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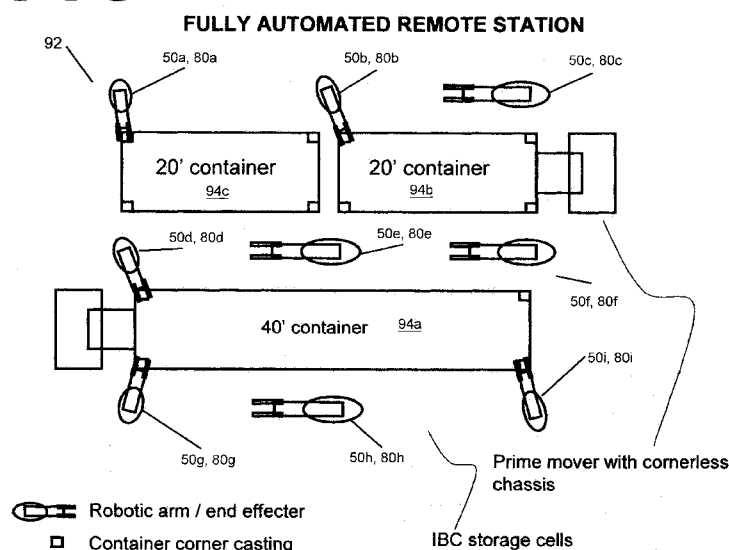
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(54) Title: DEVICE FOR HANDLING AN INTER-BOX CONNECTOR

FIG. 1

(57) Abstract: The present application discloses an automatic stevedore remote station (ASRA) (50) having a camera (60) that can detect the presence, distance, shape and orientation of an inter-box connector (twistlock) (52) via machine vision. The ASRA (50) also has a gripper (64) and a twister (66) which can move to the detected inter-box connector (52) and remove/install the inter-box connector from/onto a shipping container (94) according to detected results. The automatic stevedore remote station (ASRA) (50) is provided in the form of an industrial robot that can move both the camera (60) and its end effector (64, 66) together for handling the inter-box connector (52) at a busy wharf in a flexible and efficient manner.

DEVICE FOR HANDLING AN INTER-BOX CONNECTOR

[0001] The present application relates to a device for handling an inter-box connector. It also relates to methods of assembling, installing and using the device.

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[0002] The device and methods are further related to container shipping industry and the sub-field of handling sequences that includes the installation or removal of the inter-box connector (IBC). The inter-box connector is commonly known as "twist-lock or twistlock".

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[0003] Published patent documents, including US 6,688,249 B1, PCT/SG2007/000,444, US 7,779,604, US 6,554,557 B1, US 2006/0,115,350 A1 and PCT/SG2005/000279, have included a purpose built platform as a support structure for carrying out automated fixing and removal of IBC. These documents have suggested in slightly different ways, the need to reduce physical labour in this field and automate the process of IBC installation and removal, focused on productivity and occupational safety.

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[0004] The container port operation is characterized by the continuous processing of containers in large numbers. The entire industry, encompassing vessels, warehouses, yards, cranes and transporters are configured around the container which is basically a bulky mass volume transport aid. Two prominent classes of equipment work with the containers – A) transporters such as towed trailers and Automatic Guided Vehicles (AGV) with purpose built chassis or platforms that move containers horizontally, and – B) lifting equipment such as quay cranes, gantry cranes, boom lifters and forklifts. Even if the lifting machines can transport the containers horizontally, due to cost and speed such machines are used mainly for lifting and moving containers over very short distances only. The exception to the above is the straddle carrier which is in equal measure a transporter and a lifting machine to load and unload containers respectively on / off another transporter, e.g. the chassis towed by a motorized prime mover.

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[0005] The IBC is about 6kg and is relatively very small when compared to the container. The container lifting and moving machines used (besides the container

itself) will dwarf the twist-lock installation / removal devices mentioned in the prior art if these components are not part of a larger installation / removal system that matches the container and the handling equipment in size and robustness. With reference to matching the bulk of the container in general, it has been standard
5 practice over the past half century to involve a platform to handle containers. Similarly, all equipment mentioned in the prior art necessarily include a platform that interfaces with the containers and the large machinery, and also physically linked to the installation / removal components. Understandably the attached platform would include wedges to orientate the container to the installation / removal components
10 during the descent of the container. The platform in turn makes necessary a lifting machine to be in attendance in the prior art when the installation / removal components are in continuous operation. The complementary lifting machine then becomes a defining and critical feature of the prior art as needed in all versions of the prior art is an attached platform that is of sufficient size and robustness to
15 connect with the large (and necessary) lifting equipment. The imperativeness of the platform is that it provides the interim step of cutting down the possible variations of the container as presented to the installation / removal component before the installation / removal components swing into action while at the same time protecting the relatively small installation / removal components from the immense force of the
20 surrounding heavy equipment.

[0006] Given the range and ready availability of lifting machines in the relevant environment, the attached platform is used as a solution in the prior art as the platform / lifting machine combination requires very little interaction time and
25 distance (between the descending container within the platform and the sloped sides of the platform that guides the container laterally) from the point of contact with the platform till the container is settled down. It is especially convenient where the device of the prior art have been configured for deployment at the wharf/quayside where the quay cranes work upon the vessel at berth as twist-lock operations have traditionally
30 been accepted as part of the loading / unloading cycle of the quay crane.

[0007] However, devices in the prior art would be challenged to perform if the operational environment does not include a pre-existing lifting machine, such as the quay crane that can absorb the IBC work segment within its main function of loading

and discharging the container vessel. This situation will occur if the port operator is disposed to altogether remove twist-lock installation / removal from the quay crane cycle, enabling the quay crane to maximize the productivity in loading or unloading the vessel. Most major ports currently rely on the Corner-less Chassis towed by Prime Movers (CCPM) to transport containers to and from the yard / wharf, to cut down quay crane cycle time by making it possible to install and remove IBC whilst the container is settled on the chassis. The CCPM and Corner-less Chassis Automatic Guided Vehicle (CCAGV) that have recently been introduced in the market offer a distinct possibility to reap the advantages of having IBC operations remote from the wharf. These advantages have of course been considered in the design of the CCPM and the CCAGV. At the remote IBC operation location then, the attachment between the installation / removal component and the platform of the CCPM or CCAGV can be a coordinated arrangement such that the installation components and the platform are relatively "fixed" by means of advanced perception means (that are not in the prior art) included in the installation / removal components, in order to maximize the advantages potentially offered by the CCPM or the CCAGV.

[0008] First, devices described in the prior art cannot economically be used in a remote IBC operation location that are serviced by CCPM or CCAGV. Unless the port that decides to remove IBC operations from the wharf in order to enhance traffic flow under the quay cranes uses a straddle carrier as a primary means of transport to/from the yard, a complementary lifting machine solely to transfer the container between the platforms of the transporter and the installation / removal system will be necessary. The requirement of a lifting machine in constant attendance to provide the additional step of lifting and placing the container on the platform invariably present in the prior art plus the inability to make use of the platform already present in the CCPMs negates the investment in the usefulness of the CCPMs which are designed to save time and increase productivity. Therefore, ports that seek to remote IBC handling have to invest substantially in straddle carriers to, in effect, present the container by placing it on the platform attached to the installation / removal components already in place to work upon the container.

[0009] Second, apart from the difficulty due to the platform / lifting machine combination, the prior art relies on compulsory discharge of containers from the

vessel before loading as the collection of twist-locks in the discharge sequences must take place in order to keep the twist-locks in position to be installed upon the containers during the loading sequence. A discharge before loading situation is not offered where new built vessels are involved and, when another location such as another berth is used to discharge empty containers for storage or stuffing before overland transportation to the loading port (that breaks the discharge before loading scenario), rather than discharging at the loading port.

[0010] According to a first aspect, the present application provides a device for handling an inter-box connector. The device comprises an indexing means for identifying positions of the inter-box connector automatically, a manipulation means for mounting or dismounting the inter-box connector, and a transportation means connected. The transportation means is electrically connected to the index means for controlling its movements. The transportation means is also connected to and support the manipulation means for moving the manipulation means to the identified positions of the inter-box connector such that the manipulation means can lodge or dislodge the inter-box connector from a shipping container. Compared to known technology, the device moves its manipulation means to the inter-box connector speedily, which does not require the inter-box connector to be situated at a designated place. In contrast, the known technology often requires the shipping container to be inserted into a docking station or manoeuvre a truck with the shipping container to a designated area, which tends to be time consuming.

[0011] Here, the indexing means is also known as a sensor that can detect location, orientation, shape, size or a combination of any of these factors. The transportation means is also known as a carrier that takes the indexing means, the manipulation means, or both of them to a designated position. The manipulation means is also termed as an end effector tool, an end effector, a twistlock tool, a handler, a twist-lock handler, a jig or a similar name. The manipulation can hold, move, or rotate an inter-box connector for loading, dislodging or both.

[0012] The indexing means can comprise a camera for perceiving and analysing the inter-box connector. In other words, the device has machine vision that can capture images of the inter-box connector and determine its location, size, type, distance or

other parameters for guiding the manipulation means to the inter-box connector. The camera can even be equipped with a lamp for clear image capturing. The camera with a digital output can easily be connected to a computer for processing such that location or size of the inter-box connector can be quickly determined.

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[0013] The index means may further comprise a distance reader for detecting the positions of the inter-box connector. The distance reader is connected to transportation means such that the transportation means can move the manipulation means to the inter-box connector accurately for mounting or dismounting.

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[0014] The manipulation means can alternatively comprises a gripper for holding the inter-box connector or/and a twister for rotating the inter-box connector. Following profiles of various types of inter-box connectors, the manipulation means can hold and rotate parts of the inter-box connector securely for operation, such that mounting, dismounting or storing.

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[0015] The gripper, the twister, or both of them may be pneumatically powered. The pneumatic propulsion provides fast responses for continuous operations. The pneumatic propulsion also requires relatively lower cost and is easy to be implemented.

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[0016] The manipulation means may further comprise a position sensor for determining a cone of the inter-box connector. The position sensor can determine the position accurately such that the twister can rotate the inter-box connector precisely to a predetermined angle or location rapidly.

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[0017] The indexing means and the manipulation means can be installed together or at the same place such that the transportation means is configured/adapted to move the indexing means and the manipulation means simultaneously. Instead of manoeuvring a shipping container or a vehicle with the shipping container to a precise location, the transportation means can carry the indexing means and the manipulation means to the inter-box connector swiftly, which reduces human labour and time for lodging/dislodging the inter-box connector.

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[0018] The indexing means, the manipulation means and the transportation means can be connected to a robot controller such that the device becomes a robotic arm. Since the robotic arm can be programmed or modified easily, the device can adapt to diverse types of working environments and workloads. The robotic arm can also be maintained or repaired easily because the device can readily adopt standard components of industrial robots.

[0019] The robot controller can be configured to analyse images of inter-box connectors received by the camera for differentiating various types of inter-box connectors. The controller can further be connected to a data storage device (e.g. hard disk drive or solid state drive) that stores images of various types of inter-box connectors. The robot controller can analyse captured images, provide offsets of the image in view of the stored images and determines precise location/sizes of the inter-box connector for efficient operation.

[0020] The manipulation means can comprise an end effector of the robotic arm. The end effector can comprise the gripper and the twister. The end effector can be modified to handle other types of objects. For example, the end effector can comprise an electromagnet.

[0021] The indexing means may be fault-tolerant that the device is configured to detect mounting holes on an Intermodal freight container with various orientations, angles, distances, lighting conditions or a combination of any of these conditions. In practise, mounting holes, which at corners of the Intermodal freight container (shipping container), can clogged with dirt or covered with tapes partially. The indexing means can eliminate unnecessary images that distort or cover edges of the mounting holes. Hence, when in use, the indexing means can assist the manipulation means to capture the inter-box connector accurately, despite of the dirt or tapes.

[0022] The present application further provides a station for handling an inter-box connector, which is alternatively known as an Auto-Stevedore Remote Station. The station is also known as a cell. The station can comprise the device and a platform for mounting the device. The station has a vision system that can locate and

accurately index corner castings of an ISO standard container. The station can also achieve this indexing within a sufficiently large working envelope/range. Tolerances of the working range/envelope is sufficient large that a professional driver of a prime-mover (with corner-less chassis in tow) can stop his vehicle within a designed zone easily. Manipulation means (e.g. mechanical components of the station) can move to the container corner casting for operation, such as removing or installing an inter-box connector. The station can operate automatically in all types of environments or weather condition such that the station becomes viable for port operators to replace human labour. Risks associated with human installing or removing inter-box connectors are avoided. Moreover, the automatic station can lodge or dislodge an inter-box connector with time much less than twenty seconds, which is known as average time required for handling the inter-box connector. The automatic station clearly can operate continuously for days or months without fatigue, in contrast to human operations.

[0023] The platform can comprise an open area for receiving a box or inter-box connectors. The open area can be an area on a steel plate for holding inter-box connectors. The open area can be provided around the station. In operation, the station can dislodge an inter-box connector from a shipping container and deposit the inter-box connector onto the open area. Alternatively, the station can capture an inter-box connector from a box filled with inter-box connectors and install the captured inter-box connectors onto a shipping container.

[0024] The station may further comprise a holder for transporting the station. The holder can be hooks for receiving hoisting cables. The holder can also be screw mounting holes for secure fastening. In a further example, the station may be mounted on rails or tracks such that the station can either move itself or be propelled for relocation. As a result, the station can flexibly handle shipping containers of different lengths.

[0025] In one form, the holder may comprise two slots for receiving forks of a forklift. The forklift can thus transport the station to a designated place for operation, thus providing flexibility of relocating the station.

[0026] The station can further comprise an inter-box storage for receiving dismounted inter-box connectors. The inter-box storage is provided next to the station such that the station can either take an inter-box connector from the inter-box storage, or deposit an inter-box connector into the inter-box storage easily.

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[0027] The inter-box storage may comprise one or more floors with perforations for holding the dismounted inter-box connectors. The floors can be made of steel plates with through holes (perforations). Size and shape of the perforations are adapted to receive certain types of inter-box connectors for storage.

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[0028] The perforations of the one or more floors are placed in close proximity between each other for maximising storage area. For example, dismounted inter-box connectors of neighbouring perforations on the floors can be provided with about 100 millimetres distances between cones of the dismounted inter-box connectors.

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The inter-box storage can thus be made compact and be maximised with its storage capacity.

[0029] According to a second aspect, the present application provides a shipping port for handling shipping containers. The shipping port comprises the device for handling an inter-box connector automatically. The automatic operation avoid the inherently labour-intensive and hazardous working situation when handling the inter-box connector manually. The automatic operation further speeds container transferring for lowering operation cost of the shipping port.

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[0030] The shipping port may comprise two or more of the devices that face each other with a distance in-between for allowing a shipping container passing through in-between. When the shipping container is located between these two stations, the station can dislodge or lodge inter-box connectors simultaneously at opposite sides. Therefore, it takes much less time for handling one shipping container.

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[0031] The shipping port can comprise four or more of the devices that are separated into two groups placed on opposite sides for allowing a shipping container passing through in-between the two groups. Since a typical shipping container has

four corner castings, the four devices can handle the inter-box connector concurrently when receiving the shipping container.

[0032] The shipping port may comprise six of the devices that are separated into two groups placed on opposite sides for allowing a shipping container passing through in-between the two groups. Since a trailer or truck can transport two short containers with eight corner castings, the six devices can handle the inter-box connectors together in parallel for time reduction.

[0033] The shipping port can comprise the station that assists the handling of shipping containers. Alternatively, the shipping port can also comprise two of the stations that face each other with a distance in-between for allowing a shipping container passing through in-between them. In a further alternative, the shipping port may comprise four of the stations that are separated into two groups placed at opposite sides for allowing a shipping container passing through in-between the two groups. As yet another alternative, the shipping port may comprise six of the stations that are separated into two groups placed on opposite sides for allowing a shipping container passing through in-between the two groups. The various proposals of installing the stations help to speed up shipping container handling.

