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(71) Applicant: **BEUMER Group GmbH & Co. KG**
59269 Beckum (DE)

(72) Inventor: **Jesper, Jan Josef**
33129 Delbrück (DE)

(74) Representative: **Plougmann Vingtoft a/s**
Strandvejen 70
2900 Hellerup (DK)

(54) **PORTAL OF PICK AND PLACE ROBOTS FOR SORTING OBJECTS AND USE**

(57) A sorter system for handling a stream of objects of various shapes and sizes in bulk, e.g. 3D bulk. A first feeder section transports the objects in a first transport direction to a portal structure carrying a plurality of gantry robots, e.g. 3-10 robots, which can move along the portal structure. The robots pick objects from the first feeder section and places the objects in destination bins, e.g. roller cages, arranged in two lines within reach of the robots. Preferably, the first feeder section, the portal structure and the destination bin lines are parallel. A scanner reads information on each object regarding a destination bin for each object. The robots are controlled to either place the objects directly in their destination bins

or to park objects on an intermediate parking space, e.g. one or more feeder sections, e.g. comprising an additional feeder section transporting objects in opposite direction of the first transport direction. Such intermediate parking allows coordination between the robots to optimize a total handling capacity. Objects not picked from the first feeder section may be returned to a position upstream of the first feeder section. The robots preferably place the objects in the destination bins at the lowest point available for the object to provide a careful handling and a high packing density in the destination bins. Such system provides a high sorting capacity at a small area.

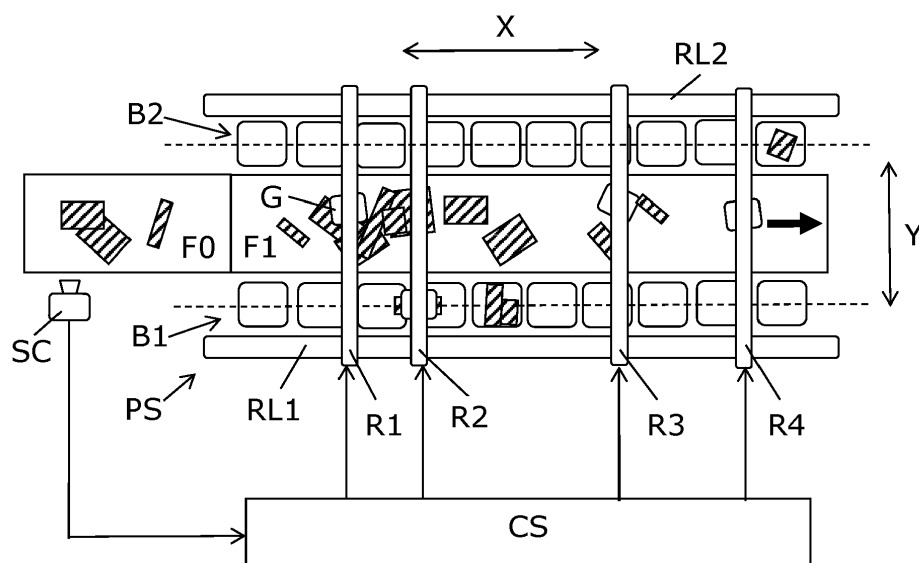


FIG. 1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to sorter systems for handling objects, specifically a stream of objects incoming in a 3D bulk. Specifically, the invention relates to a sorter system with pick and place robots for picking up incoming objects from a feeder and placing them directly in selected destination bins. The sorter system is suitable for such as: handling mail pieces, parcels, baggage, soft-bags, limp/nonrigid bags, polybags, items handled at a warehouse distribution, and items handled at a mail order distribution centre.

BACKGROUND OF THE INVENTION

[0002] Sorters, for sorting objects such as mail and/or parcels or the like, normally include a sorter system based on a conveyor. The conveyor transports objects at a constant speed to a discharge position, and in accordance with a code or the like on the individual objects, the objects are discharged from the sorter at a given discharge position, i.e. at the destination selected for each object.

[0003] Normally, such sorter has a number of fixed positions, e.g. on totes or trays, where one single object is received and transported to the discharge to arrive at its final destination. Thus, to induct objects to the sorter from a 2D or 3D bulk of objects, e.g. an incoming stream of objects in 3D bulk, the objects needs to be singulated and placed on the fixed positions on the sorter. In sorter systems without automated inductions for handling the induction to the sorter, persons perform the rather unpleasant task of manually inducing objects to the sorter, either by placing objects directly on the sorter or by performing singulation and placing objects singulated on an induction which inducts the objects on the sorter.

[0004] Such a semi-automatic sorter system occupies a large area, especially if the system is required to have a high capacity, i.e. a high number of handled objects per time. This is caused by a high number of mechanical components involved in the handling of the objects from the input of objects in bulk to their final destinations, e.g. roller cages or other movable containers, thus being sorted and prepared for further handling.

SUMMARY OF THE INVENTION

[0005] In particular, it may be seen as an object of the present invention to provide a compact sorter system occupying a limited area and having at the same time a high capacity for sorting objects, and preferably the sorter system should be able to provide a high packet density in the destination bins in which the objects are placed.

[0006] In a first aspect, the invention provides a sorter system for handling a stream of objects of various shapes and sizes in bulk, the system comprising

- a feeder system comprising at least a first feeder section arranged to transport the objects in a first transport direction,
- a destination system comprising at least first and second separate lines of destination bins,
- a pick and place robot system comprising
 - a portal structure carrying a plurality of controllable robots in a gantry configuration and being controllably movable along said portal structure, wherein each of said robots are configured with a manipulator, preferably a gripper, arranged for engaging with objects, preferably picking objects, from the at least first feeder section and transferring objects to the destination bins, and
 - a control system arranged to control movement of the plurality of robots and their manipulators, such as grippers, to transfer objects from the first feeder section to selected destination bins, and
- a scanner system comprising a scanner configured to read information on the objects, and wherein the scanner system is configured to provide data to the control system according to the information read, so as to allow the pick and place robot system to place objects in a destination bin selected in accordance with information read,

wherein the first feeder section and the first and second lines of destination bins are arranged within reach of the pick and place robot system, preferably the first feeder section and the first and second lines of destination bins being arranged within the portal structure, such as the first and second lines of destination bins being located on opposite sides of the at least first feeder section.

[0007] Such sorting system has proven to be capable of providing a high rate of success in picking up objects in 2D or 3D bulk from the feeder and placing them directly in selected destination bins, thereby eliminating a traditional tilt tray or tote sorter. The principle of using a portal structure with pick and place robots for picking objects from a feeder system and placing directly in destination bins, e.g. roller cages, has proven to occupy only a limited area, and thereby the entire sorting system with a high capacity, i.e. a high amount of handled objects per hour, can be implemented with a small footprint.

[0008] The plurality of robot can be formed by rather simple robotic actuator components, and still, it has been found that it is possible to pick up objects from bulk reliably and fast, even in case of objects arriving at a constant speed in 3D bulk.

[0009] With a plurality of robots carried by one common portal structure, it has been found that it is possible to obtain a high total capacity, since the pick and place tasks can be coordinated for optimal utilization of the plurality of robots. Especially, a coordinated utilization can be obtained with embodiments having an additional feeder

section transporting object in opposite direction of the first feeder section, since the additional feeder section can be used as an intermediate station for transferring objects between the plurality of robots. Furthermore, if the destination bin is known for the objects already when arriving to the pick and place robot system, a further advantage may be obtained in coordinating the pick and place tasks.

[0010] Still further, the sorter system can provide a high packet density of the destination bins, e.g. cage trolleys. Especially, the controller of the pick and place robot system may be arranged to operate the robots according to a filling strategy for each destination bin to ensure a high packet density by selecting objects with selecting to place objects in selected order with a suitable size and shape to provide a high packet density in each destination bin.

[0011] Implementations of a single robot has been tested to be capable of handling 1,500-2,000 handled objects per hour, depending on the layout of the system and the pick and place distances. The test has been performed with objects including rectangular shaped boxes of various size as well as plastic bags, laminated objects etc. Even with extra time required for careful placing of objects in the destination bins, at the same time ensuring a high packet density of the bins, a system having a plurality of robots can be designed to handle at least 3,000 objects per hour, e.g. more than 3,000 objects per hour. In case three or more robots are used, even higher handling capacities can be obtained.

[0012] In the following, by 'robot in gantry configuration' is generally understood a controllable device being controllable to move the gripper from one position in space to another position in space, i.e. basically the robotic actuator can move the gripper to a controllable position in space.

[0013] By 'singulated' is understood objects placed with a distance from each other.

[0014] By 'image of objects' is understood a sensed or measured representation of the physical configuration of objects. Preferably, the image has a sufficient level of detail to identify or classify single objects from a bulk of objects by means of appropriate processing. The image may be a visual image, e.g. obtained by a 2D or 3D camera. However, other technologies may be used as well, e.g. using laser scanners or other scanner technologies providing an image by non-visual sensing or measurement techniques etc.

[0015] By 'manipulator' is understood a device or element arranged to engage with an object to move the object, so as to allow the object to be transferred from a position on the feeder section to a selected bin. This device or element may be a simple element arranged to slide or push an object, or it may be a gripper, i.e. a device with one or more suction cups or controllable fingers or the like to pick and object to allow the robot to lift and move the object.

[0016] Each object may have an identification code, such as: a bar code, a postal code, an ID tag, RFID tag,

or the like. By scanning the identification code with the scanner of the scanner system, information can be read which allows the sorter system to determine a destination bin for the specific object.

[0017] Even though the sorter system is suited for handling incoming objects in a 3D bulk, it is to be understood that the sorter system can therefore also handle incoming objects in 2D bulk. However, the preferred embodiments that will be described have been tested to function even with randomly shaped and sized objects arriving in 3D bulk on the first feeder section to the pick and place robot system.

[0018] By 'lines of bins' is understood either a straight line of bins, or a curved line of bins.

[0019] In the following, preferred features and embodiments will be described.

[0020] Preferably, the first transport direction and a longitudinal axis of the portal structure are parallel, and preferably the first and second lines of destination bins are also parallel with the first transport direction. Hereby a compact and rather simple setup is provided. Especially, the first feeder section may be formed by a straight conveyor or a cascade of separate conveyors.

[0021] In some embodiments, the feeder system comprises a second feeder section arranged within reach of the pick and place robot system, preferably arranged within a width of the portal structure, and wherein the second feeder section is arranged to transport objects in a transport direction being opposite the first transport direction, such as the second feeder section being arranged adjacent to the first feeder section, such as the first line of destination bins being arranged adjacent to the first feeder section, such as the second line of destination bins being arranged adjacent to the second feeder section. Such feeder system allows the pick and place robot system can utilize the second feeder section as an intermediate parking area for objects in order to optimize a total capacity of the system. This can be achieved by optimized use of a capacity of each of the robots, e.g. by controlling two of the robots to cooperate in picking and placing an object by using the second feeder section to transfer the object from one robot to the other. Preferably, the pick and place robot system is arranged to pick one object from the first feeder section and to place the object on the second feeder section. Especially, the control system of the pick and place robot system may be arranged to optimize a total capacity of the plurality of robots by selecting to place an object on the second feeder section.

[0022] In some embodiments, at least one scanner of the scanner system is arranged upstream of the first feeder section, and wherein the control system of the pick and place robot system is arranged to distribute pick and place tasks to the respective ones of the plurality of robots based on known positions of destination bins for each of the objects arriving on the first feeder section. With such prior knowledge of the destination bins for each individual object arriving and their time of arrival, the control system of the pick and place robot system can distribute the pick

and place tasks to the individual robots effectively. Especially, the control system of the pick and place robot system may be arranged to optimize a total capacity of the plurality of robots by selecting to control one of the plurality of robots to place an object on the second feeder section, and to control another one of the plurality of robots to pick said object from the second feeder section and to place said object in the selected destination bin.

