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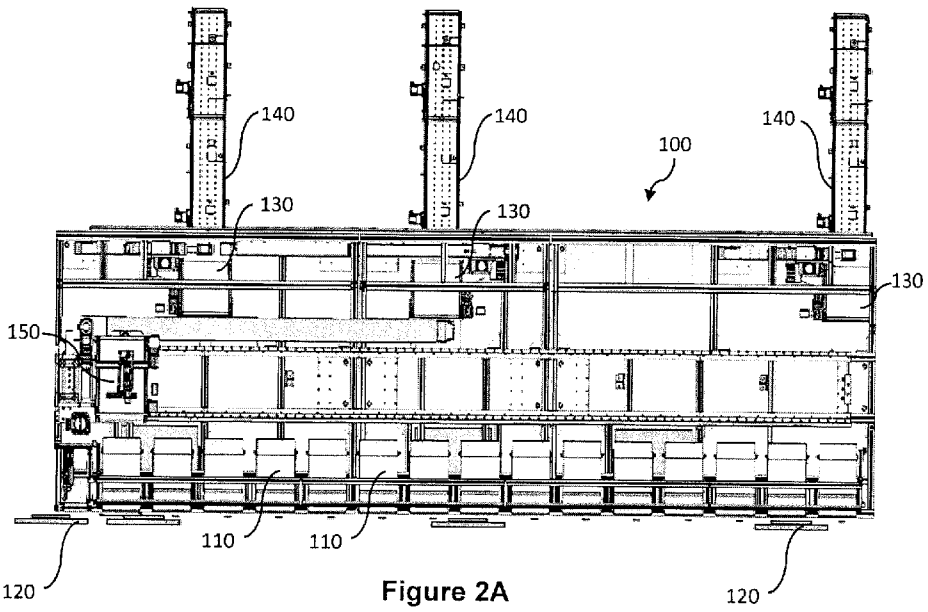

Figure 2A

(57) Abstract: A drug package assembly apparatus 100 is disclosed herein. In a described embodiment, the drug package assembly apparatus 100 comprises: a plurality of collection receptacles 110 associated with respective prescriptions; a plurality of intermediate collection stations 130 arranged to receive and hold drug packages delivered from respective sources 140 in association with the prescriptions; and a transfer mechanism 150 operable to transfer the held drug packages from the intermediate collection stations 130 to at least one of the collection receptacles 110 based on the prescriptions.

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Drug package assembly apparatus

Technical field

The present invention relates to a drug package assembly apparatus, a conveyor belt, and a method of assembling drug packages.

Background

In the practice of pharmacy, a pharmacist would often collect drug packages (e.g., resealable bags, bottles and boxes) for a prescription from different sources (e.g., boxes on a shelf) into a container. Once all drug packages for the prescription are collected, the container would be made available for collection by, for example, a patient for whom the prescription is made. However, such a process is inefficient because the pharmacist is required to move about to collect the drug packages. Depending on the locations of the drug packages and the complexity of the prescription, fulfilment of the prescription by the pharmacist may be laborious and time-consuming.

It is desirable to provide a drug package assembly apparatus, a conveyor belt, and a method of assembling drug packages which address at least one of the drawbacks of the prior art and/or to provide the public with a useful choice.

Summary

According to one aspect, there is provided a drug package assembly apparatus comprising: a plurality of collection receptacles associated with respective prescriptions; a plurality of intermediate collection stations arranged to receive and hold drug packages delivered from respective sources in association with the prescriptions; and a transfer mechanism operable to transfer the held drug packages from the intermediate collection stations to at least one of the collection receptacles based on the prescriptions.

The described embodiment is particularly advantageous. Drug packages received and held by the intermediate collection stations are transferred to the collection receptacles by the transfer mechanism according to prescriptions

associated with the collection receptacles. Instead of a pharmacist moving about to collect and assemble drug packages, drug packages are delivered by the respective sources to the apparatus for assembly by the apparatus. The apparatus thus improves efficiency of dispensing drug packages, particularly in a scenario with a large number of prescriptions to be fulfilled. The use of the intermediate collection stations also improves throughput and productivity of dispensing the drug packages via the collection receptacles.

