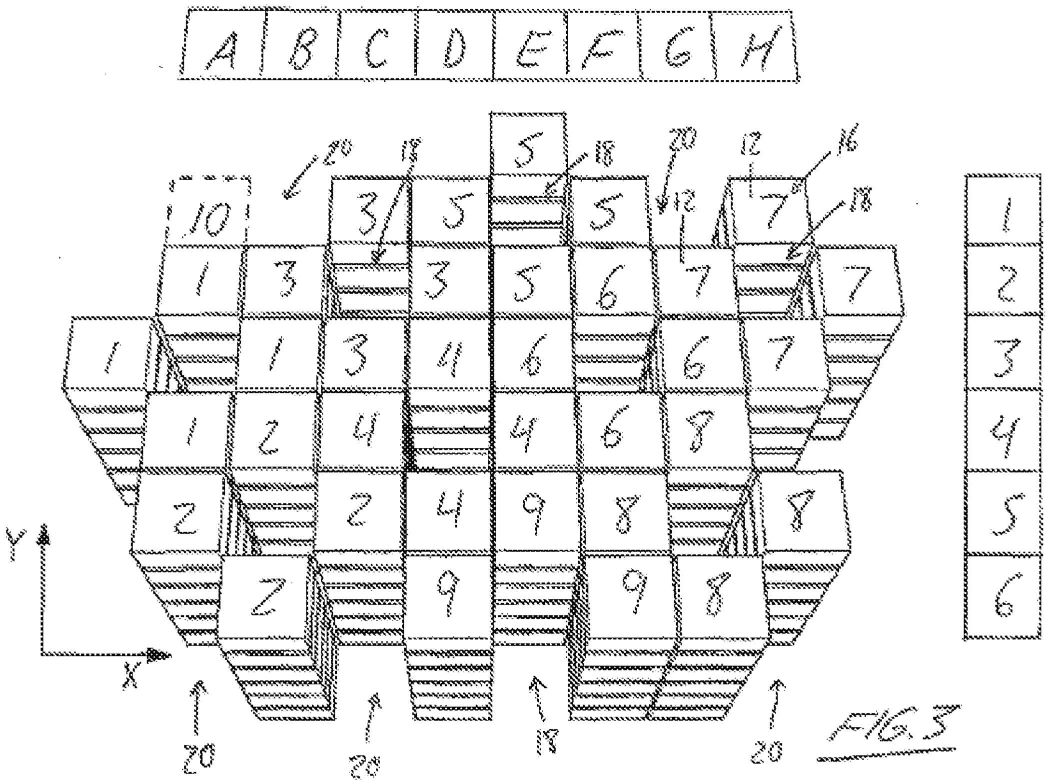


FIG. 3

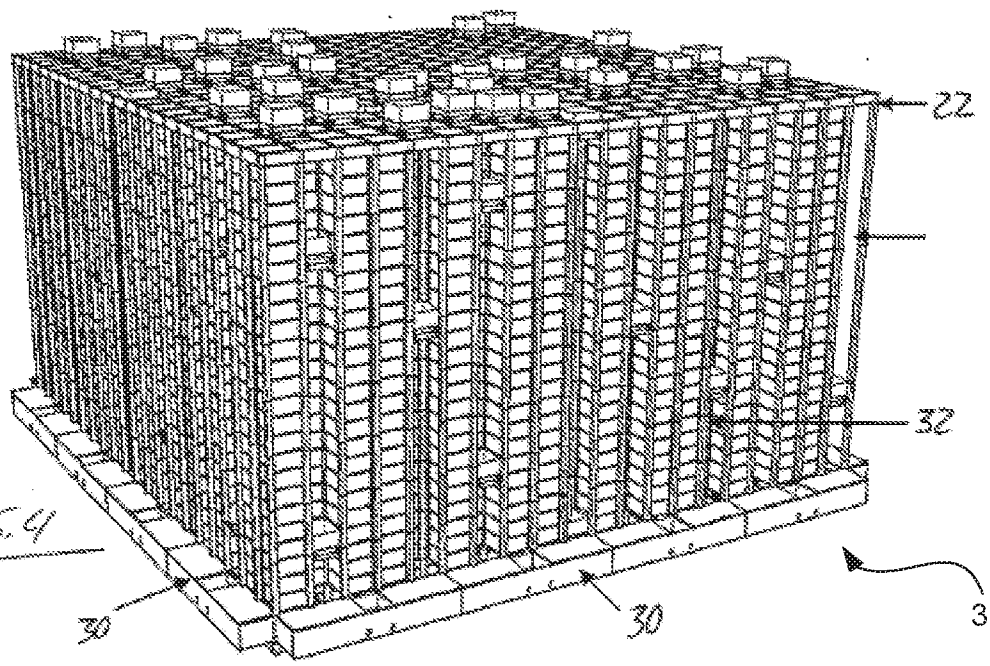
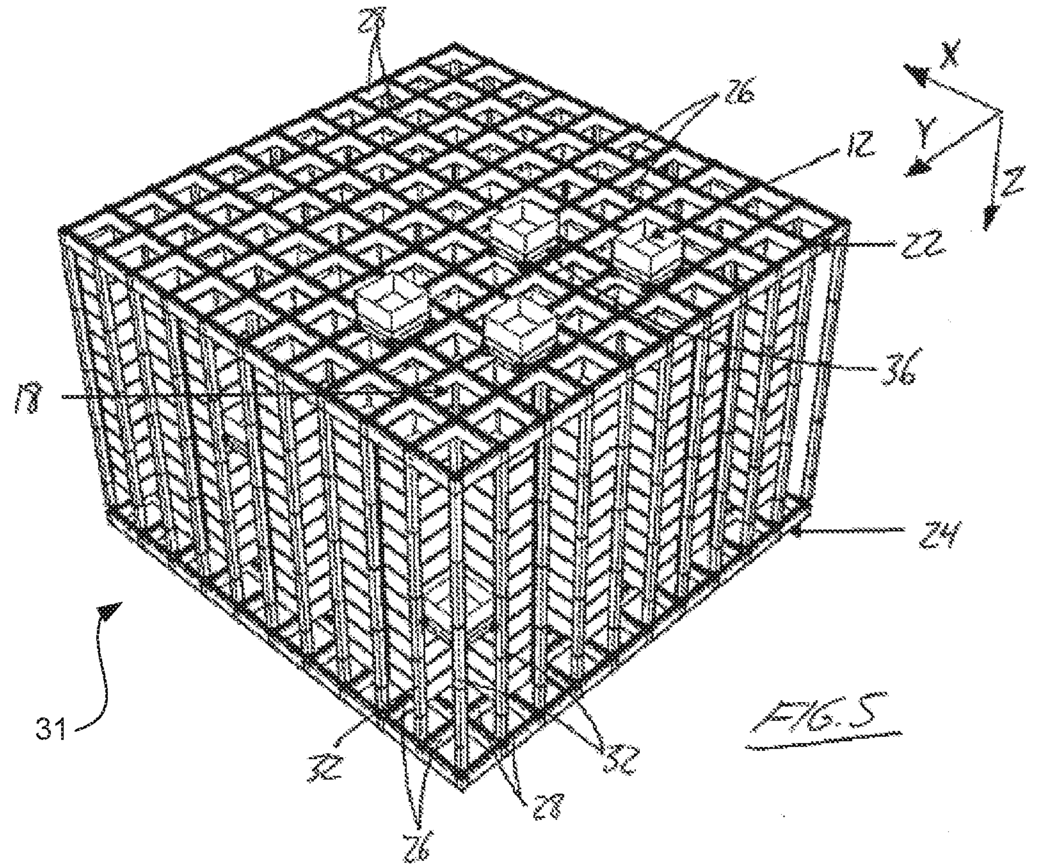