[0023] In some embodiments, the scanner system is configured to read information on an object when picked by one of the plurality of robots, and wherein the control system of the pick and place robots is configured to determine, whether to control said one robot to place the object in its destination bin or whether to control said robot to place the object on the second feeder section. This may be implemented by the robot moving the object through a scanner tunnel or the robot itself may carry a scanner. Without any prior knowledge of destination bin for an object picked up by a random one of the robots, the control system determines whether the destination bin is within reach of the robot, or whether another one or the plurality of robots is closer to the destination bin, and therefore the objects can be transferred to final placing by another robot by placing the object on the second feeder section. This could also be done to simply distribute tasks among the robots.

[0024] In some embodiments, the feeder system comprises a second and a third feeder section arranged within reach of the pick and place robot system, and wherein one of or both of the second and third feeder sections is arranged to transport objects in a transport direction opposite the first transport direction, such as the first feeder section being arranged adjacent to both of the second and third feeder sections, or such as the first feeder section being arranged adjacent to the first line of destination bins. With two additional feeder sections, further possibilities for distributing tasks among the robots exist compared to embodiments with one additional feeder section by selectively use the two additional feeder sections as an intermediate parking area for objects, e.g. to transfer an object between two robots. Especially, the control system of the pick and place robot system may be arranged to control robots to pick objects from the first feeder section and to place objects selectively on the second or third feeder section. Especially, all of the first, second and third feeder sections may be arranged to transport objects on respective surfaces being on one common vertical level. With such aligned heights all of the three feeder sections, object handling is facilitated for the robots.

[0025] Preferably, the pick and place robot system is arranged to sense a lowest point of space in a destination bin and to place an object on said lowest point of space in the destination bin. Especially, the control system of the pick and place robot is arranged to determine a weight of an object and to control placing of the object in a destination bin accordingly, so as to ensure careful handling of objects and at the same time minimize time for per-

forming the task of placing objects. Hereby, a careful handling of objects can be achieved, and at the same time a good packet density in each bin can be obtained.

[0026] Especially, the control system of the pick and place robot may be configured to control the plurality of robots according to a packet strategy for each of the destination bins, taking into account at least a size of objects to be placed in each destination bin, and a time of arrival to the plurality of robots of objects be placed in each destination bin, so as to optimize a filling or packet density of each destination bin. This allows a high packet density of the destination bin, thereby ensuring a high utilization of total space required for the sorter system and the further handling of the objects, and also the space required for the further handling of the destination bins in further transport of the objects.

[0027] In some embodiments, the sorter system comprises a system configured to distribute objects upstream of the first feeder section, such as a system configured to distribute objects in 3D bulk to objects in 2D bulk. Especially, the system may be configured to singulate objects upstream of the first feeder section. Such system can facilitate the task of picking objects for the pick and place robot system and thus helps to increase a handling capacity of the pick and place robot system.

[0028] In some embodiments, the sorter system comprising a return conveyor arranged to return objects which have not been picked by the pick and place robot system, such as a return conveyor positioned below the first feeder section and arranged to transport objects from an end of the first feeder section to a position upstream of the first feeder section. Hereby, a temporal overload of the pick and place robot system exceeding its handling capacity can be overcome, since objects can then be reintroduced to the robots on the first feeder section. Especially, the control system may be configured to keep track of objects reintroduced and to prioritize such objects in the handling by the pick and place robots. Especially, the control system may select to avoid picking an object if its destination bin is known, and it is not possible for the object to fit in the destination bin at that time, or placing the object in its destination bin at that time would result in a poor pack density of that destination bin.

[0029] In some embodiments, a plurality, e.g. 2-4, lines of destination bins, such as parallel lines of destination bins, arranged on each side of the first feeder section, wherein said plurality of lines of destination bins are arranged within reach of the pick and place robot system. This may further help to reduce the area occupied by the sorter system, since such plurality of lines of destination bins can form a compact destination area for the pick and place robots.

[0030] In some embodiments, the first feeder section is placed at an elevated position, so as to allow the destination bins to be transported below the feeder section. Especially, the first feeder section is elevated so that a filled destination bin may be manually or automatically rolled below the first feeder section from one side of the

first feeder section to the opposite side of the feeder section, and at the same time the feeder section transports objects on its surface at a vertical level above the transporting of the bins. This allows a flexible handling of the destination bins, which further helps to reduce the area required for the sorter system.

[0031] In general a destination bin could be a box, a container, a roller container, or a bag or the like. The individual bins may be manually or automatically moved out of the lines of destination lines when filled and replaced by empty bins.

[0032] In some embodiments, the destination bins are roller bins arranged to be rolled in and out of said lines of destination bins either manually or by means of an actuator. Especially, the destination bins may be roller cages or cage trolleys.

[0033] In some embodiments, the portal structure may be a curved structure or at least has a curved part, i.e. wherein the portal structure has a horizontal structure carrying the plurality of robots, wherein this horizontal structure is curved to form a curved set of rails on which the plurality of robots can move.

[0034] In some embodiments, a bin is located at an end of the first feeder section to collect objects which have not been picked by the pick and place robot system.

[0035] In a second aspect, the invention provides a method for automatically sorting a stream of objects of various sizes and shapes in bulk, the method comprises

- transporting the objects on a first feeder section in a first transport direction to a pick and place robot system with a plurality of robots carried by a portal structure and being movable along the portal structure,
- placing first and second lines of destination bins on opposite sides of the first feeder section, so that the destination bins are within reach of the pick and place robot system,
- reading information on each object,
- selecting a destination bin for each object in accordance with the information read, and
- controlling the plurality of robots to pick each of the objects from the first feeder section and place the objects in the selected destination bins.

[0036] In a third aspect, the invention provides use of the system according to the first aspect for handling objects comprising at least one of: mail pieces, parcels, baggage, items handled at a warehouse distribution, items handled at a mail order distribution centre, items handled at a smalls handling centre.

[0037] In a forth aspect, the invention provides use of the method according to the second aspect for handling objects comprising at least one of: mail pieces, parcels, baggage, items handled at a warehouse distribution, items handled at a mail order distribution centre, and items handled at a smalls handling centre.

[0038] In further aspects, the invention provides:

- A mail distribution centre comprising a sorter system according to the first aspect.
- A parcel or mail order distribution centre comprising a sorter system according to the first aspect.
- A baggage handling system comprising a sorter system according to the first aspect.
- A warehouse distribution centre comprising a sorter system according to the first aspect.
- A smalls handling centre.

[0039] The above is a non-exhaustive list of applications. It is to be understood that the sorter system may be advantageously used in other applications as well where a bulk of incoming objects should be distributed to a plurality of target locations fully automatically or at least with a limited amount of manual handling only.

[0040] The individual aspects of the present invention may each be combined with any of the other aspects. These and other aspects of the invention will be apparent from the following description with reference to the described embodiments.

BRIEF DESCRIPTION OF THE FIGURES

[0041] The invention will now be described in more detail with regard to the accompanying figures. The figures show one way of implementing the present invention and is not to be construed as being limiting to other possible embodiments falling within the scope of the attached claim set.

FIG. 1 illustrates a block diagram of a sorter system embodiment,

FIG. 2 illustrates a 3D drawing of an embodiment with a single wide feeder section for transporting singulated objects to the pick and place robot system, FIG. 3 illustrates a 3D drawing of an embodiment with three separate feeder sections wherein the central feeder section transports objects in the opposite direction of the outer feeder sections,

FIG. 4 illustrates a 3D drawing of an embodiment with a central feeder section for introducing objects and two outer feeder sections connected to form a loop,

FIG. 5 illustrates a 3D drawing of an embodiment with a single feeder section and a cascade of conveyors and a scanner upstream of the feeder section to distribute objects before they are introduced to the feeder section and to provide knowledge of destination bins for the objects when arriving to the pick and place robots,

FIG. 6 illustrates an example of a robot with a gripper with suction cups in an adjustable and controllable configuration,

FIG. 7a and 7b illustrate a preferred suction cup gripper with an adjustable gripper configuration and a rotation and tilting mechanism to allow the gripper to be used with a gantry robotic actuator, and

FIG. 8 illustrates steps of a method embodiment.

DETAILED DESCRIPTION OF AN EMBODIMENT

[0042] FIG. 1 illustrates a block diagram of a top view of a sorter system embodiment with a single feeder section F1 arranged to transport objects (shaded boxes) in a transport direction (bold arrow) along a longitudinal direction X. The feeder section F1 receives objects from an upstream feeder F0. The objects arrive to the feeder section F1 in 2D or 3D bulk.

[0043] Two lines (dashed lines) of destination bins B1, B2 are arranged adjacent to the feeder section F1, on respective sides of the feeder section F1 and parallel with the longitudinal direction X.

[0044] A pick and place robot system serves to pick objects from the feeder section F1 and place the objects in selected ones of the destination bins B1, B2. The pick and place robot system has a portal structure PS with two parallel rails RL1, RL2 which carries four controllable robots R1, R2, R3, R4 in a gantry configuration and positioned at respective positions along the rails RL1, RL2. The robots R1, R2, R3, R4 are controlled to move along the rails RL1, RL2 of the portal structure PS, controlled by a control system CS. Each of the robots R1, R2, R3, R4 has a controllable gripper G arranged for picking objects. The gripper G may have a plurality of suction cups for gripping an object. Especially, the gripper may have a controllable configuration to allow adaptation to optimal gripping of differently sized and shaped objects. The control system is arranged to control both movement of the robots R1, R2, R3, R4 in both X and Y directions as well as a vertical direction, and further the control system CS is arranged to control the function of the grippers G.

[0045] A scanner SC serves to read information on each of the objects, e.g. by scanning an identification code or the like. Data indicative of the read information is provided to the control system CS, so as to allow the pick and place robot system to place each object in a destination bin selected in accordance with information read, e.g. a read ZIP code or the like.

[0046] In the shown embodiment the scanner SC is located upstream of the robots R1, R2, R3, R4, and thus the control system CS can, e.g. along with a visual identification based on a vision system (not shown), navigate the robots R1, R2, R3, R4 to pick an object, and to directly place the object in the selected destination bin. Hereby an effective sorting is provided, occupying only a limited area.

[0047] FIG. 2 illustrates a 3D drawing of an embodiment having a basic configuration similar to the block diagram of FIG. 1, namely with one single feeder section F1 for transporting to the pick and place robot system in a transport direction (bold arrow). In the embodiment on FIG. 2, a singulation system upstream of the feeder section F1 serves to provide objects singulated to the feeder section F1, so the feeder section F1 transports singulated objects to the robots R1, R2, R3, R4 carried on the portal

structure PS.

[0048] The lines of destination bins B1, B2 adjacent to the feeder section F1 are here shown as roller cages or trolleys. Both the feeder section F1 and the destination bins B1, B2 are positioned within the portal structure PS and are parallel with a longitudinal axis of the portal structure PS, namely a direction parallel with the transport direction (bold arrow).

[0049] The feeder section F1 is shown here to be rather wide compared to a width of the portal structure PS, and the width of the feeder section F1 may especially be at least 50% of a width of the portal structure, such as 50-90%, such as 60-80% of a width of the portal structure.

[0050] FIG. 3 illustrates a 3D drawing of an embodiment which is similar to the one in FIG. 2 with respect to the portal structure PS, the robots R1, R2, R3, R4, and the destination bins B1, B2 arranged on lines. However, in the embodiment of FIG. 3, three separate and parallel feeder sections F1_1, F1_2, F3 are located within the portal structure PS to transport objects in directions (bold arrows) being either the same or opposite directions. As seen, the outer feeder sections F1_1 and F1_2 are arranged adjacent to the central feeder section F2. Feeder section F1_1 is arranged adjacent to the first line of destination bins B1, and feeder section F1_2 is arranged adjacent to the second line of destination bins B2. All of the three feeder sections F1_1, F1_2, F2 are arranged to transport objects on respective surfaces being on one common vertical level.