Preferably, at least one of the intermediate collection stations and the transfer mechanism includes a conveyor belt. The conveyor belt may have a contact surface with a plurality of protrusions arranged along a plurality of longitudinal axes, wherein the protrusions are spacedly arranged in each axis, and the protrusions in each axis are spaced apart from those in an adjacent one of the axes. The protrusions may be arranged in a grid formation.

Preferably, each protrusion satisfies at least one of the relationships:

$d \geqslant r$;

$h = r(1 - \sin\theta)$; and

$L \leqslant 0.25 \times C$,

where: 'd' represents a distance between the protrusion and a neighbouring protrusion; 'r' represents a radius of a cylindrical portion of a rollable object to be conveyed by the conveyor belt; 'h' represents a height of the protrusion; 'θ' represents an angle formed by a radial line, which extends through the radius point of the cylindrical portion and a point of contact between the cylindrical portion and the protrusion, with respect to the contact surface; 'L' represents a length of the protrusion in a conveyance direction of the conveyor belt; and 'C' represents an outer circumference of a pulley associated with the conveyor belt. Rolling movements of cylindrical objects on the conveyor belt due to inertia can thus be reduced or restricted by the protrusions. This is particularly advantageous because drug packages in the form of a bottle are quite common.

The conveyor belt may be provided with at least one of: a pair of wall members arranged to restrict movement of drug packages on the conveyor belt past lateral sides of the conveyor belt; and a gate member arranged at one end of the conveyor belt, and moveable between open and closed positions to permit and block passage of drug packages therethrough, respectively. Drug packages on the conveyor belt may, depending on placement, be susceptible to lateral movements (movements in a lateral direction). The wall members are useful in preventing drug packages from thus falling off via the lateral sides of the conveyor belt. The gate member is useful in selectively allowing passage of drug packages through said one end of the conveyor belt. In particular, the gate member is useful in preventing unintentional passage of drug packages via said one end of the conveyor belt, which may occur due to inertial movements of the drug packages.

Preferably, the gate member is formed with recesses matching the protrusions in position and shape. This configuration reduces the width of a gap between the gate member and the contact surface of the conveyor belt when the gate member is at the closed position, and is useful in reducing the chance of smaller drug packages unintentionally passing through the gate member via the gap.

The transfer mechanism may include a pusher operable to push a drug package into a corresponding one of the receptacles via an opening associated with the receptacle. Preferably, the associated opening partially defines an edge portion arranged at an oblique angle with respect to a vertical axis of the opening, wherein the pusher is inclined at the same oblique angle. In the event where a drug package is stuck between the conveyor belt of the transfer mechanism and the corresponding collection receptacle, the pusher is operable to push the stuck drug package into the corresponding collection receptacle via the associated opening, ensuring uninterrupted operation of the apparatus.

Each collection receptacle may be provided with at least one of: a lockable door, which is configured to permit access to the respective collection receptacle if the respective collection receptacle is determined to contain all drug packages

associated to the respective collection receptacle; a sensor operable to detect presence of a removable container for drug packages in the respective collection receptacle; and a light indicator operable to indicate a status of the respective receptacle for collection. The lockable door ensures that corresponding collection receptacle is not accessed prematurely. The sensor is useful in that, in the event where a container is improperly placed in, or missing from, a collection receptacle, the collection receptacle can be excluded from association with a prescription or a portion of the prescription until rectification takes place. The light indicator can operate in association with the lockable door to indicate the status of a corresponding collection receptacle for drug package collection.

Preferably, each intermediate collection station is provided with a sensor arranged to detect presence of a drug package held at the respective intermediate collection station. Where drug packages for a prescription are provided to one of the intermediate collection stations, the sensor can detect presence or arrival of these drug packages, ensuring that only these drug packages are held for collection by the transfer mechanism. The sensor is thus useful in preventing drug packages belonging to different prescriptions being collected and transferred by the transfer mechanism.