FIG. 4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26

FIG. 5

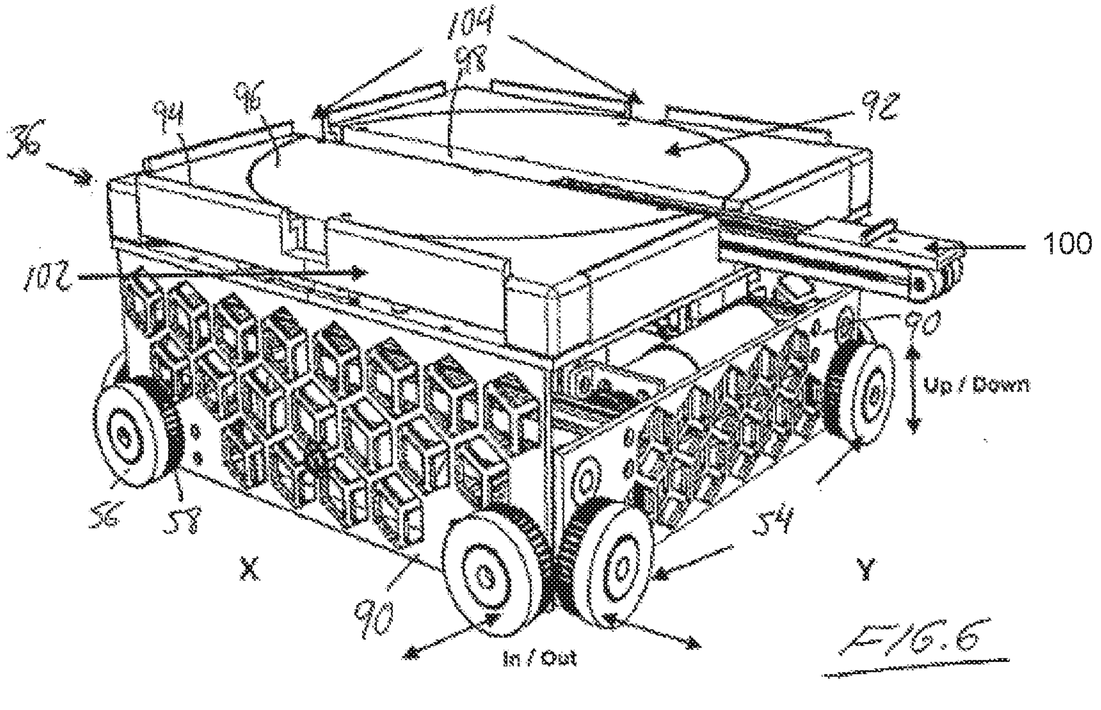
104
98
92
94
96
36
100
102
90
Up / Down
56
58
54
X
Y
90
In / Out

