



(43) International Publication Date
20 September 2012 (20.09.2012)

(51) International Patent Classification:
B65G 63/00 (2006.01)

(21) International Application Number:
PCT/IN2012/000035

(22) International Filing Date:
12 January 2012 (12.01.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
738/CHE/2011 11 March 2011 (11.03.2011) IN

(72) Inventors; and

(71) Applicants : SUBRAMANIAN, Venkataraman [IN/IN];
20a, Raman Street, Chitlapakkam, Chennai 600 064 (IN).
VENKATRAMAN, Guruprasad [IN/IN]; 20a.raman
Street, Chitlapakkam, Chennai 600 064 (IN).

(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, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,

HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, 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, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

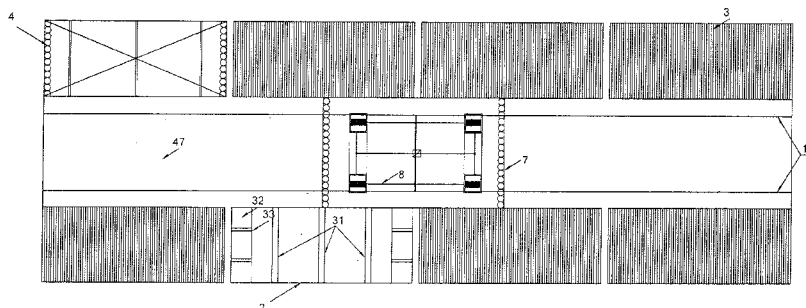
— of inventorship (Rule 4.17(iv))

Published:

— without international search report and to be republished
upon receipt of that report (Rule 48.2(g))

(54) Title: MULTI LEVEL AUTOMATED STORAGE AND HANDLING SYSTEM FOR CONTAINERS AND BULKY OBJECTS

FIG. 2



(57) Abstract: Present methods of handling and storing containers have serious challenges in respect of space utilization, equipment utilization and random retrieval. All three factors do influence operation efficiency and economics. Further there is no end to end handling solution for handling and storing and all equipments work in isolation limiting the scope of automation. The invention aims at converting handling and storing from equipment based to system based design lending itself for end to end automation. This is achieved by splitting entire operations into sub operations at micro level, dedicating designed equipments for each operation and integrating with central system controller. The system has a multi-tiered structure to store containers, elevator assembly to move containers vertically, transfer module assembly to move containers to move along and transfer arm/power arm assembly to move across and buffering bay assembly to transfer from one point to other and transfer equipment assembly to load and unload containers and a central system controller to integrate all equipments for end to end automation.



WO 2012/123956 A2

Title of Invention:

Multi Level Automated Storage and Handling System for Containers and Bulky Objects

Field of Invention:

- 5 End to end integrated material handling systems for containers and other bulky objects.

Prelude:

Material handling plays a considerable role in any industry, be a project, a manufacturing activity or a service industry. Each handling requires a dedicated innovative solution based on the type, size, shape, weight, quantity of the material to be handled, distance, elevation, pressure, cycle, temperature, environment, purpose and finally, but not the least, economics. Each such solution deploys various handling equipments and techniques in different combinations to achieve the desired result. This invention is a breakthrough in the technology for handling containers and other bulky objects with the concept of an integrated system based handling suited for complete automation. This invention covers a wide range of applications. Explanation is directed and detailing done towards a typical embodiment in the area of automatic handling and stacking of containers with provision to load and unload onto/from trucks in container terminals. This is followed by a brief outline of a few possible embodiments that are illustrative and not exhaustive.

Background of the Invention:

Container terminals across the world are grappling with high utilization and ever increasing demand. Of all the components / processes in terminal operations, container handling and storage plays a crucial role in determining capacity. In other words, a terminal's capacity, measured in Twenty-foot Equivalent Unit / Hectare (TEU / Ha), is constrained by this component. Currently ports are operating between 22,000 TEU / Ha and 29,000 TEU / Ha. Most of the ports run at around 27,000 TEU / Ha.

The industry is looking for a solution that makes the best use of the scarce land space which increases the throughput and efficiency.

Prior Art:

- 30 US Patent: 7,785,056
US Patent: 7,845,898
US Patent: 7,972,102

The above prior art solutions deal with movement of containers from one point to another with human intervention and do not provide automated stacking and retrieval.

Our earlier invention multi-level automated car parking system (PCT/IN2006/000344) is also taken as related prior art from storage and retrieval point. There are significant differences in terms of capacity (number of storage spaces), handling weight, size and last mile connectivity.

- Typical storage capacity: Capacity of tower in case of cars is around 200 storage spaces whereas in container handling, the typical capacity is many times.
- Typical handling weight: Weight of cars is typically around 1MT to 2MT whereas in containers, the weight is typically between 2.5MT and 30MT.
- Typical handling size: Cars are typically 5.5 m long, 2.2 m wide and 1.6 m high. Containers are 14 m long, 2.6 m wide and 2.8 m high.
- Platform Carrier / Pallet: Cars are placed on platform carriers / pallets. This implies equal number of platform carriers or pallets as storage spaces. While this is practical in a car parking situation (where the capacity is a few hundreds), this does not fit in a container handling situation as this results in thousands of pallets and handling them is extremely difficult and poses operational challenges and lead to further inefficiencies in container handling.
- Last mile connectivity: Cars are driven-in and driven out of the storage tower. So the prior art limited itself to storage of cars within the towers and not on transporting the cars into / out of the tower. Whereas containers have to be transported to the storage tower through external means.

These have necessitated basic changes to the invention in concept and design.

Our application for multi level automated storage for over dimensional and bulky objects (PCT/IN2009/000137) is also taken as related prior art.

With the design of the prior art, field trials were carried. Major shortcomings / deficiencies were noticed in the prior art specifically around basic handling point and hence design, stability in storage, last mile connectivity in and out of storage tower (unable to automate end to end), operational requirements / constraints and solution applicability in the said environment in terms of reliability, safety and cost. These demanded changes to basic design elements and more innovation.

- Basic handling point and hence design: Prior art was designed on the premise that reinforcements at the container base are reliable. Handling equipment was designed to leverage the reinforcement members as support while moving containers. Containers were pushed / pulled on the rollers and supported throughout on the reinforcements. Field trials

pointed out that the reinforcements were not reliable and often the most damaged and distorted parts of a container. This led to a fundamental shift in the container handling point from reinforcement members at the container base to cast iron legs at the four corners of a container, and associated concept and design.

- 5 • Stability in storage: Each slot had a bed of rollers over which containers were placed. In effect, containers were resting on rollers which led to a state of unstable equilibrium, i.e., the system moves away from the equilibrium after small disturbances. Considering the location (typically near sea) and the heights, the probability of containers being disturbed (due to wind forces, etc.) is very high.
- 10 • Last mile connectivity: Prior art considered containers to be placed in / taken out of elevators by means of external agencies (such as mobile cranes). Considering the storage arrangement, elevator cage dimensions and the reach of the cranes with respect to size of the containers, this arrangement could not meet the operational needs in terms of skill required, time and automation.
- 15 • Solution applicability in the said environment in terms of reliability and safety: Prior art design introduced many points of failure through its design of reinforcement member being used as support and bed of rollers as storage space affecting safety and reliability.

20 However, notwithstanding the above solutions, the industry has adopted the best available solution for stacking and handling containers across the world. This is also taken as prior art. The same is discussed below in length considering the universality of its application.

Containers are stacked in the stack yard on ground one over other up to 6 heights and one beside other up to 6 rows using Rubber Tyred Gantry (RTG) / Rail Mounted Gantry (RMG) cranes. It has drawbacks that impair operational efficiency and throughput.

25 Draw backs of the present practice are

- Limitation of stacking heights due to inherent design considerations of cranes and operational flexibility and due to design limitations of reefer containers.
- No provision for random access to stored containers necessitating multiple unproductive handling at times which adversely affect operation efficiency, throughput and logistics control.
- 30 • Lack of real time visibility (track and trace functionality) into a specific container location within container terminals.
- Single costly equipment, i.e. RTG/RMG crane is used to move the container in X, Y and Z planes besides loading and unloading (single chain of operation) resulting in reduced throughput and underutilization of capital equipment.
- 35

- Further it has limited compatibility to modern security measures like fire detection and protection, and surveillance

It is seen that no prior art is available as a solution for end to end automatic handling and stacking of containers with provision to load and unload onto/from trucks in container terminals and the industry is under pressure on account of steady growth of business without scope of matching supply of land resources.

The invention is therefore aimed at addressing the disadvantages and drawbacks of present state of art technology and offers a solution without aforesaid limitations; but with further advantages such as higher space and equipment utilization, improved operational efficiency and higher throughput.

Summary of the Invention:

The invention is a seamlessly integrated end to end system that provides for automated handling of containers and other bulky objects. Explanation is directed towards a typical embodiment of container handling in container terminals from unloading areas to the final delivery area comprising of specialized components for movement and multi-level stacking of containers. The embodiment covers components for

- unloading from trucks
- handling at receipt
- multi-level stacking
- selective retrieval (random access) or sequential retrieval
- handling at delivery
- loading onto trucks

and integration thereof of either all / any of the aforesaid components.

The object of the present embodiment is to enhance global supply chain logistics effectiveness by offering highest space utilization factor, higher efficiency in operations, logistics control (real time visibility for track and trace) and higher throughput in the container terminals and storage yards.

This invention is applicable across a wide variety of material handling needs with similar object/benefits. While it is not possible to cover all the applications, some embodiments are outlined to indicate versatility of the invention. These are merely illustrative and not exhaustive and are not to limit the scope of application of the invention.

Description of the Embodiment:

These and other characteristics of the invention will be clear from the detailed description of the typical embodiment, given as a non-restrictive example, with reference to the introduction, attached drawings and component identification herein:

5 Introduction of the system:

The system primarily comprises of three (3) sub-systems:

1. Storage and Retrieval System (referred as Storage System): where containers are stacked across many heights and many rows and retrieved upon request. This comprises of the following components:
 - 10 a. Storage tower: Steel / RCC tower that serves as the housing for the stacked containers and all the components of the storage system. It has a number of tiers (of equal height) for multi-level storage with a central causeway in each tier and identified and marked storage locations for containers referred as addressed storage slots in each tier either side of the central causeway
 - 15 b. One or more transfer module assembly (referred as transfer module), in each tier, traversing the central causeway for moving containers to the desired addressed storage slot (along the line of storage) with its transfer arm assembly (referred as transfer arm) for moving containers in and out of the addressed storage slots (transverse to the line of storage)
 - 20 c. One or more elevator assembly (referred as elevator) consisting of elevator for moving containers vertically to the desired level and elevator power arm assembly (referred as elevator power arm) to move the containers in and out of the elevator (transverse to the line of storage)
2. Transfer System: one or more for each elevator of the storage system where containers
25 are transferred from the receiving / unloading area to the storage system and from the storage system to the delivery / loading area. This essentially involves unloading containers from the truck, moving containers to the storage system, receiving containers from the storage system and loading containers onto the trucks for delivery. This comprises of the following components:
 - 30 a. One buffering bay assembly that serves as a storage buffer between the unloading / loading operations and stacking / retrieval operations of the storage system with its power arm assembly (referred as buffering bay power arm) for moving containers from

unloading area to storage system and receiving containers from storage system to loading area.

- b. One transfer station with its loading area, unloading area and transfer equipment comprising of a travelling gantry, lifting tackle and spreader where containers are unloaded from trucks and loaded onto the trucks

3. Central System Controller: The central system controller commands, controls, monitors and co-ordinates among all the systems – storage system and its components, transfer system and its components and a human machine interface for operating personnel.

Brief description of the drawings:

10 The accompanying drawings and component identification are intended to provide further understanding of the invention and are incorporated in and constitute a part of the invention. The drawings illustrate an embodiment of the invention and together with the description illustrate principle of invention. The drawings should not be taken as implying any necessary limitation or the essential scope of the invention. The drawings are given by way of non-limitative example to
15 explain the nature of the invention.

Fig.1. Container storage tower: indicates the storage layout across tiers. For clarity, containers are shown in select spaces in a tier and across alternate tiers.

Fig.2. Typical storage tier for container: plan view that shows the elevator section, typical arrangement in a tier with addressed storage slots with and without container on either
20 side of a central causeway and transfer module on the fixed first track on the causeway

Fig.3. Transfer module assembly: plan and elevation of the transfer module assembly with its components, fixed second track (for transfer arm movement) and drive arrangement

Fig.4. Side structures for transfer module: supporting structures fixed on the transfer module to secure the containers on the transfer module, while the transfer module carries the
25 container along the fixed first track.

Fig.5. Transfer arm assembly: plan and elevation of the transfer arm assembly with lifting devices and drive arrangement

Fig.6. Elevator cage assembly: plan and elevation of the elevator cage with its elevator power arm assembly in position, fixed fourth track (for elevator power arm movement)

30 Fig.7. Power arm assembly: plan and elevation of the power arm assembly with lifting devices and drive arrangement. Identical for elevator power arm and buffering bay power arm assemblies.