The transfer mechanism may include an image capturing device for capturing an image of a visual representation of identification information associated with each collection receptacle and to be association with the respective prescription. This arrangement allows a collection receptacle to be associated with new identification information, such as a barcode, for fulfilment of another prescription, upon fulfilment of a prescription and collection of drug packages associated with the fulfilled prescription from the respective collection receptacle. This arrangement eliminates or reduces the need for the identification information to be manually entered upon each collection of drug packages by a user, and works in association with the sensor of the collection receptacle, if implemented, to ensure that drug packages are dispensed into the right receptacles.

Preferably, the system is modular. The system, if implemented to be modular, allows the drug dispensing or assembling capacity to be adjusted to meet changing needs. Different possible configurations of the modular system are exemplified in the described embodiment.

The transfer mechanism may be controlled to perform the method including: collecting a first drug package held by one of the collection stations; if a second drug package related to the first drug package satisfies a delay condition, providing the collected first drug package to one of the collection receptacles corresponding to the first drug package, and collecting and providing an intermediate drug package to another one of the collection receptacles corresponding to the intermediate drug package, the intermediate drug package being unrelated to the first drug package; and collecting and providing the second drug package to the collection receptacle of the first drug package. This arrangement is useful in achieving a higher drug dispensing efficiency. If the second drug package does not satisfy the delay condition, the collected second drug package may be provided to the collection receptacle of the first drug package together with the collected first drug package. The delay condition can be configured according to implementation of the apparatus. In the described embodiment, the delay condition is the second drug package being unavailable for collection at the time of collection of the first drug package. Alternatively, where the delay condition is otherwise dependent on the availability of the second drug package for collection, the delay condition may be the second drug package being expected to arrive at the corresponding intermediate collection station within a pre-set or predetermined duration of time. In another arrangement, a position of the intermediate drug station of the second drug package relative to those of the collected first drug package and the intermediate drug package may also form the delay condition, either partially or wholly.

Preferably, the intermediate drug package and the second drug package may be collected from different collection stations. At least one of the intermediate drug

package and the second drug package may be collected from a collection station different from that of the first drug package.

Preferably, drug packages held by each individual one of the collection stations, at any given time, belong to no more than one prescription. The drug packages may include bottles, blister packs, boxes or bags containing medical items.

The apparatus may further comprise a control device arranged to: receive the respective prescriptions; control the sources to dispatch the drug packages based on the prescriptions for delivery to the intermediate collection stations; and operate the transfer mechanism to transfer the drug packages held by the intermediate collection stations to the collection receptacles.

According to another aspect, there is provided a conveyor belt for conveyance of drug packages, comprising a contact surface with a plurality of protrusions arranged along a plurality of longitudinal axes, wherein the protrusions are spacedly arranged in each axis, and the protrusions in each axis are spaced apart from those in an adjacent one of the axes. Advantages of the conveyor belt are as described above in relation to the aspect of the apparatus.

According to yet another aspect, there is provided a conveyor belt for conveyance of drug packages, comprising a contact surface formed with a plurality of protrusions, wherein each protrusion satisfies at least one of the relationships:

$$d \geqslant r;$$

$$h = r(1 - \sin\theta); \text{ and}$$

$$L \leqslant 0.25 \times C,$$

where: 'd' represents a distance between the protrusion and a neighbouring protrusion; 'r' represents a radius of a cylindrical portion of a rollable object to be conveyed by the conveyor belt; 'h' represents a height of the protrusion; 'θ' represents an angle formed by a radial line, which extends through the radius point of the cylindrical portion and a point of contact between the cylindrical portion and the protrusion, with respect to the contact surface; 'L'

represents a length of the protrusion in a conveyance direction of the conveyor belt; and 'C' represents an outer circumference of a pulley to be associated with the conveyor belt. Advantages of the conveyor belt are as described above in relation to the aspect of the apparatus.