FIG. 6

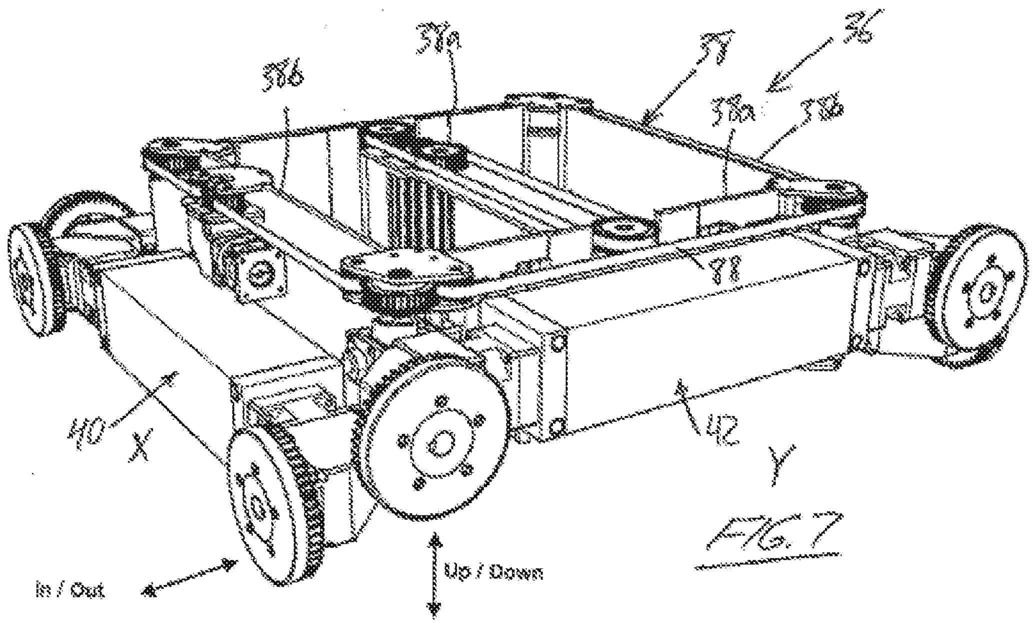

FIG. 7

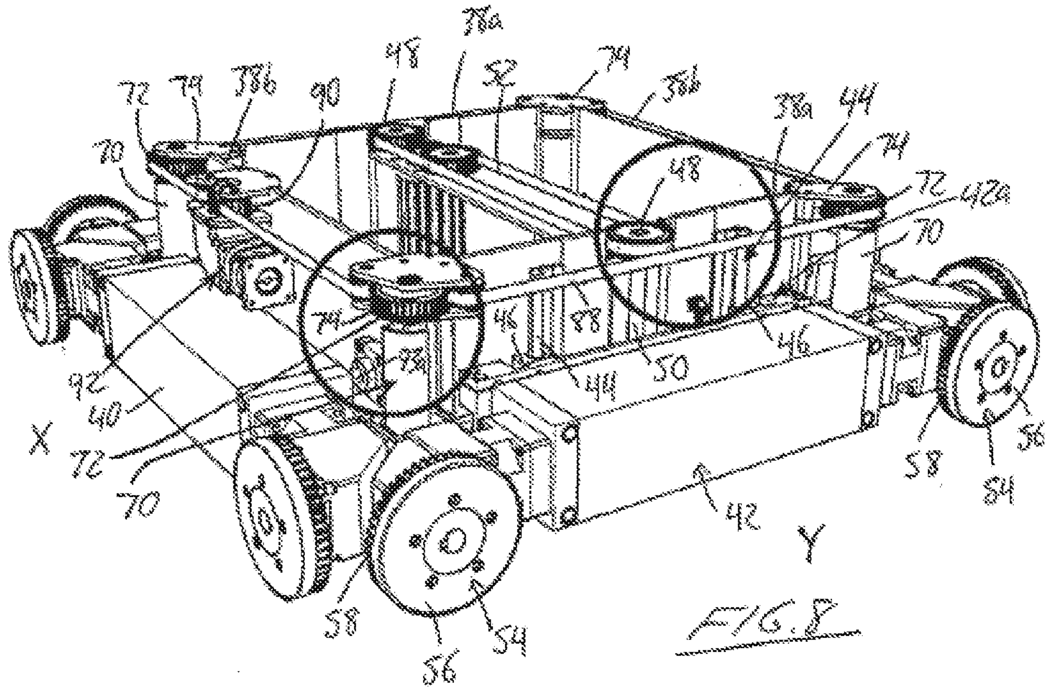

FIG. 8

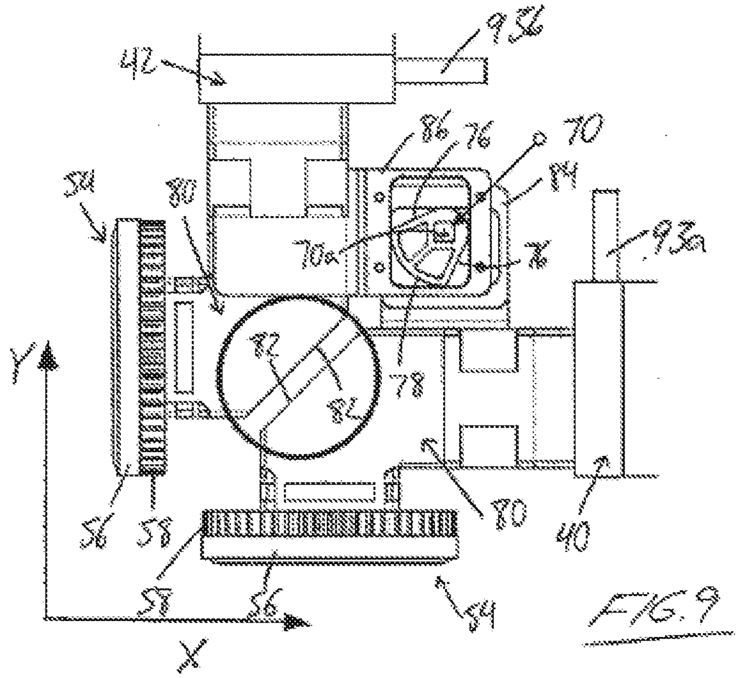
93b
42
86
76
70
84
54
80
70a
76
93a
Y
82
82
78
56
58
80
40
58
56
54
X

FIG. 9

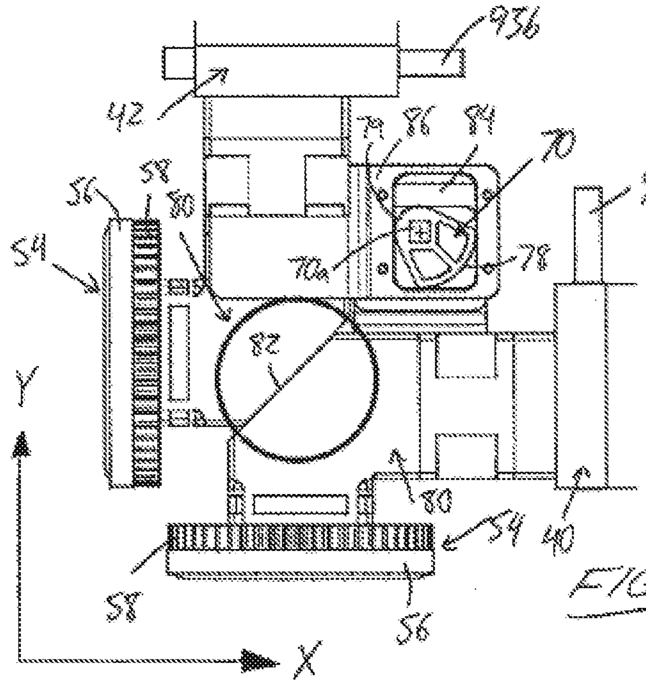
93b
42
79
86
84
70
56
58
80
54
70a
78
93a
82
Y
80
54
40
58
56
X