[0034] According to a third aspect, the present application provides a spreader for lifting shipping containers. The spreader comprises a hoisting mechanism on a frame of the spreader for lifting the spreader. The spreader further comprises the device for handling the inter-box connector. The spreader avoids hazardous human handling on the spreader for lodging or dislodging the inter-box connector (twistlock) such that a shipping port with the spreader is made safer and more efficient for handling the inter-box connectors.

[0035] According to a fourth aspect, the application provides a wharf transportation vehicle that comprises a frame for supporting a shipping container and the device for handling an inter-box connector. The device is mounted at an end of the frame for handling inter-box connectors. The wharf transportation vehicle manually operated or automatically guided for handling shipping containers efficiently because it does not require manual operation for lodging or dislodging the inter-box connectors.

[0036] According to a fifth aspect, the application provides a method of making a device for handling an inter-box connector. The method comprises a first step of providing an indexing means for identifying positions of the inter-box connector automatically, a second step of adding a manipulation means for mounting or dismounting the inter-box connector, and a third step of connecting a transportation means to both the indexing means and the manipulation means for moving the manipulation means to the identified positions of the inter-box connector. Sequences of these steps may be changed depending on situation. In a manufacturing process, the method presents a productive approach for producing the device for handling an inter-box connector.

[0037] According to a sixth aspect, the application provides a method of installing a device for handling an inter-box connector. The method (120) comprises a step of presenting the device. The device comprises an indexing means for identifying positions of the inter-box connector automatically, a manipulation means for mounting or dismounting the inter-box connector, and a transportation means connected to both the indexing means and the manipulation means for moving the manipulation means to the identified positions of the inter-box connector. The method further comprises a step of mounting the device at a site for handling inter-box connectors. The site may be fixed location on the ground or on a ceiling. The site may also be a platform that can be transported around. The site can further be a track such that the device can be moved along the track for adjusting its locations.

[0038] According to a seventh aspect, the present application provides a method of using a device for handling an inter-box connector. The method comprises a step of offering the device. The device comprises an indexing means for identifying positions of the inter-box connector automatically, a manipulation means for mounting or dismounting the inter-box connector, and a transportation means connected to both the indexing means and the manipulation means for moving the manipulation means to the identified positions of the inter-box connector. The method further comprises a step of installing or removing an inter-box connector from a shipping container. The device can be treated as a module or unit such that

the device may be relocated or grouped for handling inter-box connector in a flexible manner.

[0039] Hereby disclosed is an optical indexing means to enable the use of the totality of a multi axis industrial robot, a mechanical end effector, and IBC storage receptacles, that exists independently (as an electro-mechanical stevedoring robot) of any platform used to support ISO containers, that can locate, identify, and engage ISO standard freight containers and remove or attach IBC as required. Of particular note is the highly hazardous environment besides the typically frenzied activity of container port operations, where the automation of strenuous work processes such as the handling of IBC is obviously desirable.

[0040] In container vessel berthing operations, containers (and therefore IBC) cannot practically be positioned (without slowing down normal flow of operations by unacceptably slow movement of the machinery involved) in an exact spot without the use of a platform with sloped sides. The lack of precision as normally required for mechanized automation is bridged by the present application, thus negating the need for a purpose built intermediate platform or other structure that must be attached to the installation / removal components to position the IBC beyond positioning means afforded by a transport machine (e.g. a truck). The present application allows the use of the platform of currently popular CCPM or CCAGV that are used to transport containers between the yard and the docking wharf) to function as a platform for automated (mechanized) IBC fixing / removal. Automated operations as such are achieved by either an autonomous single robotic cell or a collective station of a few such cells that each employs an industrial robot to handle IBC. CCPM or CCAGV can be roughly indexed to the installation / removal components, in this case the stevedoring robots by using cheap and traditional methods such as road humps and traffic lights to guide a truck and the driver respectively before precise indexing by the present application to seek out the IBC placed within practical limits). The use of this application will streamline container operations and reduce wharf congestion, and in the overall (in combination with CCPM or CCAGV) to reduce the absolute number of lifting tasks, thus speeding up operations, reducing costs and also contributing to a safer workplace.

[0041] As the CCPM or the CCAGV have to enter the installation / removal system horizontally, unlike as in vertical landing of lift and place platform attached to installation / removal components, the time between initial contact with the system and eventual positioning is far more prolonged, subjecting the positioning to various inconsistencies that have not been necessary to factor into the design of, and therefore lacking in, the equipment in the prior art.

[0042] Inaccuracies are quite large due to contribution from the following:

1. [0043] Driver error or inexperience
2. [0044] Mechanical condition of the prime mover
3. [0045] The position of the container on the platform
4. [0046] CCPM or CCAGV platform condition
5. [0047] The road or floor condition
6. [0048] Unequal loading of goods within the container

[0049] The twist-lock and container corner casting as work pieces being relatively small as compared with the container and the transport machine, it would be unreasonable to expect to manoeuvre the transport machine, say a truck, to a precise position typically required by a mechanical device that is also correspondingly small and sophisticated. It becomes then a requirement for a twist-lock installation / removal system without the platform / lifting machine combination, to conform to the container in its final position immediately before installation / removal operation rather than the other way around. Nearly all material in the prior art refer broadly to the use of sensors to capture the final position of the container without actually appreciating the complexity of the task, therein providing the reason for the inability to date to put in service an automation device, even given the obviously strong motivations of safety and speed.

[0050] Assuming that CCPM driven by human operators would offer wider inconsistency than CCAGV, the inventors settled on using CCPM as the most challenging setup the indexing needs to be configured around. The driver need only position the truck such that the corner castings are within an ample work envelope. The target for the driver being a three dimensional space, the corner casting can then be expected to be pivoted on its own axis on the horizontal plane. This then

requires the critical step of indexing the mechanical device to a corner casting which can be anywhere within a target space achievable in truck positioning by the driver.

[0051] The present inventors consulted with experienced prime mover drivers and witnessed demonstrations of truck stopping and manoeuvring, to arrive at the dimensions of the target space at 800mm x 600mm x 300mm (respectively the width, height and depth of the working envelope) as a reasonable interface to bridge the limited precision of heavy vehicle handling and the limited range of a compact precision mechanical device.

[0052] The preferred setting for the present application would be defined as a fixed station as suggested by the arrangement as in Fig. 1, optimally situated to serve high capacity berths while in an isolated position away from the busy wharf area. The robotic arms described by our application would feature as posts that are situated at ground level (that can be a permanent fixture (see Fig. 1) or temporarily anchored (see Fig. 3) to suit the port operators decision), and said posts being movable on a rail structure as defined in my earlier application PCT/SG2005/000279 to allow for both 20ft and 40ft containers, separated adequately in a parallel order to allow the CCPM to drive thru permitting an allowance on both sides of a minimum 1.5 metres for the unobstructed passage of CCPM and the said allowance to be utilised by the robotic arms that require such an operating radius (radius not limited to stated value). The said arms are to be at a retracted position (the orientation coinciding with the graphic used in the legend of Figs. 1, 2 and 3) in the absence of a vehicle in the station and will move into action only when a vehicle has positioned itself and the said vehicle is completely halted, and said "complete halt" condition to be translated to the robotic cell and the said translation to function as an electronic switch. Vehicle moving in and out of station can be controlled by known methods as employed by traffic lights.

[0053] The electronic sensors (infrared light) would have identified the presence of a container as the CCPM rolls into the station by identifying the corrugated nature of the walls, and the shape and size and distance of the container corner casting. In the event of specialised containers that employ only a canvas cover the robot will signal the overseeing personnel for a human instruction. Upon detecting a container

or getting a human input indicating the presence of a container, the robotic arm seeks by electronic means (infrared distance sensors and image capture technology) to zero in on the location of the corner casting of the subjected container and starts to resolve the relevant three axes (x, y, z) required for placement or detachment of IBC.

[0054] The three axes (or positioning) relevant to the other three corner castings can be determined in a default mode, by readings taken at a single corner casting or it can switch to an alternative second mode when necessary, to share the readings taken at the other 3 corner castings to arrive at a confirmation of the exact positioning of the container when irregularities compared to known geometry of ISO (compliant) containers are detected by the robotic cell.

[0055] One of the factors that can give rise to a wrong reading when using distant sensors is the accumulated damage suffered by the relevant scan area of the corner casting. A substantial dent in the aiming point of a distance sensor can delay the transmission of a correct reading. The system employed by our preferred embodiment goes a step further to select a second position to confirm an unstable reading. An unstable reading can be flagged by the system, indicating a need for confirmation and an instruction to its own guidance software to, match and relate, for example, with the readings taken of a diagonally opposite corner casting in relation to a given first corner casting that turns out an unstable reading or produces a reading which does not fit into the known geometry of the ISO container or the set-up of robotic station as a whole.

[0056] The matter described in the preceding paragraph does not limit us to employing any particular electronic gadget but, it is proof that human labour as an input can be substituted by utilising suitable electronic sensors in conjunction with the speed of a computer's calculation to successfully replaces the speed and flexibility of human mind and body.

[0057] At present quay cranes, vessels and port operations' centralised system communicate between themselves by electronic means to work in concert with regard to the freight manifest. The introduction of electronics into yet another aspect

of port operations and the availability of image capture and recognition devices can be extended to communicate with quay cranes if required.

[0058] The accompanying figures (Figs.) illustrate embodiments and serve to explain principles of the disclosed embodiments. It is to be understood, however, that these figures are presented for purposes of illustration only, and not for defining limits of relevant applications.

[0059] Fig. 1 illustrates a first wharf that is installed with fully automated devices for handling inter-box connectors;

[0060] Fig. 2 illustrates a second wharf that is installed with partially automated devices for handling inter-box connectors;

[0061] Fig. 3 illustrates a third wharf that is installed with partial and portable automated devices for double spreader operation;

[0062] Fig. 4 illustrates a spreader installed with two fully automated devices for handling inter-box connectors;

[0063] Fig. 5 illustrates a yard/waft transportation machine installed with a fully automated device for handling inter-box connectors;

[0064] Fig. 6 illustrates an ISO standard corner casting for the inter-lock connectors;

[0065] Fig. 7 illustrates an end effector for gripping an inter-box connectors via a bottom neck;

[0066] Fig. 8 illustrates a robotic arm with an end effector for mounting or dismounting inter-box connectors;

[0067] Fig. 9 illustrates a close up view of the robotic arm with the end effector of Fig. 8;

[0068] Fig. 10 illustrates a station with a robotic arm for lodging or dislodging inter-box connectors from a shipping container on a truck;

[0069] Fig. 11 illustrates six stations divided into two groups (three stations in each group), which are located on opposite sides of a truck with two shipping containers;

[0070] Fig. 12 illustrates four stations divided into two groups (two stations in each group), which are located on opposite sides of a truck with two shipping containers;

[0071] Fig. 13 illustrates a station with a robotic arm and an inter-box storage;

[0072] Fig. 14 illustrates a forklift carrying a station (a robotic arm on a platform);

[0073] Fig. 15 illustrates a site with trucks, shipping containers, stations and forklifts for operating a container shipping port;

5 [0074] Fig. 16 illustrates two different types of end effector tools (first and second end effector tools) for attaching to a robotic arm;

[0075] Fig. 17 illustrates end effectors (i.e. end effector tools) with tolerance attachments;

10 [0076] Fig. 18 illustrates a gearbox for storing inter-box connectors and a pick-place rack for holding the inter-box connectors;

[0077] Fig. 19 illustrates another site with multiple stations (i.e. cells) for mounting or dismounting inter-box connectors;

[0078] Fig. 20 illustrates a truck loaded with two shipping containers;

[0079] Fig. 21 illustrates components of two inter-box connectors respectively;

15 and

[0080] Fig. 22 illustrates a truck with a shipping container parked near a station for dismounting an inter-box connector.

20 [0081] Exemplary, non-limiting embodiments of the present invention(s) will now be described with references to the above-mentioned figures.

[0082] The simplest embodiment of the present invention(s) is an imaging system to be fitted on self-sufficient electro-mechanical robotic cells that would each replace one human operative typically assigned to carry out said works. Therefore, this application affords the divisibility of large and rigid machinery found in the prior art into simple and effective standalone operative cells and offers alternative highly flexible deployment of automation for container ports to maximize benefits from the technology.

30 [0083] The preferred embodiment, deployable as a port automated system is a collection of said single robotic cells which can be customized into automated twist-lock handling stations that can be isolated as depicted in Fig. 1 from the container vessel berths or situated according to the peculiar arrangement of a given port. Variations in port setting can be due to traffic volume, port infrastructure and

preferred method of deployment. Varying needs of individual ports can employ this application in different configurations as depicted by the variations in Figs. 1, 2 and 3.

[0084] The application, either as a single cell or a station of multiple cells, while best suited to CCPM operations can also be adapted to suit other systems such as buffer cranes and straddle carrier operations. The application can also be fitted to quay cranes (as in Fig. 4), spreaders and transportation equipment such as trailers and straddle carriers. Incremental automation, remote stations, portable stations adapted to multi lifting setups such as double spreader and four spreader operations are also possible. The robotic arm fitted to a CCPM is depicted in Fig. 5. The mounting of the application on quay crane spreaders can further critically impact upon berthing operations as the robotic systems can also perform the on board action necessary to discharge containers. This is an especially qualitative use of the technology to be beneficially exploited in berthing operations, otherwise stevedores have to perform the task of unlocking the twist-locks while dangerously positioned on container top at heights normally exceeding ten metres.

[0085] As said earlier, accurate positioning of the container on trucks (even with mechanical guides such as humps or troughs to help the driver position the vehicle) is likely to present a challenge. It is necessary to include indexing devices that seek out the target within a narrowed (by e.g. humps) space range. Present embodiment of the indexing system relies on the standard geometric features offered by ISO standard container corner castings depicted in Fig. 6. Other means of indexing such as the use of magnetism, mechanical sensors or sonic means can also achieve the desired capture of the container position that is necessary to feedback to the multi-axis robotic arm to then transport the end effector to the necessary location accurately. Future embodiments of this technology that is similar to scanning distinctive features of targets can also detect variations in heat, presence of radiation, chemical leakages and damages to the container. As such the opportunity is offered for the inclusion of such capabilities in the remote twist-lock station as envisaged by the inventors.

[0086] The end effector (Fig. 7) currently works with separate devices for respectively, gripping the twist-lock by the bottom neck (which universally conforms

to ISO corner casting dimensions), and twisting the bottom cone of the twist-lock which inserts into the top corner casting slot of the container below. Given the separate devices used in combination, plus the ability of the indexing device to read the geometric features of the twist-lock, the application can also pick up twist-locks placed in an unplanned orientation (e.g. from a heap in a bin normally used by the vessel owner to store them).

[0087] It is also possible to integrate the clamping and twisting functions into one device (such as a pneumatic rotary actuator) by the use of cam profiles included onto the clamping parts that get compressed as the mating features attached to the rotary actuator acts on the relevant profile of the clamping parts as the rotary actuator twists the bottom cone.

[0088] It must also be noted that the present embodiment was designed with a view to include interchangeable end effectors to suit different model twist-locks, as is the situation with container handling operations.

[0089] The preferred embodiment of the application assumes the preference for the use of CCPM over traditional two – step loading / discharge cycle for which a cradle system is prescribed by the prior art citations. The involvement of a cradle would mean predetermined positions of corner fittings upon placement of freight container on said cradle, thereafter mechanical arms or spring loaded systems proceeding with their tasks in predetermined rigid fashion. Having justified the need for more efficient management of time and assets, this application suggests bypassing the intermediate step of placement onto a cradle by, direct placement onto transport vehicles and automation of the location, identification and engagement of IBC by employing a robotic station that does all the said 3 tasks in a matter of seconds by employing a set of sensors in individual actuation arms. The robotics employed in this aspect of yard operations, not only stands in for the stevedores, but is also able to observe and identify the random nature of the relevant variables and automatically prescribe itself, an appropriate action that is to be executed next, based on a combination of analogue and digital readings and calculations. The sensors can be based on infrared, sound detection, light detection, heat detection or image capture

and identification technology that combine to function with the known geometric configuration of ISO freight containers.