Fig.8. Addressed storage slot: plan and elevation of an addressed storage slot with its supporting points and fixed third track (for transfer arm movement)

Fig.9. Transfer station: Layout of transfer station (with its constituents viz. unloading area, buffering bay and loading area) relative to the storage tower

Fig.10. Buffering bay: plan of the buffering bay with buffering bay power arm assembly, fixed fifth track (for buffering bay power arm movement) and fixed side support structures and elevation showing the containers in position during transit

Fig.11. Transfer equipment: plan and elevation showing the transfer equipment structural assembly, lifting grab and container in position

Fig.12. Method of storage: Flow chart of the process of container storage in the specified addressed storage slot from the point of receiving the container on a truck at unloading area of the transfer station

Fig.13. Method of retrieval: Flow chart of the process of retrieval of a specified container from an addressed storage slot to the point of loading the container on a truck at loading area of the transfer station

Additional drawings for a few illustrative embodiments

Fig.14. Common base design for elevator & buffering bay assemblies to handle containers of different sizes: plan and elevation showing the design of the base component (one at the bottom) capable of handling containers of different sizes in the elevator and buffering bay assemblies.

Fig.15. Transfer channel: plan and elevation of a transfer channel with buffering bays at both ends and containers in transit along the transfer channel

Fig.16. Typical storage tier for container designed for sequential retrieval: plan view showing the elevator, typical arrangement in a tier with addressed storage slots with containers arranged in rows and bays without aisle space in between and transfer modules

Component identification as marked in the drawings above:

1. Tier
2. Addressed storage slot
3. Container
4. Elevator assembly
5. Balls/rollers on elevator base
6. Rollers on the transfer module
7. Transfer module assembly
8. Transfer arm assembly
9. Fixed second track (for transfer arm movement)
10. Fixed first track (for transfer module movement)
11. Transfer module drive

12. Transfer module wheels
13. Side structure assembly (identical for transfer module, buffering bay and transfer channel)
14. Horizontal members (identical for transfer module, buffering bay and transfer channel)
15. Vertical members (identical for transfer module, buffering bay and transfer channel)
- 5 16. Guide rollers (identical for transfer module, buffering bay and transfer channel)
17. Hold/release device
18. Transfer arm drive
19. Transfer arm wheels
20. Lifting & supporting device
- 10 21. Moving member
22. Holding clamp
23. Friction pads
24. Fixed fourth track (for elevator power arm movement)
25. Power arm assembly (identical assembly for elevator and buffering bay)
- 15 26. Power arm drive (identical for elevator and buffering bay power arms)
27. Power arm wheels (identical for elevator and buffering bay power arms)
28. Lifting device (identical for elevator and buffering bay power arms)
29. Contact arm (identical for elevator and buffering bay power arms)
30. Electro magnet (identical for elevator and buffering bay power arms)
- 20 31. Fixed third track (for transfer arm movement in storage slot)
32. Container cast leg support pads
33. Arresting strips
34. Rollers on buffering bay
35. Buffering bay power arm
- 25 36. Loading area (if required separately)
37. Unloading / Loading area
38. Fixed fifth track (for buffering bay power arm movement)
39. Transfer equipment
40. Transfer equipment vertical support columns
- 30 41. Gantry
42. Track for the gantry
43. Lifting tackle
44. Spreader
45. Buffering bay assembly
- 35 46. Transfer channel
47. Central causeway
48. Storage tower

Detailed description of the embodiment:

The embodiment is described in detail with reference to the introduction to the system, attached drawings and component identification provided above.

The system primarily comprises of three (3) sub-systems:

- 5 **1. Storage System:** where containers are stacked across many heights and many rows and retrieved upon request. This comprises of the following components:

- 10 **a. Storage Tower (part no.48, fig.1):** Steel / RCC tower that serves as the housing for the stacked containers and all the components of the storage system. It has a number of tiers (of equal height) for multi-level storage with a central causeway in each tier and identified and marked storage locations for containers referred as addressed storage slots in each tier either side of the central causeway.

Tiers (part no.1, fig.1), Central Causeway (part no.47, fig.2) and Addressed Storage Slots (part no.2, fig.2):

15 Each tier has two levels, a lower level at its middle with a central causeway with fixed first tracks (part no.10, fig.2) (first track level), meant for travel of transfer module assembly (part no.7, fig.2) to carry the container (part no.3, fig.2) along the line of stacking, and an upper level on both sides of the central causeway that serve as the base for addressed storage slots (storage level). The addressed storage slots have two levels at their base, an upper level (storage level) at both sides, transverse to the line of storage, to firmly support the containers on their cast corner legs when stacked and a lower level at the middle with fixed third tracks (part no.31, fig.2) (third track level), meant for travel of transfer arm assembly (part no.8, fig.2) to carry the container transverse to the line of storage. Stoppers (part no.33, fig.8) i.e. strips of steel flats are fixed on the rear end of the front corner leg support points and front end of rear corner leg support points to prevent the sliding of containers.

- 25 **b. Transfer Module Assembly (part no.7, fig.2):** Transfer modules, one or more per tier, with a steel structure frame, wheels (part no.12, fig.3), and an independent drive arrangement (part no.11, fig.3) mounted on it to move it along the fixed first track (part no.10, fig.2), on the central causeway, both in forward and reverse directions. Each transfer module has two levels the upper level (storage level) flanged on both sides with a number of balls or rollers (part no.6, fig.3) on top, transverse to the line of storage, of width to support the container cast corner legs and to carry a container at a time and the lower level at the middle with a fixed second track (part no.9, fig.3) transverse to the
- 30

line of storage. The transfer module (part no.7, fig.2) upper level is in line with the addressed storage slot upper level (storage level) and the fixed second track (part no.9, fig.3) is in line with the fixed third track (part no.31, fig.2) of the addressed storage slot (third track level). These alignments are to transfer the container from the transfer module to the addressed storage slot and vice versa.

The transfer module has side structures (part no.13, fig.4) at both ends transverse to the line of storage and the vertical members of side structures (part no.15, fig.4) are fitted with guide wheels (part no.16, fig.4) to guide the movement of containers without skewing when transferred from / to the transfer module. The transfer module structures have remotely controlled hold / release devices (part no.17, fig.4) mounted on the horizontal members of the side structures (part no.14, fig.4). The holding devices secure containers firmly when the container is moved laterally along the line of storage on the transfer module.

The transfer module (part no.7, fig.2) has a transfer arm (part no.8, fig.2), with a steel structure frame, wheels (part no.19, fig.5), and a separate drive arrangement (part no.18, fig.5) mounted on it to move it along the fixed second and third track both in forward and reverse direction transversely to the line of storage. The transfer arm has two or more lifting devices (part no.20, fig.5) positioned at locations from where container is supported. Lifting devices are powered by electrical / mechanical / magnetic / pneumatic drive. All these lifting devices work in unison. The transfer arm is designed in such a way that the transfer arm with its lifting devices in lower disposition moves unhindered under the container when the container is on the transfer module or on the addressed storage slot. The transfer arm in lifted position supports the container and move along the tracks to transfer the container from transfer module to the addressed storage slot and vice versa, the arms at their supporting points have holding clamp (part no.22, fig.5) with frictional pads (part no.23, fig.5) to hold the container by the side bottom channel member firmly and securely.

- c. **Elevator Assembly:** One or more elevator assemblies (part no.4, fig.2) are oriented and installed along the line of addressed storage slots (part no.2, fig.2). The elevators having shafts that are disposed through the plurality of floors, the elevators being vertically movable among the plurality of floors; and with opening in each floor, each elevator cage has openings on both opposite sides along the line of storage. Each elevator has two levels at its base the upper one, transverse to the line of storage, on both sides of width slightly more than the cast corner legs of containers and mounted with rows of balls or rollers (part no.5, fig.6) and this level matches the transfer module

top level (storage level) and the lower one at its middle carrying fixed fourth tracks (part no.24, fig.6).

Each elevator has an elevator power arm (part no.25, fig.7), with a steel structure frame, wheels (part no.27, fig.7), and a separate drive arrangement (part no.26, fig.7) mounted on it to move it along the fixed fourth track (part no.24, fig.6) both in forward and reverse direction to move the containers in and out of elevator. Elevator power arm has a lifting device (part no.28, fig.7) at its centre. This lifting device is powered by electrical / mechanical / magnetic / pneumatic drive. In lowered disposition, elevator power arm moves completely underneath the container in position in the elevator, from one end of the elevator to the other without disturbing the container above it. The elevator power arm positions itself at any end of the container to move the container from either side. The lifting device has a fixed bottom mounted on the structure and a vertically extending member at its top. The extending member has at its top fixed contact arms (part no.29, fig.7) on both the sides transverse to the line of storage and the contact arms are sufficiently long enough to provide uniform pressure on the container for moving and wide enough to make contact with all sizes of containers. These arms further have one or more remotely controlled electromagnets (part no.30, fig.7) at its centre to ensure additional security while pushing and impart motion to the container when the container is pulled.

2. Transfer System: One transfer system for each elevator of the storage system where containers are transferred from the unloading area (part no.37, fig.9) to the storage system and from the storage system to the loading area (part no.37, fig.9). This essentially involves unloading containers from the truck, moving containers to the storage system, receiving containers from the storage system and loading containers onto the trucks for delivery. This is oriented as shown in fig. 9 at the outer side of the elevator and transverse to the line of storage. This comprises of the following components:

a. Buffering Bay Assembly (part no.45, fig.9): Buffering Bay Assembly serves as storage buffer between the unloading / loading operations and stacking / retrieval operations of the storage system to provide cushion between the possible differences in their operating speeds. The capacity of the buffering bay (measured by its length) is to meet the operational requirements of each project. The buffering bay has two levels; upper level, at its both sides along its length, of width sufficient to handle containers through support rollers supporting cast corner legs of container and the lower one at the middle with fixed fifth track (part no.38, fig.10). Side structures (part no.13, fig.10) with guide rollers (part no.16, fig.10) are provided on both sides of the buffering bay along

the length for movement of containers without skewing. One or more support rollers and / or guide rollers are provided with drives to help move the containers along the buffering bay.

Each buffering bay has one buffering bay power arm (part no.35, fig.10), with a steel structure frame, wheels (part no.27, fig.7), and a separate drive arrangement (part no.26, fig.7) mounted on it to move it along the fixed fifth track (part no.38, fig.10) both in forward and reverse direction. Buffering bay power arm has a lifting device (part no.28, fig.7) at its centre. This lifting device is powered by electrical / hydraulic / pneumatic / magnetic drive. In lowered disposition, power arm moves completely underneath the container, from one end of the bay to the other without disturbing the containers above it. The buffering bay power arm positions itself at any end of the container to move the container from either side. The lifting device has a fixed bottom mounted on the structure and a vertically extending member at its top. The extending member has at its top fixed contact arms (part no.29, fig.7) on both ends across the buffering bay and the arms are sufficiently long enough to provide uniform pressure on the container for moving and wide enough to make contact with all sizes of containers. These contact arms further have one or more remotely controlled electromagnets (part no.30, fig.7) at its centre to ensure additional security when pushing the container and impart motion to the container when the container is pulled.

b. Transfer Station: Transfer Station is a collective term that includes container unloading area (part no.37, fig.9) from truck, transfer equipment (part no.39, fig.11) and container loading area (part no.37, fig.9) on the truck and is positioned after buffering bay (part no.45, fig.9) and in line with the buffering bay. It is a continuation of the buffering bay but without side structures and without the track at the middle.

Unloading Area (part no. 37, fig.9): In unloading area transfer equipment (part no.39, fig.11) unloads the container out of a truck and feeds into the buffering bay for further handling. The unloading area is in level with the top level of buffering bay and provided with rows of balls / rollers. Spherical balls are provided to allow free movement in both directions - free movement of containers along the unloading / loading areas and free movement of trucks across the unloading / loading areas.

Transfer Equipment (part no.39, fig.11): To unload / load the containers from / to the truck. It consists of a framed structure with a number of columns (part no.40, fig.11), the columns support a travelling gantry (part no.41, fig.11) with drives mounted on them, capable of moving in forward and reverse direction on the gantry tracks (part no.42, fig.11) provided on the columns and gantry is provided with a device that lifts and

lowers a lifting tackle (part no.43, fig.11) to which a standard spreader (part no.44, fig.11) is fitted.

Loading Area (part no.37, fig.9): Loading area is same or similar to the unloading area. In cases where operational / safety requirements demand a separate loading area, the embodiment provides an alternative approach. Trucks are made to drive past the unloading area and positioned at a designated loading area (part no.36, fig.9), some distance from the unloading area. Once the truck is positioned in the loading area, container is moved to the unloading area from the buffering bay through the buffering bay power arm. The travelling gantry lifts the container from the unloading area and moves on the fixed tracks to the loading area and loads the container on to the waiting truck.

3. **Central System Controller:** The central system controller commands, controls, monitors and co-ordinates among all the systems – storage system and its components, transfer system and its components and a human machine interface for operating personnel.

Central System Controller comprises of hardware (Programmable Logic Controllers / Micro Controllers / Equivalent, Control Panels, Human Machine Interface, Control Cabling and sensors and drives) and software to enable all the components of the system to integrate seamlessly and deliver desired results in terms of operational efficiency, reliability and safety.

