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(54) **SUSPENDED AUTOMATION SYSTEM**

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*B25J 9/00* (2006.01)

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(52) **U.S. Cl.**

(72) Inventor: **Kenneth C. MILLER**, Aptos, CA (US)

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(2013.01)

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(57) **ABSTRACT**

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§ 371 (c)(1),

(2) Date: **May 19, 2017**

**Related U.S. Application Data**

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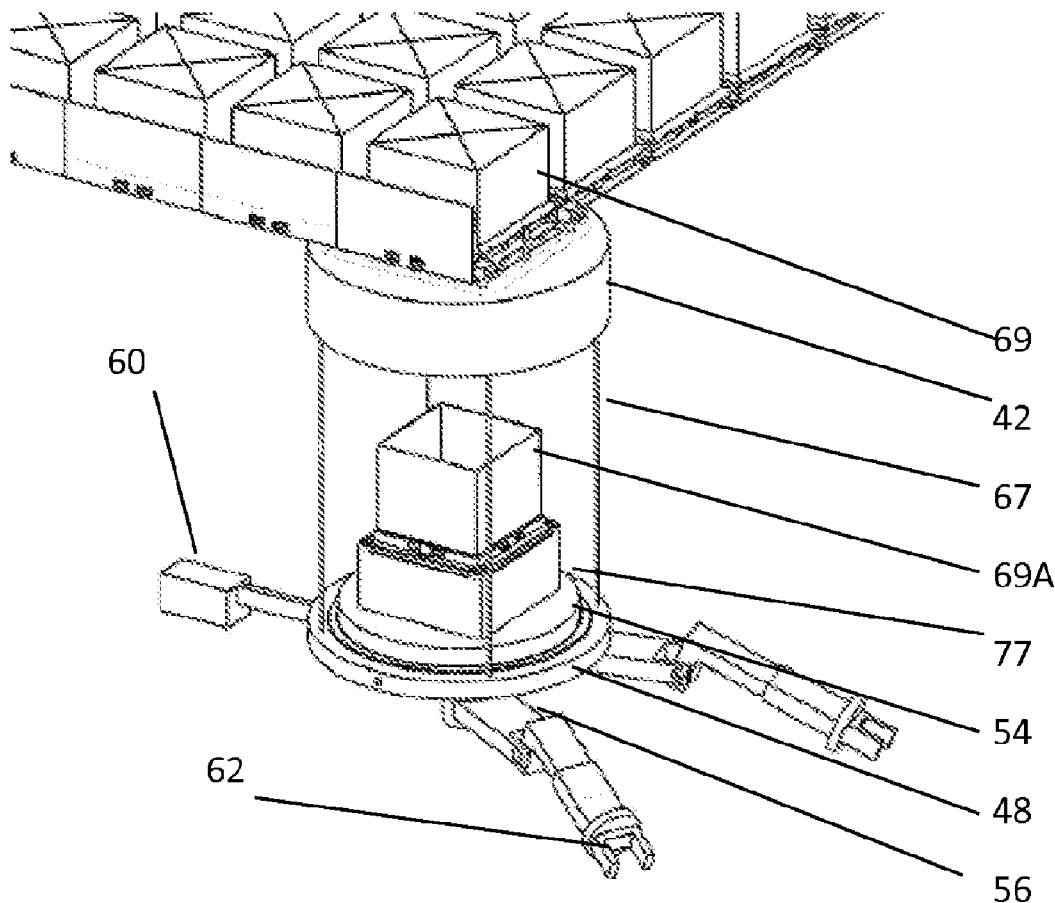
A suspended automation system includes a rail array secured to a ceiling. A gantry moves in an X-Y plane defined by the rail array with a drive mechanism. A controller with a human user interface allows for selective movement of the gantry to transport, and in some instances store or manipulate articles. A motorized rotating platform and one or more of a robotic arm, a camera, or a counter-balance are added to the platform to facilitate storage and manipulation, as well as actions in the area below the ceiling. A rail array in some embodiments is equipped with storage modules located above the rail array, the storage modules can take a variety of shapes and sizes for storage of an article. A related process of article movement and actions can be accomplished by the suspended automation system. Still another related process is overhead storage and selectively delivery of an article.

**Publication Classification**

(51) **Int. Cl.**

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*B25J 11/00* (2006.01)