[0090] CCPM were designed as such, to accommodate their cargo with the corner fittings exposed for access by human operatives to either install twist locks upon the container (for loading onto the vessel) or to remove twist locks (during vessel discharging operations). The investment already made on this mode of transport is substantial. The introduction of direct receipt sequence from quay cranes will further optimise the investment if a given yard is working with excess capacity, as the hourly rate of the quay crane increases - referring to the absolute number of containers handled - coupled with the robotic system handling the twist-locks. A yard already working at optimum level employing the cradle system will experience a higher optimum level if it makes a switch to this non-cradle sequence and applies the said robotic features.

[0091] The innovative inclusion of recognition technology enables the familiar multi-axis industrial robot to be deployed as a remote robotic station that automates IBC handling in operations involving CCPM. The CCPMs, upon receiving freight containers from the lifting machines (e.g. quay cranes, straddle carriers, container forklifts) allow IBC operations (either by automated means or by 'hand') independent of lifting machine involvement. This is of critical value for port operators especially where it concerns the quay crane as the CCPM allow the dedication of the quay crane spreader to only the loading and discharging of the container vessel thus speeding up the quay crane cycle by far. Cradle based systems of the prior art, while implying a safer working environment, also demand a proportionate regression to the working speed of pre-CCPM days as they are not compatible with CCPM. Given the highly dangerous nature of dock work (especially involving the installation and removal of IBC amidst large moving machines), it is inevitable that the human operative is gradually phased out in favour of automated means of handling IBC. However, all devices of the prior art have to date failed to keep pace with the fast improving (in operational speed terms) lifting technology which all ports are heavily investing into. The present application ideally complements the use of CCPM, which is a clear advantage over traditional two - step loading / discharge cycles. The use of CCPM is unlikely to be given up by major ports that have invested heavily in them.

The different dimensions of individual vehicles, the different models, the different modes (AGV or CCPM), tyre sizes, non-level ground, and individual driver error can, in total, pose a vast combination of corner fitting positions that require a machine to sense these variations when the ' human stevedore ' is phased out for safety reasons.

[0092] Yet another benefit of employing the application described by this application is the transfer of substantial work away from the docking area that contribute to neat and organised dock operations. Once the CCPM are loaded they would immediately proceed out of the docking area which will definitely contribute to transshipment hubs that are experiencing space constraints due to rapidly growing international trade. The subsequent tasks applicable to each container's sequence movement will be transferred to lower expense equipment like straddle carriers which do not incur berthing charges for the ship and in turn allow the port to handle an increased number of vessels in a given day. The application of this application increases productivity by increasing the rate of turnover and attaining lower costs from multiple aspects as for the port and the vessel owner and yet also having stepped up to provide and maintain a safer workplace.

[0093] The said remote station can be a separate "hangar" type of building or it can be portable to be fitted into urgent high intensity situations like double spreader or quad spreader operations. As such the robotic system so configured can be portable to be pressed into service where and when required by trailers or forklifts. This is made possible by the weatherproof construction of the system with additional provisions to withstand the marine environment.

[0094] Otherwise (without the mechanical gravity assisted orientation of the container) the installation / removal components would require far more ability to sense the position of the container corner casting than mentioned in the prior art. Inevitably then, all proposed equipment in the prior art relies on the involvement in operation of a lifting equipment to settle the container onto a platform that is a component of the installation removal system before twist-lock installation or removal operation and thereafter to pick up the container for transportation to the yard or loading to the vessel.

[0095] In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, non-explicitly recited elements.

[0096] As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

[0097] Throughout this disclosure, certain embodiments may be disclosed in a range format. The description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0098] It will be apparent that various other modifications and adaptations of the application will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the application and it is intended that all such modifications and adaptations come within the scope of the appended claims.

Reference Numerals

	50	device
	52	inter-box connector
5	54	indexing means
	56	manipulation means
	58	transportation means
	60	camera
	62	distance reader
10	64	gripper
	66	twister
	68	position sensor
	70	cone
	72	robot controller
15	74	robotic arm
	76	end effector
	78	mounting holes
	80	station
	82	inter-box storage
20	84	dismounted inter-box connectors
	86	floor
	88	perforations
	90	platform
	92	shipping port
25	94	shipping container
	96	holder
	98	open area
	100	box
	102	spreader
30	104	group
	106	frame
	108	hoisting mechanism
	110	wharf transportation vehicle
	112	frame

- 120 method
- 122 providing
- 124 adding
- 126 connecting
- 5 128 presenting
- 130 mounting
- 132 site
- 134 offer
- 142 generator and compressor
- 10 144 CCPM
- 146 corner-less chassis
- 148 traffic control system
- 150 double humps to position vehicle
- 152 permanent fixtures on road for deployment
- 15 154 removable concrete blocks to prevent vehicle from damaging robots
- 156 robot module with a 35mm steel plate base
- 158 3-ton forklift
- 160 storage module
- 162 first end effector
- 20 164 second end effector
- 166 deck twist-lock
- 168 hatch cone
- 169 midlock
- 170 midlock end effector
- 25 172 quick change coupling system
- 174 deck and hatch (twist-type) end effector
- 176 tolerance attachment with snap off construction to protect robotic arm if truck moves when an end effector engages a container corner casting
- 178 pick and place rack
- 30 180 gearbox from vessel containers filled with IBCs
- 182 centre corner castings
- 184 trailer with two shipping containers
- 186 midlock
- 188 hatch cone

190 deck twist-lock

192 site with a robotic arm

Claims

1. Device (50) for handling an inter-box connector (52), the device (54) comprising:
5 Indexing means (54) for identifying positions of the inter-box connector (52) automatically,
Manipulation means (56) for mounting or dismounting the inter-box connector (52), and
Transportation means (58) connected to both the indexing means (54) and
10 the manipulation means (56) for moving the manipulation means (56) to the identified positions of the inter-box connector (52).
2. The device (50) of Claim 1, wherein
The indexing means (54) comprises a camera (60) for perceiving and
15 analysing the inter-box connector (52).
3. The device (50) of Claim 1 or 2, wherein
The index means (54) further comprises a distance reader (62) for detecting
the positions of the inter-box connector (52).
20
4. The device (50) of any of the preceding Claims, wherein
The manipulation means (56) comprises a gripper (64) for holding the inter-box connector (52) and a twister (66) for rotating the inter-box connector (52).
- 25 5. The device (50) of Claim 4, wherein
The gripper (64), the twister (66), or both of them (64, 66) are pneumatically powered.
6. The device (50) of any of the preceding Claims, wherein
30 The manipulation means (56) further comprises a position sensor (68) for determining a cone (70) of the inter-box connector (52).
7. The device (50) of any of the preceding Claims, wherein

The indexing means (54) and the manipulation means (56) are installed together such that the transportation means (58) is configured to move the indexing means (54) and the manipulation means (56) simultaneously.

- 5 8. The device (50) of any of the preceding Claims, wherein
The indexing means (54), the manipulation means (56) and the transportation means (58) are connected to a robot controller (72) such that the device (50) becomes a robotic arm (74).
- 10 9. The device (50) of Claim 8, wherein
The robot controller (72) is configured to analyse images of inter-box connectors received by the camera (60) for differentiating various types of inter-box connectors (52)
- 15 10. The device (50) of Claim 8, wherein
the manipulation means (56) comprises an end effector (76) of the robotic arm (74).
- 20 11. The device (50) of any of the preceding Claims, wherein
The indexing means (54) is fault-tolerant that the device (50) is configured to detect mounting holes (78) on an Intermodal freight container (80) with various orientations, angles, distances, lighting conditions or a combination of any of these conditions.
- 25 12. Station (80) for handling an inter-box connector (52) comprising:
The device (50) according to any of the preceding claims; and
A platform (90) for mounting the device (50).
- 30 13. Station (80) of Claim 11, wherein
The platform (90) comprises an open area (98) for receiving a box (100) or inter-box connectors (52).
14. The station (80) of Claim 11 or 12 further comprising
A holder (96) for transporting the station (80).

15. The station (80) of Claim 14, wherein
The holder (96) comprises two slots (98) for receiving forks (100) of a forklift (102).

5

16. The station (80) of any of the Claims 13 to 15 further comprising
An inter-box storage (82) for receiving dismounted inter-box connectors (84).

10

17. The station (80) of Claim 11, wherein
The storage (82) comprises at least one floor (86) with perforations (88) for holding the dismounted inter-box connectors (84).

15

18. The station (80) of Claim 17, wherein
The perforations (88) of the at least one floor (86) are placed in close proximity such that dismounted inter-box connectors (84) of neighbouring perforations (88) provides about 100 millimetres distances between cones (70) of the dismounted inter-box connectors (84).

20

19. A shipping port (92) for handling shipping containers (94) comprising:
The device (50) according to any of the Claims 1 to 10.

25

20. The shipping port (92) of Claim 19 comprising
Two of the devices (50) that face each other with a distance in-between for allowing a shipping container (94) passing through in-between.

30

21. The shipping portion (92) of Claim 19 or 20 comprising
Four of the devices (50) that are separated into two groups (104) placed on opposite sides for allowing a shipping container (94) passing through in-between the two groups (104).

22. The shipping port (92) of any of the Claims 19 to 21 comprising
Six of the devices (50) that are separated into two groups (104) placed on opposite sides for allowing a shipping container (94) passing through in-between the two groups (104).

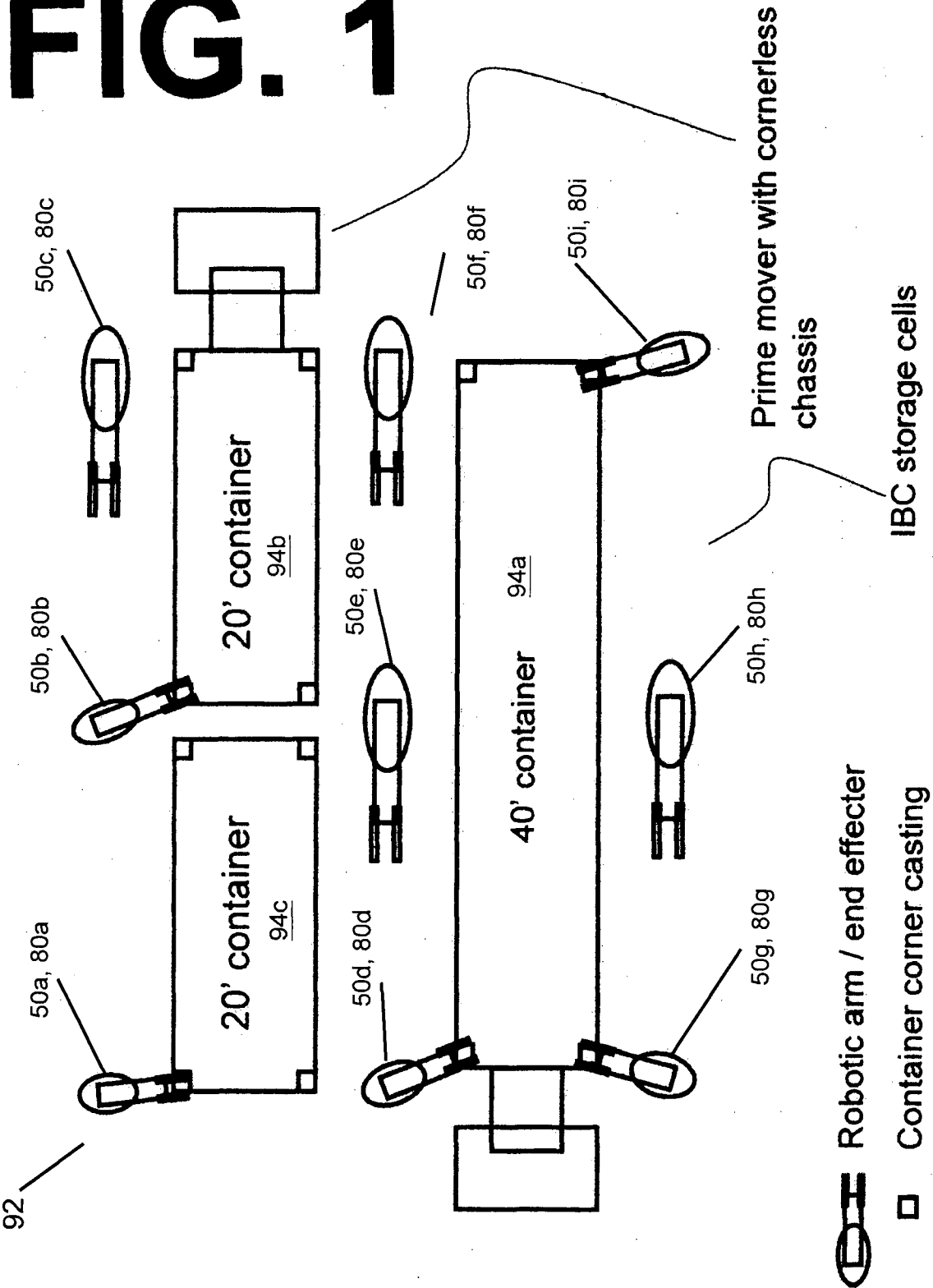
23. The shipping port (92) of any of the preceding Claims 19 to 21 comprising
The station (80) according to any of the Claims 12 to 18.
- 5 24. The shipping port (92) of Claim 23 comprising
Two of the stations (80) that face each other with a distance in-between for
allowing a shipping container (94) passing through in-between them (80).
- 10 25. The shipping port (92) of Claim 23 or 24 comprising
Four of the stations (80) that are separated into two groups (104) placed at
opposite sides for allowing a shipping container (94) passing through in-
between the two groups (104).
- 15 26. The shipping port (92) of any of the Claims 23 to 25 comprising
Six of the stations (80) that are separated into two groups (104) placed on
opposite sides for allowing a shipping container passing through in-between
the two groups (104).
- 20 27. A spreader (102) for lifting shipping containers comprising:
Hoisting mechanism (108) on a frame (106) of the spreader (102) for lifting
the spreader (102); and
The device (50) according to any of the preceding Claims 1 to 11.
- 25 28. A wharf transportation vehicle (110) comprising:
A frame (112) for supporting a shipping container (94) and
The device (50) according to any of the preceding Claims 1 to 11 at an end
(114) of the frame (112) for handling inter-box connectors (52).
- 30 29. Method (120) of making a device (50) for handling an inter-box connector (52),
the method (120) comprising:
Providing (122) an indexing means (54) for identifying positions of the inter-
box connector (52) automatically,
Adding (124) a manipulation means (56) for mounting or dismounting the
inter-box connector (52), and

Connecting (126) a transportation means (58) to both the indexing means (54) and the manipulation means (56) for moving the manipulation means (56) to the identified positions of the inter-box connector (52).

- 5 30. Method (120) of installing a device (50) for handling an inter-box connector (52), the method (120) comprising:
- Presenting (128) the device (50), the device (50) comprising:
 - 10 o Indexing means (54) for identifying positions of the inter-box connector (52) automatically,
 - o Manipulation means (56) for mounting or dismounting the inter-box connector (52), and
 - o Transportation means (58) connected to both the indexing means (54) and the manipulation means (56) for moving the manipulation means (56) to the identified positions of the inter-box connector (52);
 - 15 and
 - Mounting (130) the device (50) at a site (132) for handling inter-box connectors (52).
- 20 31. Method of using a device (50) for handling an inter-box connector (52), the method (120) comprising:
- Offering (128) the device (50), the device (50) comprising:
 - 25 o Indexing means (54) for identifying positions of the inter-box connector (52) automatically,
 - o Manipulation means (56) for mounting or dismounting the inter-box connector (52), and
 - o Transportation means (58) connected to both the indexing means (54) and the manipulation means (56) for moving the manipulation means (56) to the identified positions of the inter-box connector (52);
 - and
 - 30 - Installing or removing an inter-box connector (52) from a shipping container (94).