According to yet another aspect, there is provided a method of assembling drug packages, comprising: collecting a first drug package from a first source; if a second drug package related to the first drug package satisfies a delay condition, providing the collected first drug package to a first destination, and collecting and providing an intermediate drug package to a second destination, the intermediate drug package being unrelated to the first drug package; and collecting and providing the second drug package to the first destination. Advantages of the method are as described above in relation to the aspect of the apparatus.

It is envisaged that features relating to one aspect may be applicable to the other aspects.

Brief Description of the drawings

Example embodiments will now be described hereinafter with reference to the accompanying drawings, wherein like parts are denoted by like reference numerals. Among the drawings:

Figure 1A illustrates a schematic diagram of a front schematic view of a drug package assembly apparatus according to an example embodiment of the present invention;

Figure 1B illustrates a front perspective view of the drug package assembly apparatus of Figure 1A;

Figure 1C illustrates a perspective partial view of the apparatus of Figure 1A, showing one of a plurality of collection receptacles of the apparatus;

Figure 2A illustrates a top schematic view of the apparatus of Figure 1A, showing a cross section of the apparatus in association with sources of drug packages;

Figure 2B illustrates a rear perspective view of the apparatus of Figure 1A, with certain parts removed to show internal components of the apparatus;

Figure 3A illustrates an enlarged partial view of Figure 2B, showing an intermediate collection station and an associated moving mechanism of the apparatus of Figure 1A;

Figure 3B is a perspective view of the intermediate collection station of Figure 3A alone with the associated moving mechanism;

Figure 3C is an enlarged partial view showing a conveyor belt of the intermediate collection station of Figures 3A and 3B, showing protrusions of a contact surface of the conveyor belt;

Figure 4A is a perspective enlarged partial view of Figure 3A, showing the protrusions on the conveyor belt of the intermediate collection station;

Figure 4B is a cross-sectional view of a cylindrical portion of a rollable object placed substantially between an adjacent pair of the protrusions of the conveyor belt of the intermediate collection station of Figure 4A;

Figure 5A is a perspective partial view of a transfer mechanism and some of the collection receptacles of the apparatus of Figure 1A;

Figure 5B is a perspective view of the transfer mechanism illustrated in Figure 5A alone and without any drug packages;

Figure 5C is a perspective view of the transfer mechanism illustrated in Figure 5A together with an associated frame;

Figure 6A is a schematic side view of the transfer mechanism of Figure 5A;

Figure 6B is a perspective view of one of the collection receptacles and a portion of the transfer mechanism of the apparatus of Figure 1A;

Figure 7A is a flowchart of a method performed by the apparatus of Figure 1A;

Figure 7B is a flowchart of another method performed by the apparatus of Figure 1A;

Figure 8A shows a top schematic diagram of each instance of the apparatus of Figure 1A associated with a respective control device;

Figure 8B shows a top schematic diagram of multiple instances of the apparatus of Figure 1A associated with a single control device in a first topology; and

Figure 8C shows a top schematic diagram of multiple instances of the apparatus of Figure 1A associated with a single control device in a second topology.

Detailed Description

A drug package assembly apparatus 100 according to one embodiment will now be described. Figures 1A and 1B show a front schematic view and a perspective view of the apparatus, respectively. Figure 2A shows a top schematic view of the apparatus 100, showing a cross section of the apparatus 100. Figure 2B shows a perspective view of the apparatus 100 without a housing and from a different angle. The apparatus 100 includes a plurality of collection receptacles 110, a plurality of display units 120 arranged above the receptacles 110, a plurality of intermediate collection stations 130 adapted to be associated with respective ones of sources 140 of drug packages 200 (one such drug package 200 being shown in Figures 3A and 5A), and a transfer mechanism 150. The drug packages 200 include, for example, bottles, blister packs, boxes or bags containing medical items.