FIG. 10

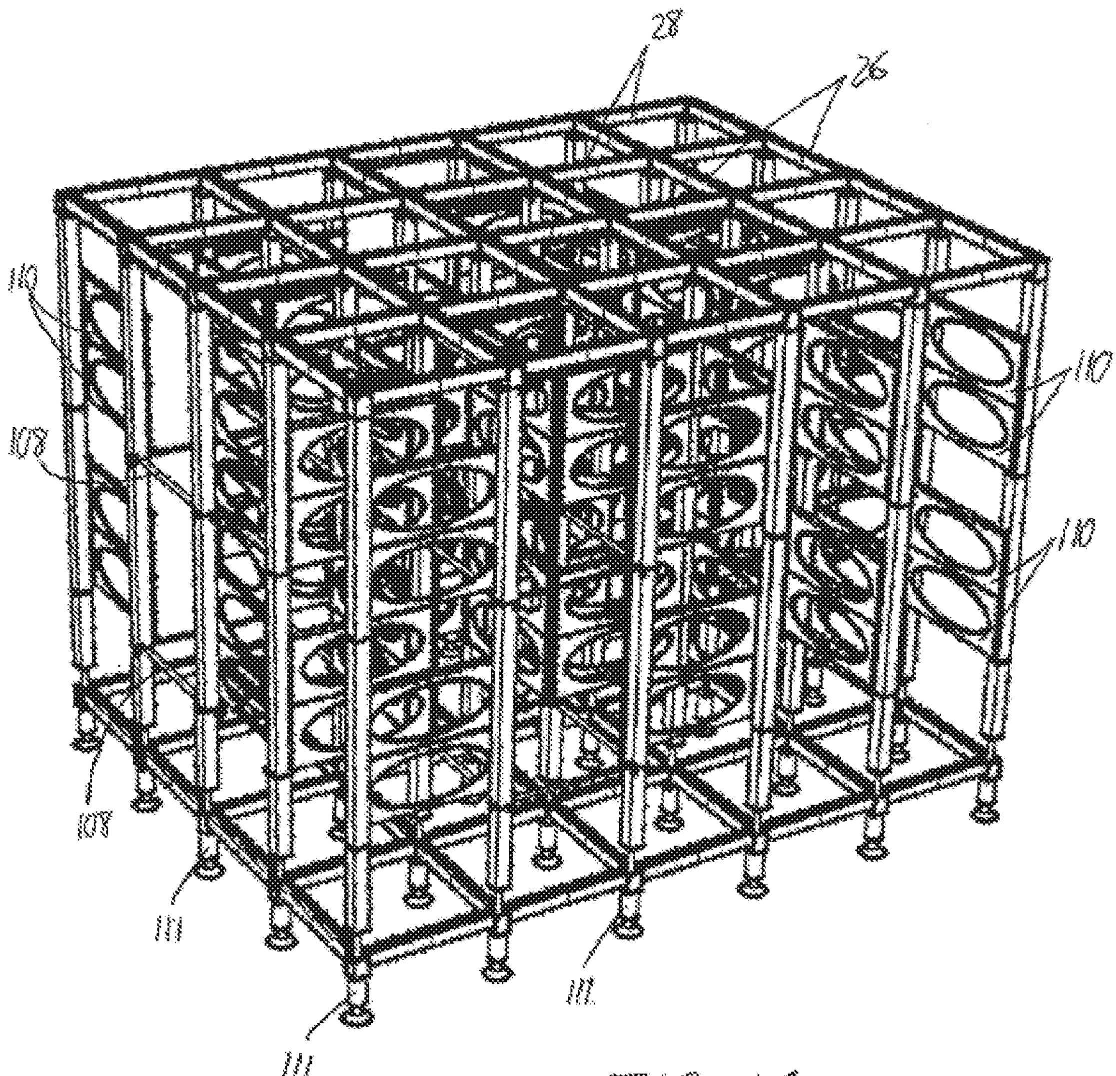

FIG. 11A

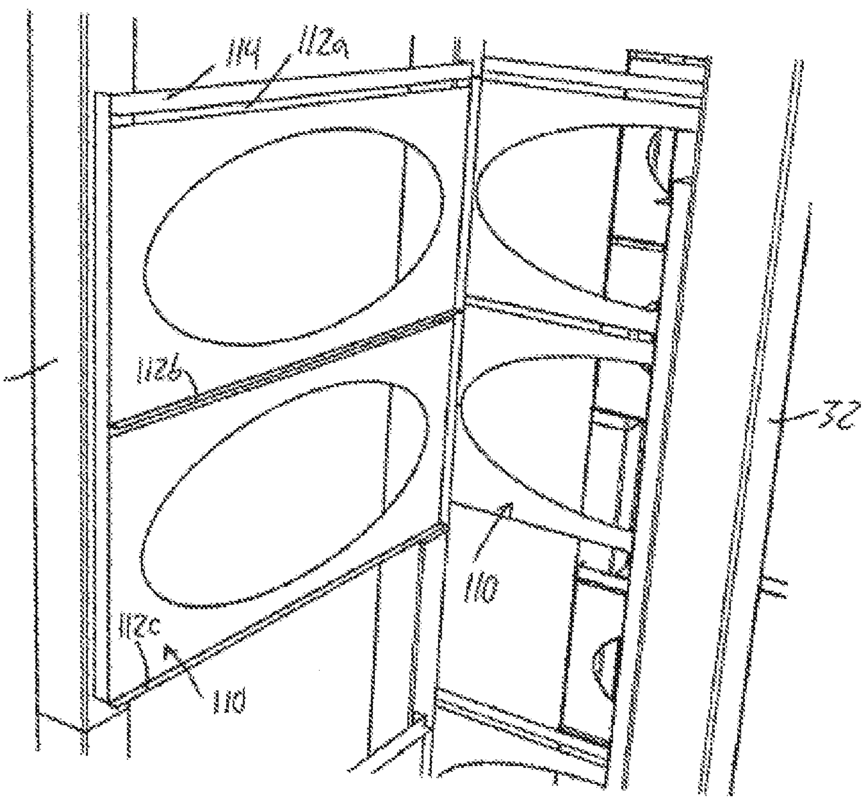

FIG. 11B

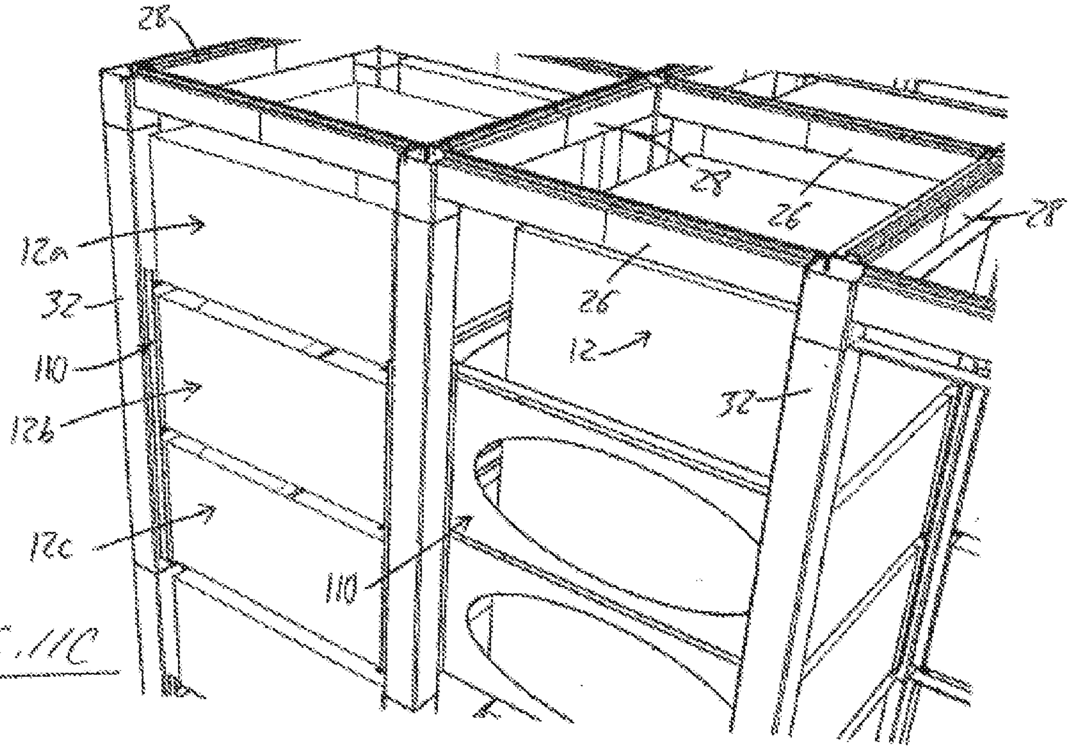

FIG. 11C

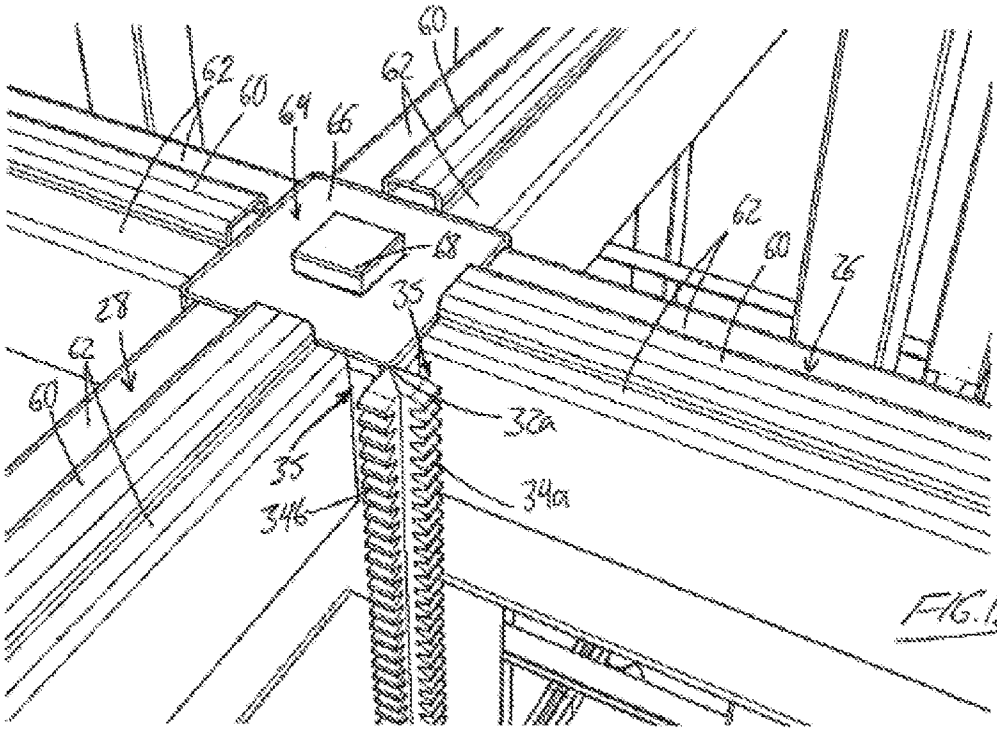