Method of operation of the embodiment:

The operation of the embodiment is explained with the figures and component identification for better understanding. All operations are controlled through the Central System Controller.

Stacking a container: Refer flow chart (fig.12) for stacking a container from truck

START – STACKING OPERATION

- A. Truck loaded with container reports at the stack yard
- B. Central System Controller Allots Slot: Central System Controller registers the request and allots a slot based on availability
- C. Truck is directed to unloading area (part no.37, fig.9) of transfer station.
- D. Container unloaded from truck by transfer equipment: Transfer equipment (part no.39, fig.11) lowers the lifting tackle (part no.43, fig.11) and grabs the container by its spreader

(part no.44, fig.11).The transfer equipment thus lifts the container so that the container is unloaded from the truck and the truck leaves the unloading area.

E. Container placed in unloading area by transfer equipment: The lifting tackle lowers and places the container on the rollers at the base of the unloading area

5 F. Container moved onto buffering bay by buffering bay power arm: The power arm (part no.35, fig.10) in the buffering bay (part no.45, fig.9) moves on the fixed fifth track (part no.38, fig.10) towards the unloading area and stops near the container at the set position as determined by the central system controller. The lifting device (part no.28, fig.7) of the power arm raises to make contact with the container through contact arm (part no.29, fig.7). The electromagnet (part no.30, fig.7) is energized to secure the contact. The power arm (part no.25, fig.7) moves along the fixed fifth track (part no.38, fig.10) of the buffering bay in the reverse direction, dragging the container along on rollers (part no.34, fig.9) and places near the elevator at the set position as determined by the central system controller. The electromagnet (part no.30, fig.7) is de-energized to release the container. The lifting device (part no.28, fig.7) is lowered and the buffering bay power arm returns to the other end of the buffering bay (near unloading area) to handle the next container.

20 G. Container moved from buffering bay into elevator by elevator power arm: The power arm (part no.25, fig.7) in the elevator (part no.4, fig.2) moves on the fixed fourth track (part no.24, fig.6) towards the buffering bay and stops at the end of the elevator at the set position as determined by the central system controller. The lifting device (part no.28, fig.7) of the power arm raises to make contact with the container through contact arm (part no.29, fig.7). The electromagnet (part no.30, fig.7) is energized to secure the contact. The power arm (part no.25, fig.7) moves along the fixed fourth track (part no.24, fig.6) of the elevator in the reverse direction, dragging the container along on rollers (part no.5, fig.6) and places inside the elevator at the set position as determined by the central system controller. The electromagnet (part no.30, fig.7) is de-energized to release the container. The lifting device (part no.28, fig.7) is lowered and the elevator power arm returns to the centre of the elevator.

30 H. Container lifted to the specified tier of storage tower by elevator (part no.4, fig.2) and reaches the set point as determined by the central system controller.

I. Container moved from elevator into transfer module by elevator power arm: The power arm (part no.25, fig.7) in the elevator (part no.4, fig.2) moves on the fixed fourth track (part no.24, fig.6) and stops at the end of the elevator at the set position as determined by the central system controller. The lifting device (part no.28, fig.7) of the power arm raises to

make contact with the container through contact arm (part no.29, fig.7). The electromagnet (part no.30, fig.7) is energized to secure the contact. The power arm (part no.25, fig.7) moves along the fixed fourth track (part no.24, fig.6) of the elevator in the reverse direction, pushing the container along on rollers (part no.5, fig.6) and places on the transfer module (part no.7, fig.2) at the set position as determined by the central system controller. The electromagnet (part no.30, fig.7) is de-energized to release the container. The lifting device (part no.28, fig.7) is lowered and the elevator returns to the centre of the elevator. As the container is transferred the guide rollers (part no.16, fig.4) on the vertical members (part no.15, fig.4) guide the movement of container without skewing. When the container is fully transferred to the transfer module, the holding device (part no.17, fig.4) on the side structures are energized and they hold the container in position.

J. Container moved to the assigned slot along central causeway by transfer module: Transfer module (part no.7, fig.2) moves with the container to the specified addressed storage slot (part no.2, fig.2) along the central causeway (part no.47, fig.2). During this the container is firmly secured in position by the holding device (part no.17, fig.4). When the container reaches the set position (in front of the specified slot) as determined by the central system controller, the holding device is de-energized and the container is released.

K. Container moved into the assigned slot by transfer arm: Transfer arm (part no.8, fig.2) is activated. The lifting and supporting device (part no.20, fig.5) is activated and the container is lifted off the transfer module through the holding clamp (part no.22, fig.5) and frictional pads (part no.23, fig.5). The transfer arm moves through its drive (part no.18, fig.5) along the fixed second track (part no.9, fig.3) in the transfer module and the fixed third track (part no.31, fig.2) on the addressed storage slot. When the container is moved to the set position as determined by the central system controller, the lifting and supporting device (part no.20, fig.5) of the transfer arm lowers and the container rests on the supports (part no.32, fig.8). The arresting strips (part no.33, fig.8) on the support ensure container is held in position without sliding. The transfer arm (part no.8, fig.5) retracts its path (in the reverse direction) along the fixed third and second tracks and returns to its home position. When the transfer arm returns to its home position, the transfer module starts its move along the central causeway and rests at its home position.

END – STACKING OPERATION

Retrieving a container: Refer flow chart (fig.13) for retrieving a container from storage tower

START – RETRIEVING OPERATION

- A. Container requested for delivery
- 5 B. Central system controller locates the slot: Central System Controller registers the request and locates the slot from where requisitioned container is to be retrieved
- C. Transfer module moved along central causeway to the specified slot: Transfer module (part no.7, fig.2) moves to the specified addressed storage slot (part no.2, fig.2) along the central causeway (part no.47, fig.2) and reaches the set point as determined by the central
10 system controller.
- D. Container moved from slot to transfer module by transfer arm: Transfer arm (part no.8, fig.2) is activated. The transfer arm moves along the fixed second track (part no.9, fig.3) in the transfer module and the fixed third track (part no.31, fig.2) in the addressed storage slot and reaches the set point as determined by the central system controller. On reaching
15 the point, the lifting and supporting device (part no.20, fig.5) is activated and the container is lifted off the storage slot through the holding clamp (part no.22, fig.5) and frictional pads (part no.23, fig.5). The transfer arm moves through its drive (part no.18, fig.5) along the fixed third track in the addressed storage slot and the fixed second track in the transfer module. When the container is moved to the set position as determined by the central
20 system controller, the lifting and supporting device (part no.20, fig.5) of the transfer arm lowers and the container rests on the transfer module. As the container is transferred the guide rollers (part no.16, fig.4) on the vertical members (part no.15, fig.4) guide the movement of container without skewing. When the container is fully transferred to the transfer module, the holding device (part no.17, fig.4) on the side structures are energized
25 and they hold the container in position.
- E. Container moved along central causeway to elevator by transfer module: Transfer module (part no.7, fig.2) moves to the elevator (part no.4, fig.2) along the central causeway (part no.47, fig.2) and reaches the set point as determined by the central system controller. When the container reaches the set position (in front of the elevator) as determined by the
30 central system controller, the holding device is de-energized and the container is released. In parallel, elevator (part no.4, fig.2) reaches the specified tier to receive the container from transfer module.

- 5 F. Container moved into elevator by elevator power arm: The power arm (part no.25, fig.7) in the elevator (part no.4, fig.2) moves on the fixed fourth track (part no.24, fig.6) towards the transfer module and stops at the end of the elevator at the set position as determined by the central system controller. The lifting device (part no.28, fig.7) of the power arm raises to make contact with the container through contact arm (part no.29, fig.7). The electromagnet (part no.30, fig.7) is energized to secure the contact. The power arm (part no.25, fig.7) moves along the fixed fourth track (part no.24, fig.6) of the elevator in the reverse direction, dragging the container along on rollers (part no.5, fig.6) and places inside the elevator at the set position as determined by the central system controller. The electromagnet (part no.30, fig.7) is de-energized to release the container. The lifting device (part no.28, fig.7) is lowered and the elevator returns to the centre of the elevator. As the container is transferred from transfer module to elevator, the guide rollers (part no.16, fig.4) on the vertical members (part no.15, fig.4) guide the movement of container without skewing.
- 10 G. Container lowered to delivery floor by elevator: Container is lowered to the delivery tier of storage tower by elevator (part no.4, fig.2) and reaches the set point as determined by the central system controller.
- 15 H. Container moved from elevator to buffering bay by elevator power arm: The power arm (part no.25, fig.7) in the elevator (part no.4, fig.2) moves on the fixed fourth track (part no.24, fig.6) towards the transfer module and stops at the end of the elevator at the set position as determined by the central system controller. The lifting device (part no.28, fig.7) of the power arm raises to make contact with the container through contact arm (part no.29, fig.7). The electromagnet (part no.30, fig.7) is energized to secure the contact. The power arm (part no.25, fig.7) moves along the fixed fourth track (part no.24, fig.6) of the elevator in the reverse direction, pushing the container along on rollers (part no.5, fig.6) and places on the buffering bay (part no.45, fig.9) at the set position as determined by the central system controller. The electromagnet (part no.30, fig.7) is de-energized to release the container. The lifting device (part no.28, fig.7) is lowered and the elevator returns to the centre of the elevator. As the container is transferred the guide rollers (part no.16, fig.4) on the vertical members (part no.15, fig.4) of the buffering bay guide the movement of container without skewing.
- 20 I. Container moved from buffering bay to loading area by buffering bay power arm: The power arm (part no.35, fig.10) in the buffering bay (part no.45, fig.9) moves on the fixed fifth track (part no.38, fig.10) towards the elevator and stops near the container at the set position as determined by the central system controller. The lifting device (part no.28,
- 25
- 30
- 35

fig.7) of the power arm raises to make contact with the container through contact arm (part no.29, fig.7). The electromagnet (part no.30, fig.7) is energized to secure the contact. The power arm (part no.25, fig.7) moves along the fixed fifth track (part no.38, fig.10) of the buffering bay in the reverse direction, pushing the container along on rollers (part no.34, fig.9) and places at the loading area (part no.37, fig.9) at the set position as determined by the central system controller. The electromagnet (part no.30, fig.7) is de-energized to release the container. The lifting device (part no.28, fig.7) is lowered.

J. Container lifted by transfer equipment: Transfer equipment (part no.39, fig.11) lowers the lifting tackle (part no.43, fig.11) and grabs the container by its spreader (part no.44, fig.11). The transfer equipment thus lifts the container from the loading area (part no.37, fig.9) and is ready to load the container onto the truck.

K. Container loaded onto truck by transfer equipment: Truck is positioned beneath the container in the lifted position in the loading area. The lifting tackle lowers and places the container on the truck.

END – RETRIEVING OPERATION

A Few Other Embodiments of this Invention (Illustrative):

I. When storage tower is required to store containers of different sizes (fig.14)

In the case of a small container yard where dedicated storage towers for different size containers is weighed down on economic considerations, a single storage tower is required to stack containers of different sizes. Each tier is designed to handle containers of a specific size. The transfer module assembly with its transfer arm assembly in each tier is designed for specific container size. The common handling facility viz. elevator assembly, transfer system comprising of buffering bay assembly and transfer station are designed to handle all containers with the changes in the base through a stepped structure design as shown in Figure 14 with each step designed to hold container of a specific size. The extending member in the lifting device at the power arm centre (both elevator power arm and buffering bay power arm) is designed to extend so as to accommodate containers of all sizes.

II. Movement of container from one point to another and its integration to storage tower (fig. 15)

The embodiment described earlier limits the container handling operations to the container yard in terminals. More often than not, the movement of containers from ship to container yard also demands automation. Presently across the world, as prior art in this area, containers are unloaded from ships and placed on berths. The movement from berth to stack yard and vice versa is handled by saddle cranes, Automated Guided Vehicles (AGVs) and combination of trucks and mobile cranes. These occupy lot of land space and the equipment deployed is capital and labour intensive impacting operational efficiency. This embodiment provides a solution to automate the container movement from one point to the other and in the present case from ship to storage yard and this is achieved through a transfer channel and buffering bay assemblies at both ends (ship end and storage tower end).

The transfer channel (part no.46, fig.15) is a structure of RCC/Steel installed at ground or at any elevation. The transfer channel is built on columns over pile foundations. The structure is designed to connect two buffering bays (part no.45, fig.15) one at ship end and the other at storage tower end. The transfer channel and the buffering bay assemblies are of the same elevation. The width of the transfer channel is designed to hold container lengthwise. Rollers, equally spaced, are provided on both sides of the base to support the containers through corner cast legs. Supporting structures (part no.13, fig.15) are provided all along the length on both sides and guide rollers are mounted on the vertical members of side structures. These guide rollers ensure movement of containers without skewing. Containers are moved through drive imparted through one or more supporting rollers at the bottom or one or more guide rollers at the vertical members attached to the side structures. Platforms are provided on both sides of the transfer channel to provide access for repair and maintenance.

The buffering bay assemblies are similar to the one described in the typical embodiment. This embodiment is further extended to the driving of piles into the sea and installation of transfer channel in the sea.

III. Transfer containers of different sizes in transfer channel

When a transfer channel is required to move the containers of all sizes, containers are to be moved lengthwise, as all containers have almost uniform width. In such arrangement a turn table arrangement is introduced between the transfer channel and the buffering bay assembly near the storage tower to align with storage tower layout for further handling at storage tower.