[0051] The two outer feeder sections F1_1, F1_2 serve to receive objects and to introduce objects from a source upstream of the pick and place robots system PS, R1, R2, R3, R4, while the central feeder section F2 transports objects in the opposite direction of the outer feeder sections F1_1, F1_2, and this central feeder section F2 serves as an intermediate area or space for parking of objects by the pick and place robots. The robots R1, R2, R3, R4 are arranged to pick objects from all of the three feeder sections F1_1, F1_2, F2. The robots R1, R2, R3, R4 are arranged to place objects on the central feeder sections F2, so as allow coordination of pick and place tasks between the plurality of robots R1, R2, R3, R4.

[0052] Especially, the scanner system may comprise a scanner located upstream of the feeder sections F1_1, F1_2, F2 to read information of destination bins for each object upstream of the robots R1, R2, R3, R4, and the control system of the robots R1, R2, R3, R4 may then be configured to coordinate pick and place tasks of the plurality of robots R1, R2, R3, R4 based on knowledge of a position of a destination bin for each object. Especially, the control system of the robots R1, R2, R3, R4 can be configured to coordinate pick and place tasks of the robots R1, R2, R3, R4 by controlling one of the robots R1, R2, R3, R4 to pick an object on one of the outer feeder sections F1_1, F1_2 and to place the object on the central feeder section F2, and to control another one of the plurality of robots to pick said object from the central feeder section F2 and to place said object in a destination bin

B1, B2. In this way a capacity of the robots R1, R2, R3, R4 can be utilized taking into account e.g. the position of the robots R1, R2, R3, R4, position of the objects and the position of their destination bins B1, B2.

[0053] In the shown embodiment, all of the three feeder sections have the same width, however it is to be understood that their widths may be different, if preferred.

[0054] FIG. 4 illustrates a 3D drawing of an embodiment with a central feeder section for introducing objects and two outer feeder sections connected to form a closed loop. The pick and place robot system PS, R1, R2, R3, R4 and the destination bins B1, B2 are similar the embodiments of FIG. 2 and 3. However, in FIG. 4 three feeder sections F1, F2, F3 are arranged adjacent to each other, wherein the central section F1 serves to receive objects and to introduce objects from a source upstream of the pick and place robots system PS, R1, R2, R3, R4. Especially, the central feeder section may transport objects in 2D or 3D bulk to the robots R1, R2, R3, R4. The two outer feeder sections F2, F3 are connected outside an area of the portal structure PS to form a loop, and thus one of the outer feeder sections F2 transports objects in the same direction (bold arrow) as the central feeder section F1, while the other outer feeder section F3 transports objects in the opposite direction of the two other feeder sections F1, F2. All three feeder sections F1, F2, F3 are arranged to transport objects on respective surfaces being on one common vertical level.

[0055] The two outer feeder sections F2, F3 can serve as an intermediate area or space for parking of objects by the robots R1, R2, R3, R4. This allows the control system of the robots R1, R2, R3, R4 to coordinate pick and place tasks of the robots R1, R2, R3, R4 by controlling one of the robots R1, R2, R3, R4 to pick an object on the central feeder section F1 and to place the object on one of the outer feeder sections F2, F3, and to control another one of the robots R1, R2, R3, R4 to pick said object from one of the outer feeder sections F2, F3, and to place said object in a destination bin B1, B2. Especially, the control system may be configured to optimize utilization of the plurality of robots by selecting between:

- 1) picking an object from the central feeder section F1 and directly placing said object in a destination bin B1, B2,
- 2) picking an object from the central feeder section F1 and placing said object on one of the outer feeder sections F2, F3, and
- 3) picking an object from one of the outer feeder sections F2, F3 and placing said object in a destination bin B1, B2,

wherein this selection step can involve several inputs so as to optimize the total pick and place performance. Especially, the control system may be configured to select between 1), 2) and 3) in response to one or more inputs. Such inputs can be: a position of an object on the first feeder section, a position of at least two of the plurality

of the robots, an amount of objects arriving on the first feeder section, an amount of objects on the second or third feeder section, a size of arriving objects, and a time of arrival of objects for placing in one destination bin.

[0056] The embodiment of FIG. 4 may be preferred, in case destination bins for the objects are unknown until the objects are picked by the robots R1, R2, R3, R4, where a scanner reads information on the objects. In case the destination bin B1, B2 for an object is near a location of the robot R1, R2, R3, R4 having picked up the object, the robot R1, R2, R3, R4 can be controlled to directly place the object in its destination bin B1, B2. Otherwise, the closed loop feeder sections F2, F3 can be used to place the object for handling by another robot R1, R2, R3, R4, or for handling of the same robot R1, R2, R3, R4 at a later time. Further, the closed loop of feeder sections F2, F3 can be used as a buffer for objects in periods where one or more of the robots R1, R2, R3, R4 is overloaded.

[0057] FIG. 5 illustrates a 3D drawing of an embodiment with a single feeder section F1 and a cascade of conveyors S_CNV and a scanner SC upstream of the feeder section F1 to distribute objects, e.g. from 3D to 2D bulk, before they are introduced to the feeder section F1 and to provide knowledge of destination bins B1, B2 for the objects when arriving to the robots R1, R2, R3, R4.

[0058] Again, in FIG. 5, the pick and place robot system PS, R1, R2, R3, R4 and the destination bins B1_1, B2_1 are similar to the embodiments of FIG. 2, 3 and 4, however in FIG. 5 additional lines of bins B1_2, B2_2 are added adjacent to each of the single lines of bins B1, B2 of FIG. 2, 3 and 4.

[0059] The scanning system is shown here to have a plurality of scanners SC positioned above the cascade of conveyors S_CNV and at respective positions along said cascade of conveyors S_CNV, such as 3-8 scanners SC, at respective positions along the cascade of conveyors S_CNV as a series of scanner tunnels SC, so as to allow the scanners SC to read information on the objects along with the distribution or separation of the objects by the cascade of conveyors S_CNV.

[0060] The control system of the robots R1, R2, R3, R4 may control the robots R1, R2, R3, R4 to selectively pick objects to be placed in one of a group of destination bins positioned at a longitudinal position in accordance with a longitudinal position of each of the plurality of robots R1, R2, R3, R4. In other words, with the known destination object for each of the objects arriving, the control system can distribute the pick and place tasks to the robots R1, R2, R3, R4 so that each of the robots R1, R2, R3, R4 only pick objects with destination bins B1_1, B1_2, B2_1, B2_2 positioned near the robots R1, R2, R3, R4. Thereby, the complete pick and place handling can be optimized. Especially, each of the robots R1, R2, R3, R4 may be assigned respective groups of destination bins B1_1, B1_2, B2_1, B2_2, e.g. two or more bins B1_1, B1_2, B2_1, B2_2 on each side of the feeder section F1 at a location near the robot R1, R2, R3, R4, and

wherein the control system then controls each of the robots R1, R2, R3, R4 to pick objects only which are to be placed in a destination bin B1_1, B1_2, B2_1, B2_2 belonging to its assigned group of destination bins B1_1, B1_2, B2_1, B2_2. These groups of destination bins B1_1, B1_2, B2_1, B2_2 can be either non-overlapping groups of destination bins or partially overlapping groups of destination bins.

[0061] The embodiment of FIG. 4 may provide a high utilization of the robots R1, R2, R3, R4, since they can be all used for directly picking from the feeder section F1 and placing in the destination bins B1_1, B1_2, B2_1, B2_2 without having to perform any intermediate pick and place step. However, a return conveyor (not shown) may transport not picked objects from an end of the feeder section F1 to a position upstream of the feeder section, e.g. a conveyor positioned below the feeder section F1. Hereby, a period of overload of one or more of the robots R1, R2, R3, R4 can be handled without any manual interaction.

[0062] In all embodiments described above, a surface of the feeder section(s) and openings of the destination bins may be at the same vertical levels, or the surface of the first feeder section(s) may be positioned at a higher vertical level than openings of the destination bins.

[0063] FIG. 6 illustrates an example of implementation of the plurality of robots, namely a gantry robotic actuator RA with an adjustable gripper G with four suction cups, here shown with a gripped object. A set of horizontal elements forming tracks for a controllably movable first cart CT1 arranged to be controllably actuated to move in a horizontal direction X, namely the first cart CT1 being arranged to move on rails forming a longitudinal part of the portal structure PS. A controllably movable second cart CT2 is arranged to be controllably actuated to move in another horizontal direction Y on tracks of the first cart CT1.

[0064] The gripper G is mounted on a member fixed to the second cart CT2 and is controllably movable in a vertical direction Z to allow height adjustment of the gripper G. The gripper G is shown mounted on this member by a controllable actuator element which allows controllable rotation around a vertical rotation axis RT_a. Further, the gripper is mounted on the member by a controllable actuator element which allows controllable tilting around a horizontal tilting axis TL_a.

[0065] The dimension of the various elements of the robotic actuator RA can easily be adapted to the required X, Y, Z distance capacity required for the pick and place robot, and also the strength of the various elements can be adapted for the load of objects to be handled. Various types of actuators for the X, Y, Z direction actuation can be used, as known in the art of gantry type of robots.

[0066] FIGs. 7a and 7b illustrate two views of a preferred gripper G embodiment with a controllable gripping configuration of four gripping members in the form of suction cups M1, M2, M3, M4. In FIG. 7a, the gripper G is shown in the fully extended gripper configuration, i.e. with

the suction cups M1, M2, M3, M4 at maximum distance from each other, thus suited for gripping large objects. In FIG. 7b, the gripper is in its fully compressed gripper configuration, i.e. with the suction cups M1, M2, M3, M4 with minimum distance from each other, thus suited for gripping small objects.

[0067] A base part B serves for mounting on a robotic actuator of the robot, by means of a controllable tilting element for tilting around a tilting axis TL_a, and by means of a controllable rotation element for rotating around a rotation axis RT_a (also seen in FIG. 6). The suction cups M1, M2, M3, M4 are mounted near distal ends of respective elongated arms A1, A2, A3, A4 which are mounted to the base part B. Each arm A1, A2, A3, A4 is slidably arranged along its length relative to the base part B actuated by a controllable actuator. This allows the arm A1, A2, A3, A4 to be controllably adjusted with respect to a position of suction cups M1, M2, M3, M4 relative to the base part B. The suction cups are aligned with their suction contacts form a plane, and wherein the arms A1, A2, A3, A4 are slidably arranged to move along axes Dx, Dy which are parallel to this plane.

[0068] Especially, it is seen that arms A1 and A2 are slidably arranged along the same axis Dx, and part of the arms are arranged to slide inside each other. Arms A3, A4 are likewise arranged to slide inside each other, so as to be slidably arranged along axis Dy. Thus, the four arms A1, A2, A3, A4 are arranged to extend in four different directions in one plane, perpendicular to each other. Depending on the chosen type of actuation, all four arms A1, A2, A3, A4 can be actuated separately to allow a high degree of flexibility with respect to gripping configuration, but requiring separate actuators, or the arms A1, A2, A3, A4 can be actuated together, e.g. in pairs. Alternatively, two actuators can be used to actuate the arms A1, A2, A3, A4 in two pairs A1, A2, and A3, A4, and further one single actuator can be used to actuate all four arms A1, A2, A3, A4, thus allowing only limited variation in the gripping configuration. It may be preferred that the actuator(s) e.g. electric motor(s), for the arms is/are mounted above the tilting and rotation points, to allow reduction of weight of the gripper G. In an embodiment, a rotation cable may transfer rotation power from the motor(s) to actuate the arms A1, A2, A3, A4 by means of a gear mechanism inside the base part B. In case of individually adjustable lengths of all four arms A1, A2, A3, A4, various gripping configuration shapes can be made to fit optimal grips for irregular objects.