In this embodiment, the collection receptacles 110 are associated with respective prescriptions. More specifically, each receptacle 110 takes the form of a respective rectangular collection compartment for collection of drug packages 200 belonging to the corresponding prescription of the respective receptacle 110. In this embodiment, each receptacle 110 defines a rectangular space or compartment for removably receiving a container 115 (e.g., a box or a tote; see Figure 1C, 6A and 6B). The container 115 serves to receive and hold drug packages 200 dispense into the respective receptacle 110. Once the container 115 of a partially or wholly fulfilled prescription is collected from the respective receptacle 110, an empty container can be placed in the respective receptacle 110 for collection of drug packages 200 of a prescription to be partially or wholly

assigned to the respective receptacle 110. In such a manner, each receptacle 110 corresponds to one prescription at any given time.

The display units 120 display a queue of prescriptions pending fulfilment and collection. In the present embodiment, when drug packages 200 of a prescription are ready for collection from the corresponding receptacle 110, the display units 120 display the prescription (e.g., a prescription number) and associated identification information (e.g., a colour). Figure 1C shows a perspective view of one of the collection receptacle 110. It can be seen from Figure 1C that each receptacle 110 is provided with a lockable magnetic door 111 and a light indicator 112. The lockable door 111 is operable to permit access to the respective collection receptacle 110 if the respective collection receptacle 110 is determined, by a control or computing device, to contain all drug packages 200 of a prescription associated to the respective receptacle 110. The light indicator 112 is operable to indicate a status of the respective receptacle 110 for collection. In this arrangement, the light indicator 112 is operable to emit light of the colour corresponding to the prescription of the respective receptacle 110. In such a manner, the light indicator 110 indicates, in association with the display units 120, a status of the corresponding receptacle 110 for collection.

Figure 3A shows an enlarged partial view of Figure 2B, illustrating one of the intermediate collection stations 130 and the transfer mechanism 150 in more detail. Figure 3B shows the collection station 130 alone and viewed from a different angle. Figure 3C shows an enlarged partial view of the intermediate collection station 130. The intermediate collection stations 130 are arranged to receive and hold drug packages 200 delivered from respective sources 140 of drug packages 200 in association with the prescriptions. In this embodiment, each intermediate collection station 130 includes a conveyor belt 131, a pair of walls 132, a plurality of sensors 133 (see Figure 3C), a gate member 134, and a moving mechanism 135.

The conveyor belt 131 of each of the intermediate collection stations 130 is adapted to receive drug packages 200 from the corresponding source 140. The sources 140 in this embodiment are respective conveyor belts. However, the sources 140 may take on any other suitable forms in other embodiments. In this embodiment, drug packages 200 held by each individual one of the collection stations 130, at any given time, belong to no more than one prescription.

The wall members 132 are associated with the conveyor belt 131 and arranged to restrict movement of drug packages 200 on the conveyor belt 131 past lateral sides of the conveyor belt 131, thereby preventing the drug packages 200 from falling off the lateral sides of the conveyor belt 131.

The sensors 133 are arranged on one of the wall members 132 and disposed respectively towards opposite longitudinal ends of said one of the wall members 132. The sensors 133 are operable to detect presence of a drug package 200 held at the respective intermediate collection station 130 for collection. In other embodiment, a single sensor may instead be used.

The gate member 134 is associated with the conveyor belt 131 and arranged at one end of the conveyor belt 131, and is moveable between open and closed positions to permit and block passage of drug packages 200 through the gate member 134, respectively. In this embodiment, the gate member 134 is arranged at an exit end of the conveyor belt 131 through which drug packages 200 conveyed by the conveyor belt 131 exit. The gate member 134 is shown in Figure 3B to be at the closed position, blocking passage of drug packages 200 therethrough. The gate member 134, when transitioning towards the open position, rises to permit access in this embodiment. Alternatively, the gate member 134, when transitioning towards the open position, may drop downward or move away from the conveyor belt 131 in other embodiments.