IV. Storage of containers / bulky objects where request for retrieval is sequential (last in, first out) (fig. 16)

When the requirement primarily demands space effective storage and where retrieval is sequential - as is typical in container manufacturing plants, bus depots, car warehouses, cars stored in ports – an embodiment of the present invention is applied as shown in Figure 16 and explained below:

The storage complex has multi-tiers with equal heights. One or more elevator assemblies (part. No.4, fig.16) are oriented at one end of the complex. In each tier a common cause way runs in front of the elevator and provides track for transfer modules. One or more transfer modules run on the fixed first track (part no.10, fig.16). Each transfer module serves one or more transfer arms. The addressed storage slots are organized as rows and bays with no space in between to allow for packed storage as shown in the figure (fig. 16).

We Claim:

1. An automated multi-level storage and retrieval unit (storage unit) without the aid of pallets for containers and like bulky objects comprising:
 - a. one or more storage towers: steel / RCC tower (part no.48, fig.1) that serves as the housing for the stacked containers or bulky objects and all the components of the storage system further comprising:
 - i. plurality of tiers (part no.1, fig.1) of equal height
 - ii. central causeway (part no.47, fig.2) in each tier with its fixed first track (part no.10, fig.2) and
 - iii. addressed storage slots (part no.2, fig.2) in each tier either side of the central causeway with its fixed third track (part no.31, fig.2); having the fixed third track oriented transverse to the line of storage
 - b. one or more transfer module assembly (part no.7, fig.2) in each tier of the storage tower, traversing along the central causeway, and further comprising:
 - i. a transfer module (part no.7, fig.3)
 - ii. a fixed second track (part no.9, fig.3) oriented transverse to the line of storage
 - iii. a transfer arm assembly (part no.8, fig.2) traversing the fixed second and fixed third tracks (part no.31, fig.8)
 - c. one or more elevator assembly (part no.4, fig.2) in each storage tower, passing through the plurality of tiers, and further comprising:
 - i. one elevator (part no.4, fig.2) passing through the plurality of tiers
 - ii. one fixed fourth track (part no.24, fig.6) oriented transverse to the line of storage
 - iii. one elevator power arm assembly (part no.25, fig.6) traversing the fixed fourth track
2. An automated unit for transfer of containers and like bulky objects (transfer unit) within yards, storage areas and the like, one or more per elevator assembly of **claim 1** above, comprising:
 - a. one or more buffering bay assembly (part no.45, fig.9) for each transfer system, interposed between interconnecting handling units or systems, further comprising:
 - i. a buffering bay (part no.45, fig.9) oriented transverse to the line of storage
 - ii. fixed fifth track (part no.38, fig.9) oriented transverse to the line of storage
 - iii. a buffering bay power arm assembly (part no.35, fig.10) traversing the fixed fifth track
 - b. one transfer station for each transfer system, further comprising:
 - i. loading area (part no.37, fig.9)

- ii. unloading area (part no.37, fig.9)
 - iii. transfer equipment (part no.39, fig.11)
3. An integrated unit of the storage unit of **claim 1** above and transfer unit of **claim 2** for multi-level automated storage and handling for containers and bulky objects above
- 5 4. A central system controller that commands, controls, monitors and co-ordinates the systems and components of **claims 1, 2 and 3** above – storage unit and its components, transfer unit and its components, integrated unit and its components and a human machine interface
5. Storage tower (part no.48, fig.1) of **claim 1**, a steel / RCC tower that serves as the housing for the stacked containers or bulky objects and all the components of the storage system of **claim 1** further comprising:
- 10
- a. a plurality of tiers (part no.1, fig.1) of equal height with each tier having two levels, a lower level at its middle with a central causeway with fixed first tracks (first track level) (part no.10, fig.2) and an upper level on both sides of the central causeway that serve as the base for addressed storage slots (storage level)
 - 15
 - b. the said central causeway in each tier (part no.47, fig.2) serving as the aisle between two lines of storage
 - c. the said addressed slots (part no.2, fig.2) having two levels at their base, an upper level (storage level) at both sides, transverse to the line of storage, and a lower level at the middle with fixed third tracks (third track level) (part no.31, fig.2), with stoppers on the rear end of the front corner leg support points and front end of rear corner leg support points to prevent the sliding of containers
 - 20
6. Transfer module assembly of **claim 1** (part no.7, fig.2), that moves containers or bulky objects in a tier both along the line of storage and transverse to the line of storage and is responsible for storage and retrieval within a tier; further comprising:
- 25
- a. transfer module (part no.7, fig.3), with a steel structure frame, wheels (part no.12, fig.3), and an independent drive arrangement (part no.11, fig.3) mounted on it to move it along the fixed first track (part no.10,fig.2), on the central causeway, both in forward and reverse directions;
 - 30
- each transfer module having two levels the upper level (storage level) flanged on both sides with a number of balls or rollers (part no.6, fig.3) on top, transverse to the line of storage, of width to support the container cast corner legs and to carry one container or bulky object at a time and the lower level at the middle with a fixed second track (part no.9, fig.3) transverse to the line of storage;
- 35
- the transfer module upper level is in line with the addressed storage slot upper level (storage level) and the fixed second track is in line with the fixed third track of the

addressed storage slot (third track level) so as to transfer the container or bulky object from the transfer module to the addressed storage slot and vice versa;

the transfer module has side structures (part no.13, fig.4) at both ends transverse to the line of storage and the vertical members of side structures (part no.15, fig.4) are fitted with guide wheels (part no.16, fig.4) to guide the movement of containers or bulky objects without skewing; the transfer module structures have remotely controlled hold / release devices (part no.17, fig.4) mounted on the horizontal members of the side structures (part no.14, fig.4) to secure firmly when the container or bulky object is moved laterally along the line of storage on the transfer module

b. the said transfer module has a transfer arm (part no.8, fig.5), with a steel structure frame, wheels (part no.19, fig.5), and a separate drive arrangement (part no.18, fig.5) mounted on it to move it along the fixed second track and fixed third track both in forward and reverse direction transversely to the line of storage; the transfer arm having two or more lifting devices (part no.20, fig.5) powered by electrical / mechanical / magnetic / pneumatic drive, positioned at locations from where container or bulky object is supported, working in unison; the transfer arm with its lifting devices in lower disposition moves unhindered under the container or bulky object; the transfer arm in lifted position supports the container or bulky object and move along the tracks to transfer the container or bulky object; the arms at their supporting points have holding clamps (part no.22, fig.5) with frictional pads (part no.23, fig.5) to hold the container or bulky object by the side bottom channel member firmly and securely.

7. Elevator assembly of **claim 1** (part no.4, fig.2), that transfers containers or bulky objects from / to the buffering bay assembly, lifts / lowers to the desired tier within the storage tower and transfers to / from the transfer module assembly, further comprising:

- a. one elevator (part no.4, fig.2) passing through the plurality of tiers with openings on two opposite sides along the line of storage; having two levels at its base the upper one, transverse to the line of storage, on both sides of width slightly more than the cast corner legs of containers and mounted with rows of balls or rollers (part no.5, fig.6) and this level matches the transfer module top level (storage level) and the lower one at its middle carrying fixed fourth tracks (part no.24, fig.6)
- b. the said elevator has an elevator power arm, with a steel structure frame, wheels (part no.27, fig.7), and a separate drive arrangement (part no.26, fig.7) mounted on it to move it along the fixed fourth track both in forward and reverse direction transverse to the line of storage; having a lifting device (part no.28, fig.7) at its centre powered by electrical / mechanical / magnetic / pneumatic drive; in lowered

disposition, elevator power arm moves completely underneath the container or bulky object in position in the elevator;

the lifting device has a fixed bottom mounted on the structure and a vertically moving member at its top; the moving member having fixed contact arms at its top (part no.29, fig.7) on both the sides transverse to the line of storage; these arms further having one or more remotely controlled electromagnets (part no.30, fig.7) at its centre to ensure additional security while pushing and impart motion to the container or the bulky object when pulled

8. Buffering bay assembly of **claim 2** (part no.45, fig.9), that serves as storage buffer between the unloading / loading operations and stacking / retrieval operations of the storage system to provide cushion between the possible differences in their operating speeds further comprising:

a. buffering bay having two levels; upper level, at its both sides along its length, of width sufficient to handle containers or bulky objects through support rollers and the lower one at the middle with fixed fifth track (part no.38, fig.10); side structures (part no.13, fig.10) with guide rollers (part no.16, fig.10) are provided on both sides of the buffering bay along the length for movement of containers or bulky objects without skewing; one or more support rollers and / or guide rollers having drives to move containers or bulky objects along the buffering bay

b. the said buffering bay having a buffering bay power arm (part no.35, fig.10), with steel structure frame, wheels (part no.27, fig.7), and a separate drive arrangement (part no.26, fig.7) mounted on it to move it along the fixed fifth track both in forward and reverse directions; having a lifting device (part no.28, fig.7) at its centre powered by electrical / hydraulic / pneumatic / magnetic drive; in lowered disposition, buffering bay power arm moves completely underneath the container / bulky object;

the lifting device has a fixed bottom mounted on the structure and a vertically moving member at its top; the moving member having fixed contact arms at its top (part no.29, fig.7) on both sides transverse to the line of storage; these arms further having one or more remotely controlled electromagnets (part no.30, fig.7) at its centre to ensure additional security while pushing and impart motion to the container or the bulky object when pulled;

9. Transfer station of **claim 2**, where containers or bulky objects are transferred from the receiving area to the storage system and from the storage system to the delivery area further comprising:

- a. an unloading area (part no.37, fig.9) wherein trucks unload the container or bulky object and feeds into the buffering bay for further handling; the unloading area level aligning with the top level of buffering bay and provided with rows of balls / rollers;
- b. a loading area (part no.37, fig.9), same or similar to the unloading area
- 5 c. transfer equipment (part no.39, fig.11): to unload / load the containers from / to the truck consisting of a framed structure with a number of columns (part no.40, fig.11), a travelling gantry (part no.41, fig.11) with drives mounted on them, capable of moving in forward and reverse direction on the gantry tracks (part no.42, fig.11) provided on the columns and gantry provided with a device that lifts and lowers a lifting tackle
- 10 (part no.43, fig.11) to which a standard spreader (part no.44, fig.11) is fitted

10. A method of using the multi-level automated storage and retrieval unit (storage unit) of **claim 1**, applied to the embodiment of handling containers, comprising the steps of:

providing the multi-level automated storage and retrieval unit of **claim 1**;

receiving a container in front of elevator;

15 determining, using software encoded in a non-transitory computer readable media, an empty addressed storage slot on a particular tier of the storage tower;

operating the elevator power arm drive to move the elevator power arm and engaging the elevator power arm electromagnet to make contact with the container;

20 operating the elevator power arm drive to move the elevator power arm in the reverse direction so as to drag the container inside the elevator at the set point determined by central system controller;

disengaging the elevator power arm electromagnet to release the container and operating the elevator power arm drive to return the elevator power arm back inside the elevator;

25 operating the elevator drive to lift the container to the specified tier of the storage tower;

operating the elevator power arm drive to move the elevator power arm and engaging the elevator power arm electromagnet to make contact with the container;

30 operating the elevator power arm drive to move the elevator power arm in the reverse direction so as to push the container outside the elevator and onto the transfer module at the set point determined by central system controller;

disengaging the elevator power arm electromagnet to release contact with the container and operating the elevator power arm drive to return the elevator power arm back inside the elevator;

engaging the hold/release device in the transfer module to secure the container firmly;

operating the transfer module drive to move the transfer module along the central causeway in front of the specified addressed storage slot of the specified tier at the set position as determined by the central system controller;

disengaging the hold/release device in the transfer module to release the container;

5 operating the transfer arm lifting device to lift the container off the transfer module;

operating the transfer arm drive to move the transfer arm with the container into the addressed storage slot to the set position as determined by the central system controller;

10 operating the transfer arm lifting device to lower the container on the addressed storage slot;

operating the transfer arm drive to move the transfer arm in the reverse direction and return the transfer arm back into the transfer module;

11. A method of using the multi-level automated storage and retrieval unit (storage unit) of **claim 1**, applied to the embodiment of handling containers, comprising the steps of:

15 providing the multi-level automated storage and retrieval unit of **claim 1**;

receiving a request for retrieving a specific container from the storage unit;

determining, using software encoded in a non-transitory computer readable media, the addressed storage slot on a particular tier of the storage tower from which the requested container is to be retrieved;

20 operating the transfer module drive of the transfer module of the specified tier to move the transfer module along the central causeway in front of the specified addressed storage slot at the set position as determined by the central system controller;

operating the transfer arm drive to move the transfer arm into the addressed storage slot to the set position as determined by the central system controller;

25 operating the transfer arm lifting device to lift the container off the addressed storage slot;

operating the transfer arm drive to move the transfer arm in the reverse direction with the container onto the transfer module to the set position as determined by the central system controller;