[0069] Such gripper G is flexible and yet compact, since even with a compact base part B, a highly flexible gripping configuration is achieved: from a very compressed and compact configuration occupying a minimum of space outside the dimension of the base part B itself, and to a fully extended gripping configuration which can be used for handling large objects. The gripper G can handle large objects at one point in time, and shortly after, it can be controlled to provide a compressed state gripping configuration to enable the gripper G to enter

the space between two large objects for gripping a small object. This allows a high flexibility in the handling of bulk objects, even objects in 3D bulk.

[0070] FIG. 8 illustrates steps of an embodiment of a method for automatically sorting a stream of objects of various sizes and shapes in bulk, the method comprises

- transporting T_O the objects on a first feeder section in a first transport direction to a pick and place robot system with a plurality of robots carried by a portal structure and being movable along the portal structure,
- placing P_DB first and second lines of destination bins on opposite sides of the first feeder section, so that the destination bins are within reach of the pick and place robot system,
- reading R_I information on each object,
- selecting D_DB a destination bin for each object in accordance with the information read, and
- controlling C_P_P the plurality of robots to pick each of the objects from the first feeder section and place the objects in the selected destination bins.

[0071] The method preferably comprising the step of providing the objects on the first feeder section. The step of reading information R_I on each object may be performed prior to providing the objects on the first feeder section, or this step of reading information, e.g. scanning, may be performed along with the robots picking the objects.

[0072] It is to be understood that in principle, all types of objects or items can be handled by the described robot systems. I.e. objects or items can be of various shapes, sizes, and with various surface characteristics. Especially, the stream of objects or items arriving at the first feeder section may comprise at least one of: mail pieces, parcels, baggage, items handled at a warehouse distribution, and items handled at a mail order distribution centre, such as shoes, clothes, textiles etc. Especially, the pick and place robot system may be designed for handling objects or items which have a maximum weight of 1-100 kg, such as 1-10 kg, such as a maximum weight of 2-3 kg. Especially, objects or items with a maximum weight of 2-3 kg can be picked up and moved at a high speed even with moderately sized robots. It is to be understood that the robot system can alternatively be designed for handling heavier objects than 100 kg.

[0073] It is understood that the function of the control system is preferably implemented by a processor system. The processor may be a computerized controller including a digital processor executing the control algorithm which is implemented in software, so as to allow easy updating and adaptation of the function of the system, e.g. by changes in sorter configuration, and by including more pick and place robots to the system which need to be controlled in order to most effectively cooperate to handle the incoming stream of objects or items.

[0074] In some embodiments, the control system can

be implemented by means of a Programmable Logic Controller (PLC). The processor may be or may comprise a dedicated robot controlling processor, or it may be implemented as part of or sharing the processor serving to control the sorter. Hereby, the addition of one or more pick and place robots to an existing sorter system may be implemented with a minimum of extra hardware for controlling the robot(s), and thus in such implementations, the program code for controlling the robot(s) can be implemented purely as processor executable program code. Likewise, the processor may be implemented as part of or sharing the processor serving to control the one or more induction for transporting items to the sorter. Still further, the processor may be implemented as part of or sharing the processor serving to control the feeder and/or the sorter, which may be advantageous to allow information from feeder and/or sorter to be used in the control of the pick and place robots. Yet other versions may have separate robot controls with interfaces to one common machine controller for controlling sorter, inductions and feeding conveyor(s). The machine controller may then have an interface to an overall system controller, which may have an interface to an ever higher order control, e.g. a Warehouse Management System (WMS).

[0075] The pick and place robot system may comprise a vision system for control of the plurality of robots to pick and place objects in an efficient manner, i.e. based on an image of objects provided upstream of and/or at the area of the plurality of robots. For such vision system various types of cameras or other image sensors exist, but preferably the may be capable of providing a high quality 3D image allowing a precise identification of shapes to allow identification of separate objects in a bulk, and also with a sufficient precise height dimension to allow precise navigation of the gripper of the robots for gripping the object. The camera may especially be a 3D line camera, a Time of Flight type 3D camera, and a stereo 3D camera. Further, it is to be understood that a 2D camera may be used, where the height dimension of the 3D image IM is computed based on image processing of a 2D photo, or it may be obtained by an alternative technology, e.g. a separate height sensor placed separate from the camera CM.

[0076] The control system can be performed with many of its functions implemented as computer program code, and in practice the program code may be partly or fully integrated with existing systems for controlling the sorter. However, it may be preferred that the control system has two or more separate processors, e.g. a separate processor serving to perform at least some of the required image processing on one or a plurality of images, e.g. 3D images to provide a fast and precise identification of objects upstream of each of the pick and place robots.

[0077] The sorter system may have a capacity for handling at least 2,000 objects per hour, preferably at least 3,000 objects per hour, especially for smalls. For heavy parts or baggage, the handling capacity may be smaller than 2,000 objects per hour.

[0078] The first feeder section may be arranged to operate at a transporting speed of up to 1.0 m/s, such as up to 1.5 m/s. For bulk unloading an initial speed of 0.1-0.3 m/s may be preferred, and thereafter a speed of such as 0.5-1.2 m/s.

[0079] In the following, various embodiments and preferred features E0.5-E84 will be defined.

[0080] E0.5. A sorter system for handling a stream of objects of various shapes and sizes in bulk, the system comprising

- a feeder system comprising at least a first feeder section arranged to transport the objects in a first transport direction,
- a destination system comprising at least first and second separate lines of destination bins,
- a pick and place robot system comprising
 - a portal structure carrying a plurality of controllable robots in a gantry configuration and being controllably movable along said portal structure, wherein each of said robots are configured with a manipulator, preferably a gripper, arranged for engaging with objects, preferably picking objects, from the at least first feeder section and transferring objects to the destination bins, and
 - a control system arranged to control movement of the plurality of robots and their manipulators, such as grippers, to transfer objects from the first feeder section to selected destination bins, and
- a scanner system comprising a scanner configured to read information on the objects, and wherein the scanner system is configured to provide data to the control system according to the information read, so as to allow the pick and place robot system to place objects in a destination bin selected in accordance with information read,

wherein the first feeder section and the first and second lines of destination bins are arranged within reach of the pick and place robot system, preferably the first feeder section and the first and second lines of destination bins being arranged within the portal structure, such as the first and second lines of destination bins being located on opposite sides of the at least first feeder section.

[0081] E1. The system according to E0.5, wherein the plurality of robots are configured with a controllable gripper arranged for picking objects from the at least first feeder section and placing objects in the destination bins, and wherein the first and second lines of destination bins are located on opposite sides of the at least first feeder section.

[0082] E2. The system according to E0.5 or E1, wherein the first transport direction and a longitudinal axis of the portal structure are parallel, preferably the first and second lines of destination bins are parallel with the first

transport direction.

[0083] E3. The system according to any of E0.5-E2, wherein the feeder system comprises a second feeder section arranged within reach of the pick and place robot system, preferably arranged within a width of the portal structure, and wherein the second feeder section is arranged to transport objects in a transport direction being opposite the first transport direction, such as the second feeder section being arranged adjacent to the first feeder section, such as the first line of destination bins being arranged adjacent to the first feeder section, such as the second line of destination bins being arranged adjacent to the second feeder section.

[0084] E4. The system according to E3, wherein the pick and place robot system is arranged to pick one object from the first feeder section and to place the object on the second feeder section.

[0085] E5. The system according to E4, wherein the control system of the pick and place robot system is arranged to optimize a total capacity of the plurality of robots by selecting to place an object on the second feeder section.

[0086] E6. The system according to any of E0.5-E5, wherein at least one scanner of the scanner system is arranged upstream of the first feeder section, and wherein the control system of the pick and place robot system is arranged to distribute pick and place tasks to the respective ones of the plurality of robots based on known positions of destination bins for each of the objects arriving on the first feeder section.

[0087] E7. The system according to E5 and E6, wherein the control system of the pick and place robot system is arranged to optimize a total capacity of the plurality of robots by selecting to control one of the plurality of robots to place an object on the second feeder section, and to control another one of the plurality of robots to pick said object from the second feeder section and to place said object in the selected destination bin.

[0088] E8. The system according to E4 or E5, wherein the scanner system is configured to read information on an object when picked by one of the plurality of robots, and wherein the control system of the pick and place robots is configured to determine, whether to control said one robot to place the object in its destination bin or whether to control said robot to place the object on the second feeder section.

[0089] E9. The system according to any of E0.5-E8, wherein the feeder system comprises a second and a third feeder section arranged within reach of the pick and place robot system, and wherein one of or both of the second and third feeder sections is arranged to transport objects in a transport direction opposite the first transport direction, such as the first feeder section being arranged adjacent to both of the second and third feeder sections, or such as the first feeder section being arranged adjacent to the first line of destination bins.

[0090] E10. The system according to E9, wherein the control system of the pick and place robot system is ar-

ranged to control robots to pick objects from the first feeder section and to place objects selectively on the second or third feeder section.

[0091] E11. The system according to E9 or E10, wherein all of the first, second and third feeder sections are arranged to transport objects on respective surfaces being on one common vertical level.

[0092] E12. The system according to any of E0.5-E11, wherein the pick and place robot system is arranged to sense a lowest point of space in a destination bin and to place an object on said lowest point of space in the destination bin, preferably the control system of the pick and place robot is arranged to determine a weight of an object and to control placing of the object in a destination bin accordingly, so as to ensure careful handling of objects and at the same time minimize time for performing the task of placing objects.

[0093] E13. The system according to any of E0.5-E12, wherein the control system of the pick and place robot is configured to control the plurality of robots according to a packet strategy for each of the destination bins, taking into account at least a size of objects to be placed in each destination bin, and a time of arrival to the plurality of robots of objects be placed in each destination bin, so as to optimize a filling or packet density of each destination bin.

[0094] E14. The system according to any of E0.5-E13, comprising a system configured to distribute objects upstream of the first feeder section, such as a system configured to distribute objects in 3D bulk to objects in 2D bulk, such as a system configured to singulate objects upstream of the first feeder section.

[0095] E15. The system according to any of E0.5-E14, comprising a return conveyor arranged to return objects which have not been picked by the pick and place robot system, such as a return conveyor positioned below the first feeder section and arranged to transport objects from an end of the first feeder section to a position upstream of the first feeder section.

[0096] E16. The system according to any of E0.5-E15, comprising a plurality, such as 2-4, of lines of destination bins, such as parallel lines of destination bins, arranged on each side of the first feeder section, wherein said plurality of lines of destination bins are arranged within reach of the pick and place robot system.

[0097] E17. The system according to any of E0.5-E16, wherein the destination bins are roller bins arranged to be rolled in and out of said lines of destination bins either manually or by means of an actuator, such as the destination bins being roller cages or cage trolleys.

[0098] E18. The system according to any of E0.5-E17, wherein the first feeder section is placed at an elevated position, so as to allow the destination bins to be transported below the feeder section.

* Embodiment one *

[0099] E19. The system according to any of E0.5-E2

or E12-E18, comprising a singulation system upstream of the first feeder section, so that the first feeder section is arranged to transport singulated objects to the pick and place robot system.

5 **[0100]** E20. The system according to E19, wherein both of the first and second lines of destination bins are arranged adjacent to the first feeder section.

[0101] E21. The system according to E19 or E20, wherein the first and second lines of destination bins, and a longitudinal axis of the portal structure are parallel with the first transport direction.