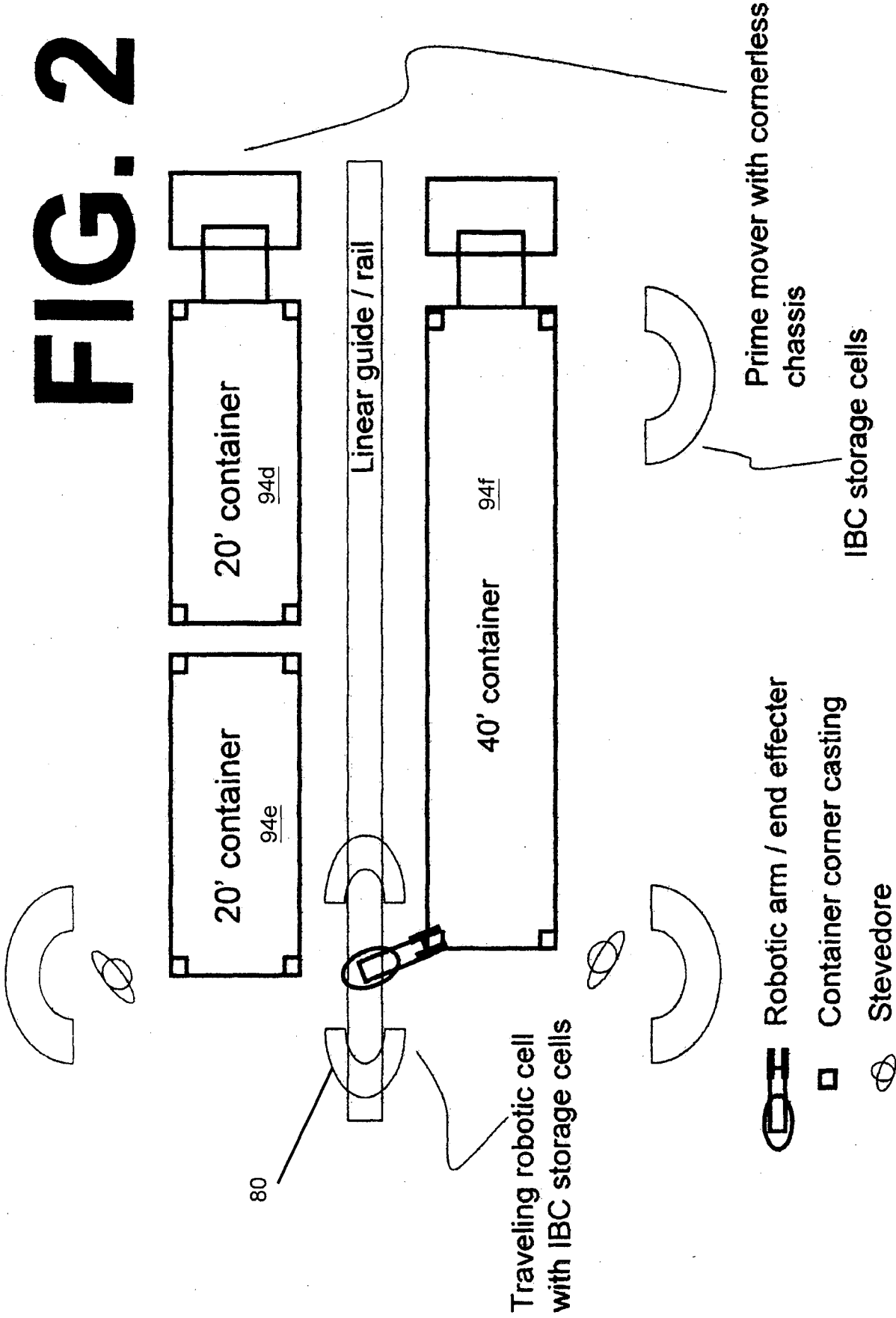
FIG. 1

FULLY AUTOMATED REMOTE STATION

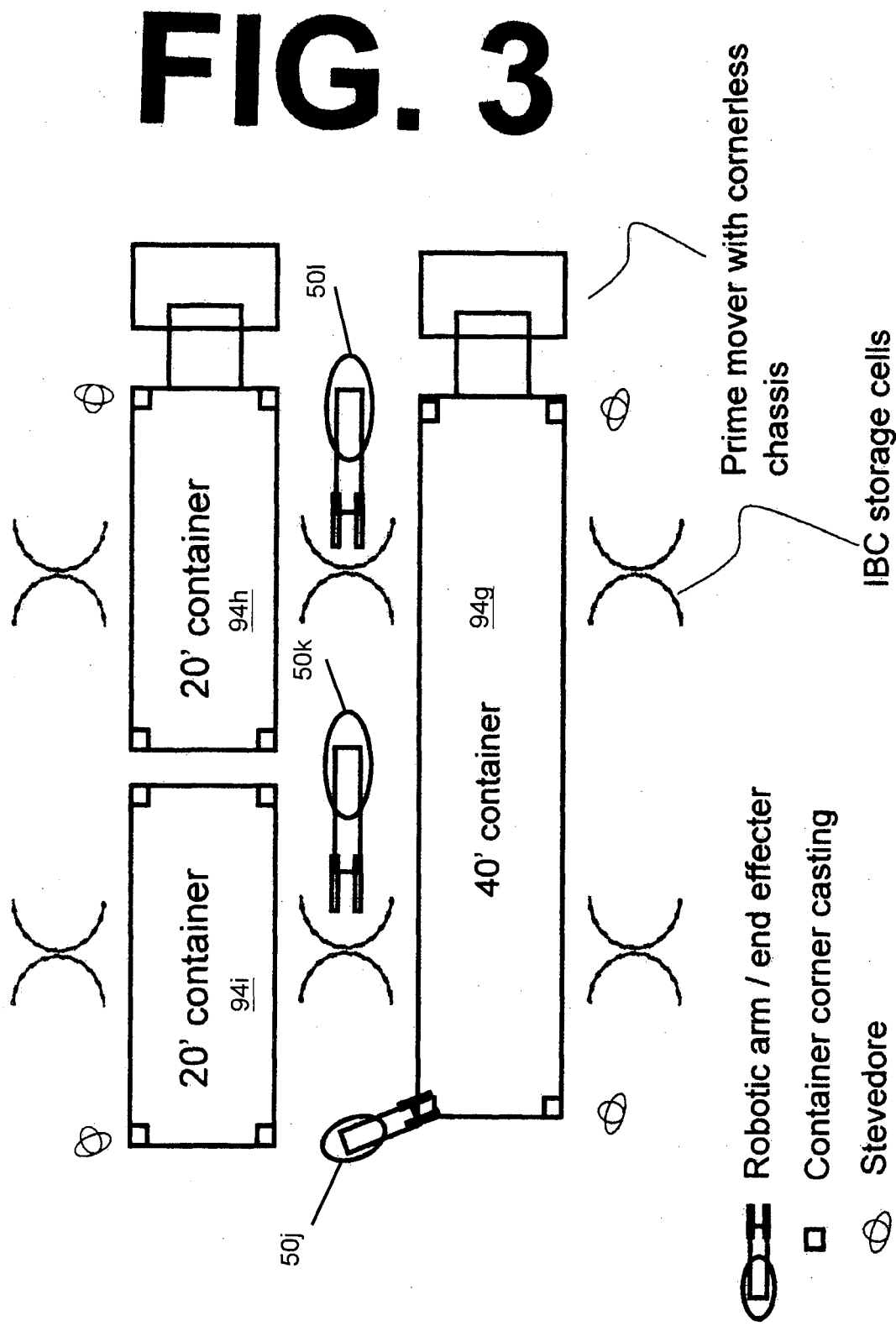


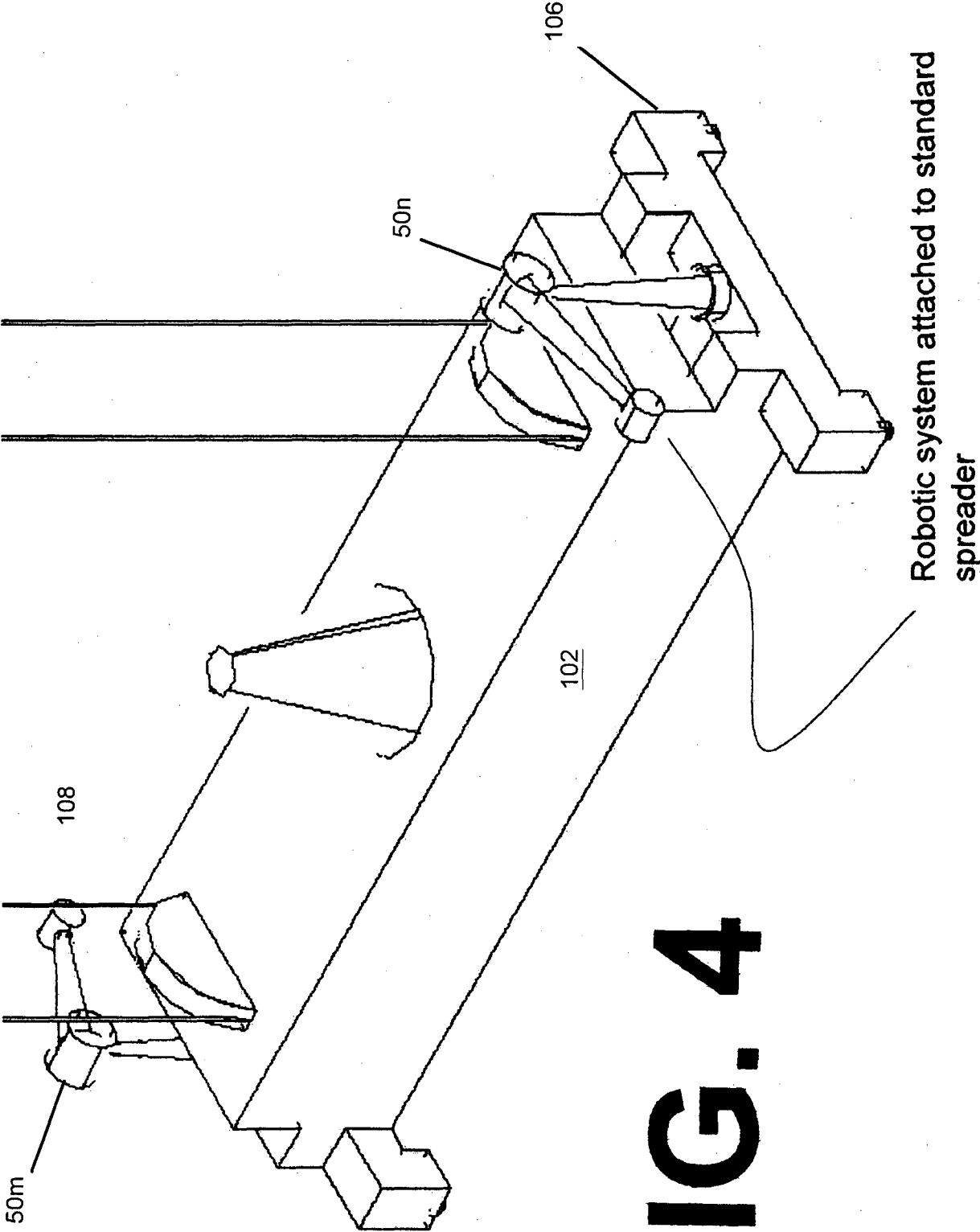
LIGHT INTENSITY PARTIAL AUTOMATED REMOTE STATION

FIG. 2



**PARTIAL & PORTABLE AUTOMATED STATION
SUITABLE FOR DOUBLE SPREADER OPERATION**





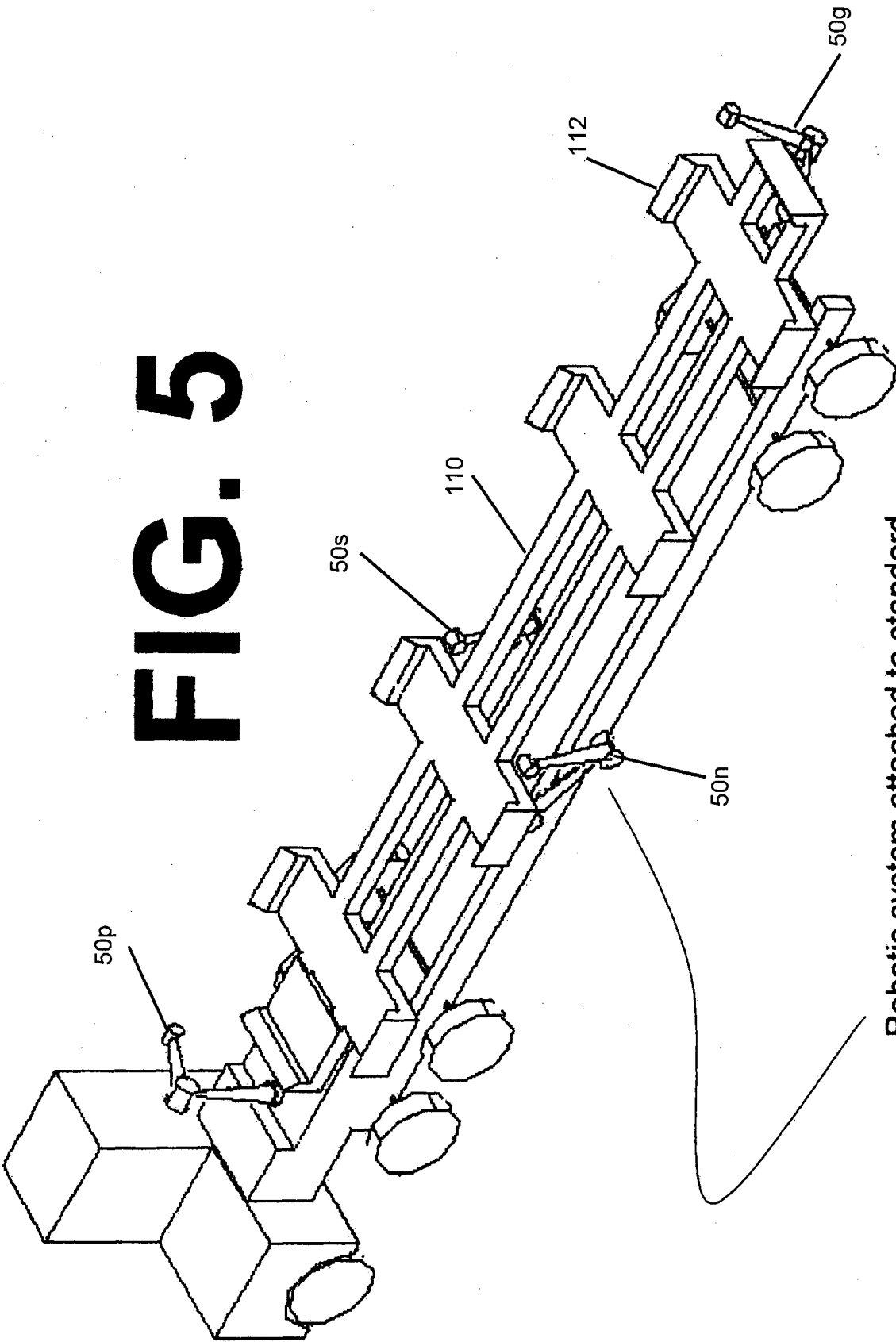


FIG. 5

Robotic system attached to standard
yard / wharf transportation machine

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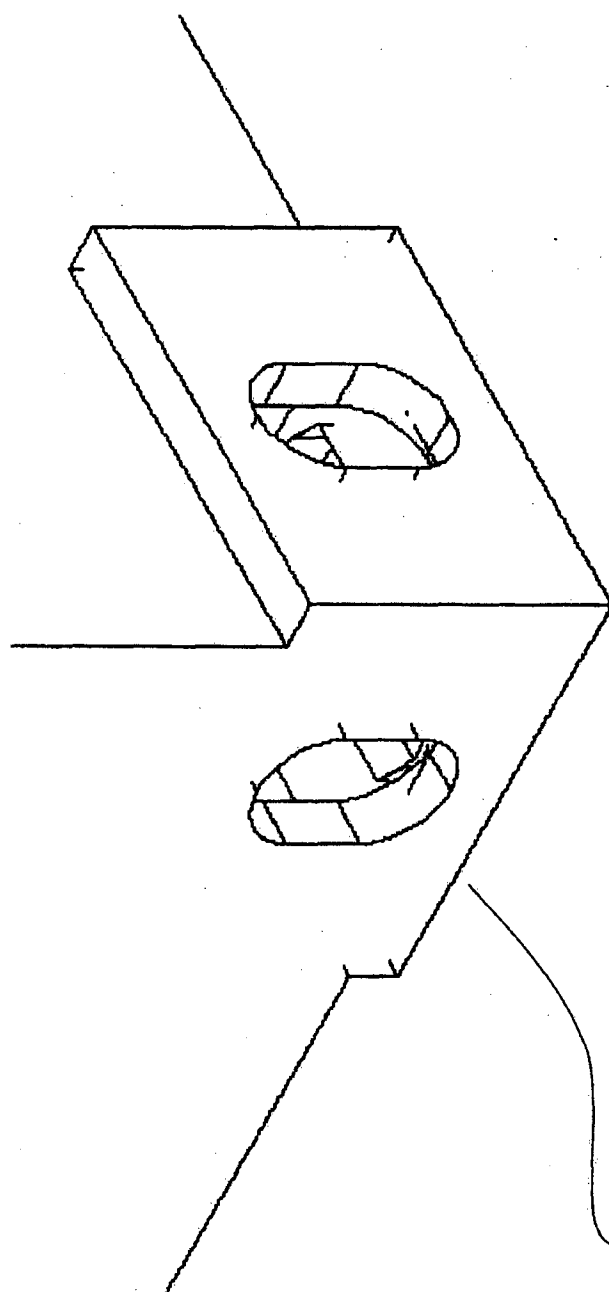