30 operating the transfer arm lifting device to lower the container on the transfer module;

engaging the hold/release device in the transfer module to secure the container firmly;

operating the transfer module drive of the transfer module to move the transfer module along the central causeway in the reverse direction in front of the elevator at the set position as determined by the central system controller;

disengaging the hold/release device in the transfer module to release the container;
operating the elevator power arm drive to move the elevator power arm and engaging
the elevator power arm electromagnet to make contact with the container;
operating the elevator power arm drive to move the elevator power arm in the reverse
5 direction so as to drag the container inside the elevator at the set point determined by
central system controller;
disengaging the elevator power arm electromagnet to release contact with the container
and operating the elevator power arm drive to return the elevator power arm back
inside the elevator;
10 operating the elevator drive to lower the container to the delivery tier of the storage
tower;
operating the elevator power arm drive to move the elevator power arm and engaging
the elevator power arm electromagnet to make contact with the container;
operating the elevator power arm drive to move the elevator power arm in the reverse
15 direction so as to push the container outside the elevator at the set point determined
by central system controller;
disengaging the elevator power arm electromagnet to release contact with the container
and operating the elevator power arm drive to return the elevator power arm back
inside the elevator;
20 12. A method of using the automated unit for transfer of containers and like bulky objects
(transfer unit) of **claim 2**, applied to the embodiment of handling containers, comprising
the steps of:
providing the automated unit (transfer unit) for transfer of containers of **claim 2**;
receiving a truck loaded with container at the unloading area;
25 operating the lifting tackle of the transfer equipment to lift the container off the truck;
releasing the truck from the unloading area;
operating the lifting tackle of the transfer equipment to lower the container in the
unloading area;
operating the buffering bay power arm drive to move the buffering bay power arm and
30 engaging the buffering bay power arm electromagnet to make contact with the
container;
operating the buffering bay power arm drive to move the buffering bay power arm in the
reverse direction so as to drag the container inside the buffering bay at the set point
determined by central system controller;

disengaging the buffering bay power arm electromagnet to release the container and operating the buffering bay power arm drive to return the buffering bay power arm back;

- 5 13. A method of using the automated unit for transfer of containers and like bulky objects (transfer unit) of **claim 2**, applied to the embodiment of handling containers, comprising the steps of:
- providing the automated unit (transfer unit) for transfer of containers of **claim 2**;
- receiving a container at one end of the buffering bay;
- operating the buffering bay power arm drive to move the buffering bay power arm and
10 engaging the buffering bay power arm electromagnet to make contact with the container;
- operating the buffering bay power arm drive to move the buffering bay power arm in the reverse direction so as to push the container along the buffering bay to the loading area at the set point determined by central system controller;
- 15 disengaging the buffering bay power arm electromagnet to release the container and operating the buffering bay power arm drive to return the buffering bay power arm back;
- operating the lifting tackle of the transfer equipment to lift the container off the loading area;
- 20 receiving the truck at the loading area;
- operating the lifting tackle of the transfer equipment to lower the container onto the truck in the loading area;
14. A method of using the integrated unit of **claim 3**, applied to the embodiment of handling containers, combining the methods of **claim 10** and **claim 12**
- 25 15. A method of using the integrated unit of **claim 3**, applied to the embodiment of handling containers, combining the methods of **claim 11** and **claim 13**
16. The bases of the elevator assembly of **claim 7**, buffering bay assembly of **claim 8** and transfer station of **claim 9**, having a stepped structure to accommodate containers of all sizes with each step designed to hold container of a specific size (fig. 14).
- 30 17. Transfer channel assembly to transfer container of specific size from one point to another, a typical instance being from ship to storage tower, comprising of two buffering bays of **claim 8** at both ends (part no. 45, fig. 15) and a transfer channel (part no. 46, fig. 15) interposed between the two buffering bays (fig. 15); the transfer channel is a RCC/steel structure at ground or at elevated level having a number of rollers at both sides of the base
35 to support the containers and having structures (part no. 13, fig. 15) carrying guide rollers

at both ends of the base to guide container movement without skewing and the container movement effected through drive imparted to one or more support / guide rollers; the transfer channel assembly having platforms on sides to provide access for repair and maintenance

- 5 18. Transfer channel assembly of **claim 17** modified to transfer containers of different sizes, in which the containers are moved length wise as the width of containers is fairly uniform and a turn table at the storage tower end to rotate the containers by 90 degrees to feed and receive containers to / from storage tower to suit the storage tower layout for automation
- 10 19. Installation of transfer channel assembly of **claims 17 and 18**, over pillars on pile foundations as a solution for container handling in ports which require frequent dredging for ships to berth and which has higher degree of space crunch
20. An automated multi-level storage and retrieval system (storage system) of **claim 1** modified where the requirement is for sequential storage and retrieval (last in, first out) characterized in that:
- 15 a. common causeway in each tier with its fixed first track (part no.10, fig.16) and
- b. one or more elevator assembly of **claim 7** on one side of the common causeway
- c. addressed storage slots (part no.2, fig.16) on the other side of the common causeway with its fixed third track (part no.31, fig.16)
- d. addressed storage slots are arranged as bank of bays without any aisle space in
- 20 between with each bay having a number of rows one behind the other (fig.16)
- e. fixed third track of **claim 6** is extended throughout the length of the bay
- f. transfer arm of **claim 6** is modified to travel along the entire length of the bay spanning many addressed slots