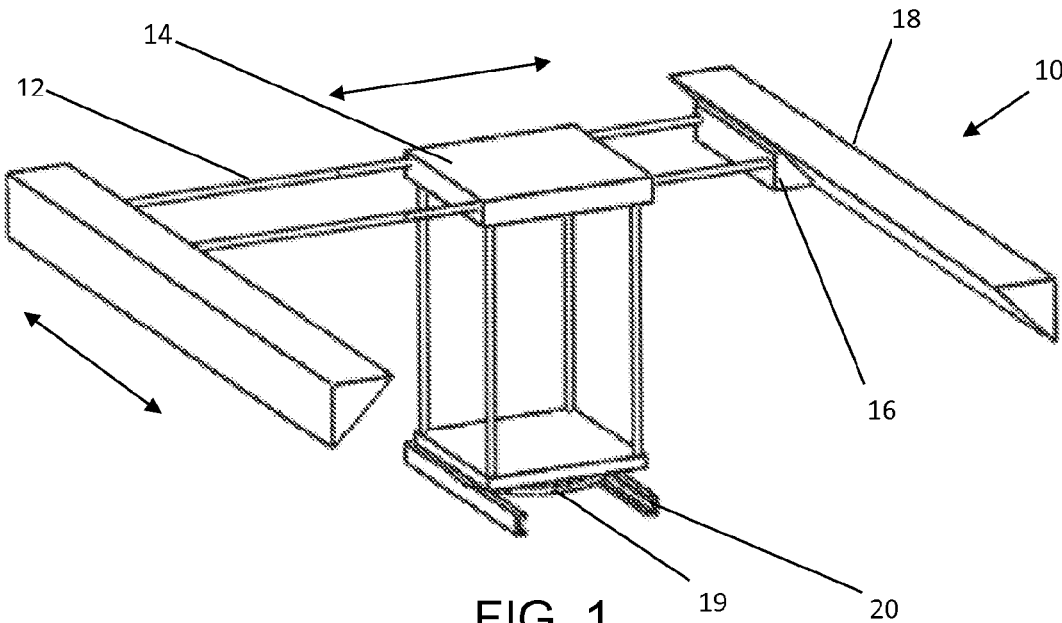


FIG. 1

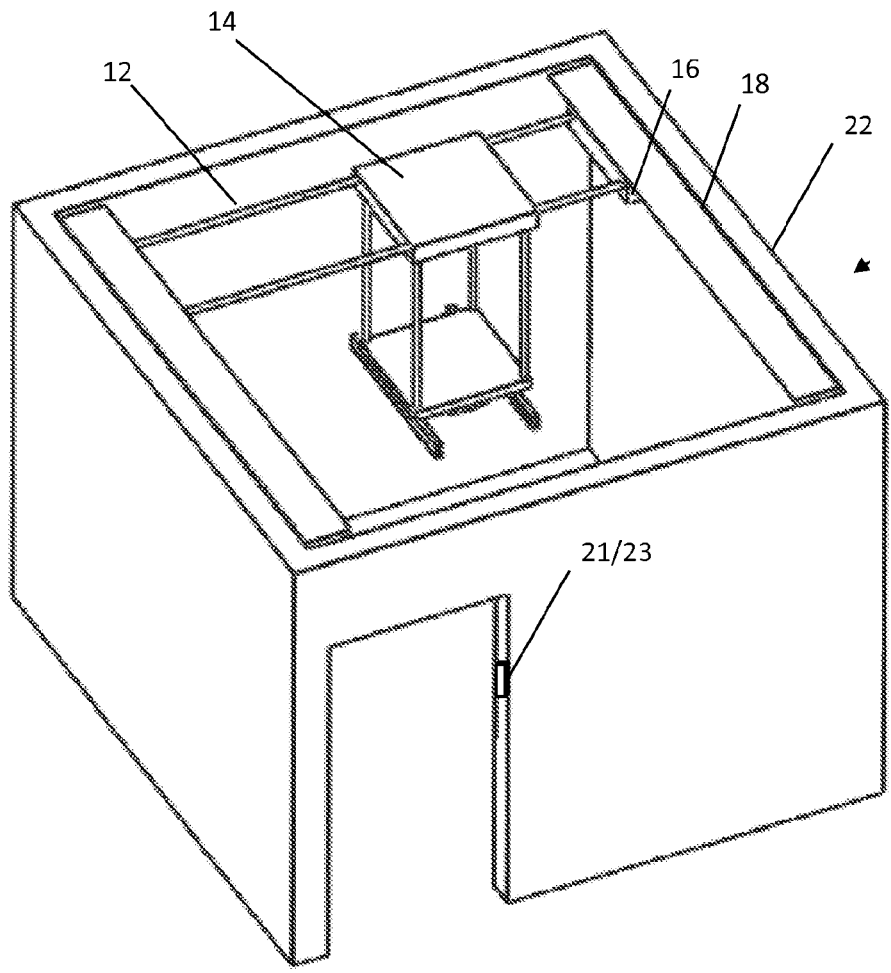


FIG. 2

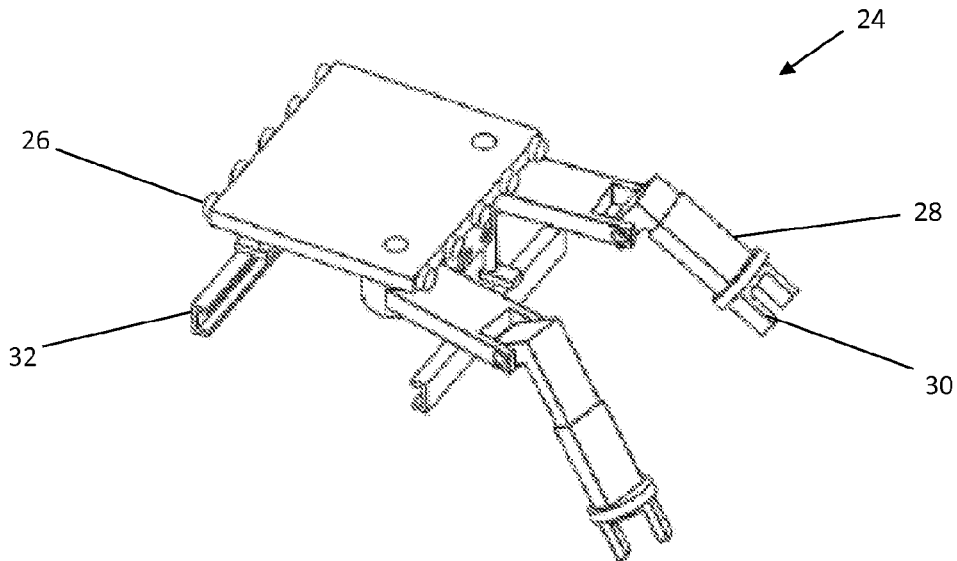


FIG. 3A

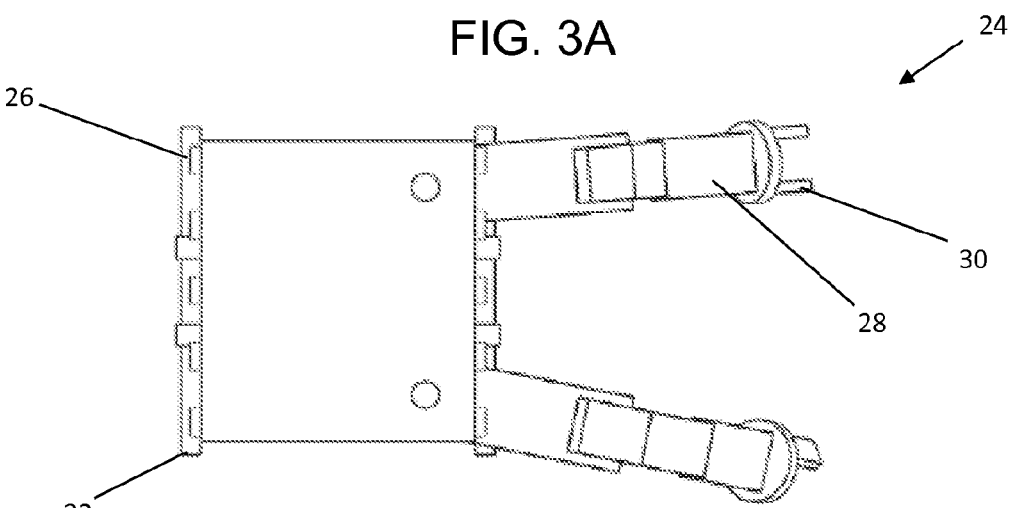


FIG. 3B

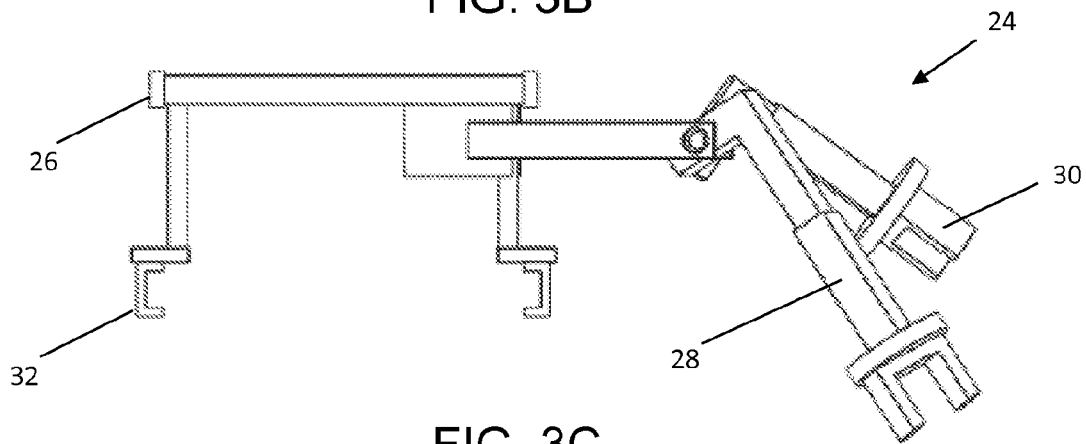


FIG. 3C

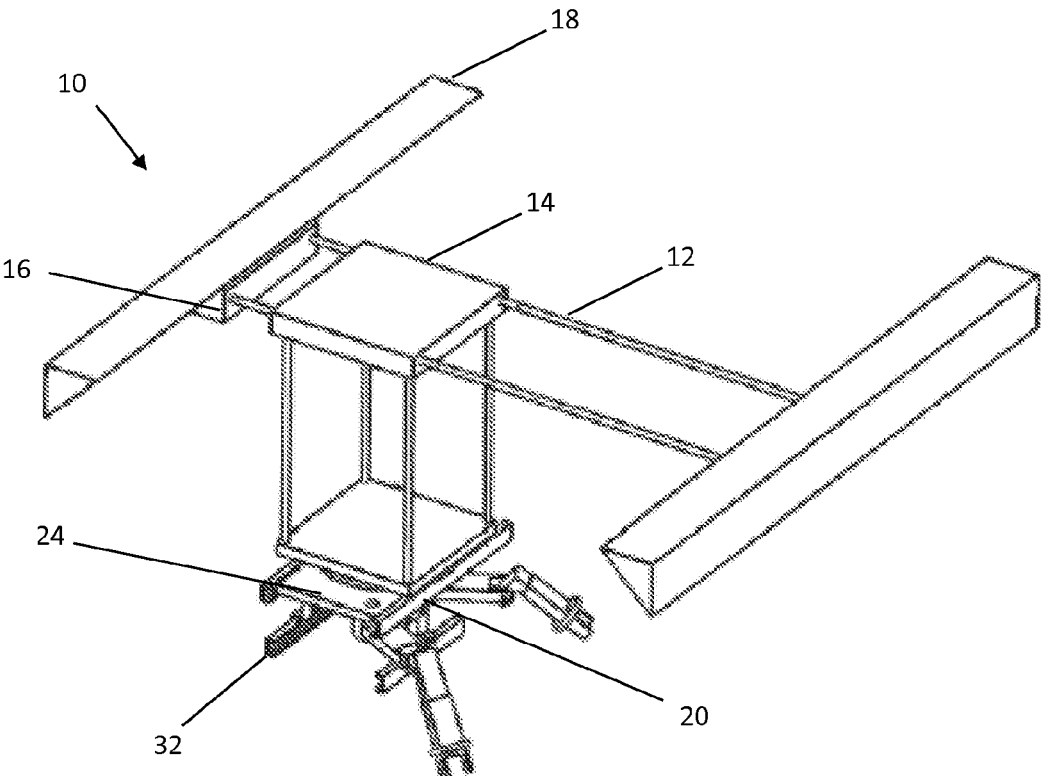


FIG. 4A

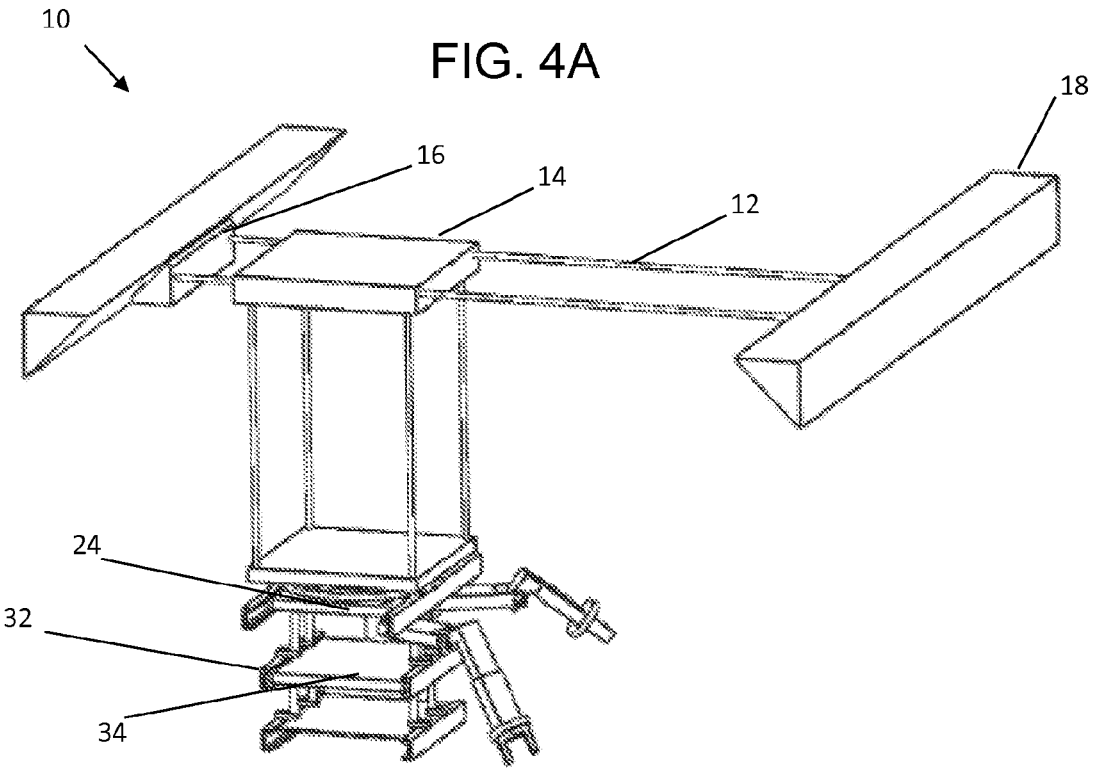


FIG. 4B

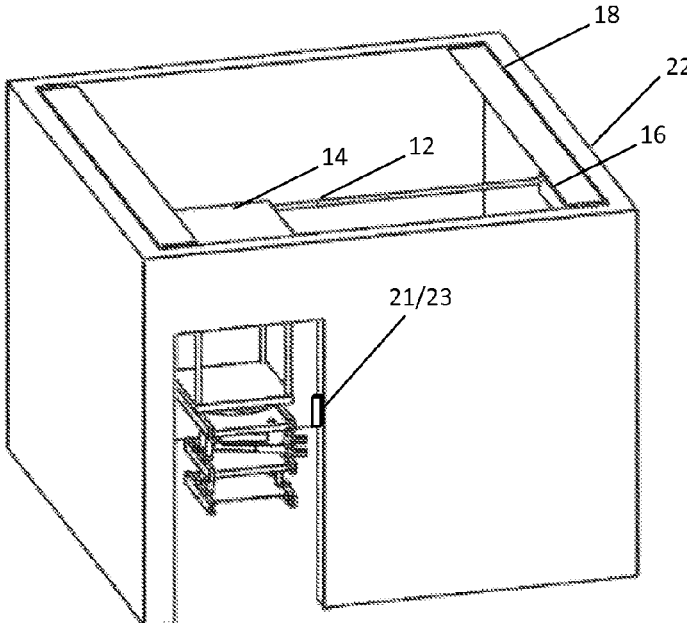


FIG. 5

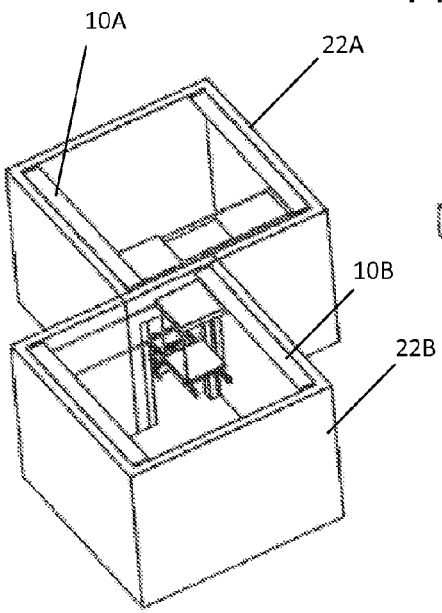


FIG. 6

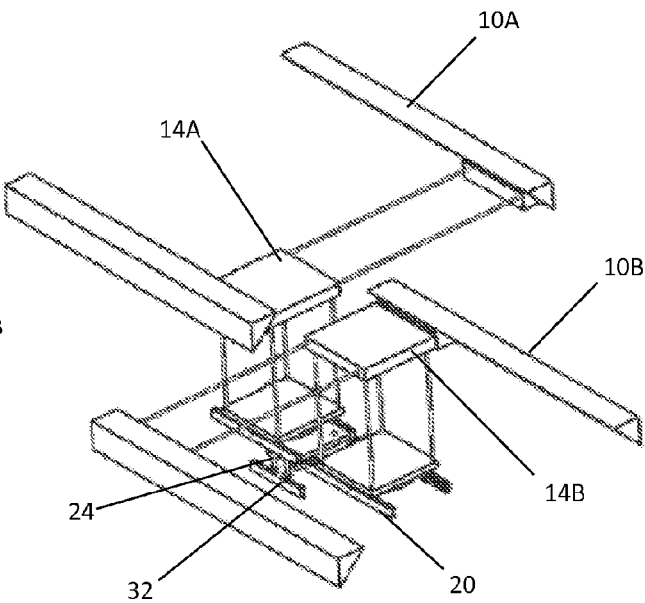


FIG. 7

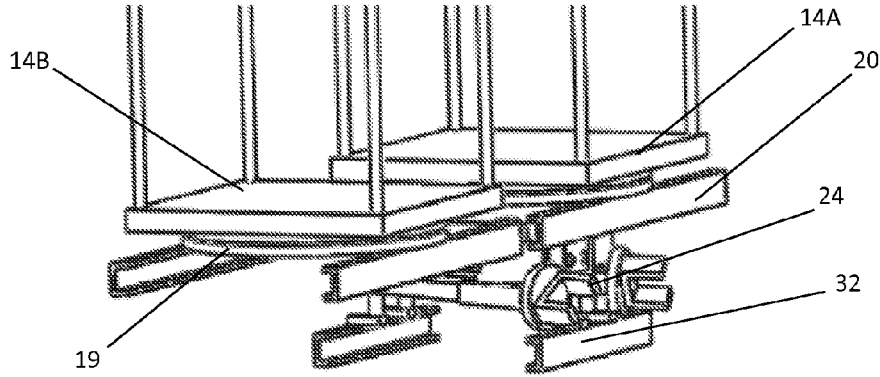


FIG. 8

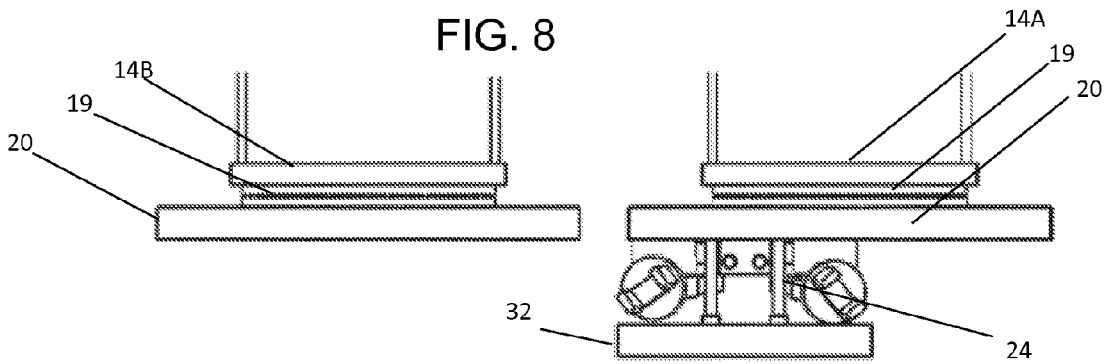


FIG. 9A

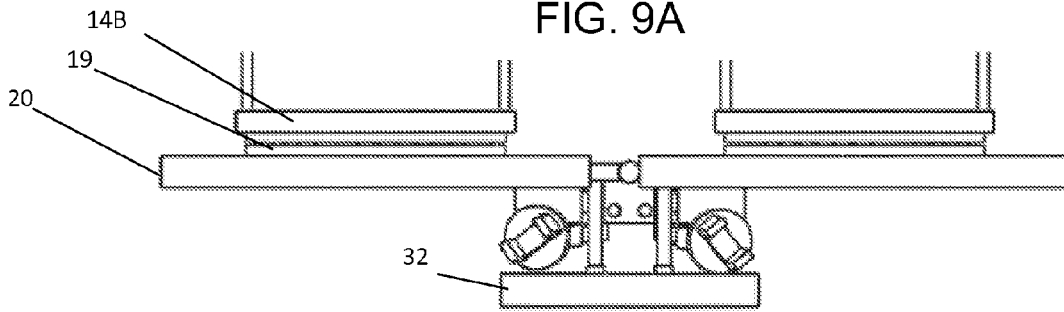


FIG. 9B

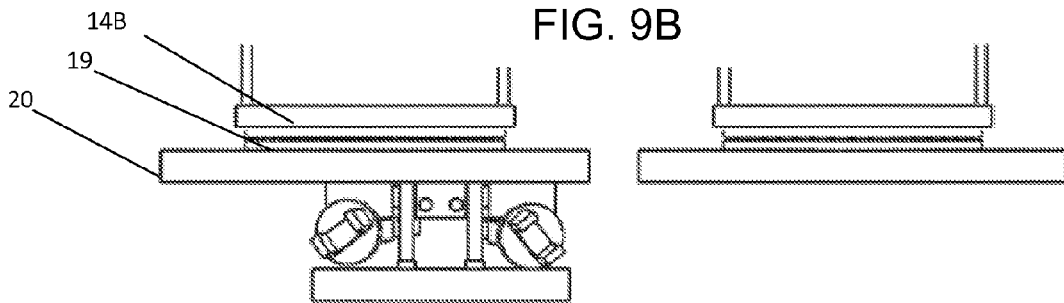