10 **[0102]** E22. The system according to any of E19-E21, wherein the first feeder section has a width of at least 50% of a width of the portal structure, such as 50-90%, such as 60-80% of a width of the portal structure.

* Embodiment two *

[0103] E23. The system according to any of E9-E18, wherein the feeding system comprises second and third feeder sections arranged to transport objects and being within reach of the pick and place robot system, wherein the second feeder section is arranged to transport objects in the first transport direction, and wherein the third feeder section is arranged to transport objects in a transport direction opposite the first transport direction, such as all of the first, second and third feeder sections being arranged to transport objects on respective surfaces being on one common vertical level.

20 **[0104]** E24. The system according to E23, wherein the first and second feeder sections serve to transport objects to the pick and place robots, such as from an upstream input of objects, while the third feeder section serves as an intermediate space for parking of objects by the pick and place robots.

25 **[0105]** E25. The system according to E23 or E24, wherein the first and second feeder sections are arranged adjacent to the third feeder section.

[0106] E26. The system according to any of E23-E25, wherein the first feeder section is arranged adjacent to the first line of destination bins, and wherein the second feeder section is arranged adjacent to the second line of destination bins.

30 **[0107]** E27. The system according to any of E23-E26, wherein the pick and place robot system is arranged to pick objects from all of the first, second and third feeder sections.

[0108] E28. The system according to any of E23-E27, wherein the pick and place robot system is arranged to place objects on the third feeder sections, so as allow coordination of pick and place tasks between the plurality of robots.

35 **[0109]** E29. The system according to any of E23-E28, wherein the scanner system comprises a scanner located upstream of the first feeder section.

40 **[0110]** E30. The system according to E29, wherein the control system of the pick and place robot system is configured to coordinate pick and place tasks of the plurality

of robots based on knowledge of a position of a destination bin for each object.

[0111] E31. The system according to E28 and E30, wherein the control system of the pick and place robot system is configured to coordinate pick and place tasks of the plurality of robots by controlling one of the plurality of robots to pick an object on the first or second feeder section and to place the object on the third feeder section, and to control another one of the plurality of robots to pick said object from the third feeder section and to place said object in a destination bin.

* Embodiment three *

[0112] E32. The system according to any of E9-E18, wherein the feeding system comprises second and third feeder sections arranged to transport objects and being within reach of the pick and place robot system, wherein the second feeder section is arranged to transport objects in the first transport direction, and wherein the third feeder section is arranged to transport objects in a transport direction opposite the first transport direction, such as all of the first, second and third feeder sections being arranged to transport objects on respective surfaces being on one common vertical level.

[0113] E33. The system according to E32, wherein the second and third feeder sections are connected to form a closed loop, such the first and second feeder sections being connected outside an area of the portal structure.

[0114] E34. The system according to E32 or E33, the first feeder section serves to transport objects to the pick and place robots, such as from an upstream input of objects, while the second and third feeder section serve as intermediate spaces for parking of objects by the pick and place robots.

[0115] E35. The system according to any of E32-E34, wherein the second and third feeder sections are arranged adjacent to the first feeder section.

[0116] E36. The system according to any of E32-E35, wherein the first feeder section is arranged to transport objects in 2D or 3D bulk to the pick and place robot system.

[0117] E37. The system according to any of E32-E36, wherein the control system of the pick and place robot system is configured to coordinate pick and place tasks of the plurality of robots by controlling one of the controllable robots to pick an object on the first feeder section and to place the object on the second or third feeder section, and to control another one of the plurality of robots to pick said object from the second or third feeder section and to place said object in a destination bin.

[0118] E38. The system according to any of E32-E37, wherein the control system of the pick and place robot system is configured to optimize utilization of the plurality of robots by selecting between:

- 1) picking an object from the first feeder section and directly placing said object in a destination bin,

- 2) picking an object from the first feeder section and placing said object on the second (or third) feeder section, and

- 3) picking an object from the second or third feeder section and placing said object in a destination bin,

wherein said step of selecting is performed in response to a plurality of inputs.

[0119] E39. The system according to E38, wherein the control system of the pick and place robot system is configured to select between 1), 2) and 3) in response to one or more inputs selected from: a position of an object on the first feeder section, a position of at least two of the plurality of the robots, an amount of objects arriving on the first feeder section, an amount of objects on the second or third feeder section, a size of arriving objects, and a time of arrival of objects for placing in one destination bin.

[0120] E40. The system according to any of E32-E39, wherein the first feeder section has a width being within a factor of 0.7-1.3 of a width of each of the second and third feeder sections.

* Embodiment four *

[0121] E41. The system according to any of E0.5-E2 or E12-E18, comprising a cascade of a plurality of conveyors upstream of the first feeder section, wherein said cascade of conveyors are arranged at different vertical levels so as to cause a distribution or separation of objects arriving in a 2D or 3D bulk upon transporting objects from an input end of said cascade of conveyors so as to provide a stream of at least partially separated objects to the first feeder section.

[0122] E42. The system according to E41, wherein the scanning system comprises at least one scanner, preferably a plurality of scanners, positioned upstream of the first feeder section.

[0123] E43. The system according to E42, wherein the plurality of scanners are positioned above said cascade of conveyors and at respective positions along said cascade of conveyors, such as 3-8 scanners at respective positions along said cascade of conveyors, such as positioned as a series of scanner tunnels, so as to allow the scanners to read information on the objects along with the distribution or separation of the objects.

[0124] E44. The system according any of E41-E43, wherein the control system of the pick and place robot system is arranged to control each of the plurality of robots to selectively pick objects to be placed in one of a group of destination bins positioned at a longitudinal position in accordance with a longitudinal position of each of the plurality of robots.

[0125] E45. The system according to any of E41-E44, wherein each of the plurality of robots are assigned respective groups of destination bins, and wherein the control system of the pick and place robot system is arranged to control each of the plurality of robots to pick objects

only which are to be placed in a destination bin belonging to its assigned group of destination bins.

[0126] E46. The system according to E45, wherein said respective groups of destination bins are non-overlapping groups of destination bins.

[0127] E47. The system according to E45, wherein said respective groups of destination bins are partially overlapping groups of destination bins.

**** Feeder ****

[0128] E48. The system according to any E1-E47, wherein the first feeder section is straight and arranged parallel with a longitudinal axis of the portal structure.

[0129] E49. The system according to any of E1-E48, wherein the first feeder section comprises a conveyor arranged to transport objects on a plane horizontal surface.

[0130] E50. The system according to any of E1-E49, wherein the first feeder section has a width occupying less than 90%, such as 5-30%, such as 10-30%, such as 20-50%, such as 50-90%, such as 50-80%, such as 60-90% of a width of the portal structure.

**** Portal structure ****

[0131] E51. The system according to any of E0.5-E50, wherein the portal structure comprises two parallel rails forming a longitudinal axis of the portal structure, wherein the plurality of robots are arranged at respective positions along said two parallel rails, and wherein the plurality of robots are arranged to move along said two parallel rails.

[0132] E52. The system according to E51, wherein the longitudinal axis of the portal structure is parallel with the first transport direction.

[0133] E53. The system according to E51 or E52, wherein a length of the portal structure is a factor of 2-10, such as 3-6, of a width of the portal structure.

[0134] E54. The system according to any of E51-E53, wherein the two parallel rails are supported by a supporting structure arranged to be mounted on a floor.

**** Robots ****

[0135] E55. The system according to any of E0.5-E54, wherein the plurality of robots are positioned at different positions along the two parallel rails, and wherein the plurality of robots are arranged to move along said rails by means of a controllable actuator controlled by the control system.

[0136] E56. The system according to any of E0.5-E55, wherein the plurality of robots are arranged to move along a longitudinal axis of the portal structure, and wherein the control system is arranged to coordinate position of the plurality of robots so that two neighbouring robots can pick objects at overlapping longitudinal positions.

[0137] E57. The system according to any of E0.5-E56, wherein each of the plurality of robots are arranged to

move their grippers with six degrees of freedom.

[0138] E58. The system according to any of E0.5-E57, wherein the plurality of robots comprises 3-10 robots positioned along a longitudinal axis of the portal structure.

5 **[0139]** E59. The system according to any of E0.5-E58, wherein the plurality of robots comprises at least two identical robots, such as all of the plurality of robots being identical.

10 **[0140]** E60. The system according to any of E0.5-E59, wherein the plurality of robots comprises at least two different robots.

[0141] E61. The system according to any of E0.5-E60, wherein each of the plurality of robots comprises:

- 15 - a horizontal bar carried by the portal structure, wherein the bar of each of the plurality of robots is controllably movable along a longitudinal axis of the portal structure, and
- 20 - a vertical bar controllably movable along a vertical axis, said vertical bar being connected at one end to the controllable gripper.

25 **[0142]** E62. The system according to any of E0.5-E61, wherein each of the plurality of robots comprises a controllable rotation element to allow the gripper to perform a controllable rotation around a rotation axis, and further comprising a controllable tilting element to allow the gripper to perform a controllable tilt around a tilting axis.

30 **[0143]** E63. The system according to any of E0.5-E62, wherein each of the plurality of robots comprises a controllable gripper having a plurality of gripping elements arranged in a spatial configuration to cooperate in gripping an object, wherein the spatial configuration is variable by means of a controllable actuator system.

35 **[0144]** E64. The system according to E63, wherein the controllable gripper comprises four elongated arms each with a suction cup, wherein the suction cups are arranged for vacuum engagement with a surface of the object for gripping the object, and wherein the controllable actuator system is arranged to move the four elongated arms along their length direction, so as to allow the four suction cups to form various gripping quadrangle sizes.

40 **[0145]** E65. The system according to any of E0.5-E64, wherein the plurality of robots comprises at least first and second robots with grippers comprising a plurality of suction cups for gripping objects, such as comprising 3-10 robots with controllable grippers comprising a plurality of suction cups for gripping objects.

50 **[0146]** E66. The system according to any of E0.5-E65, wherein the plurality of robots comprises at least first and second robots with different types or sizes of their controllable grippers, such as different types such as a suction cup gripper and a finger gripper.

55 **[0147]** E67. The system according to any of E0.5-E66, wherein each of the plurality of robots is movable to pick and place objects covering a horizontal area of at least 10 m², such as at least 50 m², such as 10-100 m².

**** Control system ****

[0148] E68. The system according to any of E0.5-E67, comprising a sensor arranged to provide a 2D or 3D image of objects on the first feeder section, upstream of a position of the plurality of robots, and wherein the control system is connected to receive said image from the sensor and to control the plurality of robots accordingly.

[0149] E69. The system according to E68, comprising at least one sensor arranged to provide a 2D or 3D image of objects on the first feeder section for each of the plurality of robots, and wherein the control system is arranged to control each of the plurality of robots in response to said images.

[0150] E70. The system according to E68 or E69, wherein each of the plurality of robots comprises a sensor mounted thereon to provide a 2D or 3D image of objects in the region of the gripper, and wherein the control system is arranged to control position of the gripper of each of the plurality of robots in response to said images.

[0151] E71. The system according to E0.5-E70, wherein each of the plurality of robots are assigned respective groups of destination bins, and wherein the control system of the pick and place robot system is arranged to control each of the plurality of robots to pick objects only which are to be placed in a destination bin belonging to its assigned group of destination bins.

[0152] E72. The system according to E71, wherein said respective groups of destination bins are non-overlapping groups of destination bins.

[0153] E73. The system according to E71, wherein said respective groups of destination bins are partially overlapping groups of destination bins.

**** General ****

[0154] E74. The system according to any of E0.5-E73, wherein each of the plurality of robots has a capacity for picking and placing at least 1,000 objects per hour.

[0155] E75. The system according to any of E0.5-E74, wherein the system is designed with a capacity to handle at least 2,000 objects per hour, such as at least 3,000 objects per hour.