62
60
64
66
62
60
68
62
60
26
28
62
60
62
35
32a
35
34b
34a

FIG.12

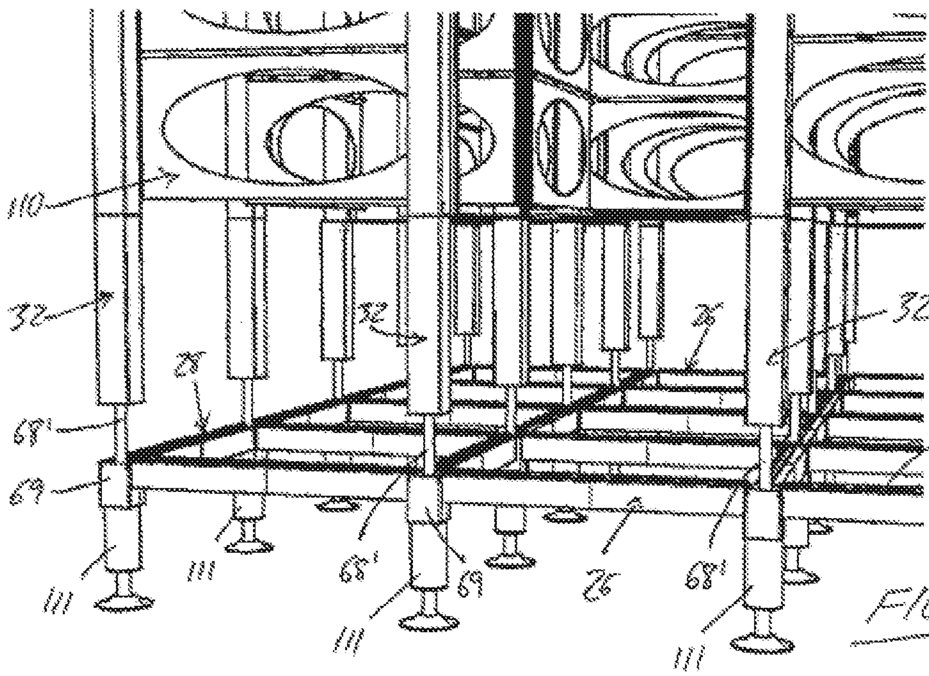
110
32
32
32
28
28
68'
69
60
69
111
111
68'
69
26
68'
111
111
111