FIG. 6

ISO standard corner casting

FIG. 7

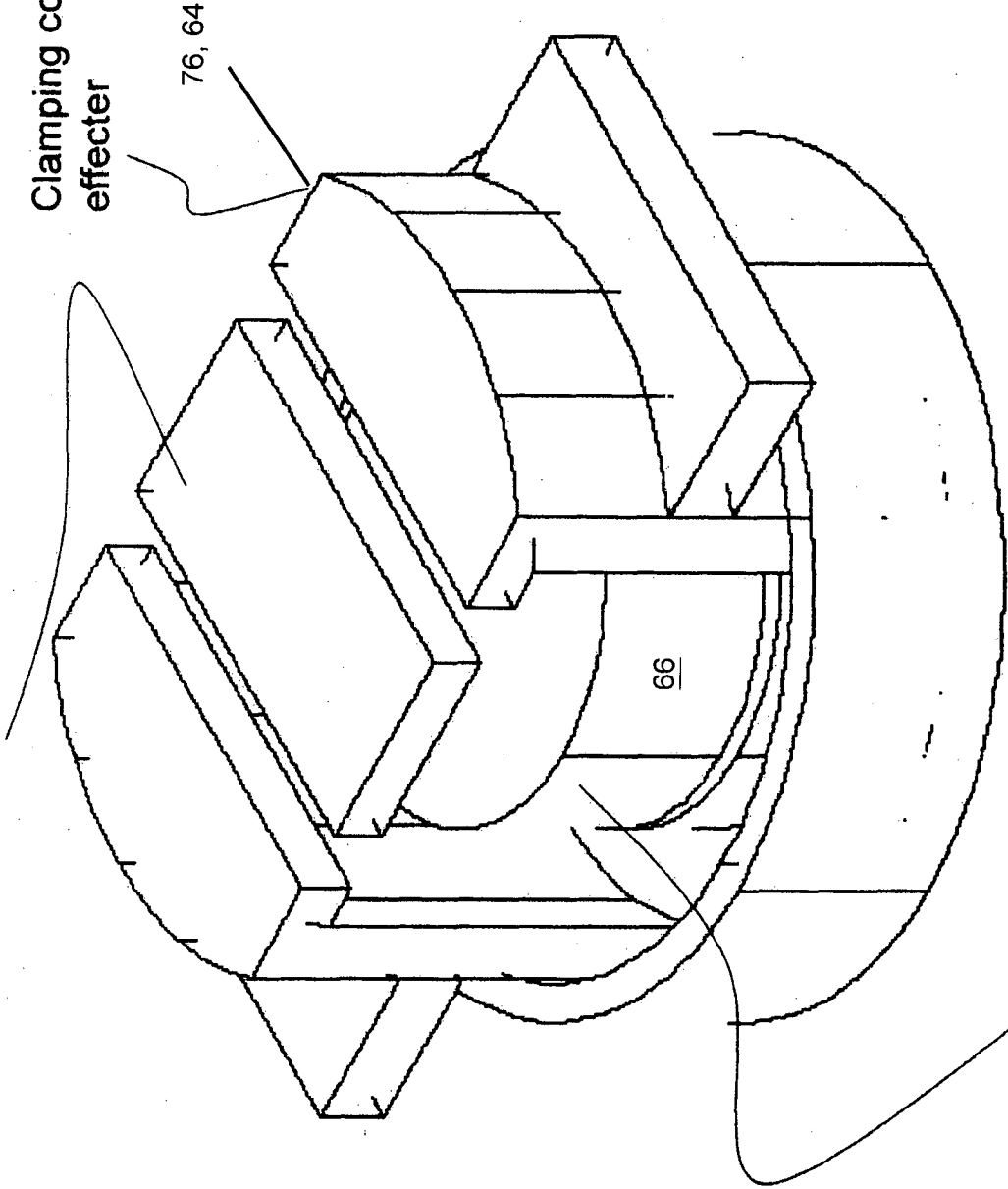
Bottom neck of IBC matching
ISO standard corner casting

Clamping component of end
effector

76, 64

66

Turning component of end effector to twist bottom cone



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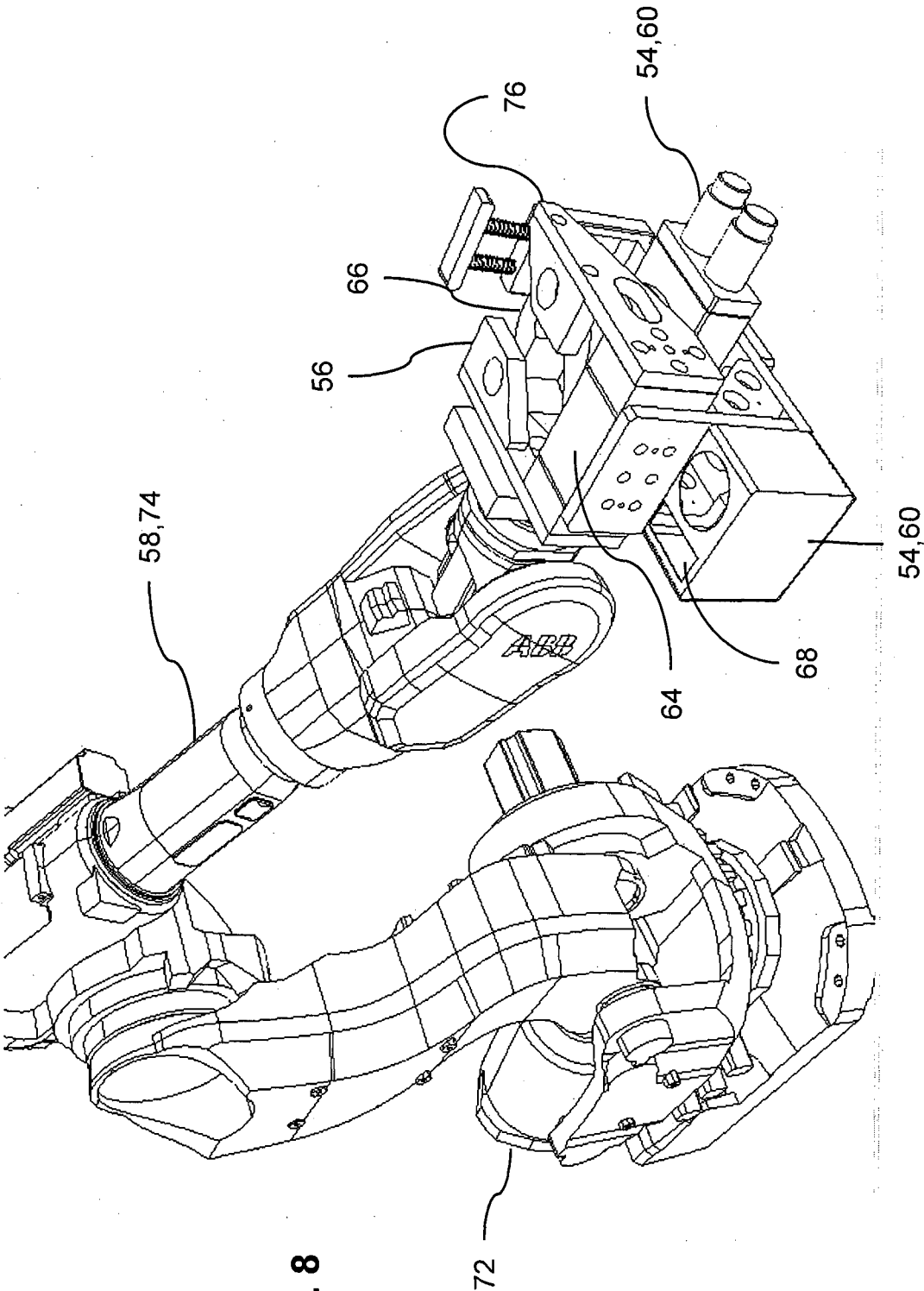


Fig. 8

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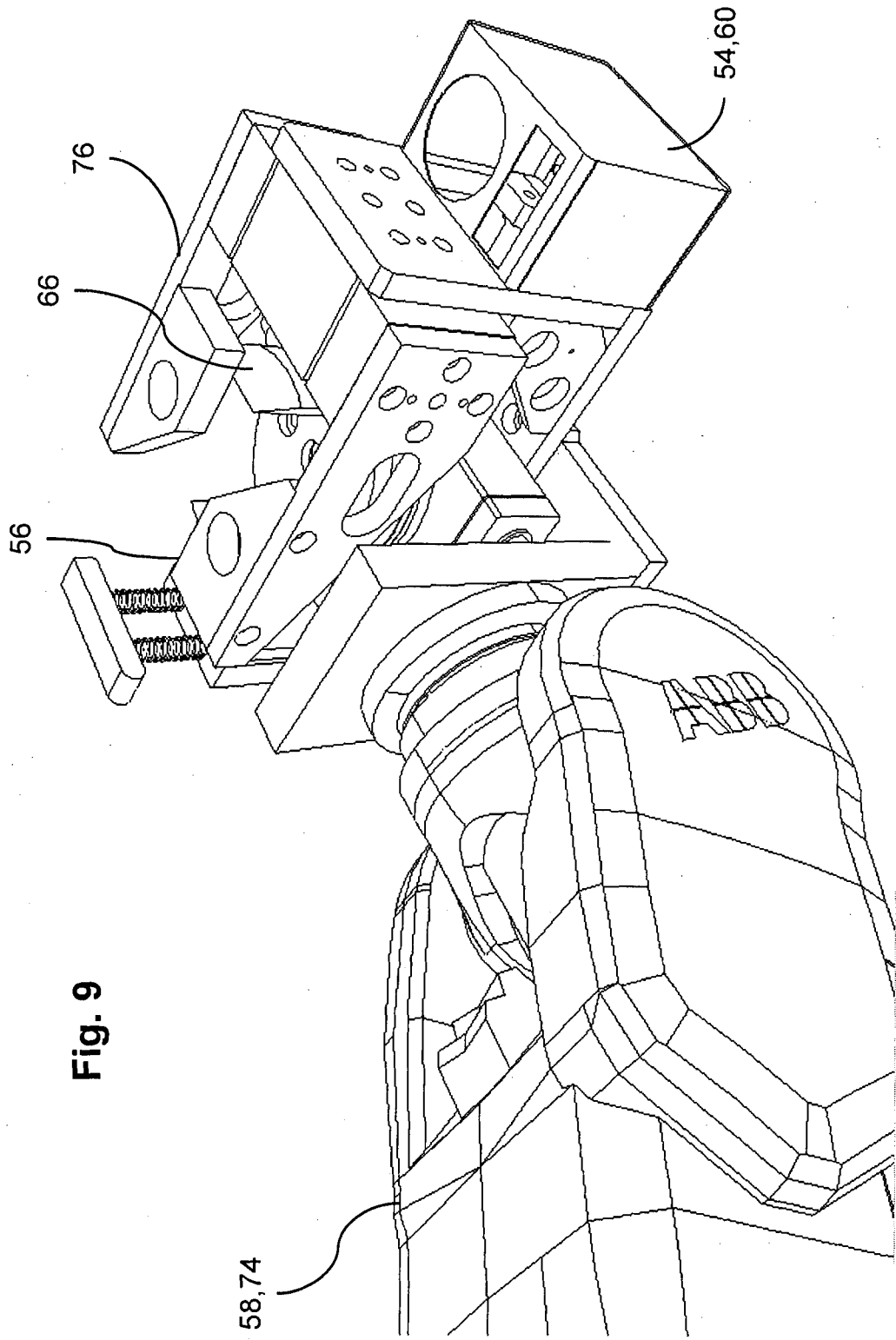