The moving mechanism 135 is operable to move the conveyor belt 131 in any direction parallel with respect to an imaginary plane on which the receptacles 110

are arranged. In other words, any movement of the conveyor belt 131 by the moving mechanism 135 does not result in a change in a shortest distance between the conveyor belt 131 and the receptacles 110. That is to say, the shortest distance between the conveyor belt 131 and the receptacles 110 remains unchanged during any movement of the conveyor belt 131 by the moving mechanism 135. The moving mechanism 135 is operable to, in this embodiment, move the conveyor belt 131 vertically between a position suitable for receiving drug packages 200 from the corresponding source 140 and another position suitable for collection of the received and held drug packages 200 by the transfer mechanism 150.

Further referring to Figure 4A, the conveyor belt 131 has a contact surface 136 with a plurality of protrusions 137 arranged along a plurality of longitudinal axes of the conveyor belt 131. The axes extend in a direction of conveyance of the conveyor belt 131. The protrusions 137 are spacedly arranged in each axis. The protrusions 137 in each of the axes are spaced apart from those 137 in an adjacent one of the axes. In this embodiment, the protrusions 137 are arranged in a grid formation. Shown in Figure 4B is a cross-sectional view of a drug package 200 in the form of a bottle, positioned substantially between an adjacent pair of the protrusions 137. Each protrusions 137 in this embodiment is rectangular in shape and satisfies the below relationships:

$$d \geqslant r;$$

$$h = r\,(1 - \sin\theta); \text{ and}$$

$$L \leqslant 0.25 \times C,$$

where: 'd' represents a distance between the respective protrusion 137 and a neighbouring protrusion 137'; 'r' represents a radius of a cylindrical portion of a rollable object (e.g., the drug package 200 in the form of a bottle) to be conveyed by the conveyor belt 131; 'h' represents a height of the protrusion 137; 'θ' represents an angle formed by a radial line, which extends through the radius point of the cylindrical portion and a point of contact between the cylindrical portion and the protrusion 137, with respect to the contact surface 136; 'L' represents a length of the protrusion 137 in a conveyance direction of the

conveyor belt 131; and 'C' represents an outer circumference of a pulley (not shown) associated with the conveyor belt 131. By satisfying the relationship of 'L', breakage or damage of the protrusions 137 due to pulley operations can be reduced or prevented.

The transfer mechanism 150 is operable to transfer the held drug packages 200 selectively from the intermediate collection stations 130 to at least one of the collection receptacles 110 based on the prescriptions. Referring to Figures 5A and 5B, the transfer mechanism 150 includes a conveyor belt 151, a pair of wall members 152, and a gate member 153 similar in configuration to those 131, 132, 134 of the intermediate collection stations 130. The conveyor belt 151, being similar to the conveyor belt 131, has a contact surface 154 with a plurality of protrusions 155 arranged along a plurality of longitudinal axes of the conveyor belt 151. The gate member 153 is shown to have a lower edge 153a formed with recesses 153b matching the protrusions 155 in position and shape. With such a configuration, a gap between the gate member 153 at the closed position and the contact surface 154 of the conveyor belt 151 is reduced or minimised, thereby reducing or preventing unintentional passage of smaller drug packages 200 between the gate member 153 and the contact surface 154. This configuration of the gate member 153 may, in another embodiment, be applied to the gate member 134 of each intermediate collection station 130. The gate member 134 in this embodiment has a lower edge flush with the contact surface 136.

Referring to Figure 5C, the transfer mechanism 150 is moveably mounted on a frame 158 including first and second support members 158a, 158b. The conveyor belt 151 is mounted on and vertically moveable along the first support member 158a. The first support member 158a is in turn mounted on and horizontally moveable along the second support members 158b. In such an arrangement, the conveyor belt 151 is moveable between the receptacles 110 and the intermediate collection stations 130 in any direction along the imaginary plane on which the receptacles 110 are arranged. In another embodiment, the transfer mechanism

150 may be further configured to be perpendicularly moveable relative to the imaginary plane.