FIG.13

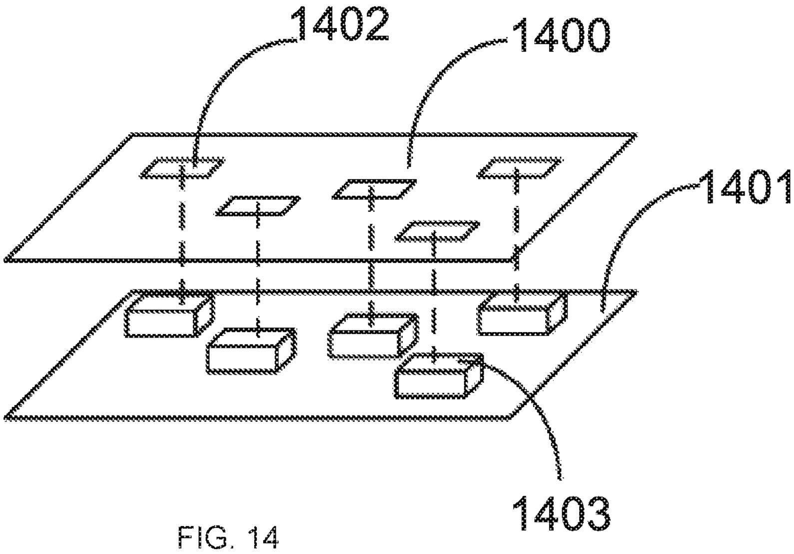
1402
1400
1401
1403

FIG. 14

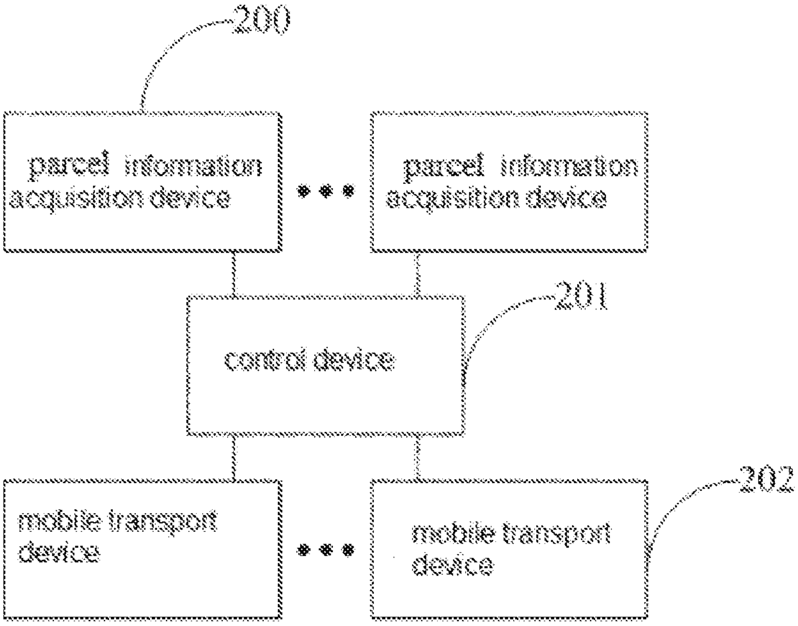
200
parcel information acquisition device
parcel information acquisition device
201
control device
202
mobile transport device
mobile transport device

FIG. 15

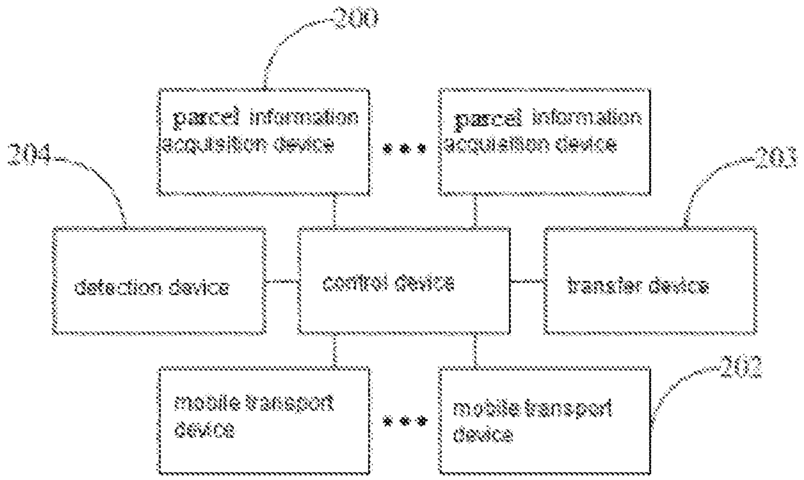
200
parcel information acquisition device
parcel information acquisition device
204
203
detection device
control device
transfer device
mobile transport device
mobile transport device
202