Fig. 9

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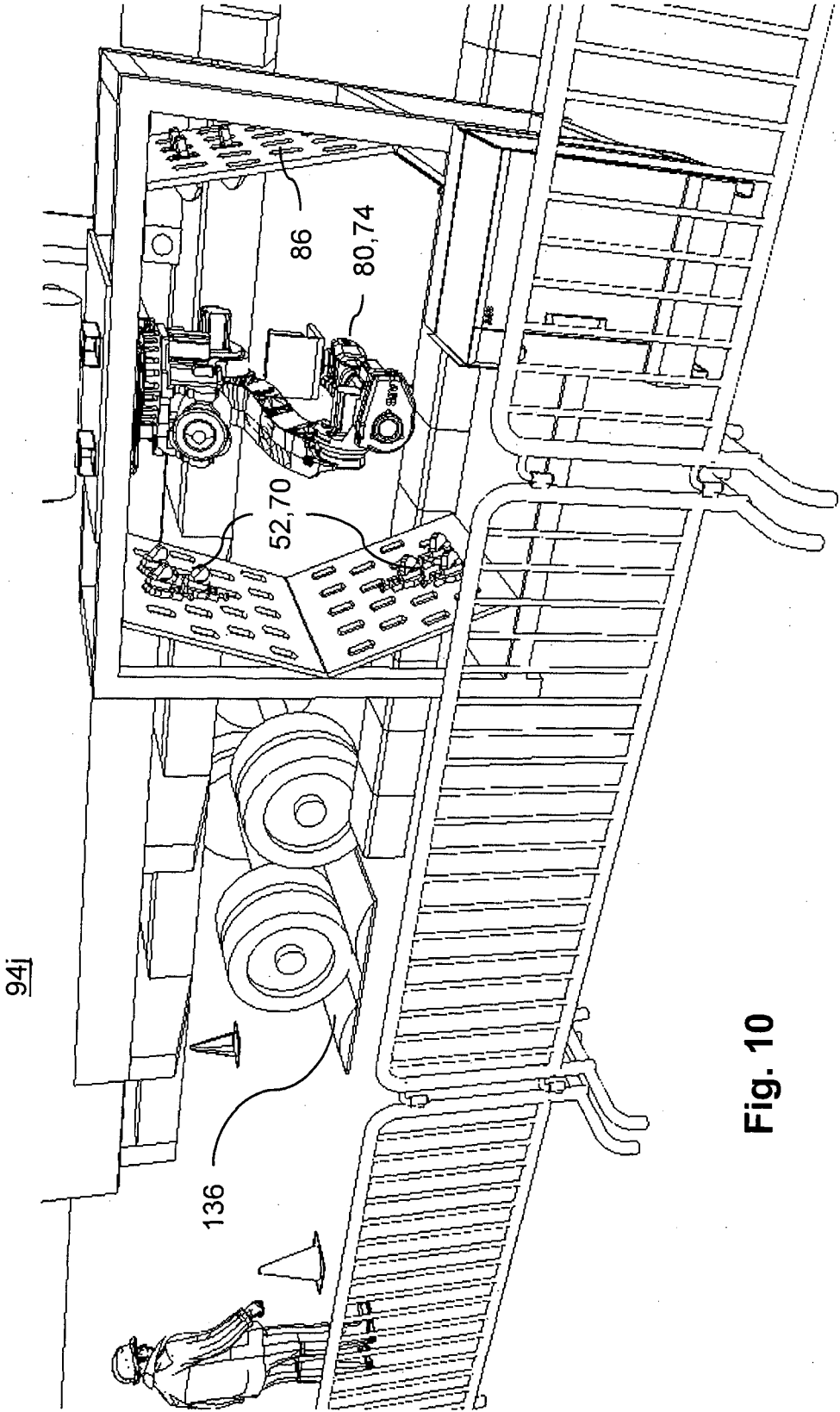


Fig. 10

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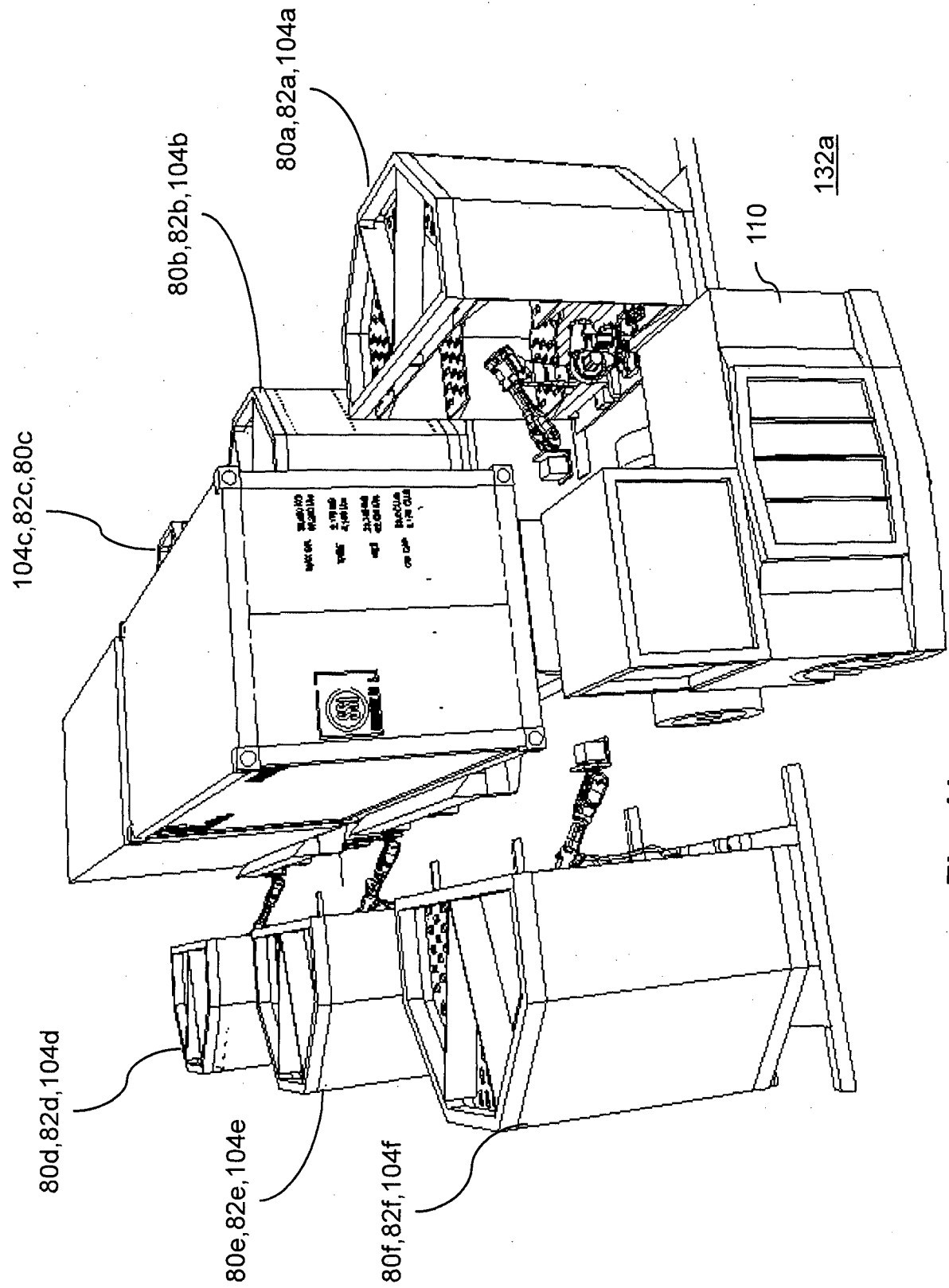


Fig. 11

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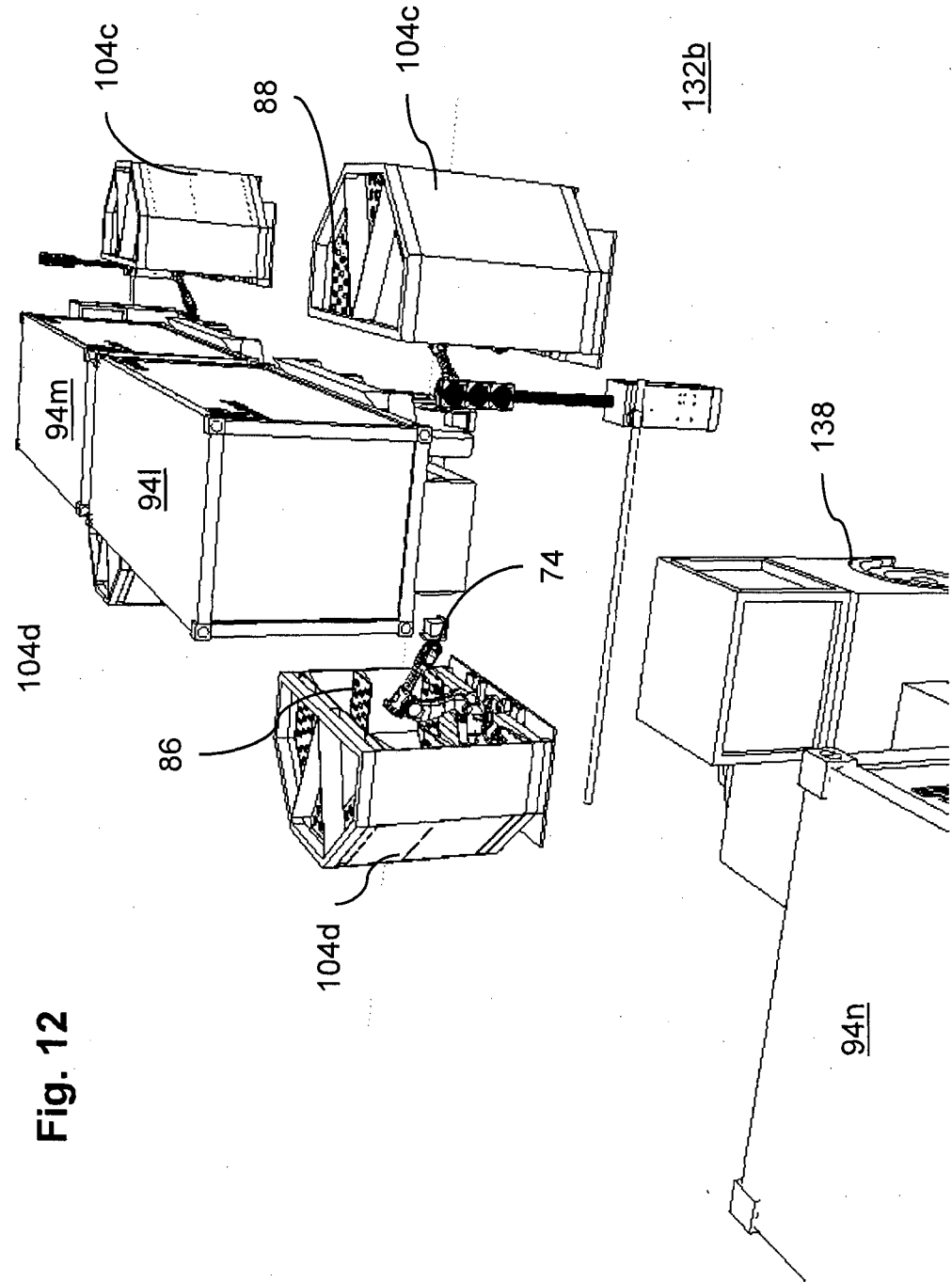


Fig. 12

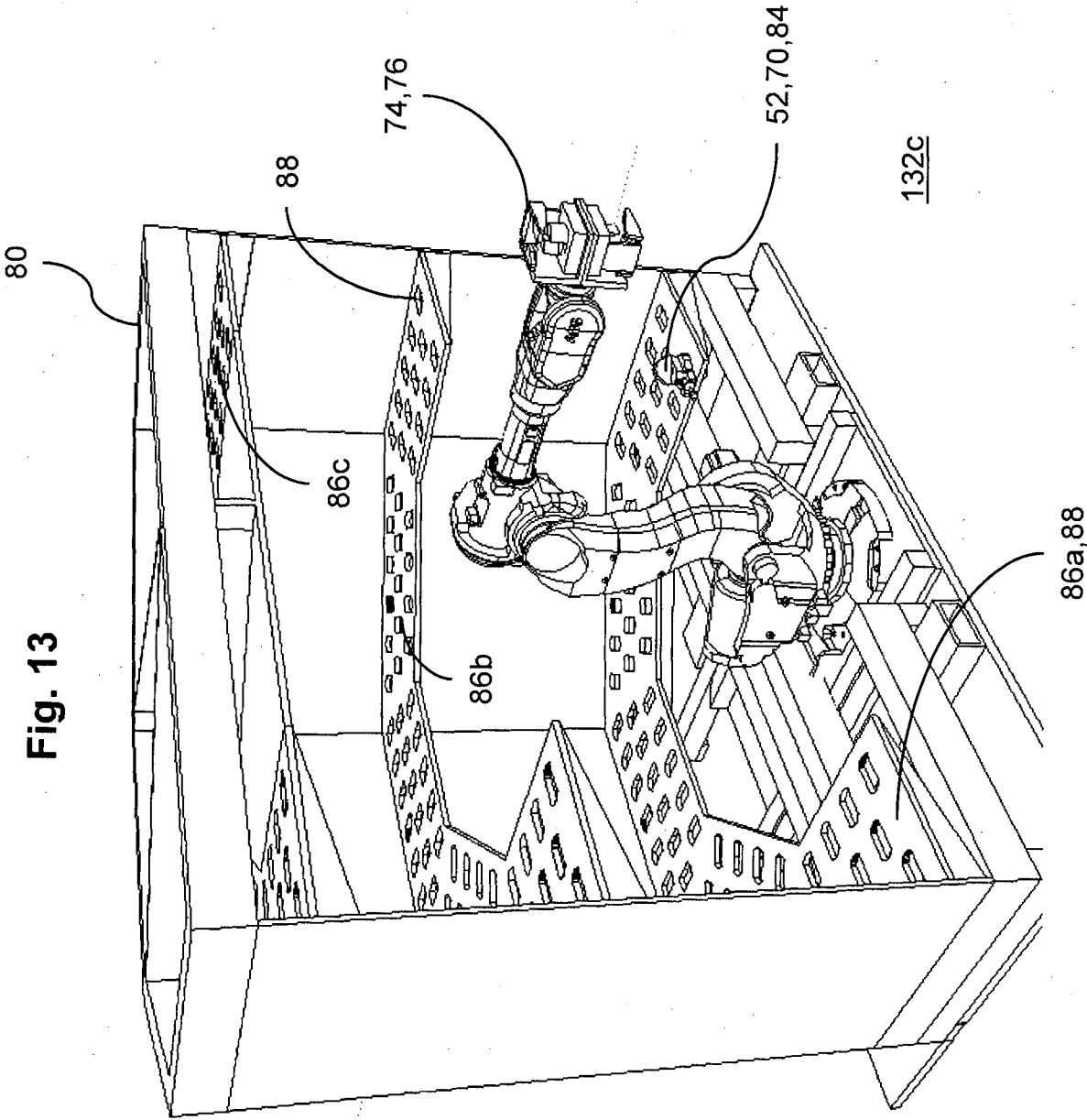
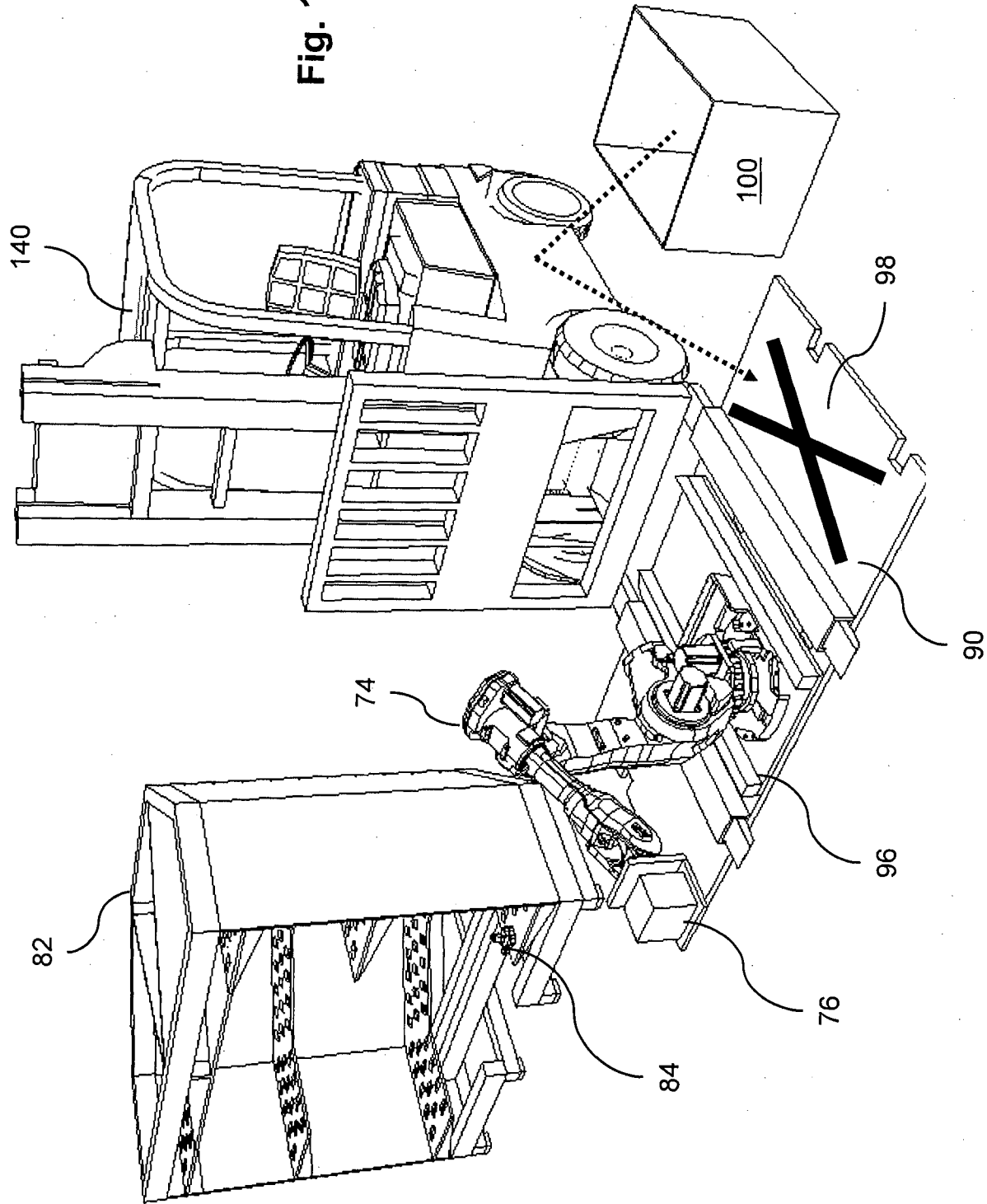