Referring again to Figure 5B, the transfer mechanism 150 further includes a pusher 156 (not shown in Figure 6A) operable to push a drug package 200 into a corresponding one of the receptacle 110 via an opening associated with the receptacle. Further referring to Figures 6A and 6B, each of the receptacles 110 is associated with a rear opening 113 partially defined by an edge portion 114 arranged at an oblique angle with respect to a vertical axis of the opening 113. The pusher 156 is inclined at the same oblique angle. With such a configuration, the pusher 156 is operable to facilitate movement of drug packages 200, especially those stuck between the transfer mechanism 150 and the receptacle 110, into the receptacle 110.

The transfer mechanism 150 further includes an image capturing device 157 (not shown in Figure 6A) for capturing an image of a visual representation of identification information associated with each collection receptacle 110 and to be in association with the respective prescription. In this embodiment, the visual representation takes the exemplary form of a barcode 116 attached to or otherwise marked on the container 115 of the respective receptacle 110. The identification information includes a unique container identifier (e.g., an identification number) corresponding to the container 115 and, once extracted or acquired from an image captured by the image capturing device 157, is associated with the respective prescription. Drug packages 200 associated with the respective prescription can accordingly be dispensed, either partially or wholly, into the corresponding container 115. Moreover, once the container 115 of a fulfilled prescription is collected from the receptacle 110, an empty container with different container identification can be placed in the same receptacle 110 for fulfilment of another prescription to be associated with the receptacle 110. To detect presence and hence replacement of one container with another, each receptacle 110 is further provided with a sensor 117 (see Figure 5A) operable to detect presence of a container in the respective collection receptacle 110.

Referring to Figure 7A, the transfer mechanism 150 in this embodiment is controlled by a control device 300 (e.g., a computing device; see Figures 8A to 8C) to perform a method 500 of assembling drug packages 200. At step 510, a determination is made by the control device 300 as to whether any of the intermediate collection stations 130 is ready for collection. If a result of the determination at step 510 is affirmative, the method 500 proceeds to step 520. If the result of the determination at step 510 is negative, the method 500 returns to the beginning and repeats step 510. The transfer mechanism 150 is controlled in step 520 to collect drug packages 200 (or a drug package 200) from the intermediate collection station 130 that is ready for collection. Next, at step 530, a determination is made by the control device 530 as to whether another one or more of the other intermediate collection stations 130 are ready for collection of drug packages 200 (or a drug package 200) belonging to the same collection receptacle as the drug packages 200 collected at step 520. If a result of the determination at step 530 is affirmative, the method proceeds to step 540, where the transfer mechanism 150 collects the drug packages 200 from the another one or more of the other intermediate collection stations 130, and then to step 550, where the transfer mechanism 150 transfers the collected drug packages 200 to a corresponding collection receptacle 110. If the result of the determination at step 530 is negative, the method proceeds directly from step 530 to step 550. Following step 550, a determination is made by the control device 300 at step 560 as to whether there are more drug packages 200 to collect. This may be dependent on whether there are prescriptions pending fulfilment. If a result of the determination at step 560 is affirmative, the method returns to step 510. If the result of the determination at step 560 is negative, the method 500 ends.

It should be noted that the control device 300 may also make a determination as to whether drug packages 200 belonging to a prescription can fit into a single receptacle 110. If a result of determination is negative and, for example, two receptacles 110 are determined to be needed for the prescription, the transfer mechanism 150 may be controlled to collect and transfer a first portion of the drug

packages 200 for the prescription to one of the receptacles 110 corresponding to the prescription (through a first performance of steps 510 to 560), and to collect and transfer a second portion of the drug packages 200 for the same prescription to another one of the receptacles 110 corresponding to the same prescription (through a second performance of steps 510 to 560). Preferably, the two corresponding receptacles 110 are adjacent ones of the receptacles 110.