FIG. 9C

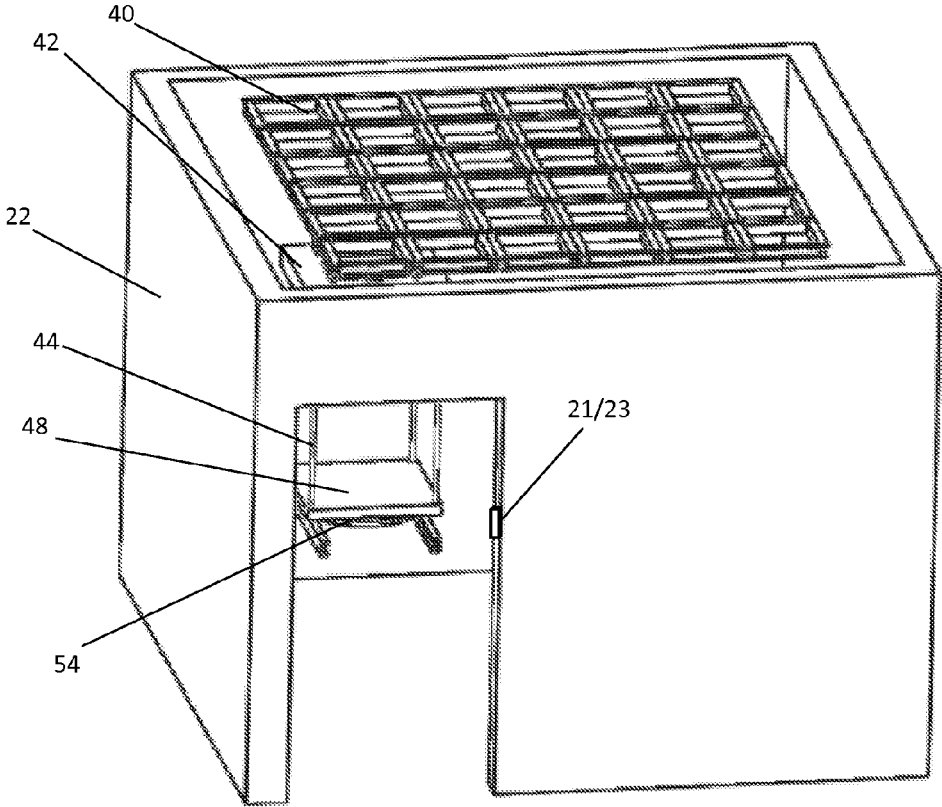


FIG. 10A

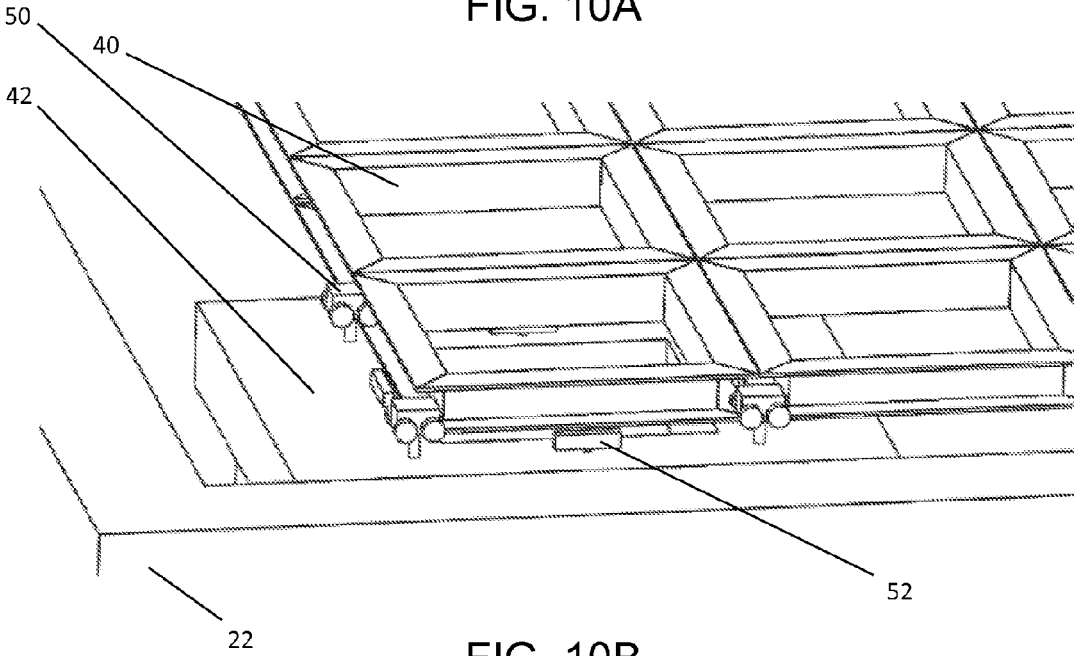


FIG. 10B

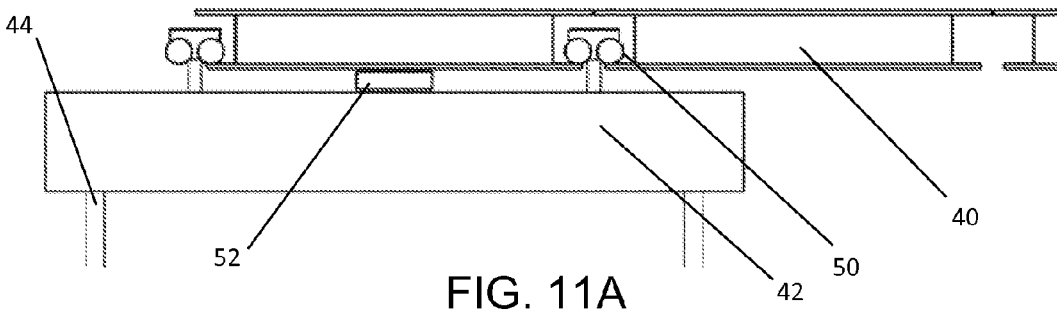


FIG. 11A

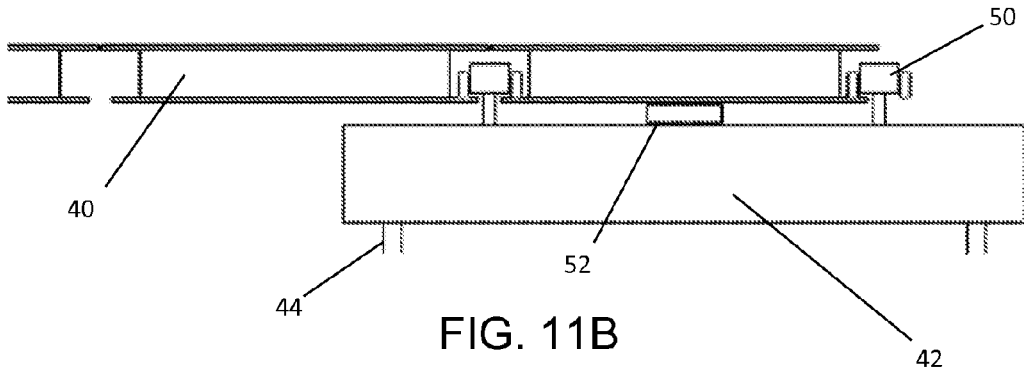


FIG. 11B

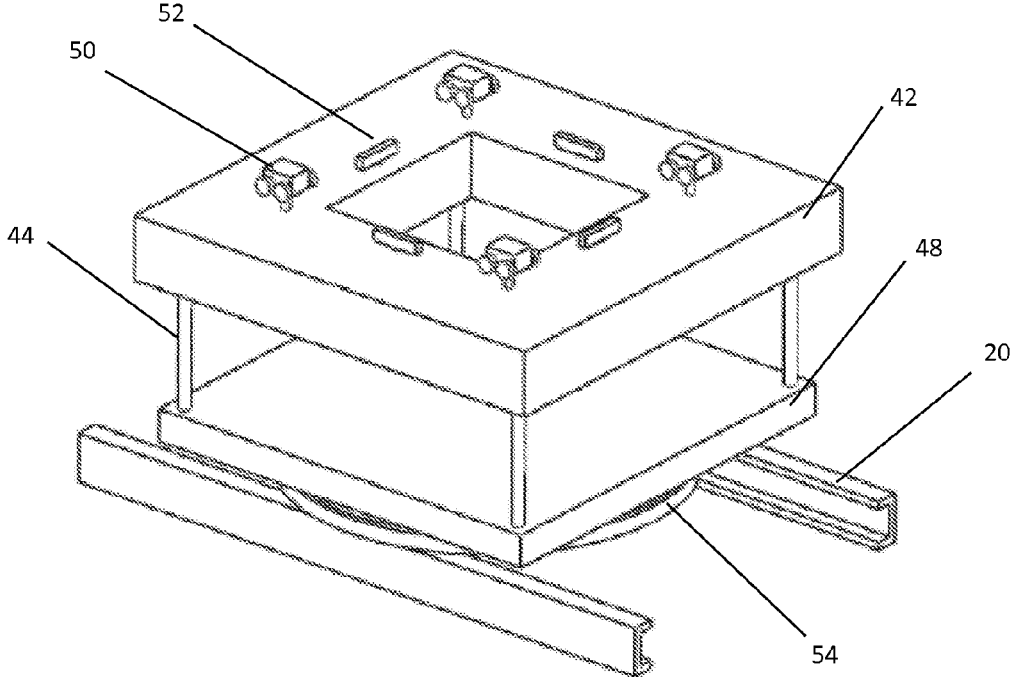


FIG. 12



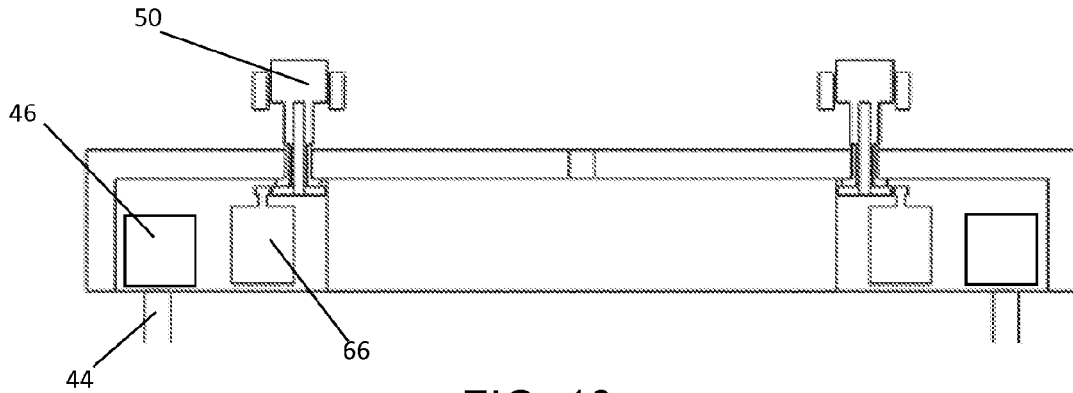


FIG. 13

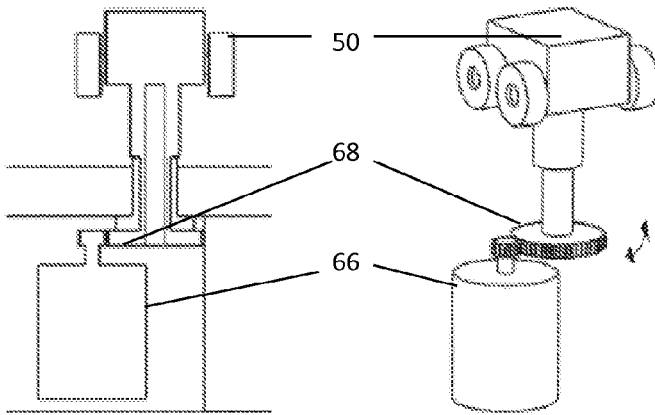


FIG. 14A

FIG. 14B

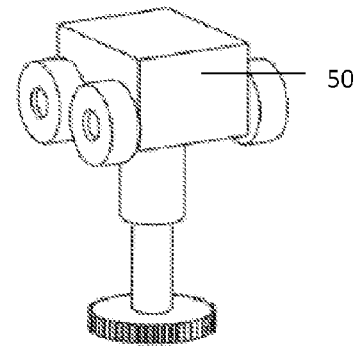


FIG. 14C

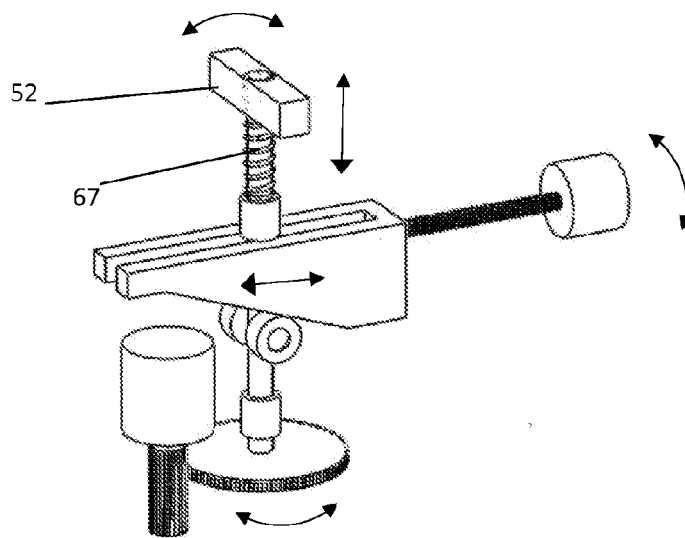


FIG. 15

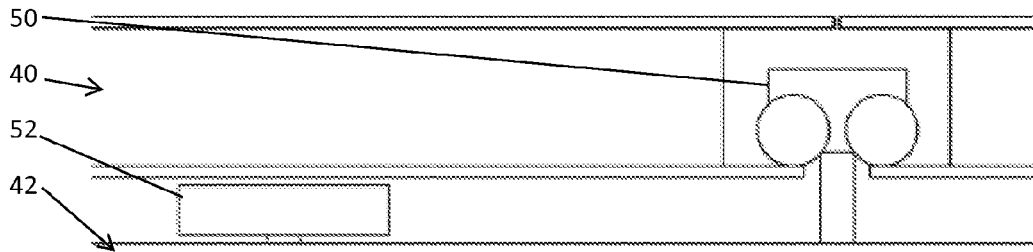


FIG. 16A

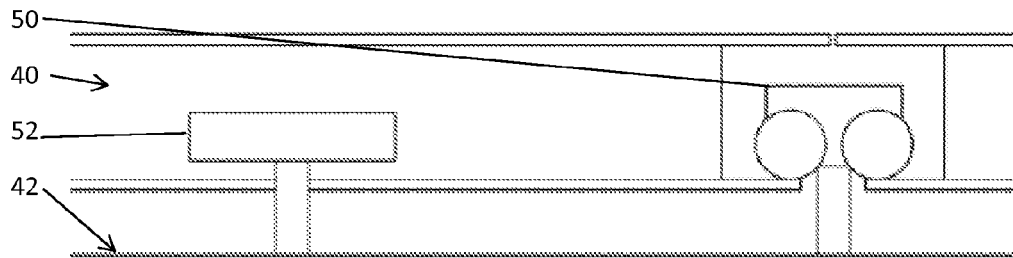


FIG. 16B

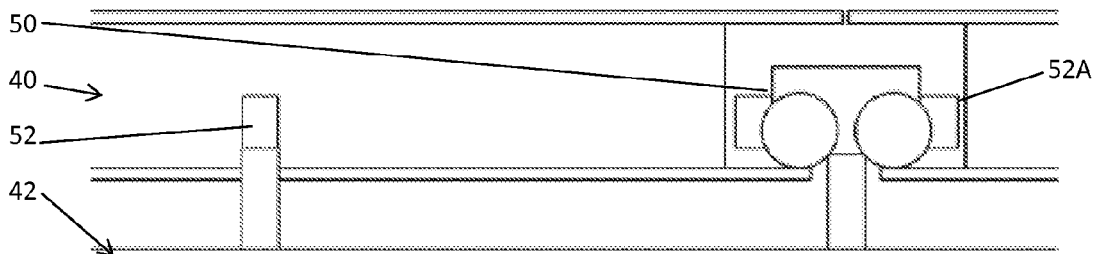


FIG. 16C

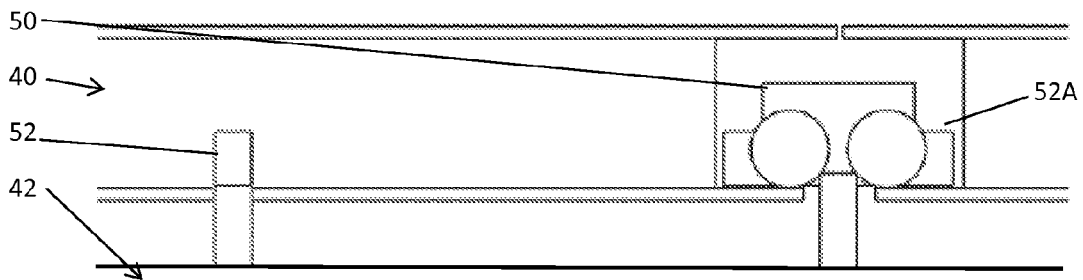


FIG. 16D