[0156] E76. The system according to any of E0.5-E75, wherein the system is adapted for handling objects having a weight of 50 g to 20 kg, or for handling objects having a weight of 10-35 kg.

[0157] E77. The system according to any of E0.5-E76, wherein said scanner is arranged to scan a scan code or identification code on each of the objects, such as a visual scan code or identification code, such as a bar code or QR code, so as to read information on each of the objects.

[0158] E78. Use of the system according to any of E0.5-E77 for handling objects comprising at least one of: mail pieces, parcels, baggage, items handled at a warehouse distribution, items handled at a mail order distribution centre, and items handled at a smalls handling

centre.

[0159] E79. A mail distribution centre comprising a sorter system according to any of E0.5-E77.

[0160] E80. A parcel or mail order distribution centre comprising a sorter system according to any of E0.5-E77.

[0161] E81. A baggage handling system comprising a sorter system according to any of E0.5-E77.

[0162] E82. A warehouse distribution centre comprising a sorter system according to any of E0.5-E77.

[0163] E83. A smalls handling centre comprising a sorter system according to any of E0.5-E77.

[0164] E84. A method for automatically sorting a stream of objects of various sizes and shapes in bulk, the method comprises

- transporting (T_O) the objects on a first feeder section in a first transport direction to a pick and place robot system with a plurality of robots carried by a portal structure and being movable along the portal structure,
- placing (P_DB) first and second lines of destination bins on opposite sides of the first feeder section, so that the destination bins are within reach of the pick and place robot system,
- reading (R_I) information on each object,
- selecting (D_DB) a destination bin for each object in accordance with the information read, and
- controlling (C_P_P) the plurality of robots to pick each of the objects from the first feeder section and place the objects in the selected destination bins.

[0165] E85. Use of the method according to E84 for handling objects comprising at least one of: mail pieces, parcels, baggage, items handled at a warehouse distribution, items handled at a mail order distribution centre, and items handled at a smalls handling centre.

[0166] To sum up: the invention provides a sorter system for handling a stream of objects of various shapes and sizes in bulk, e.g. 3D bulk. A first feeder section transports the objects in a first transport direction to a portal structure carrying a plurality of gantry robots, e.g. 3-10 robots, which can move along the portal structure. The robots pick objects from the first feeder section and places the objects in destination bins, e.g. roller cages, arranged in two lines within reach of the robots. Preferably, the first feeder section, the portal structure and the destination bin lines are parallel. A scanner reads information on each object regarding a destination bin for each object. The robots are controlled to either place the objects directly in their destination bins or to park objects on an intermediate parking space, e.g. one or more feeder sections, e.g. comprising an additional feeder section transporting objects in opposite direction of the first transport direction. Such intermediate parking allows coordination

between the robots to optimize a total handling capacity. Objects not picked from the first feeder section may be returned to a position upstream of the first feeder section. The robots preferably place the objects in the destination bins at the lowest point available for the object to provide a careful handling and a high packing density in the destination bins. Such system provides a high sorting capacity at a small area.

[0167] Although the present invention has been described in connection with the specified embodiments, it should not be construed as being in any way limited to the presented examples. The scope of the present invention is to be interpreted in the light of the accompanying claim set. In the context of the claims, the terms "comprising" or "comprises" do not exclude other possible elements or steps. Also, the mentioning of references such as "a" or "an" etc. should not be construed as excluding a plurality. The use of reference signs in the claims with respect to elements indicated in the figures shall also not be construed as limiting the scope of the invention. Furthermore, individual features mentioned in different claims, may possibly be advantageously combined, and the mentioning of these features in different claims does not exclude that a combination of features is not possible and advantageous.

[0168] In general, when directional terms like "horizontal" and "vertical" or similar directional references are used in the present disclosure, these terms are meant to be understood as relative terms e.g. where the term "vertical" refers to a direction essentially perpendicular to the substrate surface, and "horizontal" refers to a direction essentially parallel to the substrate.

Claims

1. A sorter system for handling a stream of objects of various shapes and sizes in bulk, the system comprising
 - a feeder system comprising at least a first feeder section arranged to transport the objects in a first transport direction,
 - a destination system comprising at least first and second separate lines of destination bins,
 - a pick and place robot system comprising
 - a portal structure carrying a plurality of controllable robots in a gantry configuration and being controllably movable along said portal structure, wherein each of said robots are configured with a manipulator, preferably a gripper, arranged for engaging with objects, preferably picking objects, from the at least first feeder section and transferring objects to the destination bins, and
 - a control system arranged to control movement of the plurality of robots and their ma-

nipulators, such as grippers, to transfer objects from the first feeder section to selected destination bins, and

- a scanner system comprising a scanner configured to read information on the objects, and wherein the scanner system is configured to provide data to the control system according to the information read, so as to allow the pick and place robot system to place objects in a destination bin selected in accordance with information read,

wherein the first feeder section and the first and second lines of destination bins are arranged within reach of the pick and place robot system, preferably the first feeder section and the first and second lines of destination bins being arranged within the portal structure, such as the first and second lines of destination bins being located on opposite sides of the at least first feeder section.

2. The system according to claim 1, wherein the first transport direction and a longitudinal axis of the portal structure are parallel, preferably the first and second lines of destination bins are parallel with the first transport direction.
3. The system according to claim 1 or 2, wherein the feeder system comprises a second feeder section arranged within reach of the pick and place robot system, preferably arranged within a width of the portal structure, and wherein the second feeder section is arranged to transport objects in a transport direction being opposite the first transport direction, such as the second feeder section being arranged adjacent to the first feeder section, such as the first line of destination bins being arranged adjacent to the first feeder section, such as the second line of destination bins being arranged adjacent to the second feeder section.
4. The system according to claim 3, wherein the pick and place robot system is arranged to pick one object from the first feeder section and to place the object on the second feeder section.
5. The system according to claim 4, wherein the control system of the pick and place robot system is arranged to optimize a total capacity of the plurality of robots by selecting to place an object on the second feeder section.
6. The system according to any of the preceding claims, wherein at least one scanner of the scanner system is arranged upstream of the first feeder section, and wherein the control system of the pick and place robot system is arranged to distribute pick and place

tasks to the respective ones of the plurality of robots based on known positions of destination bins for each of the objects arriving on the first feeder section.

7. The system according to claim 5 and 6, wherein the control system of the pick and place robot system is arranged to optimize a total capacity of the plurality of robots by selecting to control one of the plurality of robots to place an object on the second feeder section, and to control another one of the plurality of robots to pick said object from the second feeder section and to place said object in the selected destination bin. 5 10
8. The system according to claim 4 or 5, wherein the scanner system is configured to read information on an object when picked by one of the plurality of robots, and wherein the control system of the pick and place robots is configured to determine, whether to control said one robot to place the object in its destination bin or whether to control said robot to place the object on the second feeder section. 15 20
9. The system according to any of the preceding claims, wherein the feeder system comprises a second and a third feeder section arranged within reach of the pick and place robot system, and wherein one of or both of the second and third feeder sections is arranged to transport objects in a transport direction opposite the first transport direction, such as the first feeder section being arranged adjacent to both of the second and third feeder sections, or such as the first feeder section being arranged adjacent to the first line of destination bins. 25 30
10. The system according to claim 9, wherein the control system of the pick and place robot system is arranged to control robots to pick objects from the first feeder section and to place objects selectively on the second or third feeder section. 35 40
11. The system according to claim 9 or 10, wherein all of the first, second and third feeder sections are arranged to transport objects on respective surfaces being on one common vertical level. 45
12. The system according to any of the preceding claims, wherein the pick and place robot system is arranged to sense a lowest point of space in a destination bin and to place an object on said lowest point of space in the destination bin, preferably the control system of the pick and place robot is arranged to determine a weight of an object and to control placing of the object in a destination bin accordingly, so as to ensure careful handling of objects and at the same time minimize time for performing the task of placing objects. 50 55

13. The system according to any of the preceding claims, wherein the control system of the pick and place robot is configured to control the plurality of robots according to a packet strategy for each of the destination bins, taking into account at least a size of objects to be placed in each destination bin, and a time of arrival to the plurality of robots of objects be placed in each destination bin, so as to optimize a filling or packet density of each destination bin.
14. The system according to any of the preceding claims, comprising a system configured to distribute objects upstream of the first feeder section, such as a system configured to distribute objects in 3D bulk to objects in 2D bulk, such as a system configured to singulate objects upstream of the first feeder section.
15. The system according to any of the preceding claims, comprising a return conveyor arranged to return objects which have not been picked by the pick and place robot system, such as a return conveyor positioned below the first feeder section and arranged to transport objects from an end of the first feeder section to a position upstream of the first feeder section.
16. The system according to any of the preceding claims, comprising a plurality, such as 2-4, lines of destination bins, such as parallel lines of destination bins, arranged on each side of the first feeder section, wherein said plurality of lines of destination bins are arranged within reach of the pick and place robot system.
17. The system according to any of the preceding claims, wherein the destination bins are roller bins arranged to be rolled in and out of said lines of destination bins either manually or by means of an actuator, such as the destination bins being roller cages or cage trolleys.
18. The system according to any of the preceding claims, wherein the first feeder section is placed at an elevated position, so as to allow the destination bins to be transported below the feeder section.
19. Use of the system according to any of claim 1-18 for handling objects comprising at least one of: mail pieces, parcels, baggage, items handled at a warehouse distribution, items handled at a mail order distribution centre, and items handled at a smalls handling centre.