Fig. 14



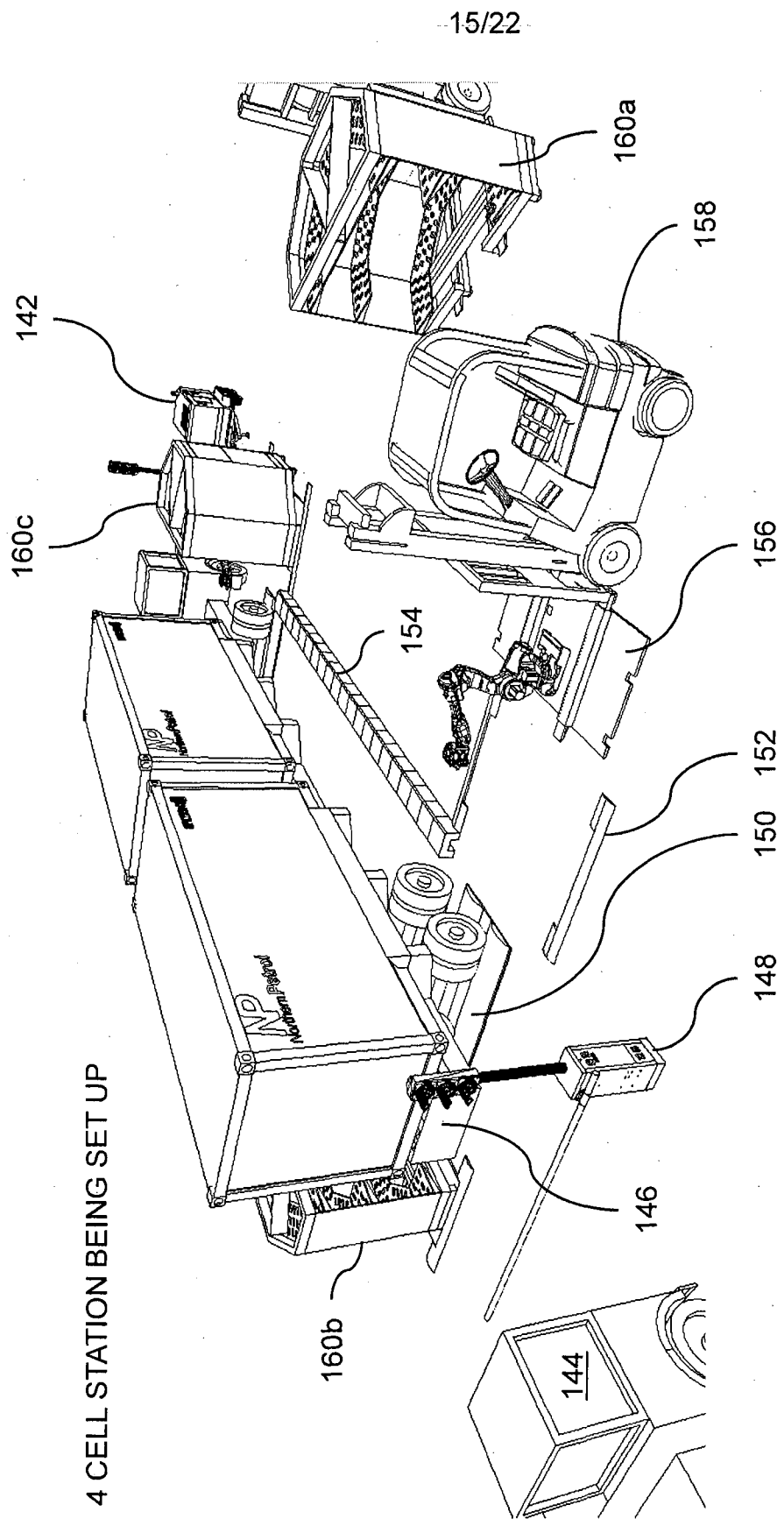


Fig. 15

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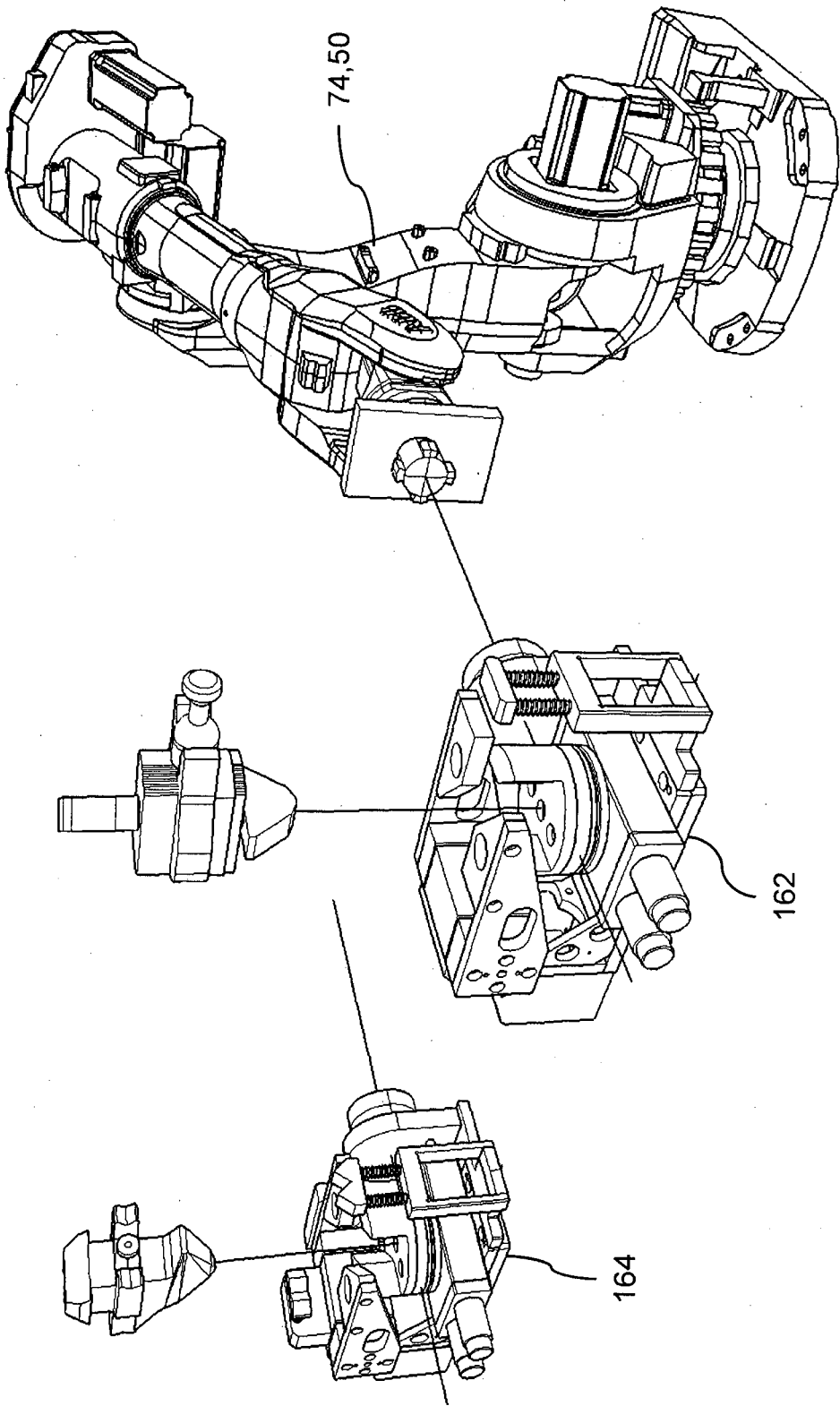


Fig. 16

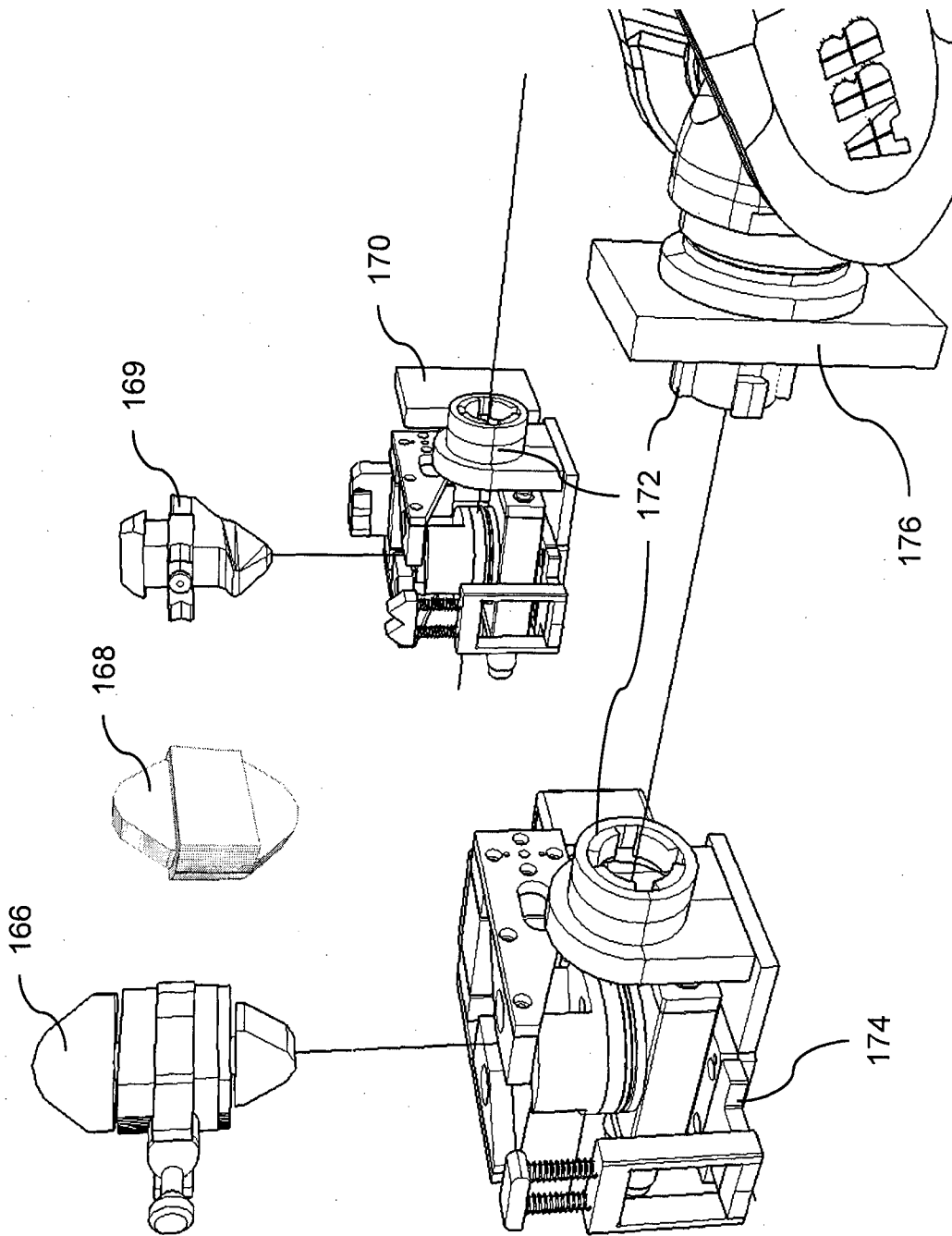


Fig. 17

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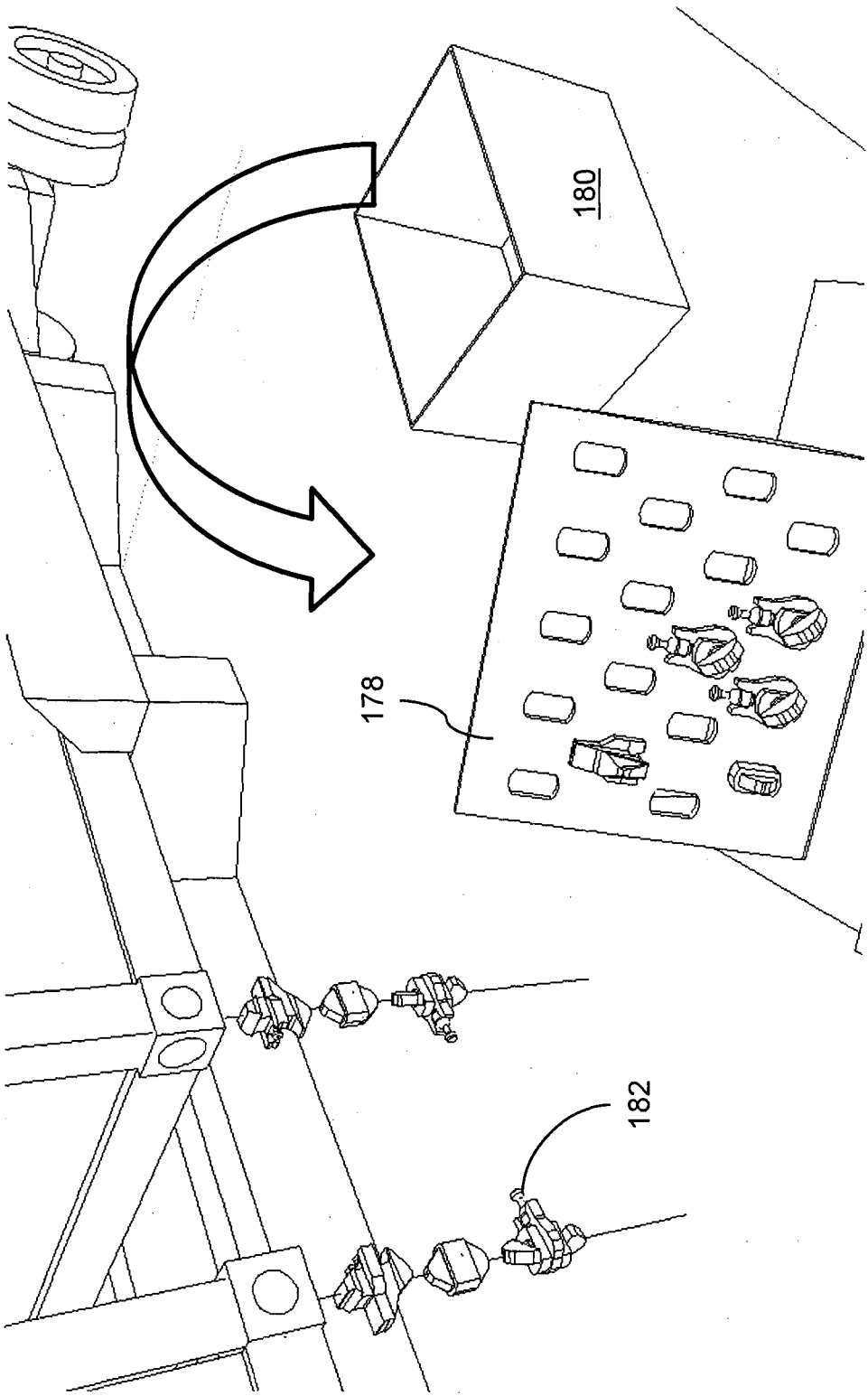