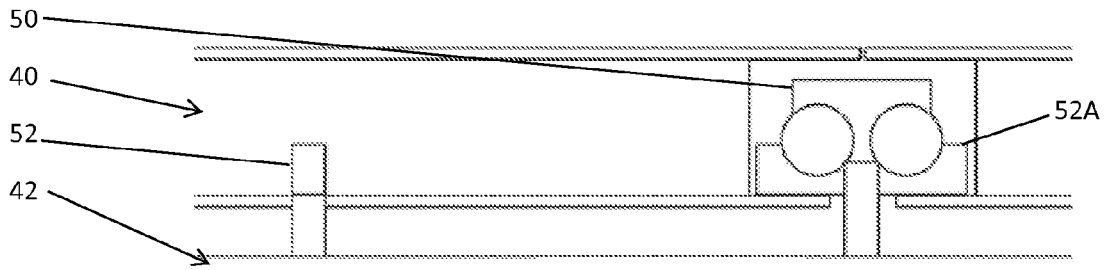


FIG. 16E

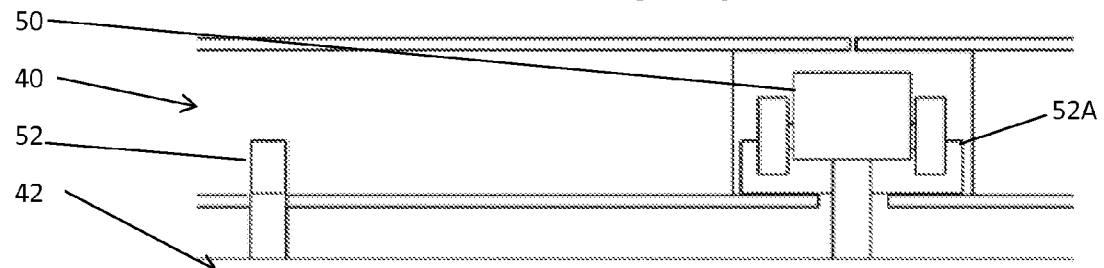


FIG. 16F

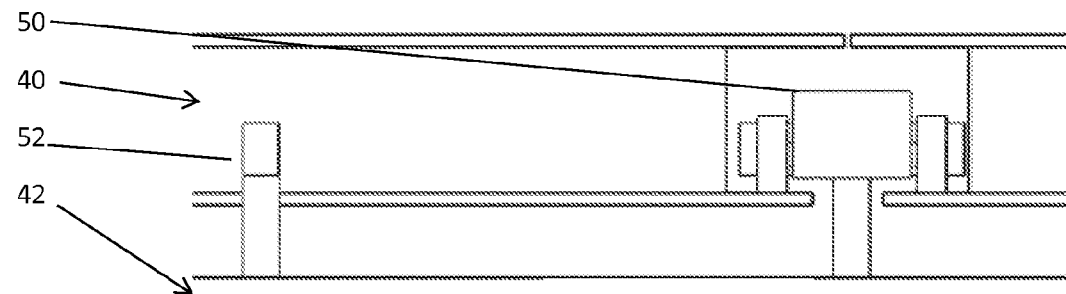


FIG. 16G

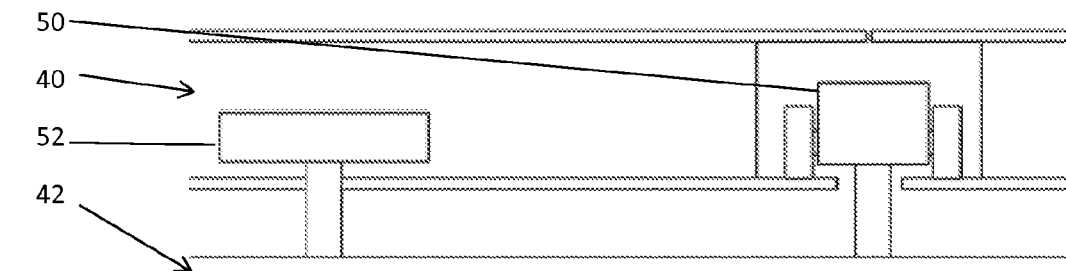


FIG. 16H

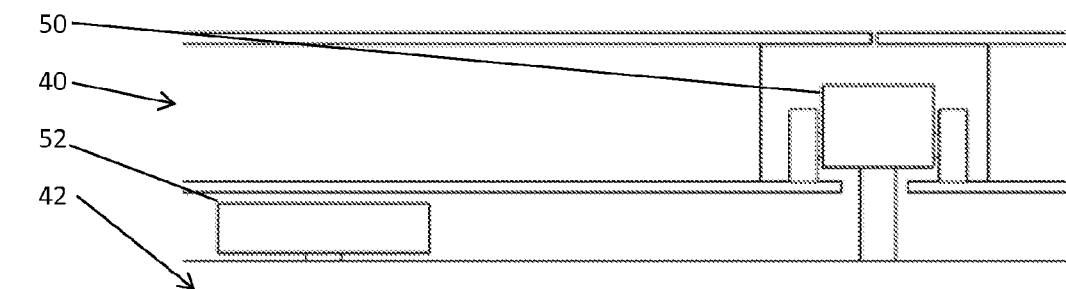


FIG. 16I

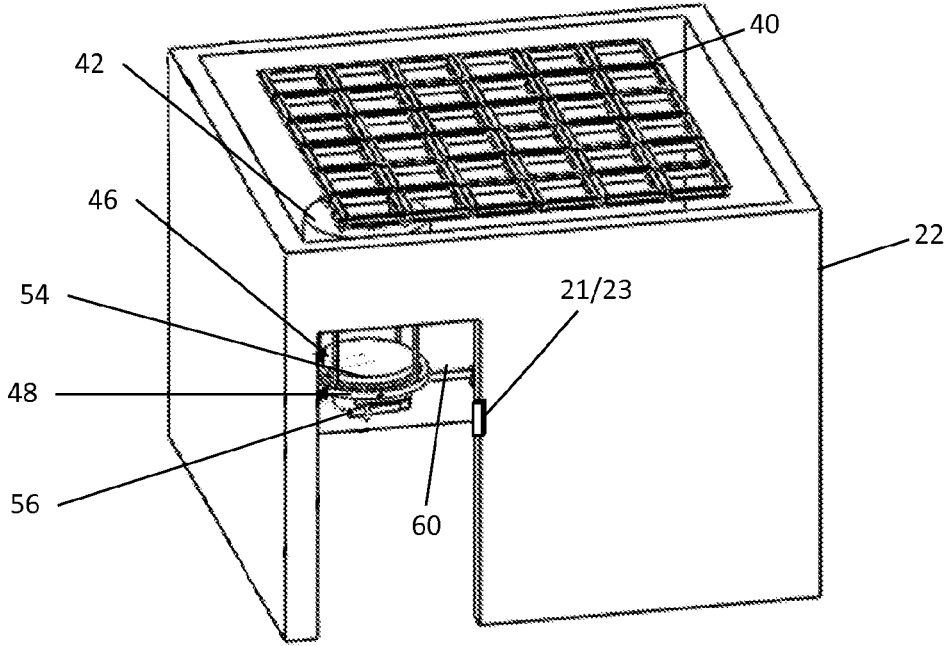


FIG. 17A

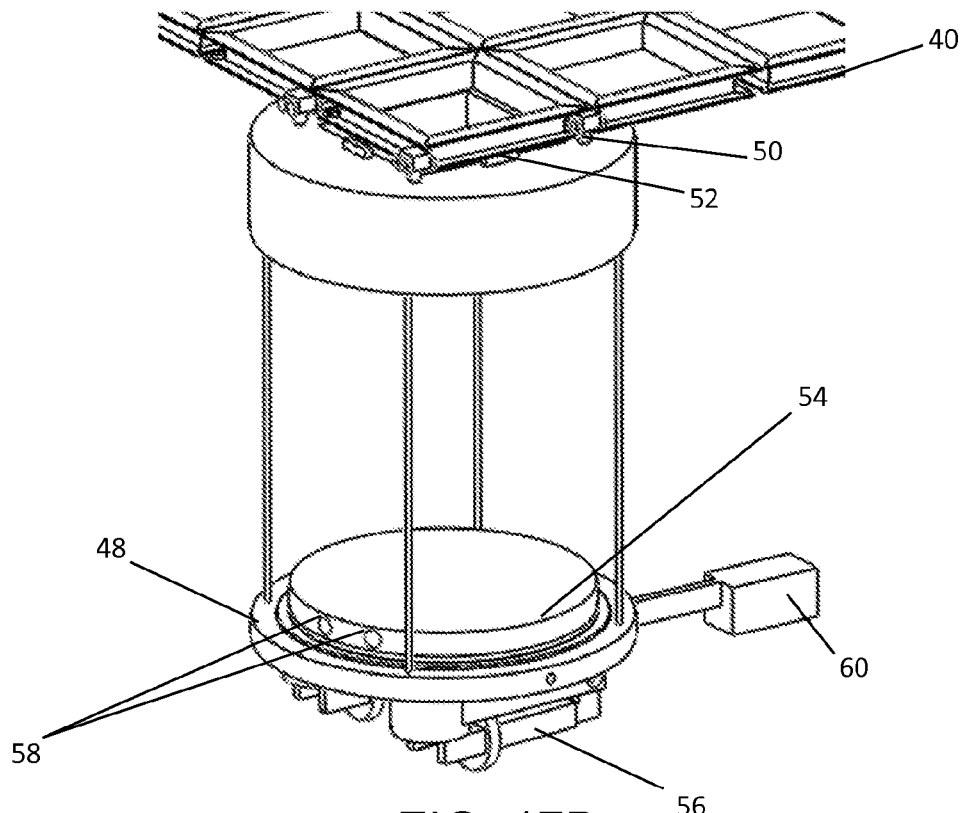


FIG. 17B

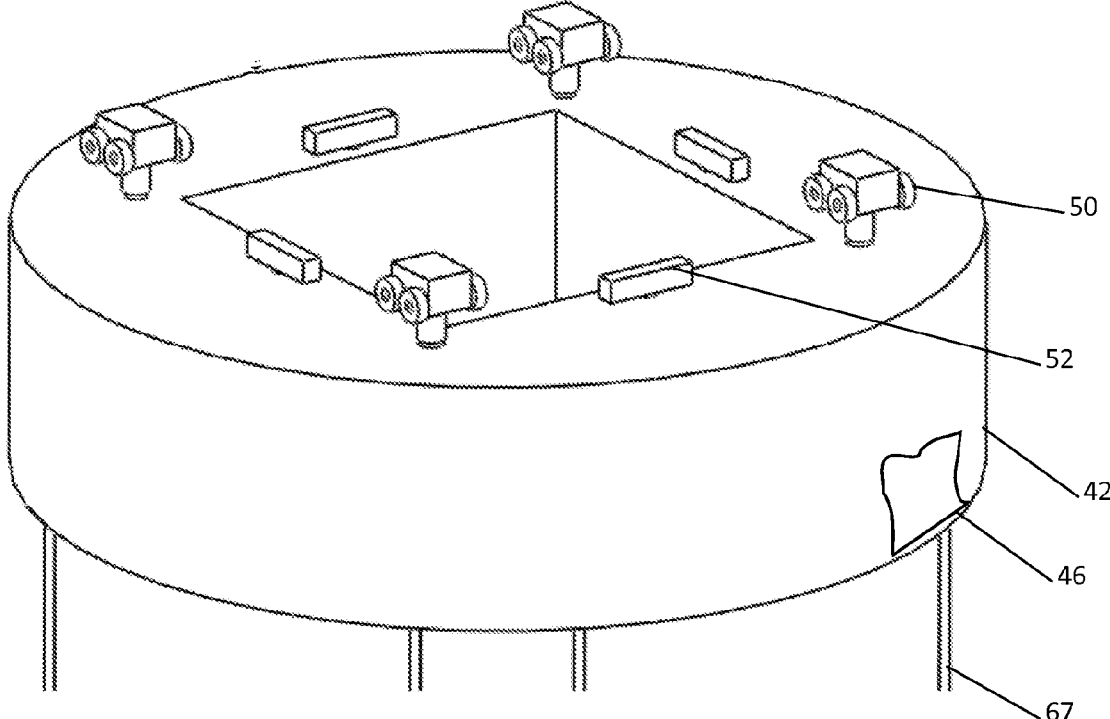


FIG. 18

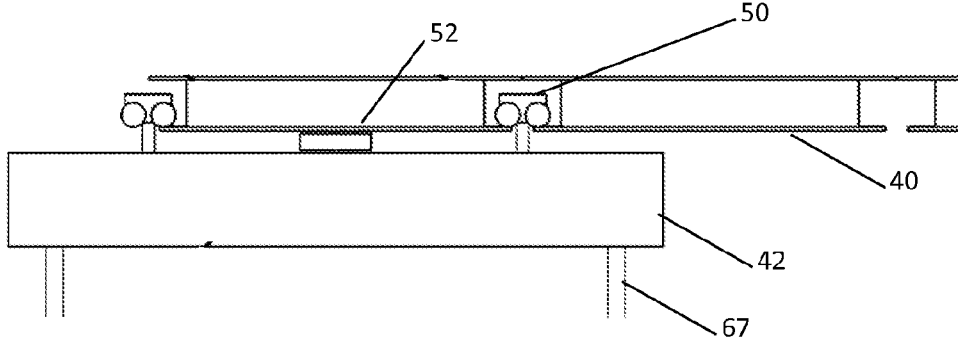


FIG. 19A

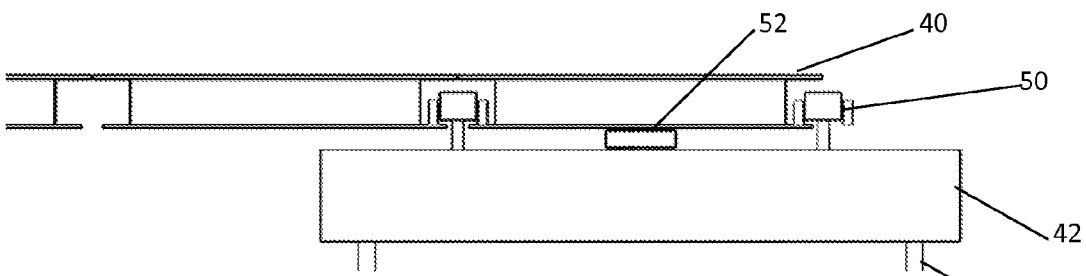


FIG. 19B

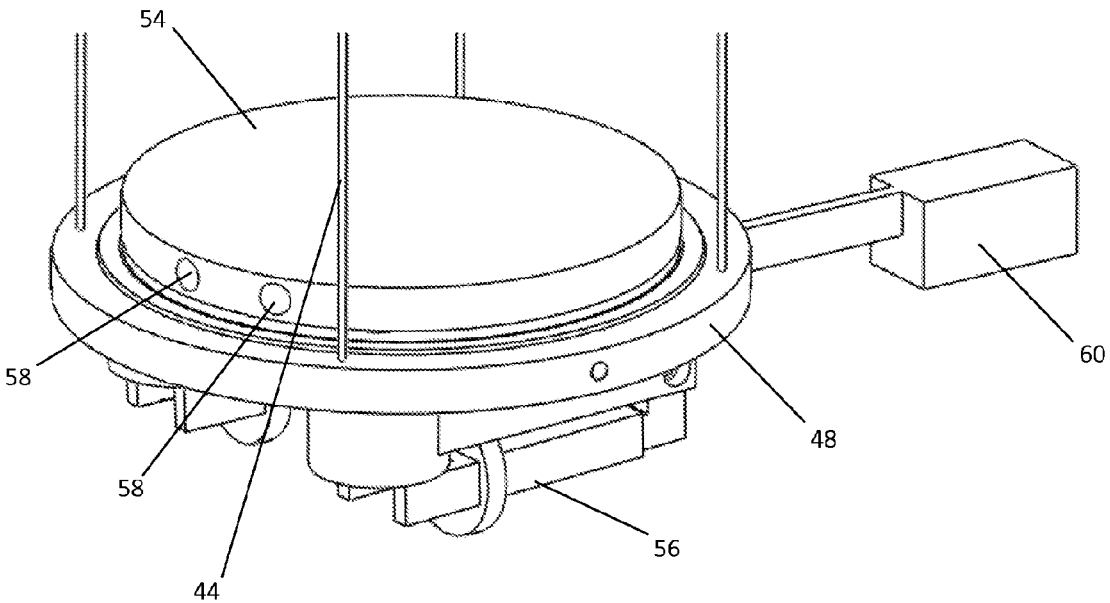


FIG. 20A

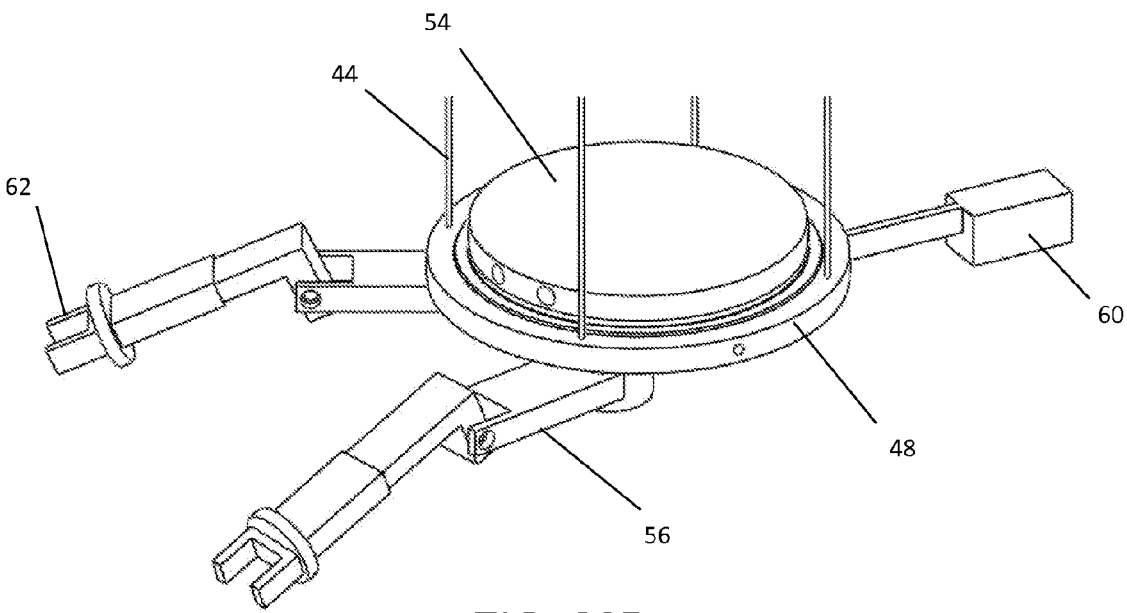


FIG. 20B

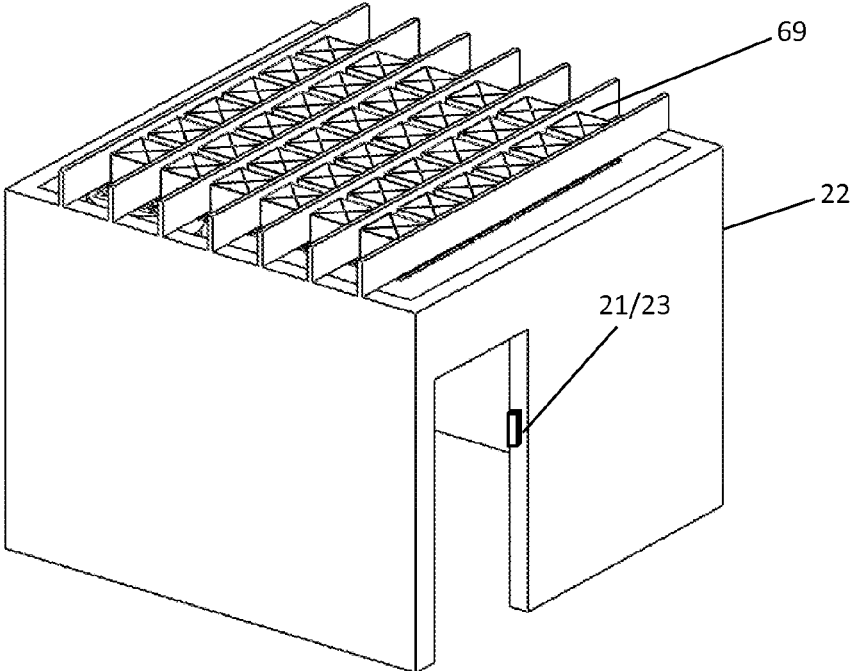


FIG. 21