FIG. 16

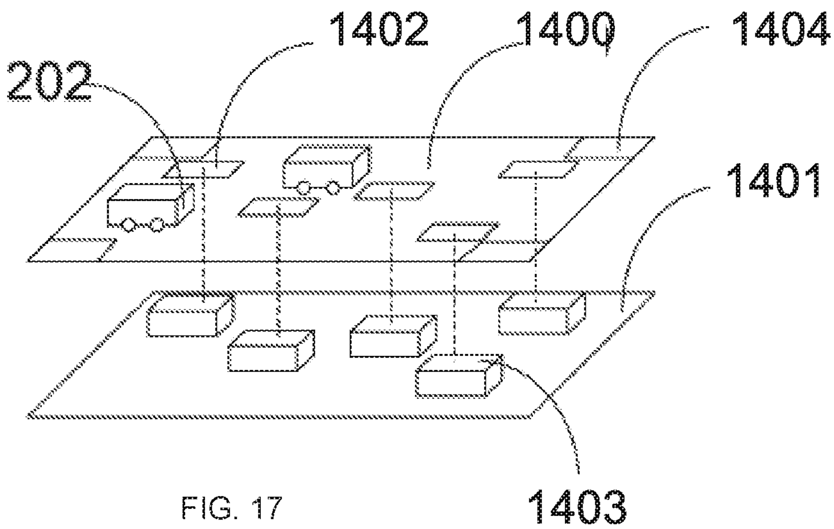
1402
1400
1404
202
1401
1403

FIG. 17

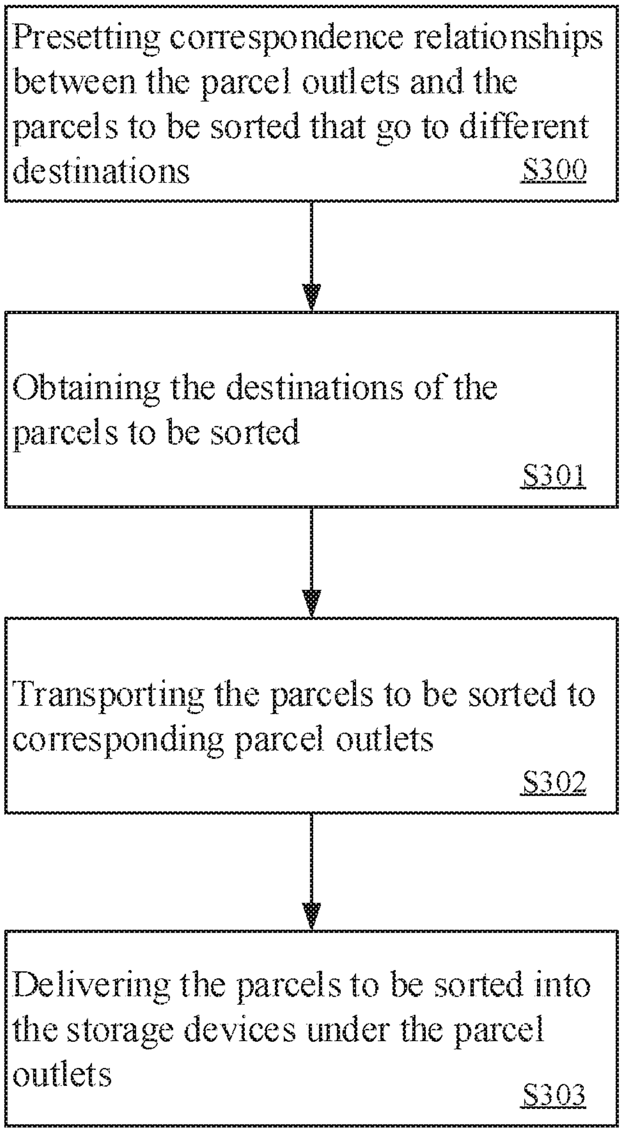
Presetting correspondence relationships between the parcel outlets and the parcels to be sorted that go to different destinations
S300
Obtaining the destinations of the parcels to be sorted
S301
Transporting the parcels to be sorted to corresponding parcel outlets
S302
Delivering the parcels to be sorted into the storage devices under the parcel outlets
S303