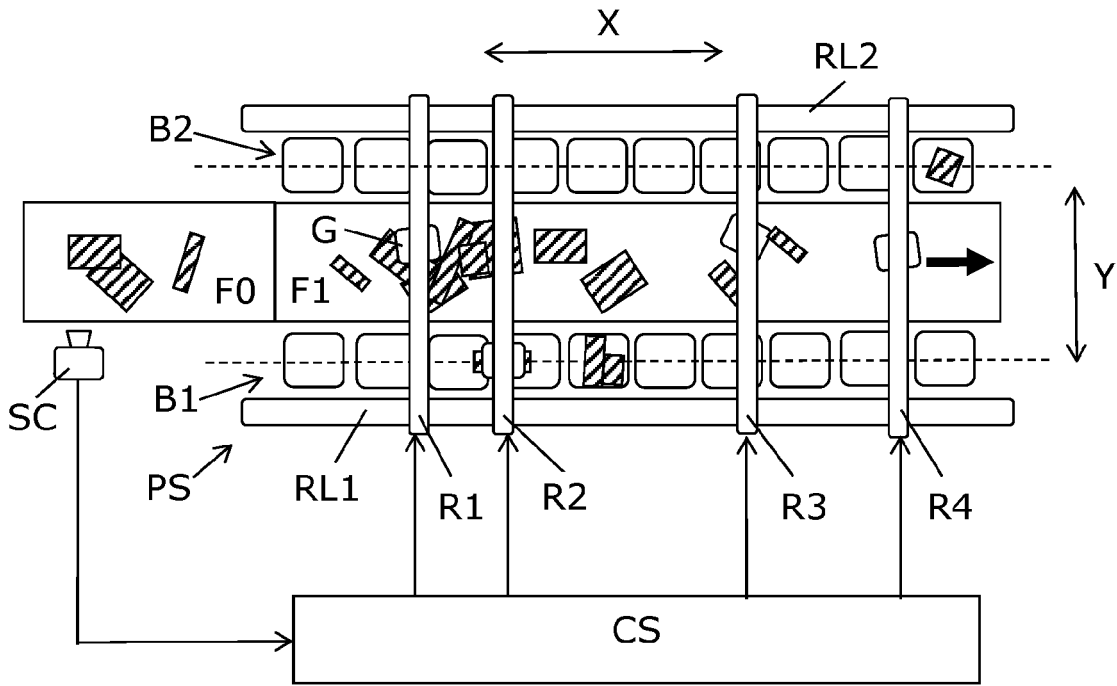


FIG. 1

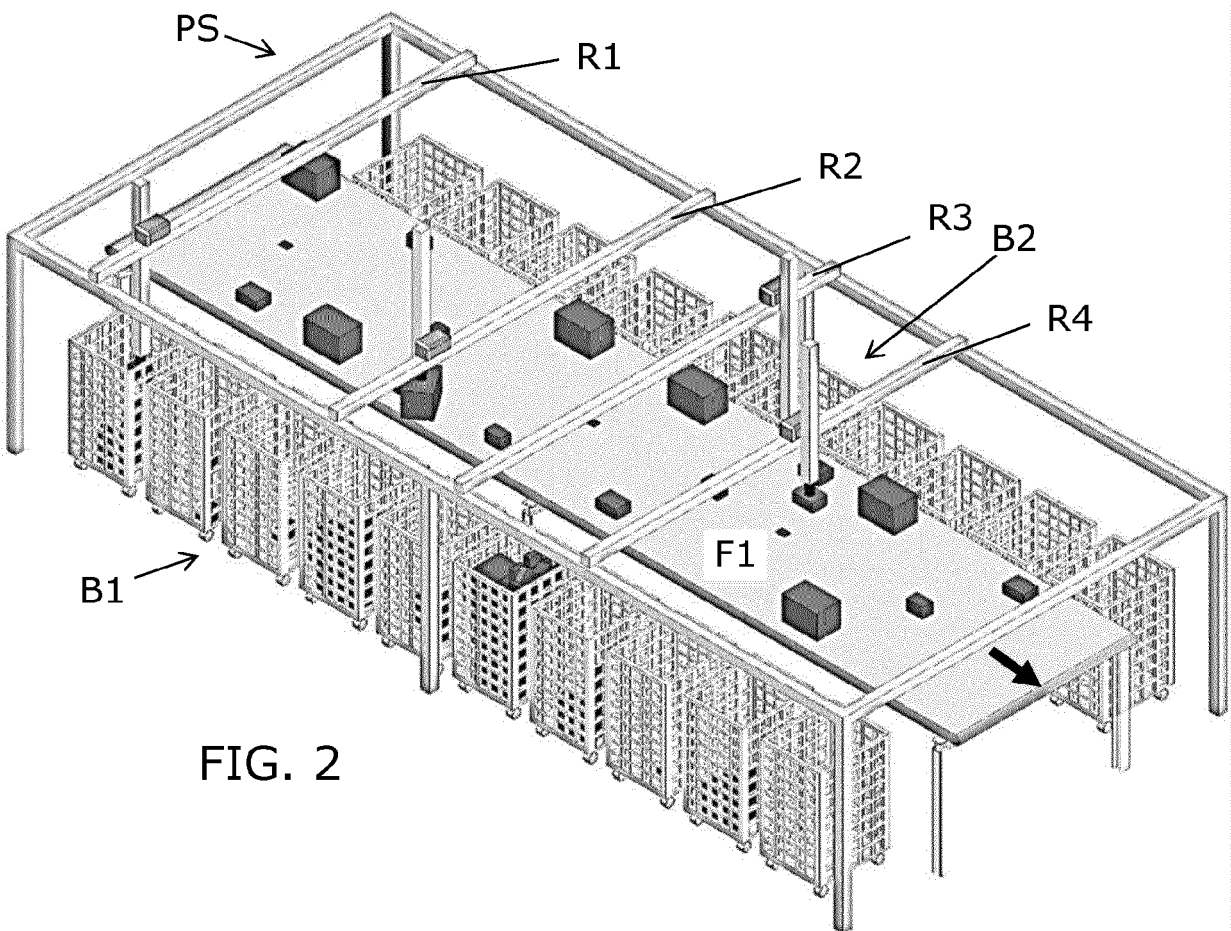
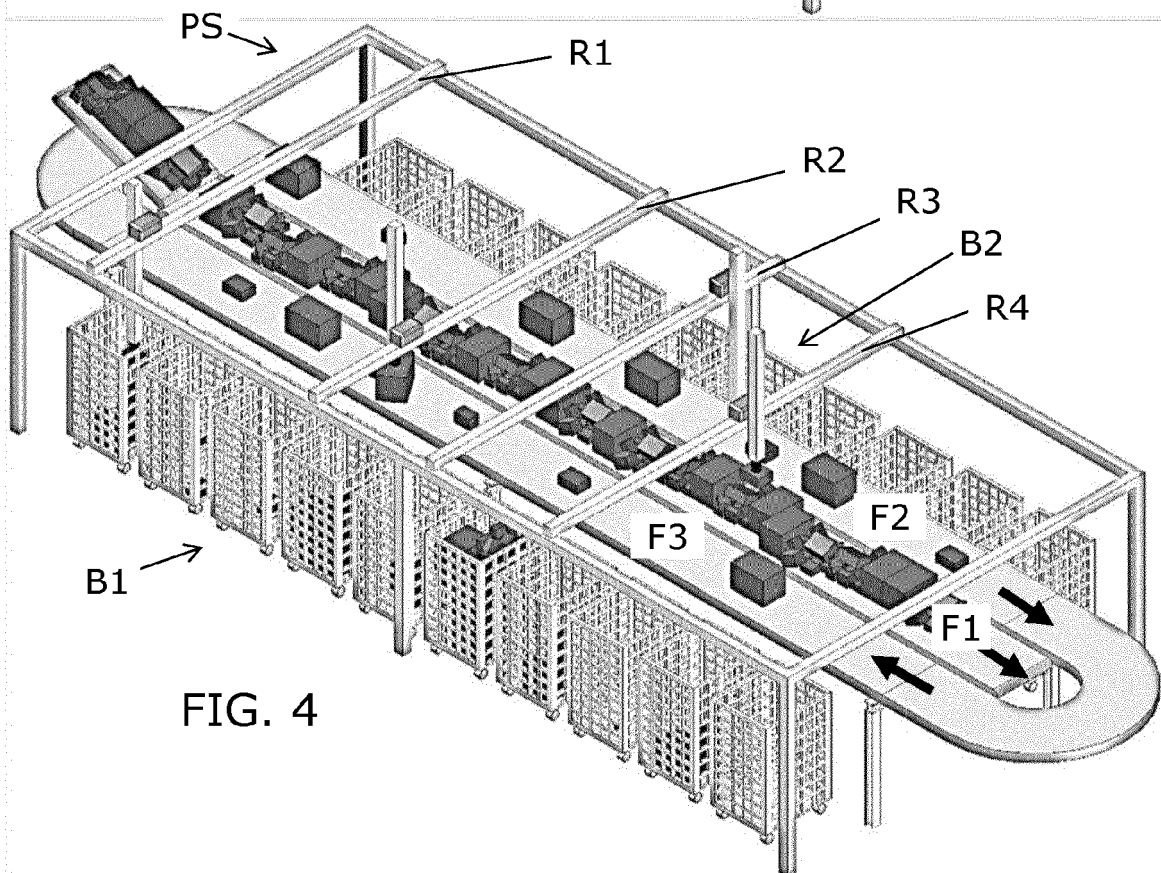
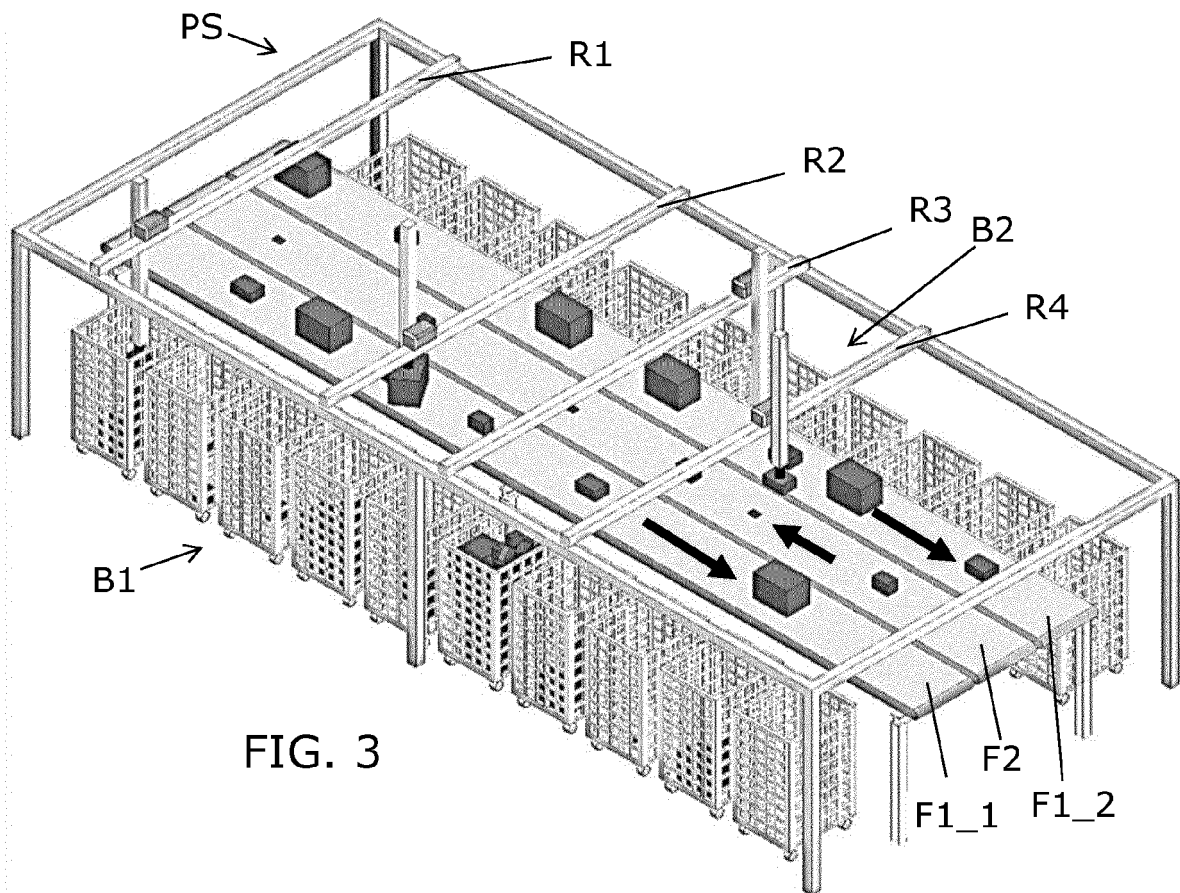
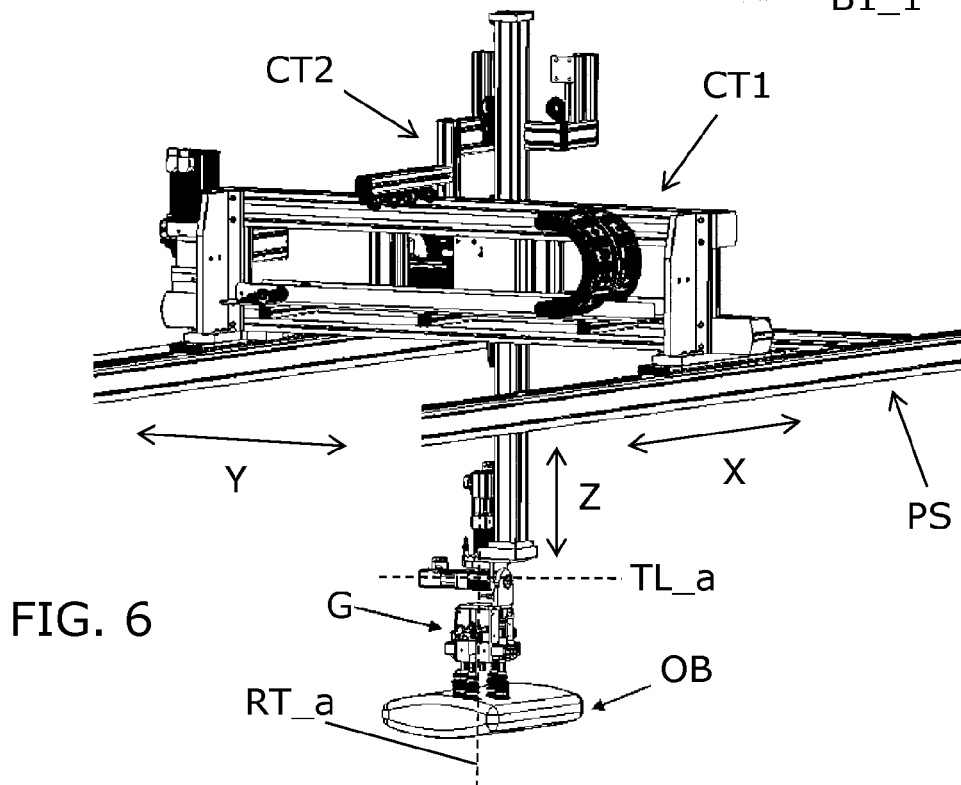
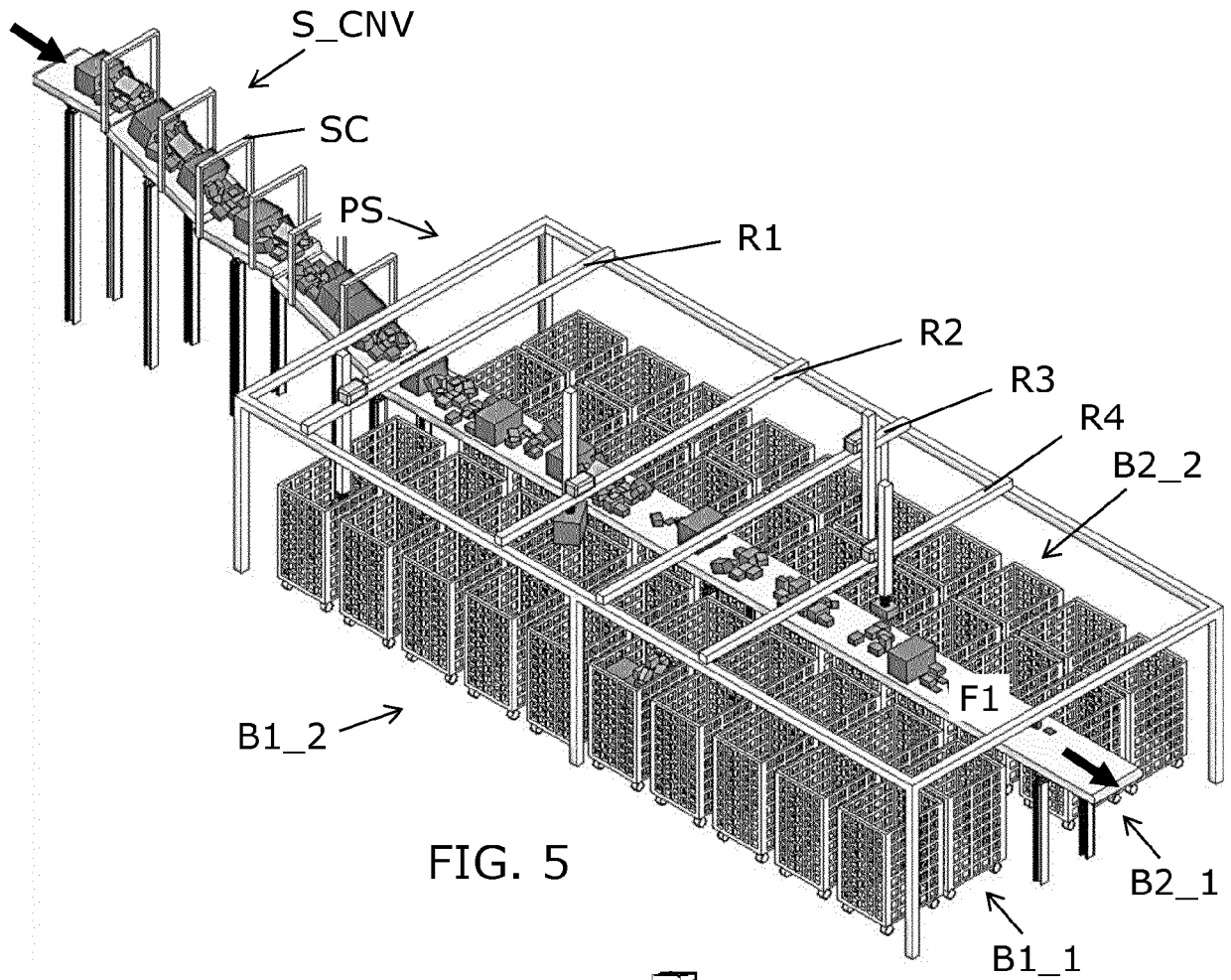
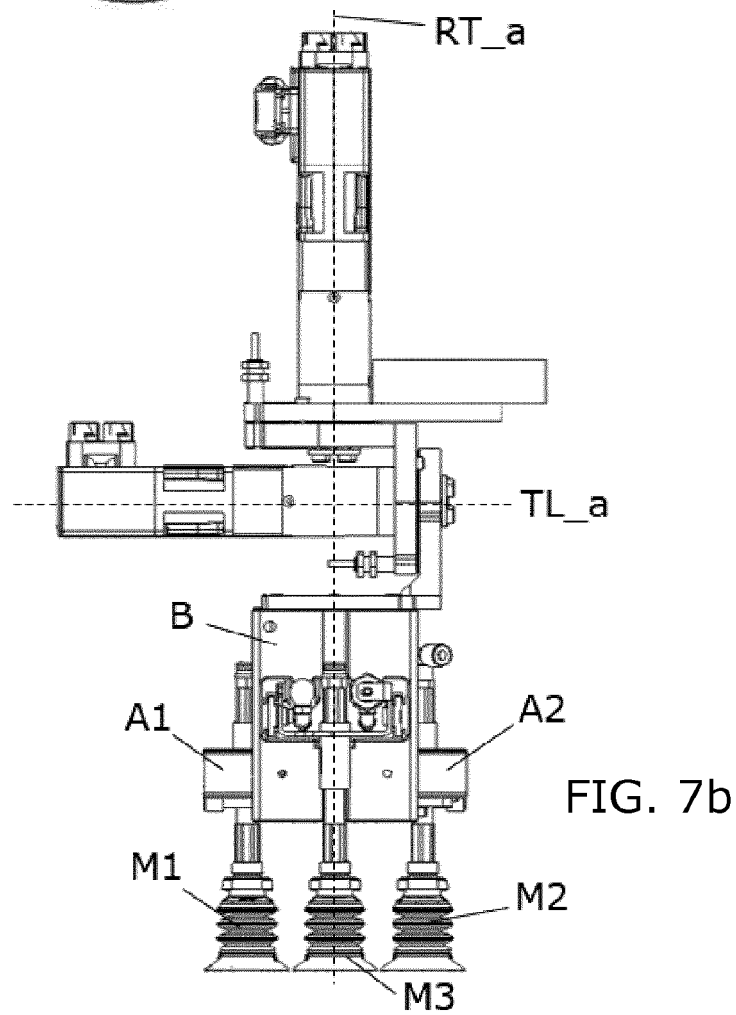
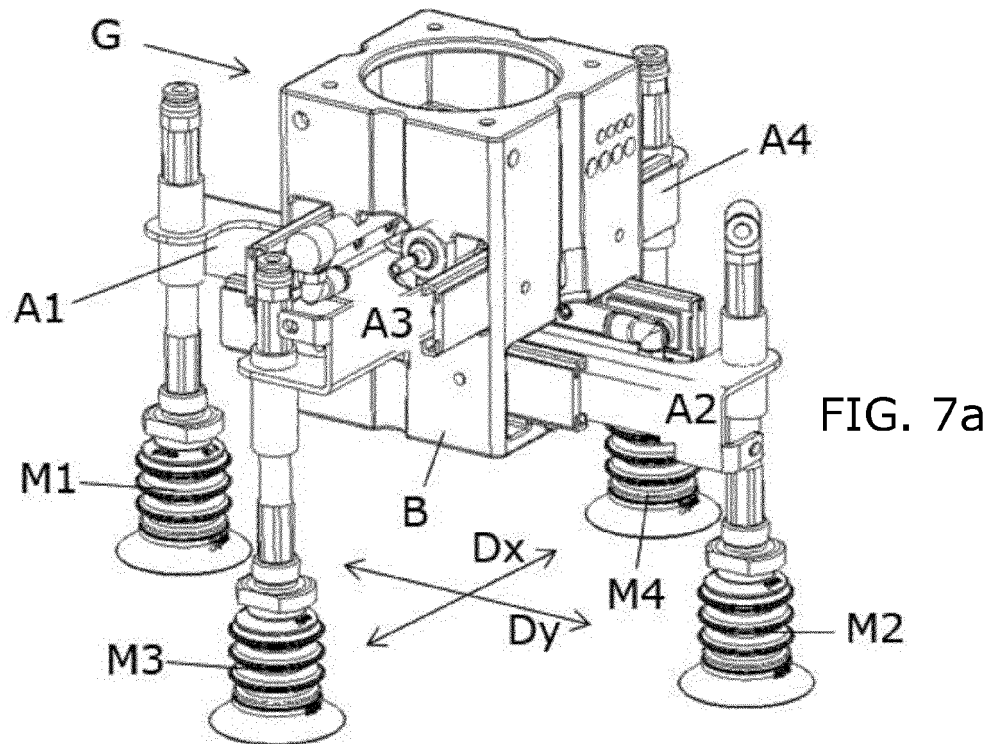