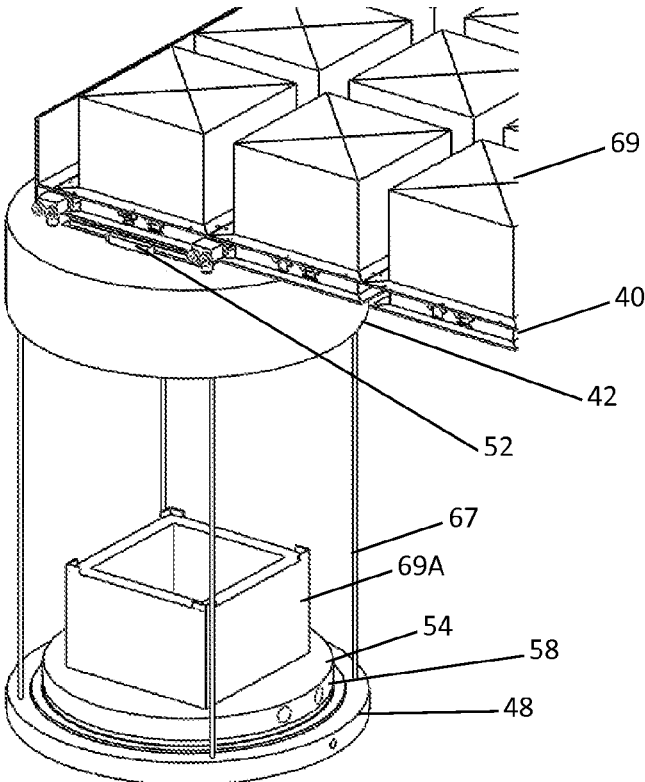


FIG. 22A

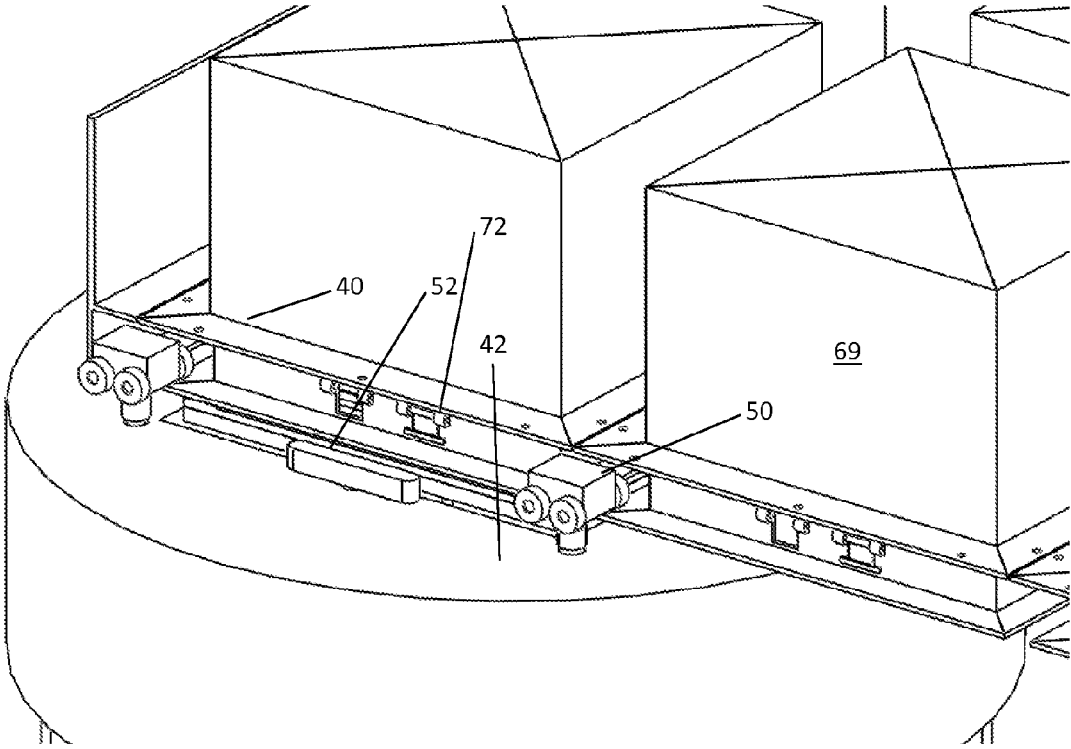


FIG. 22B

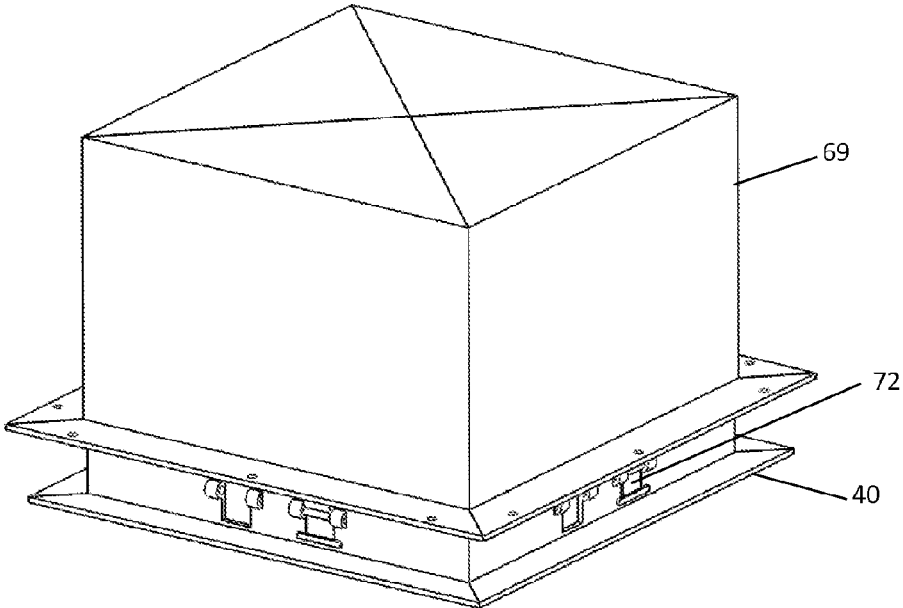


FIG. 23A



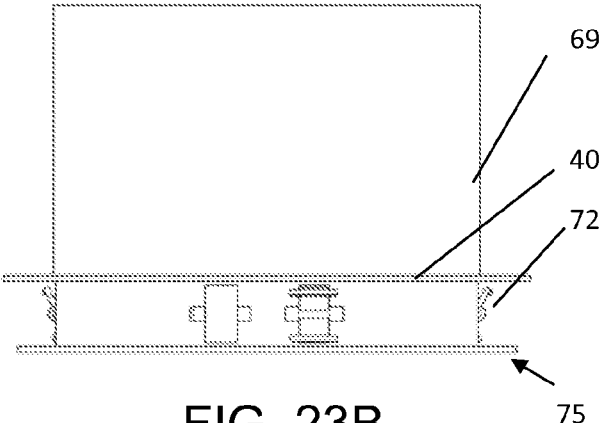


FIG. 23B

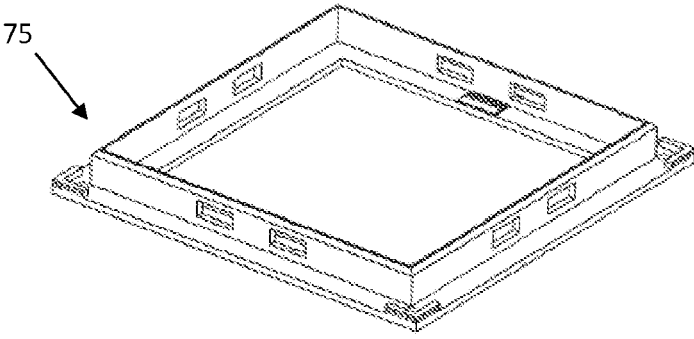


FIG. 23C

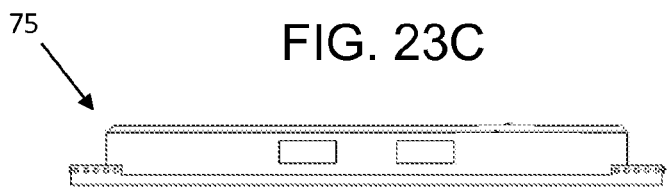


FIG. 23D

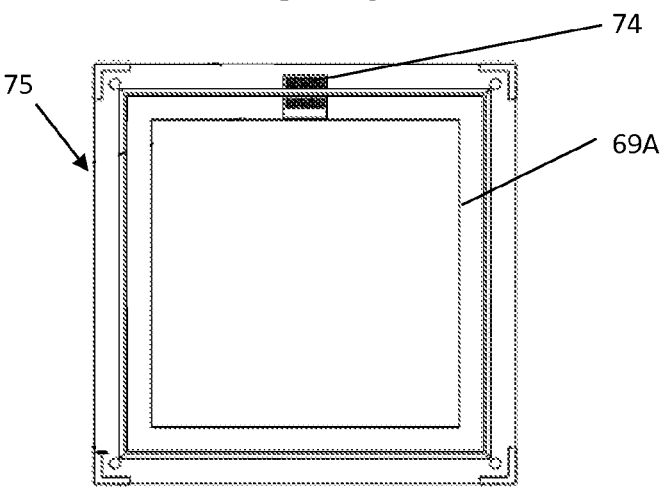


FIG. 23E

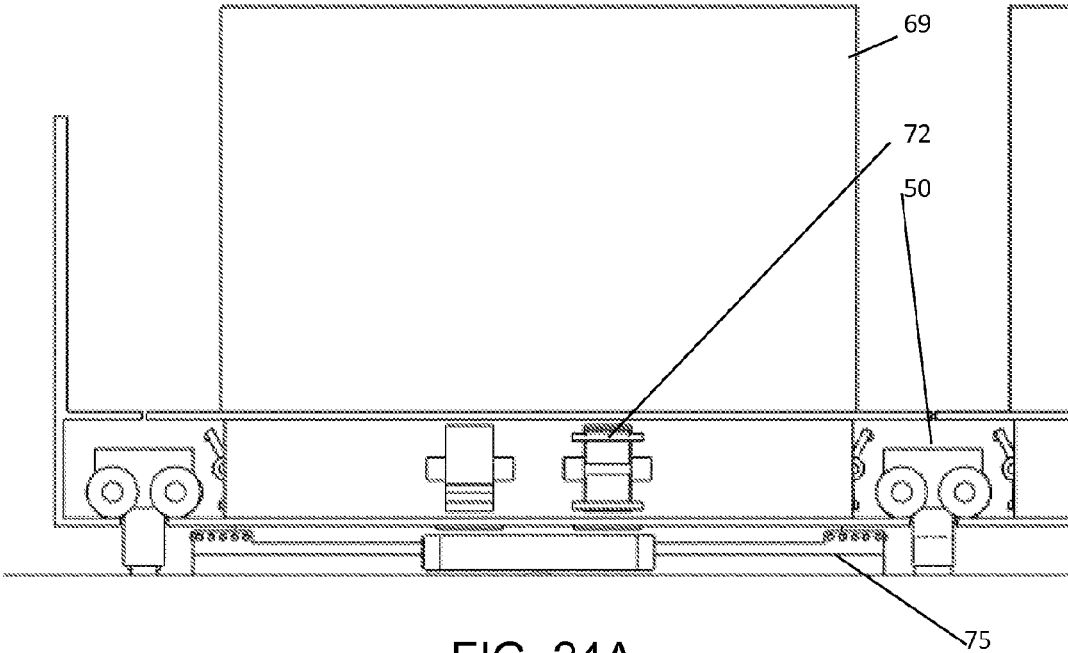


FIG. 24A

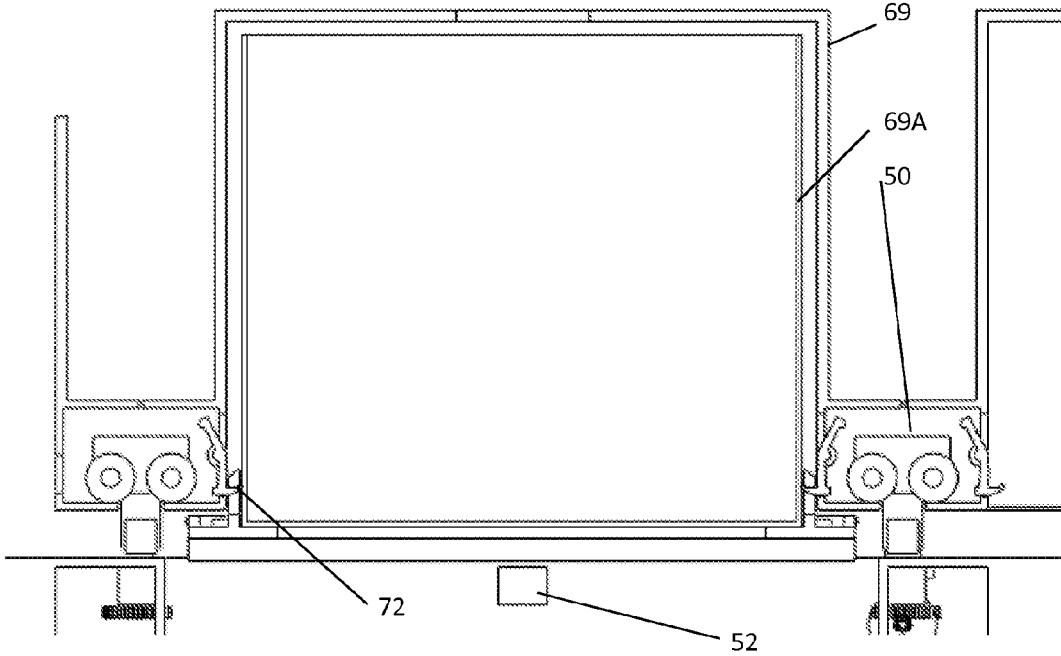


FIG. 24B

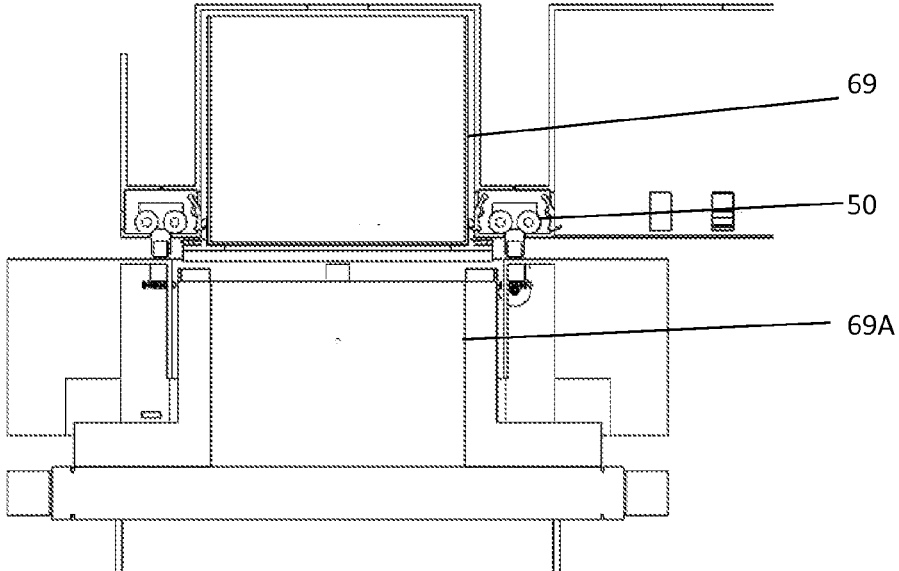


FIG. 25

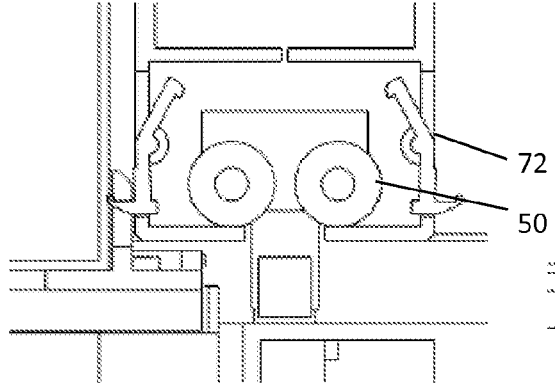


FIG. 26A

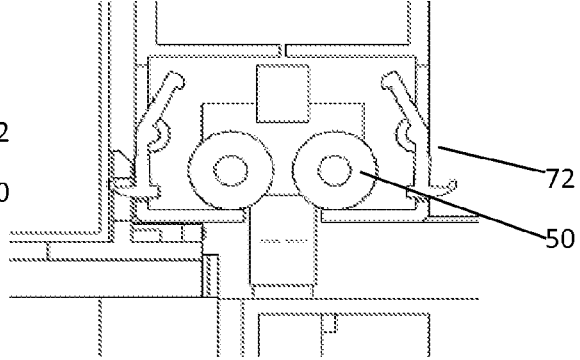


FIG. 26B

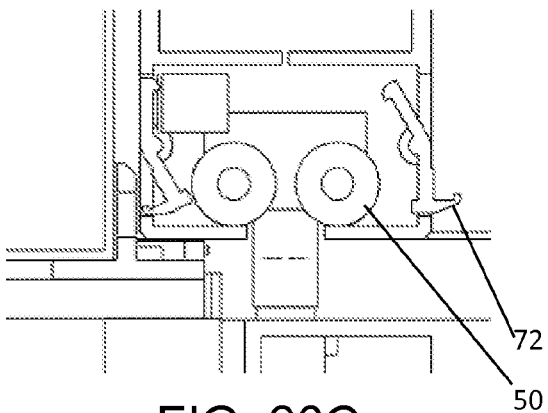


FIG. 26C

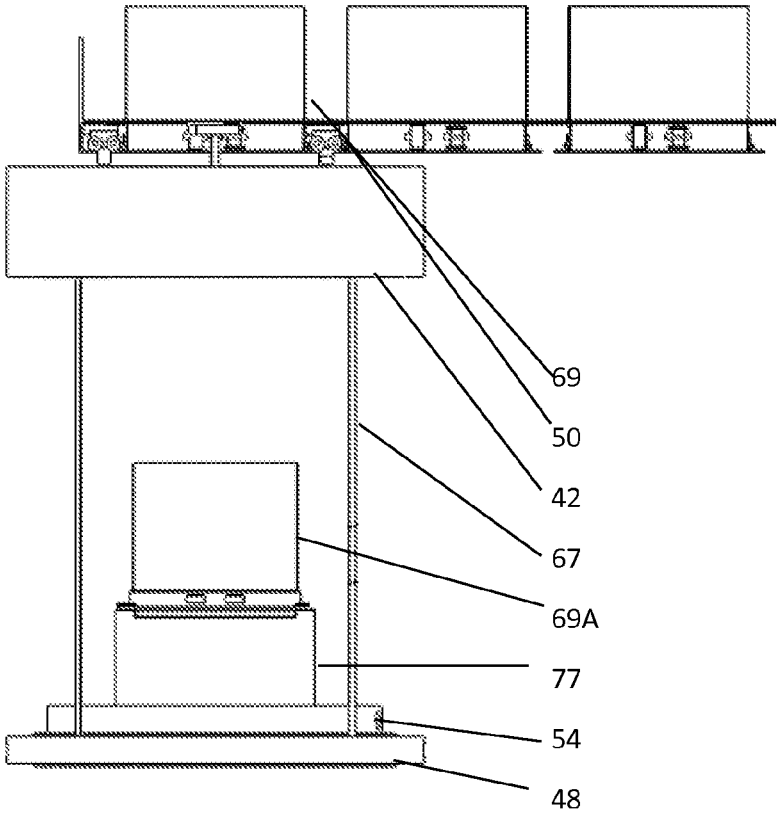