Fig. 18

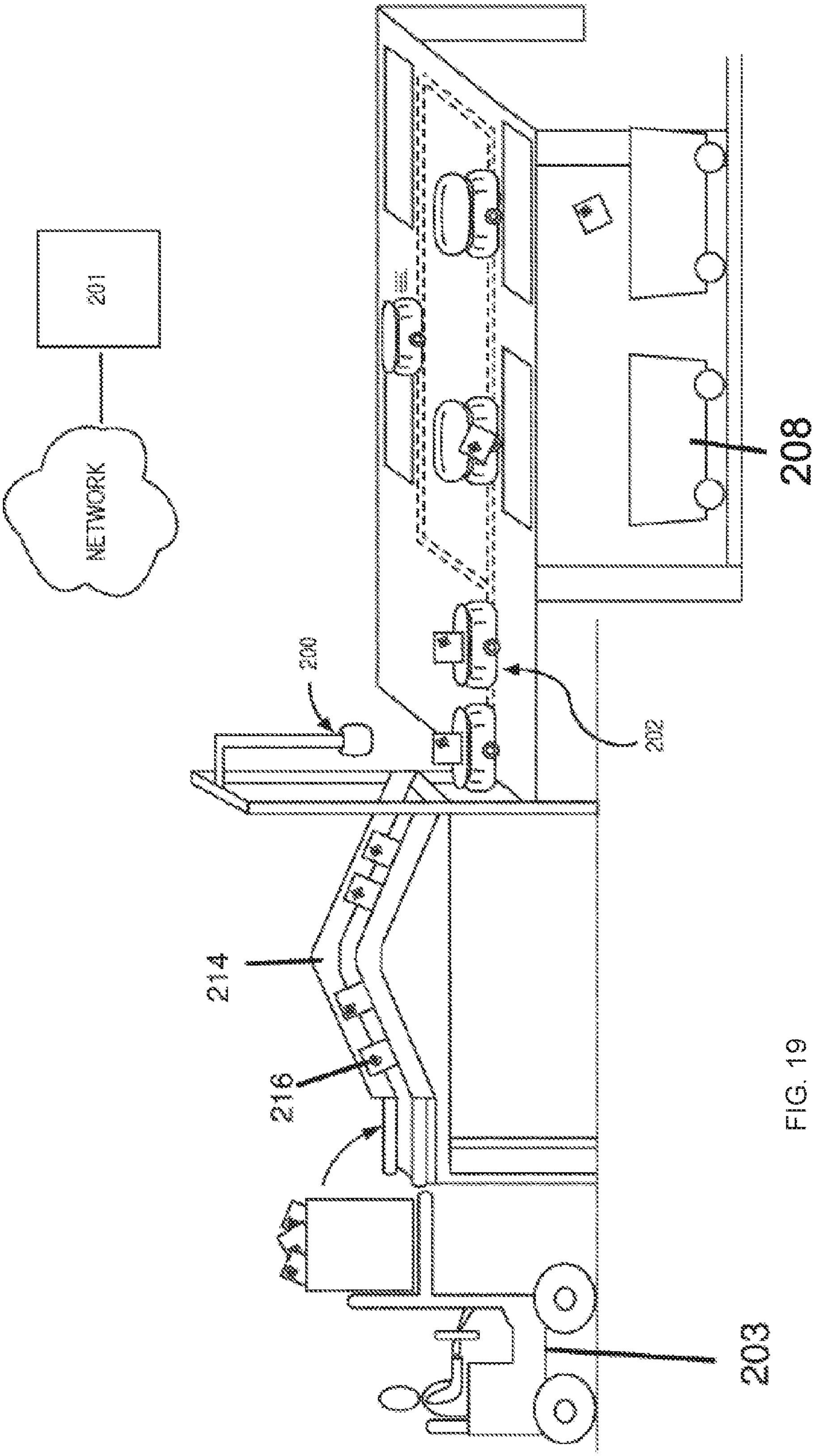

FIG. 19

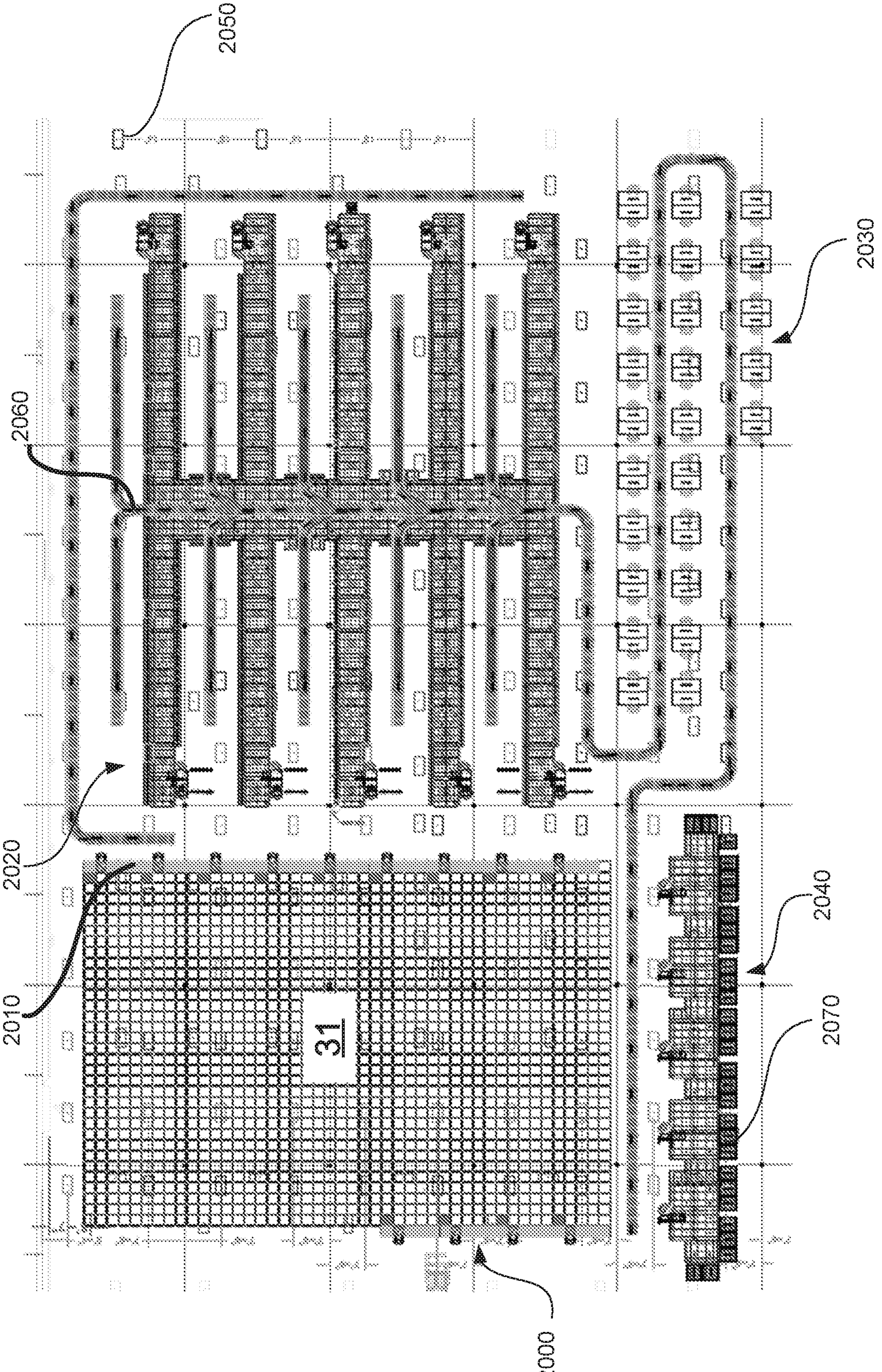

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/059690

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B65G 1/04; B65G 1/06; B65G 1/137; G06Q 10/08 (2018.01)

CPC - B65G 1/0492; B65G 1/04; B65G 1/137; B65G 1/1373; G06Q 10/08 (2018.08)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 414/273; 414/277; 414/807; 700/218 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014/0100998 A1 (AMAZON TECHNOLOGIES, INC.) 10 April 2014 (10.04.2014) entire document	1, 2
Y	US 2017/0101263 A1 (FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.) 13 April 2017 (13.04.2017) entire document	1, 2
A	US 9,111,251 B1 (AMAZON TECHNOLOGIES INC.) 18 August 2015 (18.08.2015) entire document	1, 2
A	US 2015/0307276 A1 (JAKOB HATTELAND LOGISTICS AS) 29 October 2015 (29.10.2015) entire document	1, 2
A	US 2016/0060037 A1 (RAZUMOV) 03 March 2016 (03.03.2016) entire document	1, 2

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 December 2018	18 JAN 2019

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774