Fig. 18

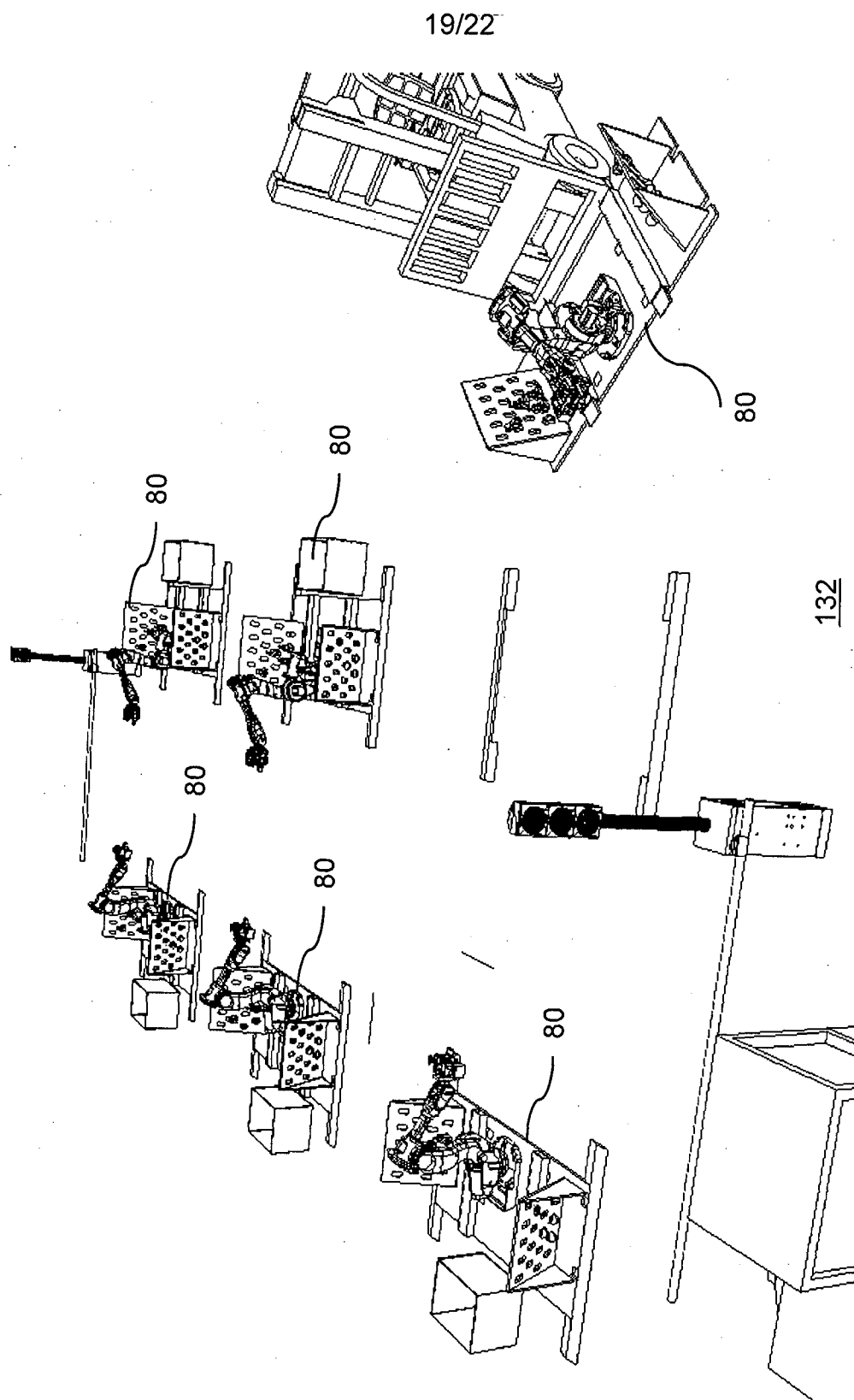


Fig. 19

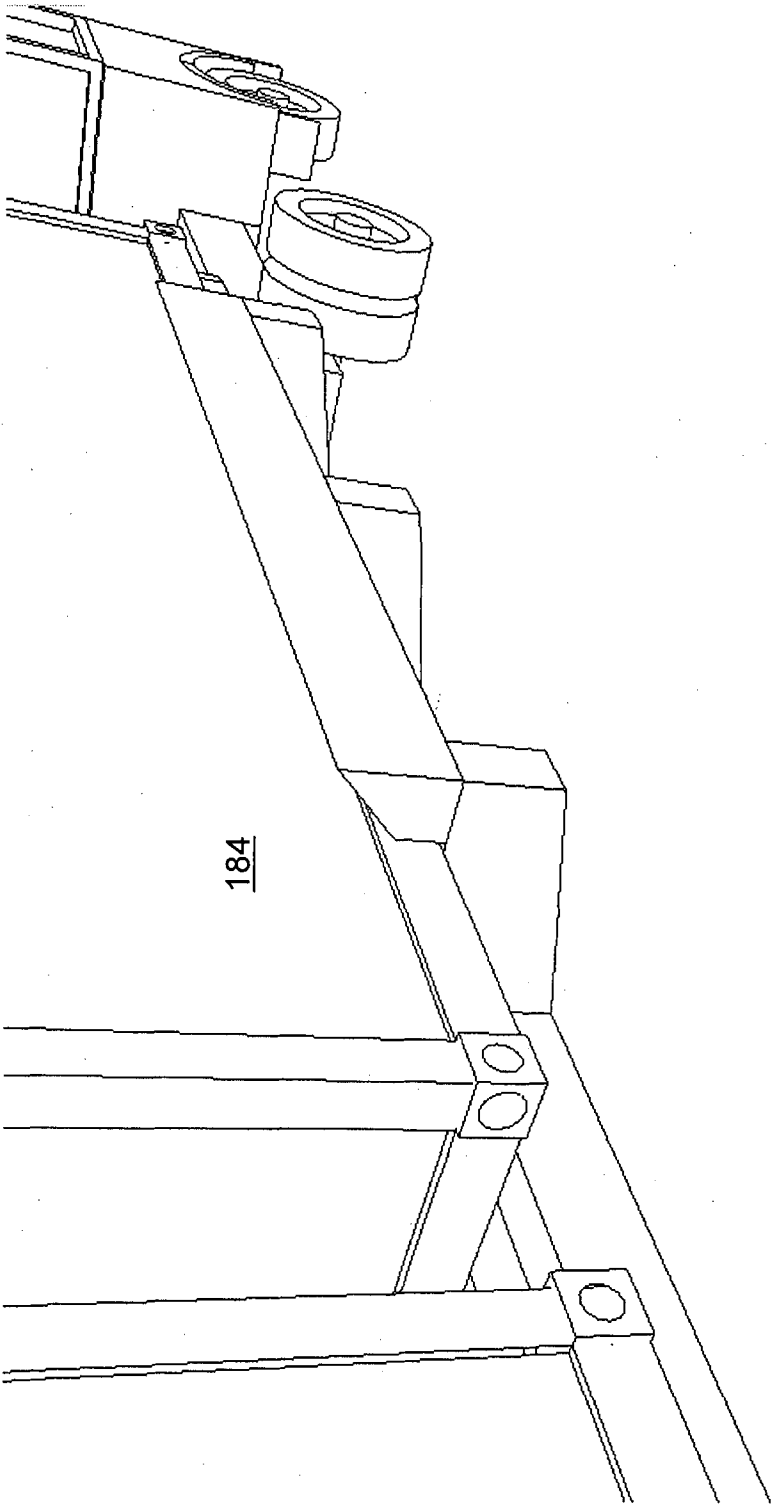


Fig. 20

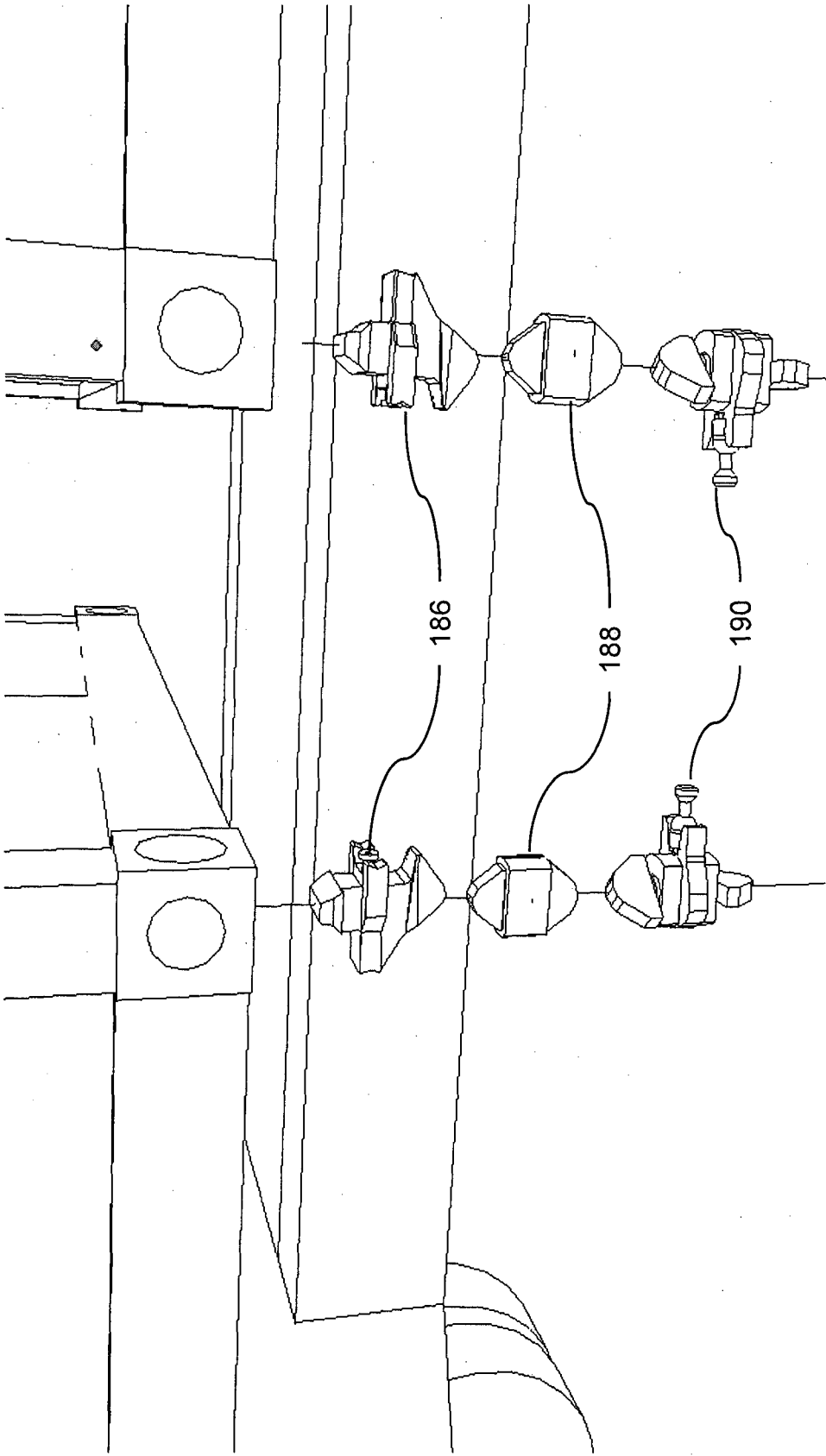


Fig. 21

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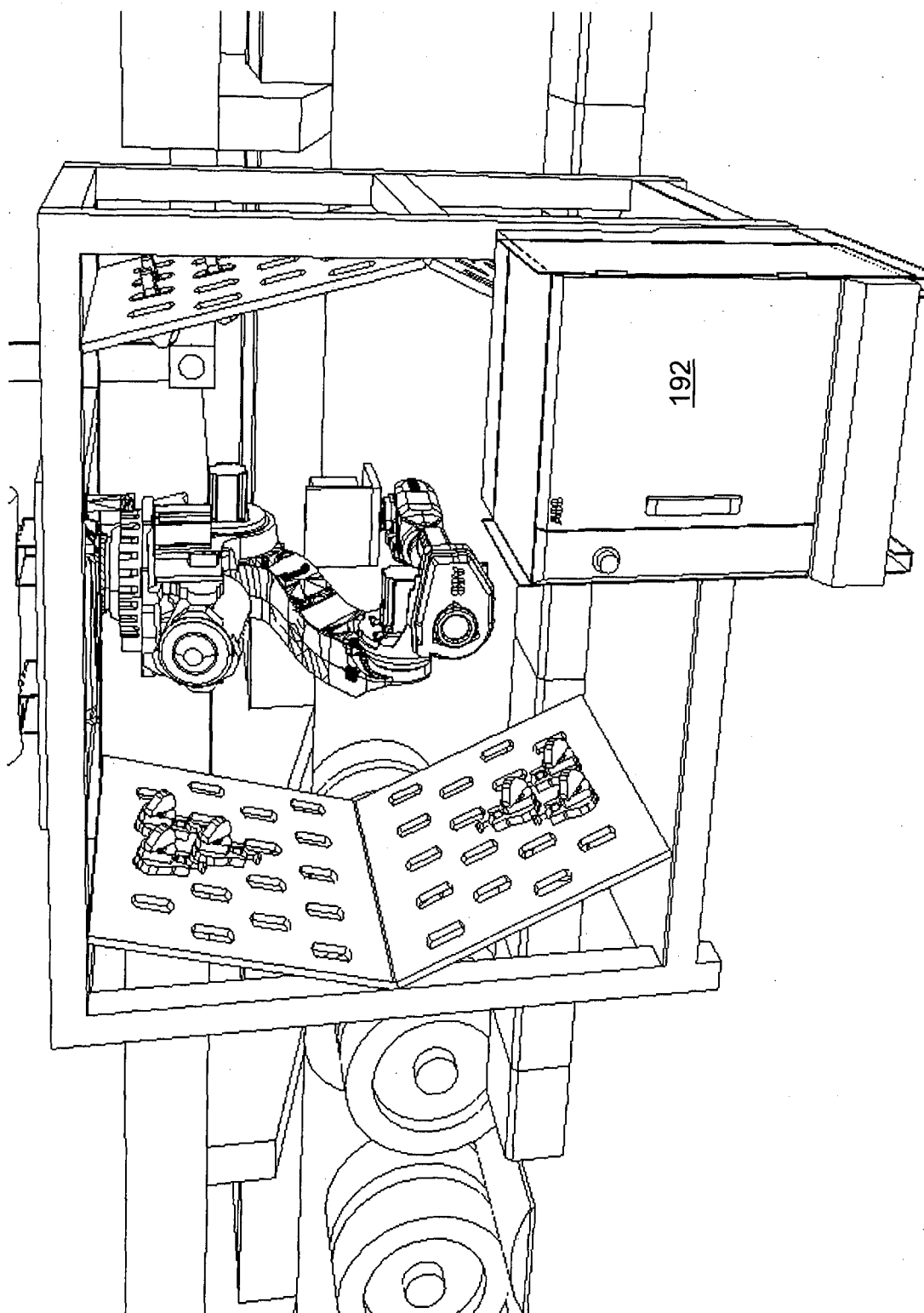


Fig. 22