FIG. 27

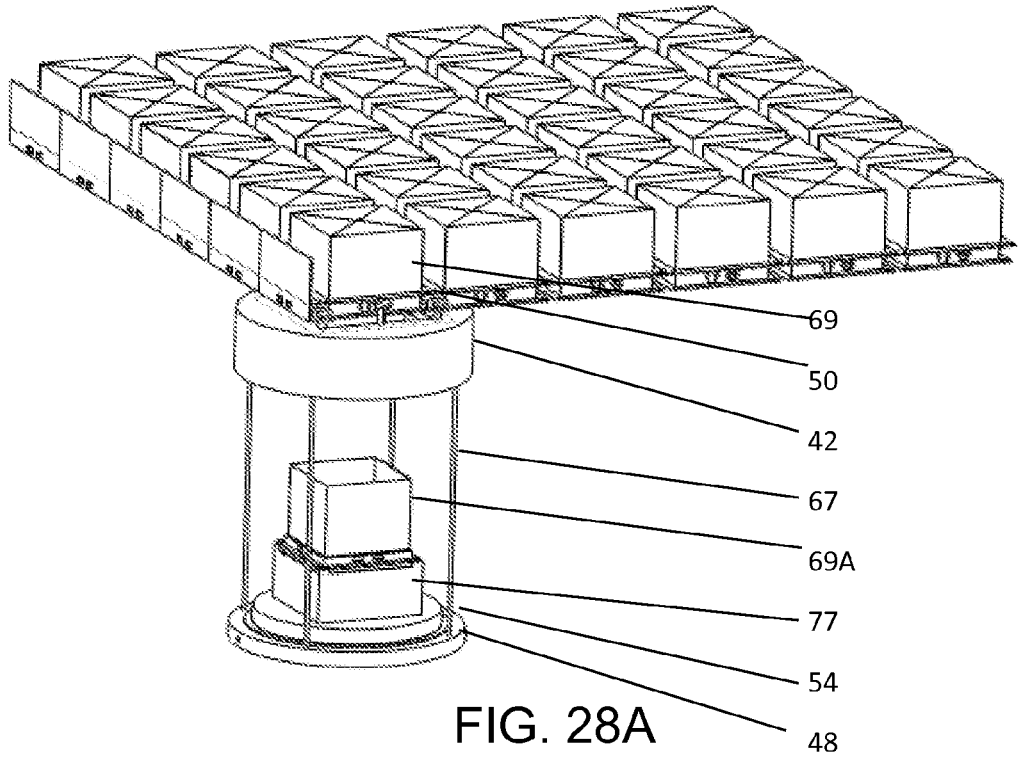


FIG. 28A

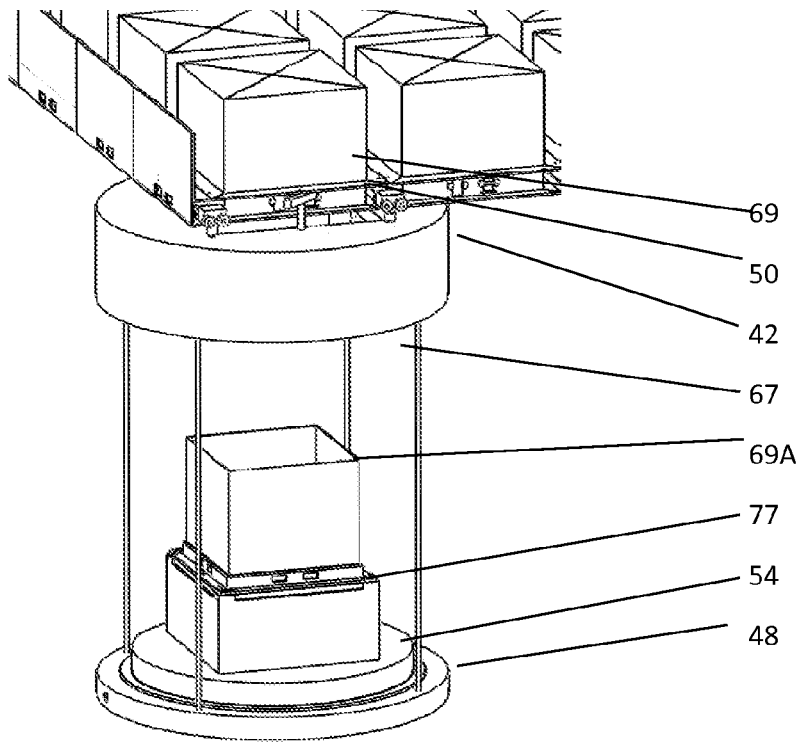


FIG. 28B

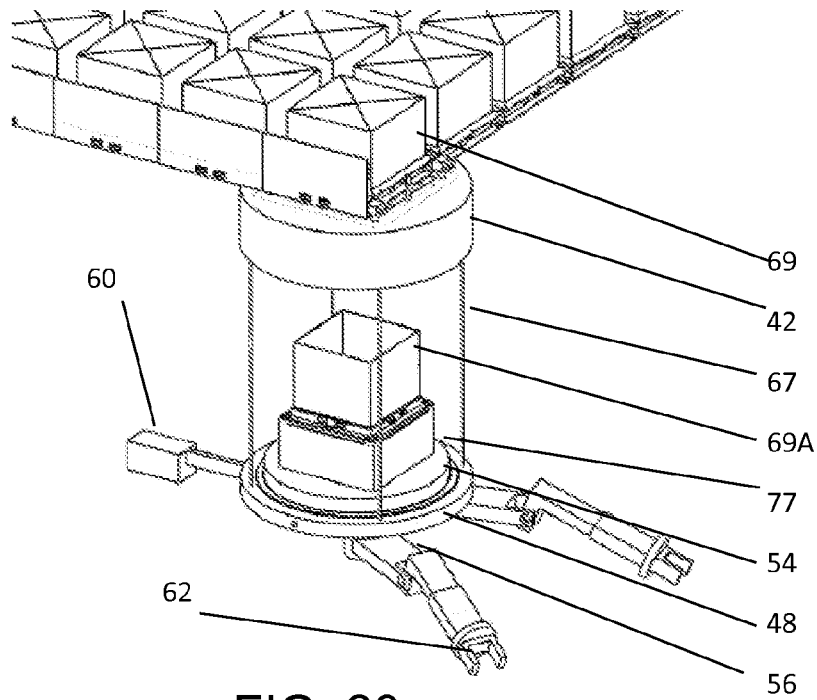


FIG. 29

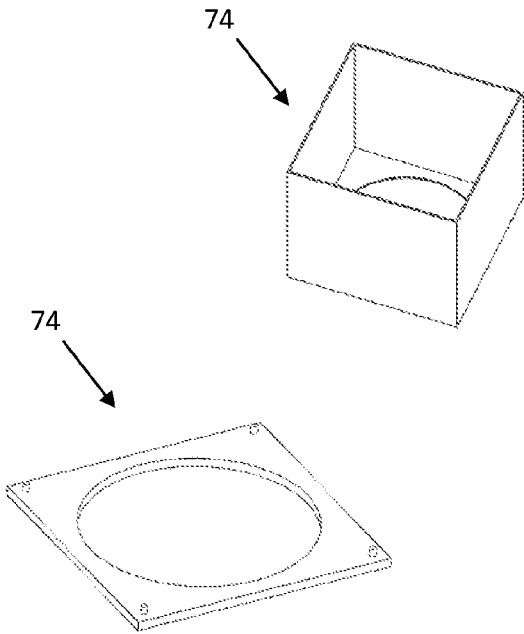


FIG. 30A

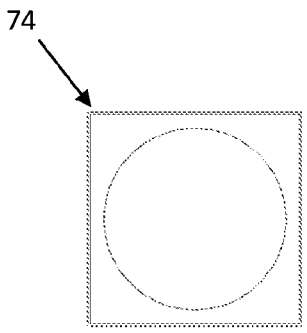


FIG. 30B

FIG. 30C

## SUSPENDED AUTOMATION SYSTEM

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority benefit of U.S. Provisional Application Ser. No. 62/083,176 filed 22 Nov. 2014; and priority benefit of U.S. Provisional Application Ser. No. 62/102,453 filed 12 Jan. 2015; and priority benefit of U.S. Provisional Application Ser. No. 62/127,141 filed 2 Mar. 2015; the contents of which are hereby incorporated by reference.