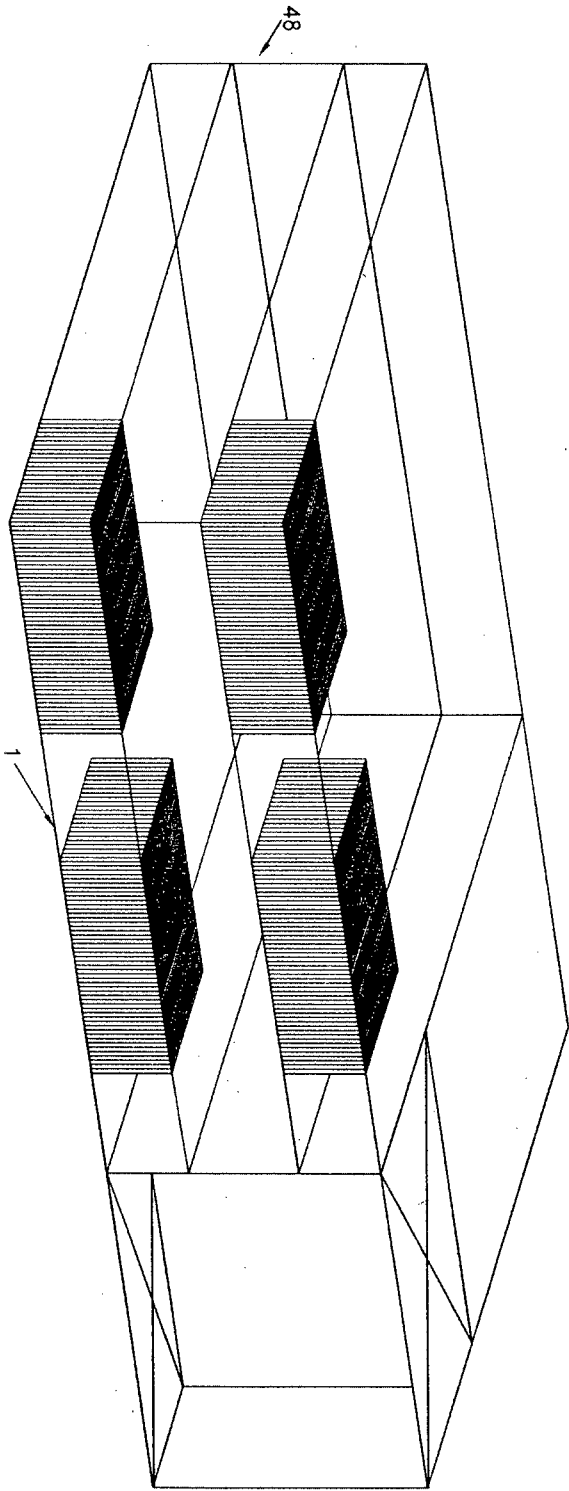


FIG. 1

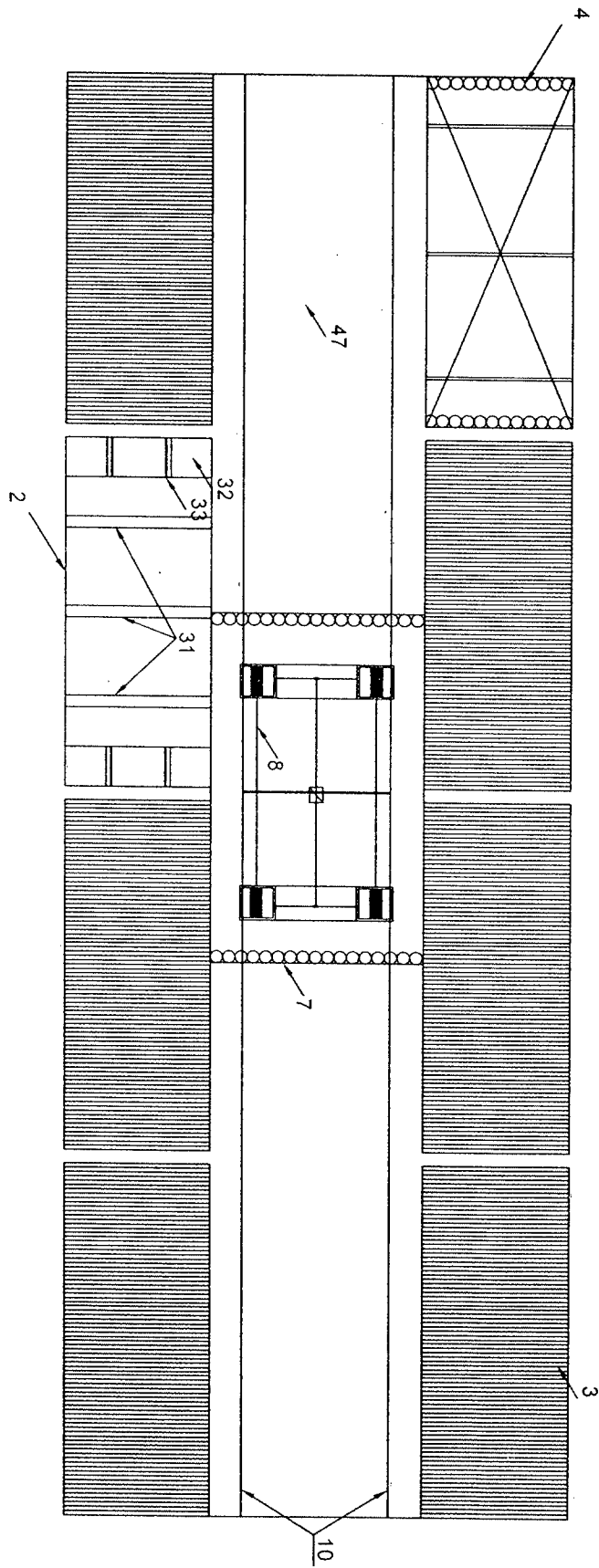


FIG. 2

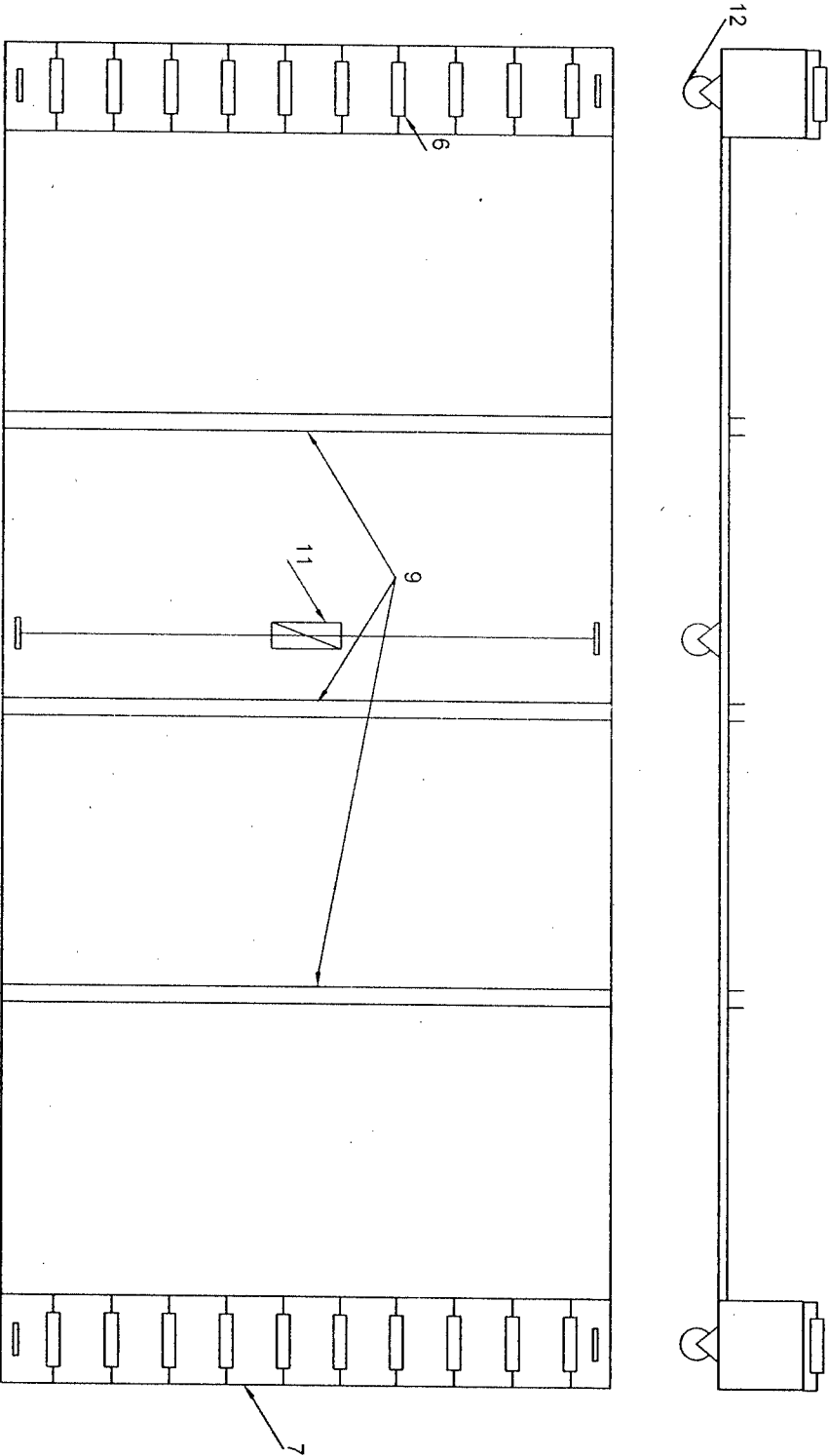


FIG. 3

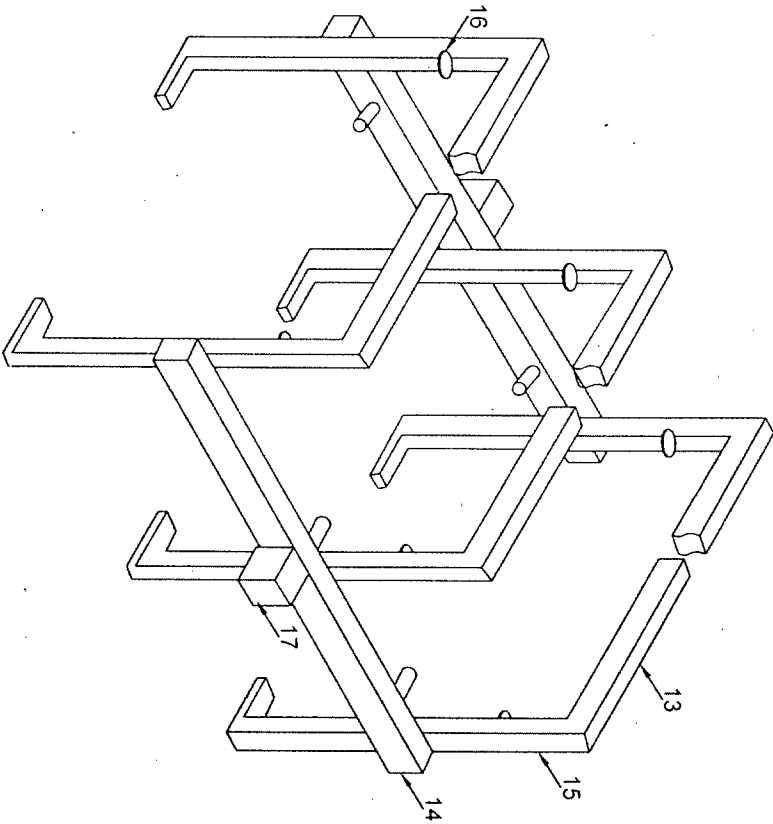


FIG. 4

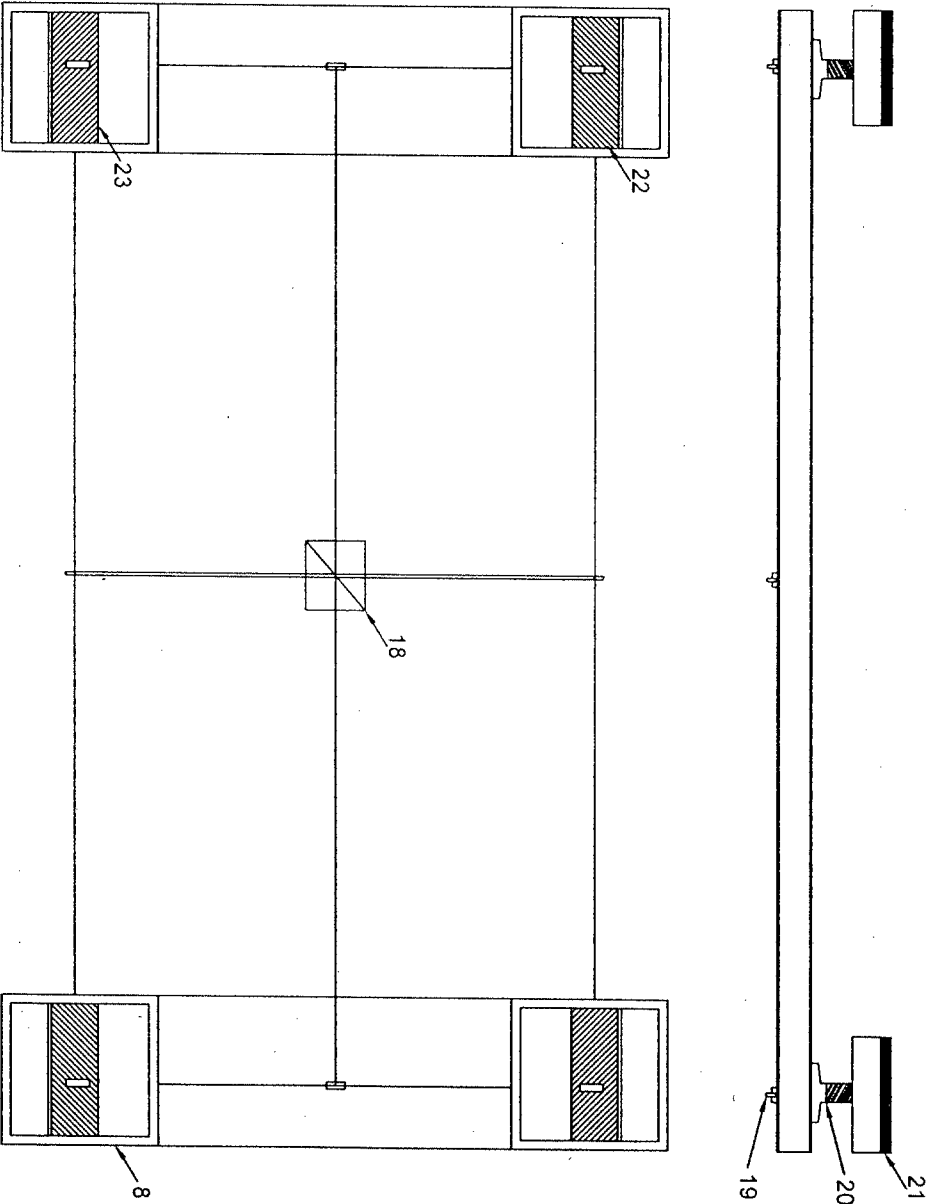


FIG. 5

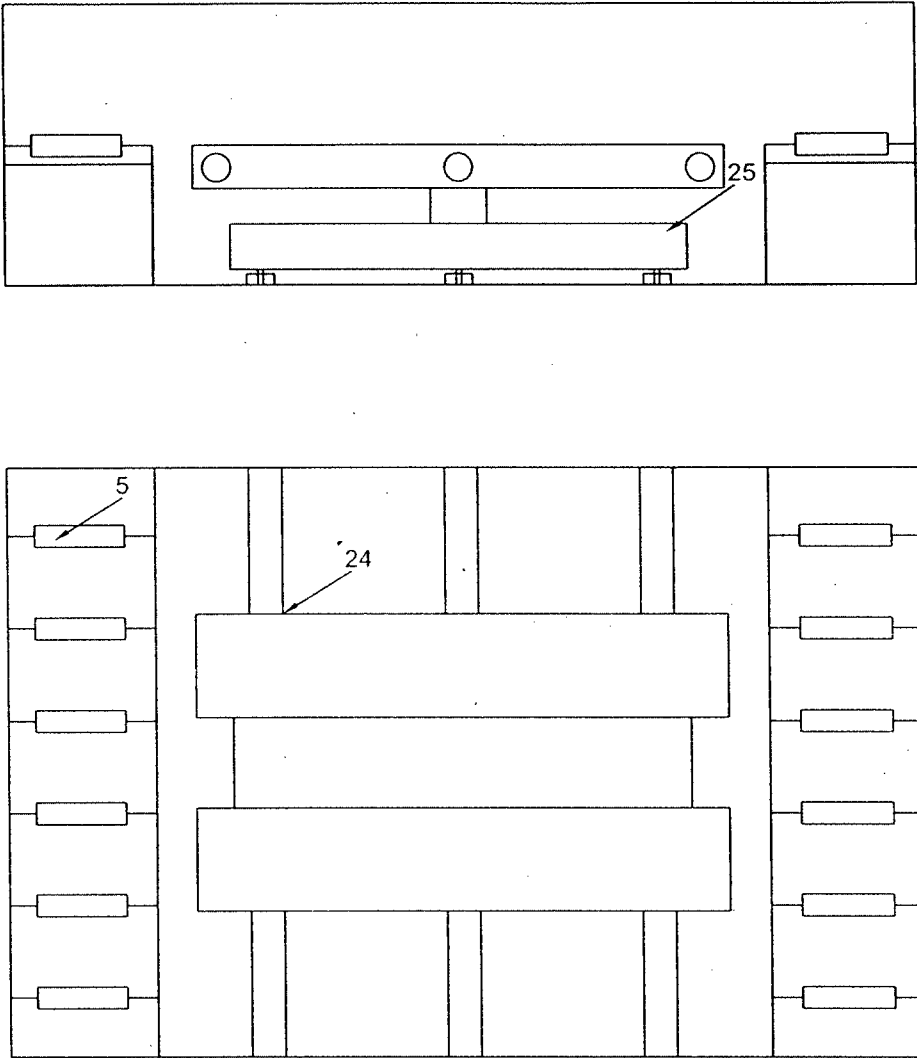