FIG. 2







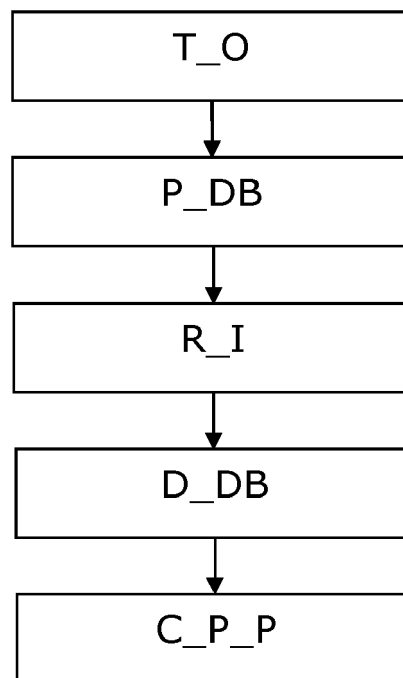


FIG. 8



EUROPEAN SEARCH REPORT

Application Number

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	WO 2019/207200 A1 (ZENROBOTICS OY [FI]) 31 October 2019 (2019-10-31)	1-3, 14, 15, 19	INV. B07C5/36
A	* page 13, line 28 - page 14, line 11; figures 2-4 * * page 12, line 15 - line 19 *	4-13, 16-18	
Y	WO 2021/198053 A1 (BEUMER GROUP AS [DK]) 7 October 2021 (2021-10-07)	1-3, 14, 15, 19	
A	* figures 5a-5c *	4-13, 16-18	
			TECHNICAL FIELDS SEARCHED (IPC)
			B07C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 4 July 2022	Examiner Wich, Roland
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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		WO 2019207200 A1	31-10-2019

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