### FIELD OF THE INVENTION

[0002] The present invention in general relates to an automated system and in particular for a ceiling mounted interior space automated construction, maintenance, storage, logistics, or production system configured with robotic arms.

### BACKGROUND OF THE INVENTION

[0003] Moving typical wheeled, tracked or legged robots around the interior of buildings and from room to room in order to perform household tasks such as setting tables, clearing dishes, washing dishes, putting away dishes, dusting, vacuuming, collecting clothing, washing clothing, cooking, painting, sanding, general maintenance, etc. requires that the robots to be capable of moving around on the floor which may have many obstacles such as thresholds, carpets, steps, stairs, toys, rugs, people, pets, tables, chairs, furniture, etc. that could interfere with the robot's ability to navigate the space. There is also a problem with current robotic systems of not being able to reach above, over and around lamps, furniture, etc. as well as accessing the ceiling. In addition, there is no method for robots to easily transport bins, trays, vacuum systems, washing systems, etc. from room to room in a building while simultaneously performing the aforementioned tasks. There is no current means to provide power to home robotic systems without the use of on-board batteries or cords/tethers. There is currently no solution for ceiling mounted automation systems to move robots from room to room due to the header above doorways.

[0004] Additionally, as population densities increase globally, living spaces are expected to shrink. Much of the required space in a living setting is devoted to storage of articles. The ability to access articles and appliances without having devoted floor space for such storage would greatly facilitate shrinking personal living space.

[0005] Thus, there exists a need for an improved robotic automation systems for covered and interior spaces. There also exists a need for such a system to store, retrieve and manipulate articles in the interior space without devoted floor space usage.

### SUMMARY OF THE INVENTION

[0006] A suspended automation system includes a rail array secured to a ceiling. A gantry moves in an X-Y plane defined by the rail array with a drive mechanism. A controller with a human user interface allows for selective movement of the gantry to transport, and in some instances store or manipulate articles. A human user interface can be a display, touch screen tablet, auditory, smart phone, or a joystick.

[0007] A motorized rotating platform and one or more multiple degree of freedom robotic arms, one or more cameras, or one or more motorized counter-balances are added to the platform to facilitate storage and manipulation, as well as actions with the area below the ceiling. A rail array in some embodiments is equipped with storage modules located above the rail array, the storage modules can take a variety of shapes and sizes for storage of an article. The article is lowered and transported from by the storage module by the gantry to the platform.

[0008] A related process is also provided that includes actions and article transport. Construction of walls or objects under the ceiling, painting, cleaning, and food preparation are some of the tasks that can be accomplished by the suspended automation system. Still another related process is overhead storage and selectively delivery of an article. The article is amenable to manipulation in transit to a user selected delivery point through the actions of one or robotic arms, equipped with variable tools.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention is further detailed with respect to the following figures that depict various aspects of the present invention.

[0010] FIG. 1 illustrates a wire supported X-Y-Z gantry system in accordance with embodiments of the invention;

[0011] FIG. 2 illustrate the wire supported X-Y-Z gantry system of FIG. 1 mounted in a room or a walled enclosure in accordance with embodiments of the invention;

[0012] FIGS. 3A-3C illustrate a series of perspective views of motorized robotic modules for use with the X-Y-Z gantry system of FIG. 1 in accordance with embodiments of the invention;

[0013] FIG. 4A illustrates a perspective view of the wire supported X-Y-Z gantry system of FIG. 1 outfitted with a motorized robotic module in accordance with embodiments of the invention;

[0014] FIG. 4B illustrates a perspective view of the wire supported X-Y-Z gantry system of FIG. 1 outfitted with a motorized robotic module with additional platforms suspended from the motorized robotic module from the auxiliary rails in accordance with embodiments of the invention;

[0015] FIG. 5 illustrates the wire supported X-Y-Z gantry system configured with the additional platforms of FIG. 4B mounted in a room or a walled enclosure in accordance with embodiments of the invention;

[0016] FIG. 6 illustrates adjoining rooms or enclosures with separate X-Y-Z gantry systems in accordance with embodiments of the invention;

[0017] FIG. 7 illustrates the transfer between the adjoined rooms of FIG. 6 with the alignment of the extension rails in accordance with embodiments of the invention;

[0018] FIG. 8 is a perspective view of the supported platforms and the alignment of the extension rails for transfer of the motorized robotic module in accordance with embodiments of the invention;

[0019] FIGS. 9A-9C illustrate the progress of the transferring of the motorized robotic module between wire supported X-Y-Z gantry systems of adjoining rooms or enclosures in accordance with embodiments of the invention;

[0020] FIGS. 10A and 10B illustrate a ceiling mounted X-Y rail systems in a room or enclosure in accordance with embodiments of the invention, with a magnified view thereof illustrated in FIG. 10B;

[0021] FIGS. 11A and 11B are sequential side views of a gantry engaged in the X-Y rail system in accordance with embodiments of the invention in translating in the plane of the page

[0022] (FIG. 11A) and orthogonal to the plane of the page after one rail of in-plane translation (FIG. 11B);

[0023] FIG. 12 is a perspective view of platforms A, B, and C with the four drive wheel modules and four lift bars shown on the upper surface of a gantry in accordance with embodiments of the invention;

[0024] FIG. 13 is a side cut away view of a gantry showing the actuator motor for turning the drive wheel modules and the motorized winches that drive the cables up and down in accordance with embodiments of the invention;

[0025] FIGS. 14A-14C are a detail views of the actuator motor and gear train for turning the drive wheel modules in accordance with embodiments of the invention;

[0026] FIG. 15 is a perspective view of the lift bar show the gears, cam and rollers that drive the up and down and turning action of the lift bars in accordance with embodiments of the invention;

[0027] FIGS. 16A-16I are a series of sequential side views showing the X-Y rail and the actions of the lift bar and drive wheel module in accordance with embodiments of the invention;

[0028] FIGS. 17A and 17B illustrate a ceiling mounted X-Y rail systems in a room or enclosure in accordance with embodiments of the invention, with the magnified view of FIG. 17B showing platform C supporting one or more multiple degree of freedom (DOF) robotic arms, one or more cameras, and counter balance in accordance with embodiments of the invention;

[0029] FIG. 18 is a perspective of a round version of a gantry with drive wheel modules and lift bars balance in accordance with embodiments of the invention;

[0030] FIGS. 19A and 19B are sequential side views of a gantry of FIG. 18 engaged in the X-Y rail system in accordance with embodiments of the invention in translating in the plane of the page (FIG. 19A) and orthogonal to the plane of the page after one rail of in-plane translation (FIG. 19B);

[0031] FIGS. 20A and 20B are perspective views of a platform showing the camera, counter-balance arm extended and tools with the arms shown retracted and extended, respectively in accordance with embodiments of the invention;

[0032] FIG. 21 is a perspective view of a ceiling storage modules;

[0033] FIGS. 22A and 22B are perspective views of a platform of FIG. 20A suspended below the ceiling units of FIG. 21 with a storage module insert resting on the platform to provide access to the storage unit volume, FIG. 22B is a magnified view of platform drive wheels relative to the rail defining a storage module of FIG. 22A;

[0034] FIGS. 23A-23E are views of a storage unit as shown in FIG. 21 as a perspective view (FIG. 23A), a side view (FIG. 23B), a perspective view of the unit frame (FIG. 23C), a side view of the unit frame (FIG. 23D) and a bottom view of the unit frame (FIG. 23E);

[0035] FIGS. 24A and 24B are a side view of the wheels of a platform relative to a storage unit (FIG. 24A) and a front view of the wheels of a platform relative to a storage unit (FIG. 24B);

[0036] FIG. 25 is a wide front view of the of the wheels of a platform relative to a storage unit with portions of the platform extended below the storage unit;

[0037] FIGS. 26A-26C are a series of sequential views of the wheel module of a platform below cosmetic panel/storage platform/module (FIG. 26A), the platform raised by cables to contact the cosmetic panel/storage platform/module (FIG. 26B), and in lift bar lift bar rotated to unlatch Latch (FIG. 26C);

[0038] FIG. 27 is a side view of ceiling storage module with platforms B/C suspended from the cables;

[0039] FIGS. 28A and 28B are perspective views of the system of storage modules and platforms shown in FIG. 27 (FIG. 28A) and a magnified view of the platform and wheel module (FIG. 28B);

[0040] FIG. 29 is a perspective views of the system of storage modules and platforms shown in FIG. 27 with arms, cameras, and counterbalances associated with the platform;

[0041] FIGS. 30A-30C are a perspective view of a cosmetic panel with an opening to accommodate module C (FIG. 30A), a perspective view of module C with a bottom opening to accommodate internal elevation (FIG. 30B) and a bottom view of module C with a bottom opening (FIG. 30C).

#### DESCRIPTION OF THE INVENTION

[0042] The present invention has utility as a ceiling mounted automated construction, maintenance, storage, warehousing logistics, or production system for a covered or interior space configured with robotic arms. The ceiling defining a portion of an interior room or a trellis that is either indoors or outdoors. Through resort to innovative support systems including an overhead gantry system, cables, or an X-Y rail grid, a suspended platform is traversed throughout the system area.

[0043] Referring now to the figures, in a first inventive embodiment, an over-head X-Y-Z gantry system 10 is shown in FIG. 1 as a wire 12 supported gantry 14. The wires 12 are attached on opposing sides to slides 16 that ride on side rails 18. As indicated by the bidirectional arrows, the gantry cars 14 move from side to side along the support wires 12, and back and forth from front to back via the slides 16, thereby providing a full set of movement in the x-y plane. Power may be supplied to the gantry cars 14 through the support wire 12. Gantry 14 may be used to support almost any electronic equipment; illustratively including lights, stereo components, speakers, smoke detectors, security systems, laser systems, modems, routers, computers, and combinations thereof.

[0044] FIG. 2 illustrates a room or enclosure 22 outfitted with the X-Y-Z gantry system 10 that carries a rotating platform capable to reach most any point in the volume of the room—wall to wall and floor to ceiling where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawing. Extension rails 20 on the gantry cars 14 extend out to mate with corresponding rails on other gantry 14 in other rooms. The extension rails 20 are mounted to a swivel plate 19 that provides for a complete rotation of the extension rails 20 and anything attached to the extension rails 20. A controller 21 includes a computer system provides a human user interface 23 that is a display, touch screen tablet, auditory, smart phone, or a joystick receives user input as to the desired articles from storage, the location of delivery and the scheduling of delivery. The



controller 21 then instructs the movement of the gantry system 10 to retrieve or store articles. The controller 21 also provides manipulation instructions to the robotic module 24 as to desired actions. Exemplary actions include room construction, painting, sweeping the floor, and cleaning the room. Each robotic arm contains an interface at the distal end for a variety of interchangeable motorized tools (graspers, hands, drills, suction cups, etc.). Each arm supplies electrical power to the various tools. Sensors are routinely associated with a robotic arm, as is conventional to the art, to provide telemetry, grasp strength, and article manipulation feedback data to a controller 21 or a human user of the controller 21 via the human interface 23.

[0045] FIGS. 3A-3C illustrate motorized robotic modules 24 that ride and travel on the extension rails 20 from one room to the other (after corresponding gantry cars have been aligned with extension rails extended). The robotic module 24 are equipped with inline wheels 26 that ride on the extension rails 20, as well as one or more manipulating arms 28 with terminations 30 designed to accommodate various grabbing attachments and tools. The manipulating arms 28 typically have a shoulder, elbow, and wrist to provide a wide range of motion with interchangeable hands, grippers, and tools. The robotic module 24 folds to minimize volume, and is capable of being remotely controlled by human or computer based operators. In specific embodiments the robotic module 24 may be configured with an auxiliary set of rails 32 to support a second robotic module or platform below the first robotic module (extendable to other platforms or modules). Robotic modules 24 may additionally contain; one or more cameras, vacuum cleaner systems, dishwashing systems, floor washing systems, carpet cleaning systems, toilet cleaning systems, dusting systems, painting systems, maintenance systems, construction systems, tool kits, baskets, trays, bins, etc. Embodiments of the robotic modules 24 configured with a vacuum cleaning system may include related tools and equipment illustratively including filters, collection bins, one or more retractable hoses, attachments (nozzles, motorized brushes, etc.). Embodiments of the robotic modules 24 configured with dish cleaning capabilities may include features such as a water collector from faucet (supply), a water heater, a water pressurizer and sensor, an air compressor, a retractable hose (one or more), tools (brushes, nozzles, etc.), and a wet vacuum. Embodiments of the robotic modules 24 configured with wet cleaning system (for floors, bathrooms, carpets, etc.) may include a water collector from faucet (supply), a water heater, a water pressurizer and sensor, an air compressor, a retractable hose (one or more), tools (brushes, nozzles, etc.), and a wet vacuum. Embodiments of the robotic modules 24 configured with a painting system may include a paint supply, airbrush, airless delivery, paint rollers, and paint related tools. Embodiments of the robotic modules 24 configured with a maintenance system may include hand tools, as well as, motorized tools that illustratively include drills sanders, and caulking guns. The robotic modules 24 may include a collection/delivery bin or tray that illustratively includes uses for dishes, toys, laundry, etc.