FIG.6

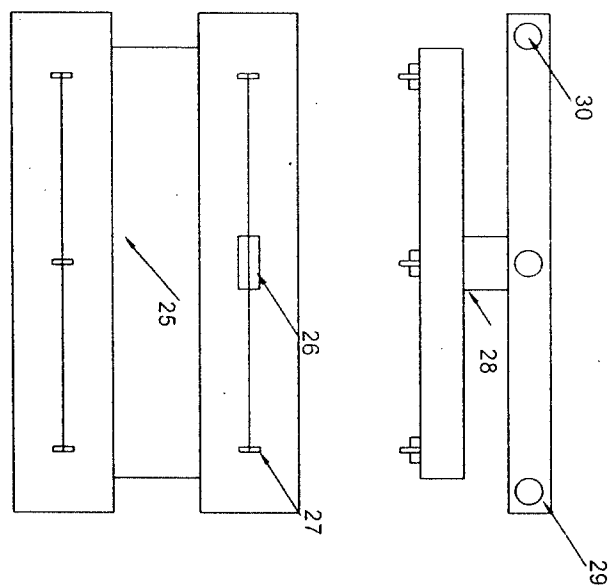


FIG.7

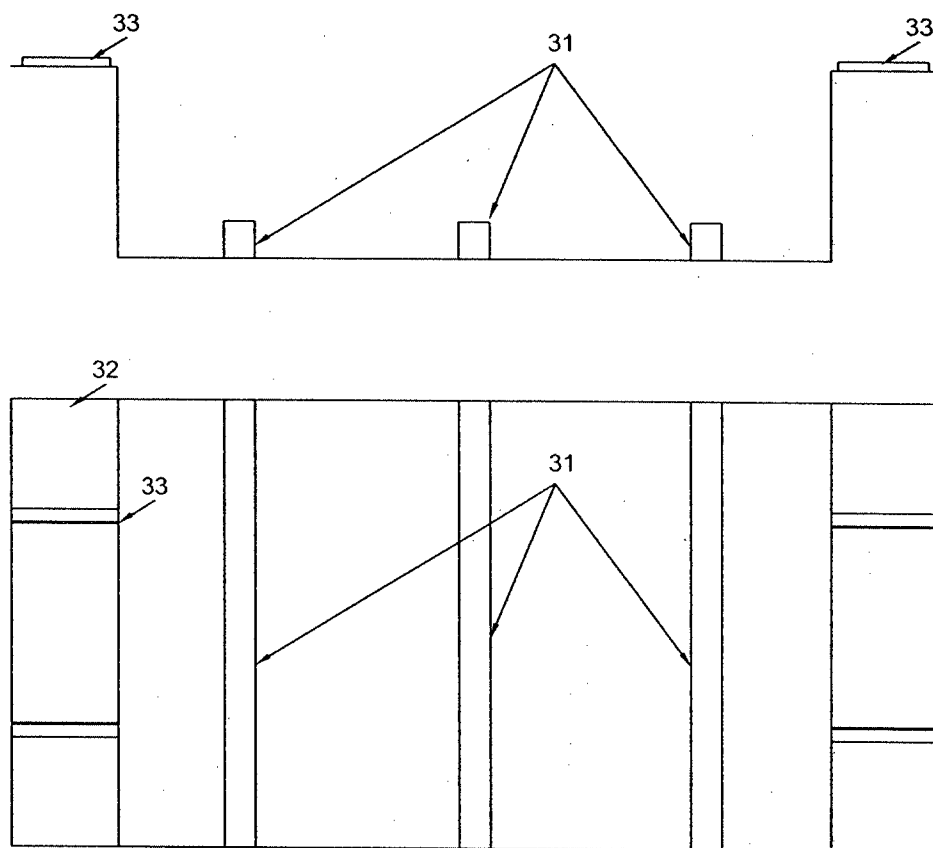


FIG. 8

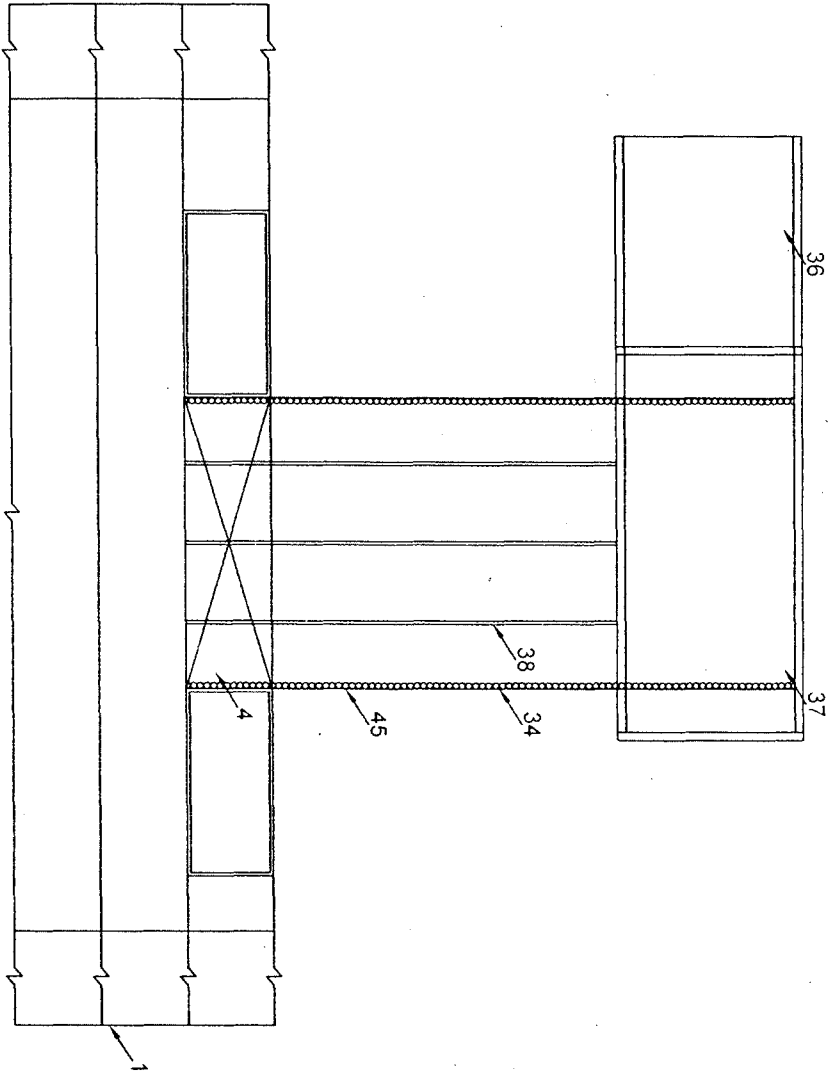


FIG. 9

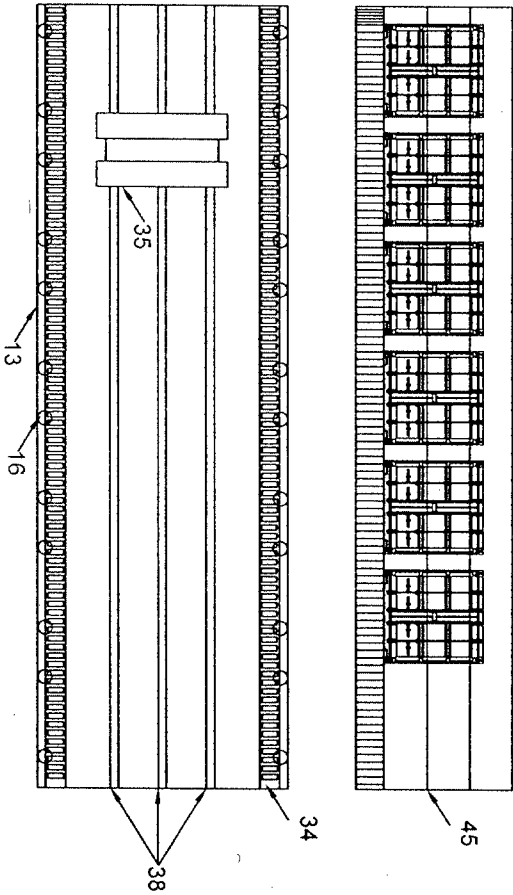


FIG. 10

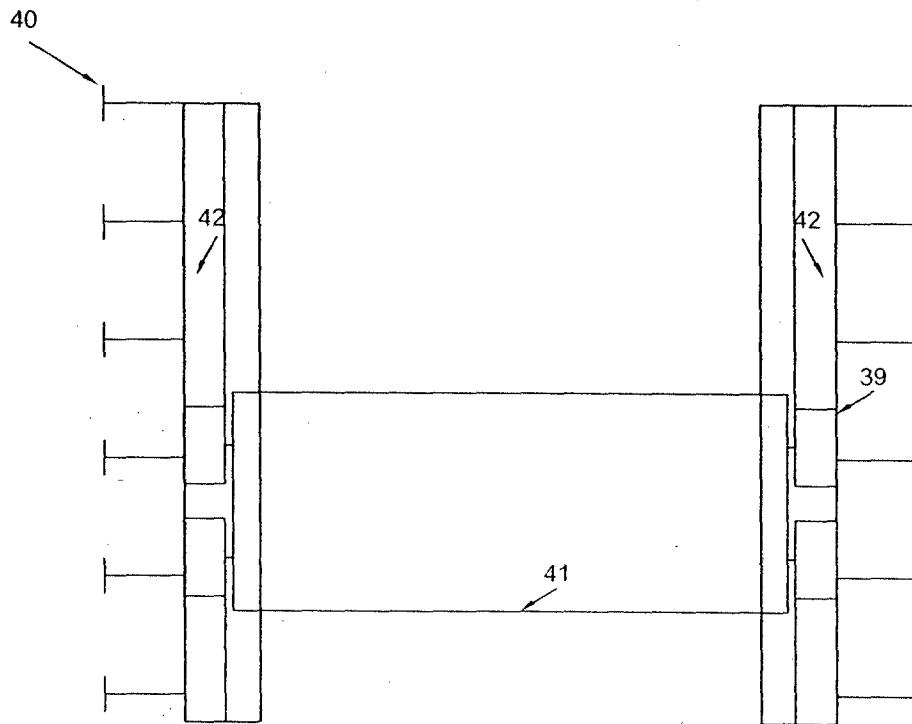
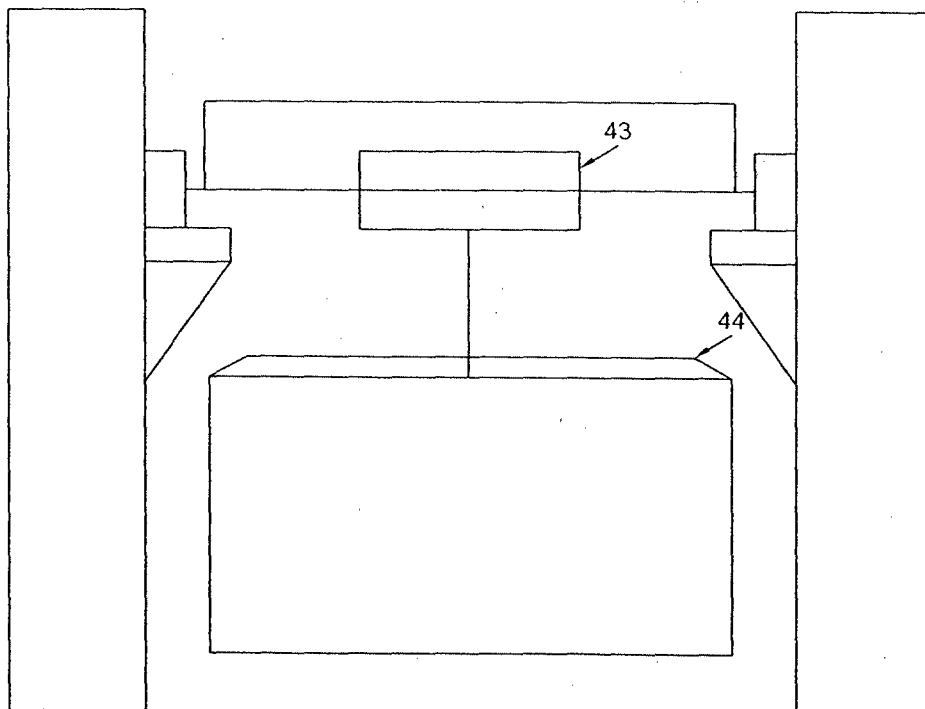