[0046] Construction applications of the robotic modules 24 may include floor laying and tile installation grouting, concrete laying, etc.

[0047] The aforementioned modular embodiments may transfer from room to room by moving along the rails (to be described in greater detail below). Modules 24 may also

move from room to room by moving along the rail sets located on other modules 24. Multiple modules 24 may hang from each other under the lower platform portion of the gantry car 14, and module 24 may be transported from room to room by association with the module directly supported by the gantry car.

[0048] Translation drive options to move the gantry cars 14 and robotic modules 24 include the use of cables, linear motors, rack and pinion, screw drives, and drive wheels

[0049] FIG. 4A illustrates a perspective view of the wire supported X-Y-Z gantry system 10 of FIG. 1 outfitted with a motorized robotic module 24 where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. FIG. 4B illustrates a perspective view of the wire supported X-Y-Z gantry system 10 outfitted with a motorized robotic module 24 with additional platforms 34 suspended from the motorized robotic module 24 from the auxiliary rails 32 where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. FIG. 5 illustrates the wire supported X-Y-Z gantry system 10 configured with the additional platforms 34 of FIG. 4B mounted in a room or a walled enclosure 22 where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings.

[0050] FIG. 6 illustrates adjoining rooms or enclosures (22A, 22B) with separate X-Y-Z gantry systems (10A, 10B) where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. FIG. 7 illustrates the transfer of motorized robotic module 24 between the adjoining rooms (22A, 22B) of FIG. 6 with the alignment of the extension rails 20 where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. FIG. 8 is a perspective view of the gantry cars (14A, 14B) and the alignment of the extension rails 20 for transfer of the motorized robotic module 24 where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. FIGS. 9A-9C illustrate the progress of the transferring of the motorized robotic module 24 between wire supported X-Y-Z gantry systems (10A, 10B) of adjoining rooms or enclosures (22A, 22B) via the alignment of the extension rails 20 of gantry cars (14A, 14B) where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. It is noted that in a specific inventive embodiment, instead of the rails 20 extending to enable robotic modules 24 to pass from one gantry system to the next, the robotic modules 24 could be capable of bridging the gap themselves.

[0051] FIGS. 10A, 10B, 11A, 11B, and 12 illustrate a ceiling mounted X-Y rail system 40 in a room or enclosure 22 is provided which support a motorized gantry 42 which translates on the X-Y rails 40 where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. The X-Y rails 40 supply electrical power to gantry 42. Gantry 42 contains three or more motorized lifts 46 (see FIG. 13) that drive cables 44 which support, raise, lower and tilt a platform B 48. It is appreciated that differential winch operation causes a suspended platform to tilt, an orientation that can promote loading and unloading thereof. Gantry 42 also contains four drive wheel modules 50 and four lifts 52 which work in concert to move gantry in X-Y directions on the X-Y rails 40. Gantry 42 supplies electrical power to platform B 48. Platform B 48 supports a motorized rotating platform C 54. Platform B 48 supplies electrical power to platform C 54. Platform C 54 supports

one or more multiple degree of freedom (DOF) robotic arms **56** (see FIGS. **17B** and **20B**), one or more cameras **58**, and may support one or more motorized counter-balance systems **60**. Platform **C 54** supplies electrical power to the arms **56**, cameras **58**, and counter-balance system **60**. Each arm **56** contains an interface **62** at the distal end for interchangeable motorized tools (graspers, hands, drills, suction cups, etc.). Each arm supplies electrical power to the various tools. The arms, cameras and/or counter-balances may be attachable and detachable (automatically or manually) from a platform. A docking system between the arms, cameras and/or counter-balances; and platform enables manual or automatic mechanical attachment, and electrical. In a preferred embodiment, standard electrical/mechanical interfaces therebetween are provided so that various components from various manufacturers can be installed and function in the present invention.

**[0052]** In order to reduce the weight and volume of platform **C 54**, the counter-balance system(s) **60** may have various sized detachable weights which may be stored in a location separate from the rail system **40** or other platforms. Different weights may be used for different tasks. The weights have a common interface to the counter-balance system **60** for automatic change.

**[0053]** The cameras **58** may be mounted on motorized pan-tilt mechanisms with zoom capability. The arms **56** fold up for compact storage and can be tele-operated. Any of the platforms **A, B, or C** may contain batteries. The volume above and between the X-Y Rails may be used to contain other components: storage modules **69**, lights, cameras, speakers, audio and video components, displays, smoke detectors, sensors, electronic equipment, dishwashers, vacuum cleaners, air purifying systems, air heating and cooling systems, charging stations, or a combination thereof.

**[0054]** FIG. **11A** is a side view of the rail system positioned as shown in FIG. **10B**. With a linear translation in the plane of the page by one rail and a right angle rotation of the wheel modules **50**, the gantry **42** is positioned to translate orthogonal to the plane of the page in FIG. **11B**. The gantry **42** is shown for clarity detached from the rail grid **40** in FIG. **12**.

**[0055]** FIGS. **13, 14A-14C, 15, and 16A-16I** illustrate the lifting and drive mechanisms for translating the four drive wheel modules **50**, and lifting-rotating the modules **50** to affect navigation throughout the X-Y rails **40** where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. The four drive wheel modules **50** are powered by an electric motor **66** providing drive power through a gear train **68**. The electric motors are energized through line power, battery supplied electricity, or a renewable energy source in electrical communication therewith. The lift shown generally at **46** has rotational, lateral translational and vertical translational degrees of freedom imparted by gearing shown generally at **67** including worm gears, screw gears. It is appreciated that mechanical couplings to impart such motions beyond these are well known to the art and illustratively include stepper motors, hydraulics, pneumatics, and a combination thereof. The sequence of steps associated with the change of direction of a gantry **42** with respect to X-Y rails **40** are shown in FIGS. **16A-16I**. From the position of the wheel module **50** and lift **52** in FIG. **16A**, the lift **52** is elevated into the rail **40** (FIG. **16B**) and rotated **90** degrees, while a second lift **52A** position behind the wheel module **50** is rotated out of phase

with lift **52** (FIG. **16C**). The lifts **52** and **52A** are then lowered along with the platform **42** (FIG. **16D**), the platform **42** is then raised to disengage the wheel module **50** from contact with the rail **40** (FIG. **16E**) and the wheel module **50** is rotated **90** degrees (FIG. **16F**) and lowered to re-engage with the rail **40** (FIG. **16G**), lifts **52** and **52A** are rotated back to original positions as they are no longer be load bearing (FIG. **16H**), and the platform is returned to the original position of FIG. **16A** save for a **90** degree rotation of the wheel module **50**. It should be appreciated that only one wheel module **50** is shown for visual clarity and that all four such modules and interspersed lifts are operated in concert to affect a direction change for the gantry **42** relative to the X-Y rails **40**.

**[0056]** Automating the storing and retrieving of items in a building requires a location to store the items and a system to automatically retrieve and replace the items. Most buildings do not have storage space that is conveniently located for access by automated systems (robots, automation, etc.). The storage spaces that are available (drawers, cupboards, cabinets, closets, shelves, etc.) are usually a cluttered mess and not organized for automation. If people have access to these storage areas, they may become unusable for automatic retrieval because the items will be moved around without the knowledge of the automated system.

**[0057]** FIGS. **21, 22A, 22B, 23A, 23B, 23C, 23D, 23E, 24A, 24B, 25, 26A, 26B, and 26C** illustrate another embodiment of the present invention with storage modules present above the X-Y rails **40** where like numeral have the meaning ascribed to thereto with respect to the aforementioned drawings. An array of storage modules **69** are provided that are ceiling mounted. This is depicted with interspersed ceiling joists in FIG. **21**. This is accomplished by mounted to, for example, sheet-rock, ceiling joists, or drop ceiling systems) X-Y rails **40** in each room **22** which support a motorized gantry **42** which can translate orthogonally on the X-Y rails **40**. The X-Y rails **40** supply electrical power to gantry **42**.

**[0058]** A gantry **42** contains three or more (4x) motor driven winches **46** that extend and retract cables **44** which support, raise, lower and tilt a platform **B 48**. Gantry also contains drive wheel modules (4x) **50** and lifts (4x) **52** which work in concert to move carriage **A** in orthogonal directions on the X-Y rails. Gantry **42** supplies electrical power to platform **B 48**.

**[0059]** In a specific inventive embodiment, gantry **42** contains motorized winches **46** that extend and retract cables **44** which support, raise, lower, tilt and now rotate platform **B 48**. Gantry **42** supplies electrical power to platform **B 48** which in turn supplies power to platform **54**.

**[0060]** A latch **72** provides selective access to the storage modules **69**. A mechanical/electrical interface **74** is provided between the storage module **69** and a cosmetic panel **75**, as best illustrated in FIGS. **23A-23E** A cosmetic panel **75** and a bottom surface of a storage module **69** or lower portion **69A** thereof are amenable to surface treatment such as painting or texturing for aesthetic reasons to create a ceiling having a desired appearance. Cosmetic panels **75** can be acoustic tiles, 3-D sculptures, video displays, foam, glass, wood, metal, plastic, lights, IR heaters, or a combination thereof. FIGS. **30A-30C** illustrate a lower portion **69A** with a circular central door omitted for visual clarity or a cosmetic panel **75** with such an opening.

**[0061]** As a result, the volume above, between and below the X-Y rails **40**, as well as the space between the ceiling

joists is used to store modules 69 in a controlled storage location for automated retrieval and replacement, said modules illustrative have within them storage units, storage bins, storage shelves, tables, robots, games, displays, refrigerators, freezers, ovens, microwaves, humidors, fire extinguishers, wine racks, lights, cameras, speakers, audio and video components, displays, smoke detectors/alarms, sensors, electronic equipment, dishwashers, vacuum cleaners, air purifying systems, air heating and cooling systems, charging stations, or a combination thereof. It is appreciated that the rails can form a variety of shapes and sizes to accommodate storage modules 69 that are of a variety of shapes and sizes such as cuboidal or hemispherical volumes. The storage modules 69 can be accessed robotically via the robotic arms 56 or manually. A storage module 69 as depicted has an inserted and inverted inner portion 69A with a top opening that is complementary to module 69 to form a closed unit. It is appreciated that the inner portion 69A is a removable floor, a tray, or having sidewalls that extend to an extreme of contacting an upper surface of the module 69. It is appreciated that the entire contents of a module 69 are delivered to a user or an article is accessed, the storage module 69 closed, and only the desired article delivered. A pencil box and a refrigerated items being exemplary of the former and the latter, respectively.

**[0062]** A controller 21 provides a human user interface 23 that is a display, touch screen, auditory, or a joystick receives user input as to the desired articles from storage, the location of delivery and the scheduling of delivery. The controller 21 has access to a database inventory of articles stored in the storage modules 69, or to be stored in the modules. The controller then instructs the movement of the gantry 42 to retrieve or store articles and any desired manipulation of the robotic arms 56.

**[0063]** A sequence of latch 72 manipulations to access a storage module 69 and secure the same in the context of the present invention are illustrated in FIGS. 24A, 24B, 25, 26A, 26B, and 26C. The various latch positions and access to the volume of a storage module 69 are shown.

**[0064]** FIGS. 27, 28A, 28B, and 29 illustrate an embodiment of the present invention in which a module 77 is present on platform 48. A door/opening in the storage portion 69A and/or cosmetic panel 75 enable a sub-platform to be lowered into contact and optionally electrical communication with module 77. As a result the contents of a given storage module 69 can be manipulated in all three dimensions as defined by the extent of a rail system 40, and accessed manually or robotically. With module 77 containing additionally functionality such as an electric power source to operate an article such as an appliance, a scale to weigh contents of a storage module 69, or other such functionality a variety of manual operations are amenable to automation. By way of example if storage modules are laboratory animal cages or terrariums, the occupants of each module 69 are monitored and supplied by way of an inventive system in an automated way by a local or remote user. In still another example, food stuffs are retrieved from storage, prepared, served, then used utensils are cleaned and removed by an inventive system.

**[0065]** It is appreciated that a variety of sensors, video displays, speakers and microphones on the X-Y rails, translation platforms, storage platforms, cosmetic panels or a combination thereof. As a result, a tele-presence is created that allows for more complex control and operational feed-

back. It is also appreciated that any platform or module detailed herein may contain batteries to serve as a main or backup power source for an inventive system or stored article.

**[0066]** The foregoing description is illustrative of particular embodiments of the invention, but is not meant to be a limitation upon the practice thereof. The following claims, including all equivalents thereof, are intended to define the scope of the invention.

1. A suspended automation system comprising:
  - a rail array secured to a ceiling;
  - a gantry;
  - a drive mechanism coupled to said gantry for transit of said gantry in an area an area of said rail array;
  - a platform suspended from said gantry; and
  - a controller with a human user interface for selectively moving said gantry.
2. The system of claim 1 wherein said drive mechanism includes interspersed powered wheel modules and lifters.
3. The system of claim 2 wherein said lifters are adjustable in a Z direction and said wheel modules are pivotable between X and Y directions on said rail array.
4. The system of claim 1 wherein said gantry is automatically transferrable to a second rail array.
5. The system of claim 1 further comprising one or more robotic arms suspended from said platform.
6. The system of claim 5 further comprising one or more counter-balances to said one or more robotic arms.
7. The system of claim 1 further comprising one or more cameras suspended from said platform.
8. The system of any one of claims 1 to 7 claim 1 further comprising one or more sensors associated with said rail array, said gantry, or said platform.
9. The system of any one of claims 1 to 7 claim 1 further comprising cables between said gantry and platform, said cables being retracted with winches in said gantry to raise said platform.
10. The system of any one of claims 1 to 7 claim 1 further comprising a gantry pivot for rotating said gantry.
11. The system of any one of claims 1 to 7 claim 1 further comprising a motorized platform pivotably mounted to said platform.
12. The system of any one of claims 1 to 7 claim 1 further comprising a gantry pivot for rotating said gantry.
13. The system of any one of claims 1 to 7 claim 1 wherein said human user interface is a display, touch screen tablet, auditory, smart phone, or a joystick.
14. The system of claim 1 further comprising a gantry pivot for rotating said gantry.
15. The system of claim 1 further comprising a plurality of storage modules located above said rail array, each of said plurality of storage modules having a volume for storage of an article, the article lowered and transported from said gantry to said platform.
16. The system of claim 1 wherein the ceiling is part of a room or trellis.
17. A process of performing an operation in a room area comprising operating a system of claim 1.
18. A process of retrieving an article in a room area comprising:
  - storing the article in a system having a rail array secured to a ceiling, a gantry, a drive mechanism coupled to said gantry for transit or said gantry in an area of said rail array, a platform suspended from said gantry, a con-

trolley with a human user interface for selectively moving said gantry, and a plurality of storage modules located above said rail array, each of said plurality of storage modules having a volume for storage of an article, the article lowered and transported from said gantry to said platform;

requesting the article via the user interface; and allowing sufficient time for said gantry to translate to one of said plurality of storage modules containing the article, access the article, lower the article and optionally move the article to a user selected delivery point for retrieving the article in the room area.

**19.** The process of claim **18** wherein the delivery point is a transfer point for said gantry to a second area.

**20.** The process of claim **18** wherein the article is further manipulated by robotic arms associated with said platform prior to the delivery point.

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