FIG. 11

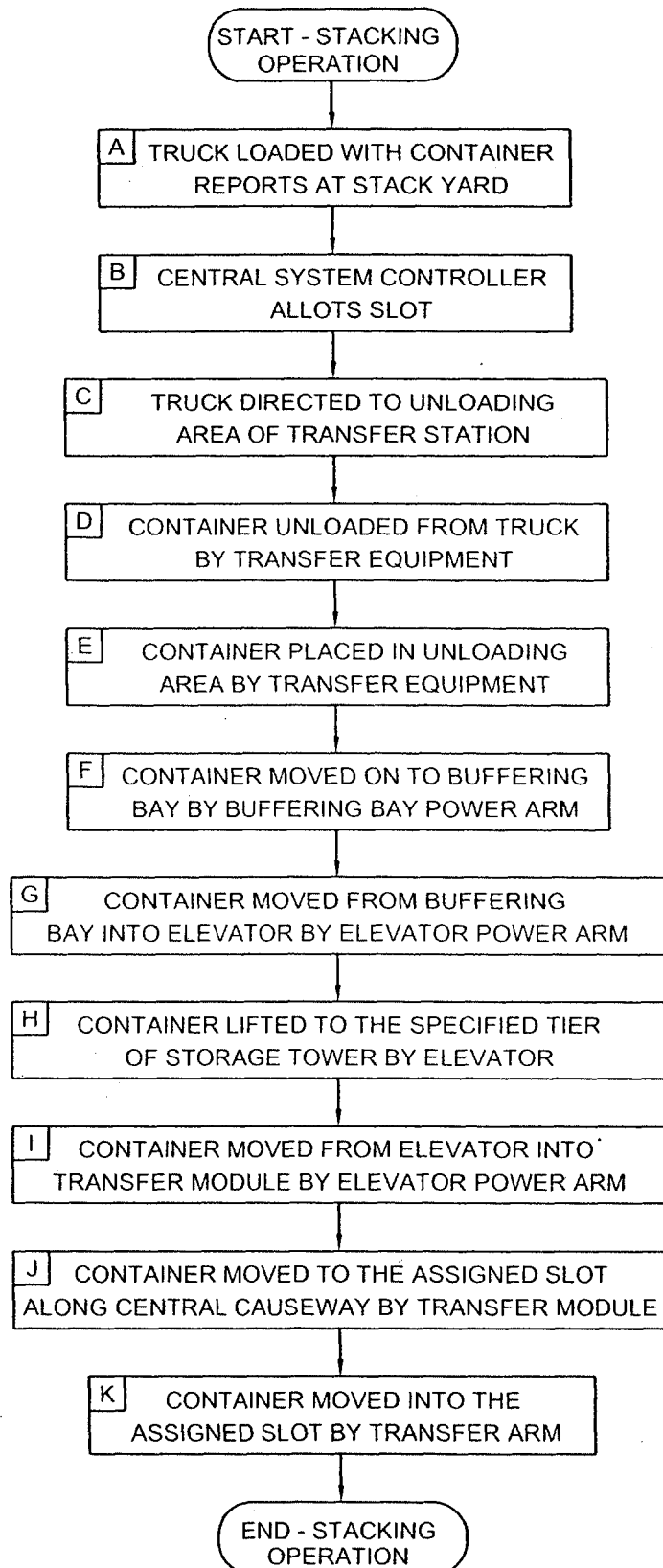


FIG. 12

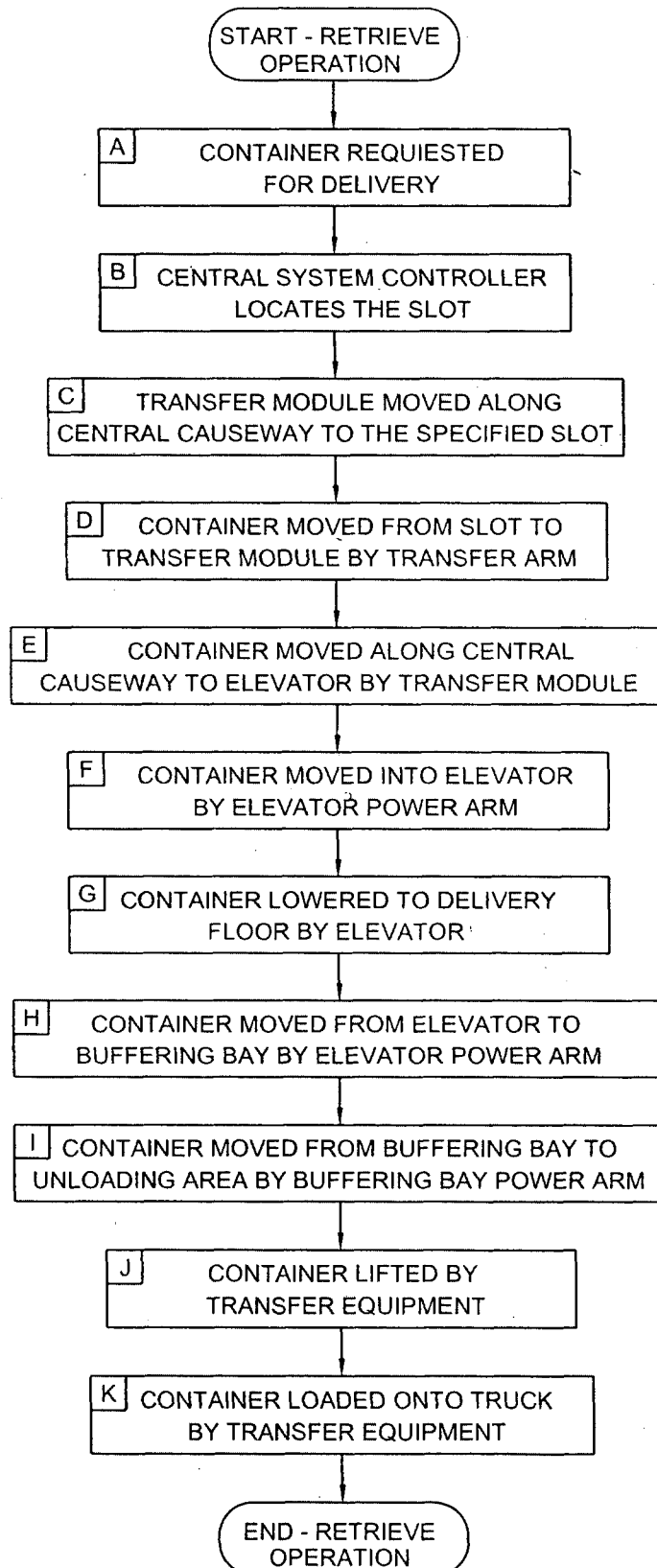


FIG. 13

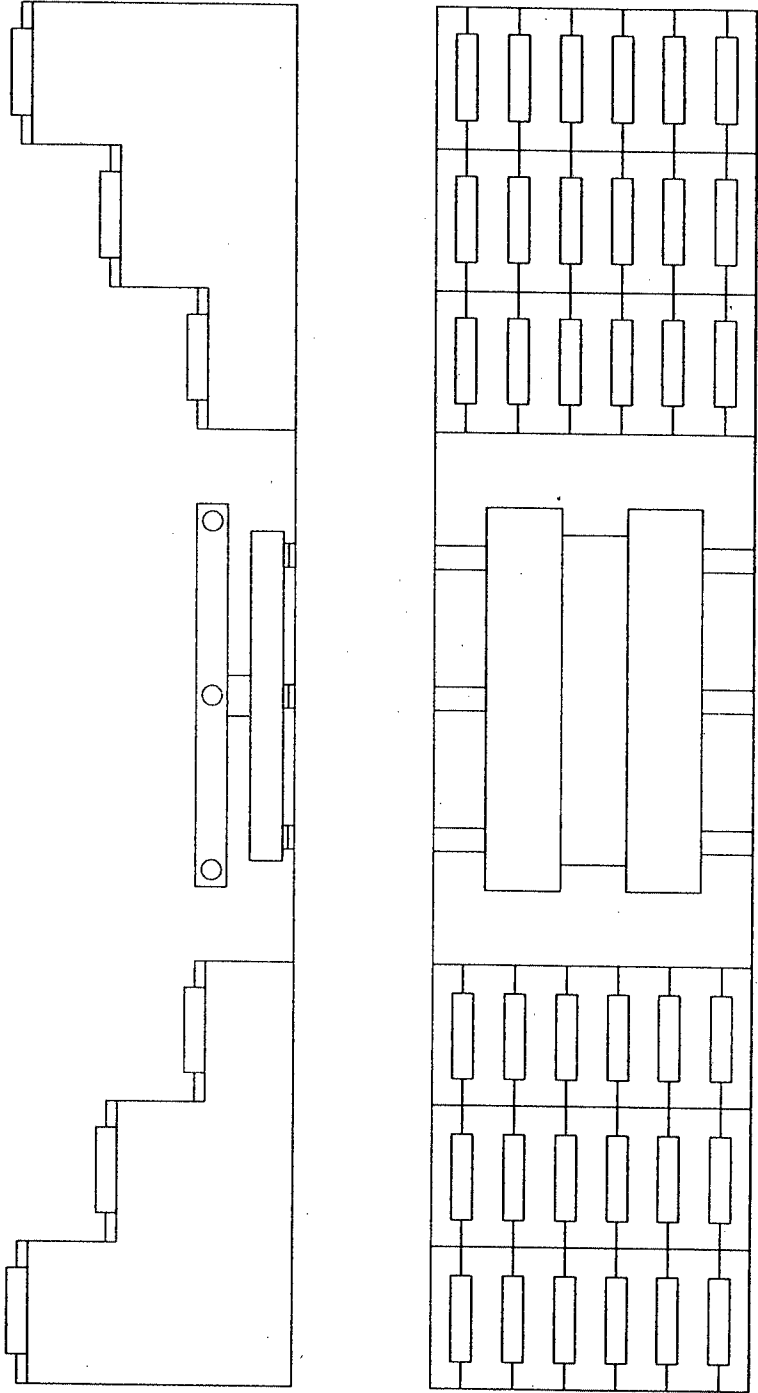


FIG. 14

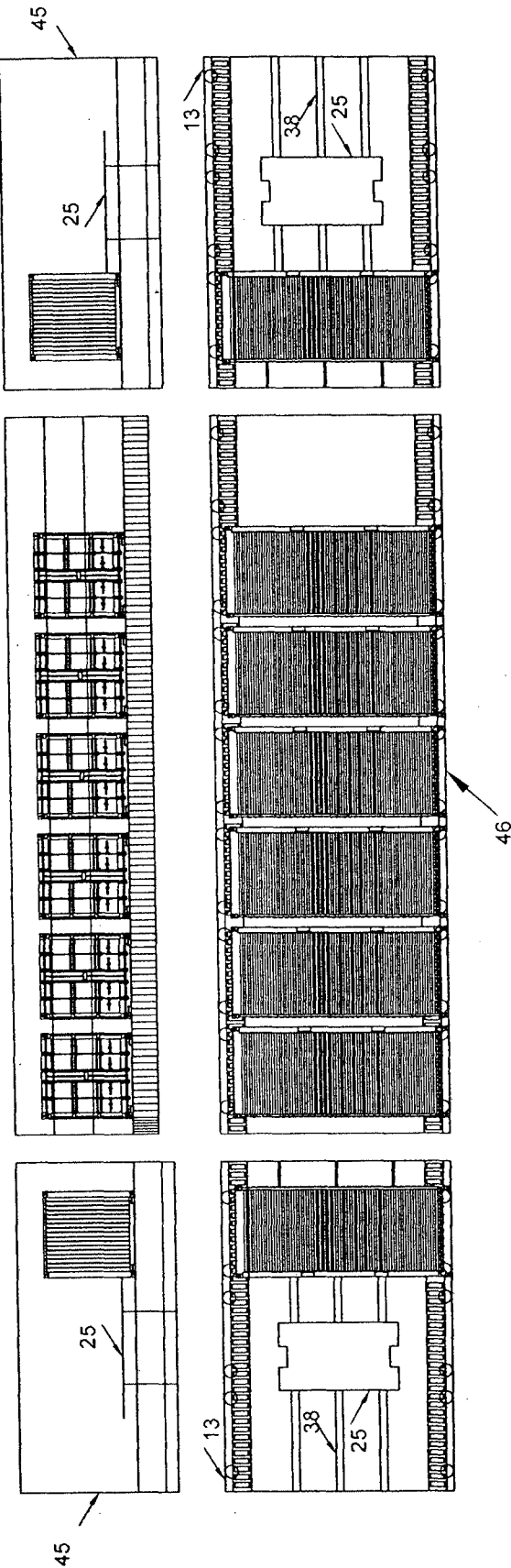


FIG. 15

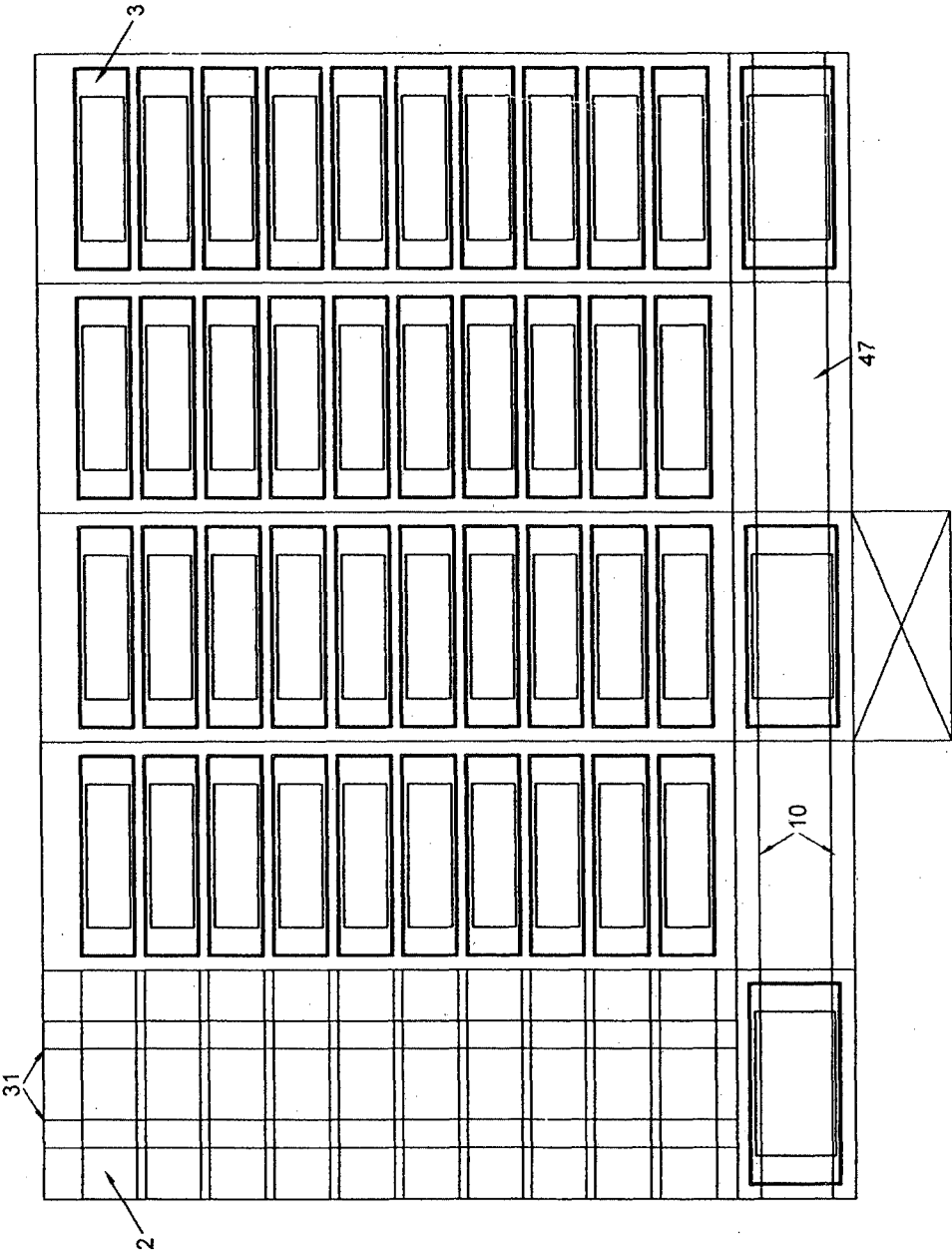


FIG. 16