Referring to Figure 7B, the transfer mechanism 150 is further controlled by the control device 300 to perform a method 600 of assembling drug packages 200. At step 610, the transfer mechanism 150 is controlled to collect a first drug package 200 held by one of the collection stations 130. Next, at step 620, a determination is made by the control device 300 associated with the apparatus 100 as to whether a second drug package 200 related to the first drug package 200 satisfies a delay condition. If a result of the determination at step 620 is affirmative, the transfer mechanism 150 is controlled at step 630 to provide the collected first drug package 200 to one of the collection receptacles 110 corresponding to the first drug package 200, and then, at step 640, to collect and provide an intermediate drug package 200 to another one of the collection receptacles 110 corresponding to the intermediate drug package 200. It should be noted that the intermediate drug package 200 is unrelated to the first drug package 200. More particularly, the intermediate drug package 200 does not belong to the same prescription as the first drug package 200. After step 640, the transfer mechanism 150 is controlled at step 650 to collect and provide the second drug package 200 to the collection receptacle 110 of the first drug package 200. The method 600 then proceeds from step 650 to step 670.

If the result of the determination at step 620 is negative, the transfer mechanism 150 is controlled at step 660 to collect the second drug package 200 and then to provide the collected second drug package 200 to the collection receptacle 110 of the first drug package 200 together with the collected first drug package 200. The method 600 then proceeds from step 660 to step 670.

At step 670, a determination is made by the control device 300 as to whether there are more drug packages 200 to be transferred from the intermediate collection stations 130 to the collection receptacles 110. If a result of determination at step 670 is affirmative, the method returns to step 610. If the result of determination at step 670 is negative, the method 600 ends.

It should be noted that any reference to any drug package 200 in the context of Figure 7B means one or more drug packages 200.

In this embodiment, the delay condition is the second drug package 200 being unavailable for collection at the time of collection of the first drug package 200. In another arrangement, the delay condition can be, for example, the second drug package 200 being expected to be unavailable for collection within a predetermined time duration (e.g., two seconds) after the time of collection of the first drug package 200. This arrangement is advantageous where drug packages 200 for the same prescription tend to arrive at different intermediate collection stations 130 within the predetermined time duration. For example, if two drug packages 200 for the same prescription are arriving at an adjacent pair of the intermediate collection stations 130 within the predetermined time duration, the transfer mechanism 150 may be controlled to, after picking up the one drug package 200, wait for a short period of time to pick up the other drug package 200.

In another arrangement, the delay condition is dependent on a distance between the intermediate collection station 130 of the collected first drug package 200 and that of the second drug package 200 to be collected. For example, the delay condition may be satisfied if such a distance is of a nature that collection of the two drug packages 200, one after another, is inefficient due to the distance to be traversed by the transfer mechanism 150. The delay condition may also be dependent on a position of the intermediate collection station 130 of the intermediate drug package 200.

The apparatus 100 in this embodiment is modular and includes three modular units arranged together with each modular unit having a corresponding zone or source 140. Depending on the number of prescriptions and the number of receptacles 110 needed, further sources 140 may be added with a corresponding increase in the number of intermediate collection stations 130 and in the number of collection receptacles 110. This enables flexible capacity expansion to meet changing needs, with drug packages 200 placed on the sources 140 in association with a queue of prescriptions pending fulfilment.

In the example of Figure 7B, the first, intermediate, and second drug packages 200 are received and held by respective ones of the intermediate collection stations 130. In other words, each of the intermediate drug package 200 and the second drug package 200 is collected from a respective collection station 130 different from that of the first drug package 200. However, in other embodiments, the apparatus 100 and the sources 140 of drug packages 200 can be arranged such that some of drug packages 200 belonging to a prescription are delivered to and held by a same one of the intermediate collection stations 130 at different time points.

As can be understood from the above, one function of the apparatus 100 is to assemble drug packages 200. In particular, the transfer mechanism 150 collect, from the intermediate collection stations 130, held drug packages 200 belonging to a same prescription and transfer the collected drug packages to one of the collection receptacles 110 corresponding to the respective prescription. By virtue of the collection and transfer operations of the transfer mechanism 150, assembly or collation of drug packages 200 is achieved. The terms “assembly” and “collate” and their derivatives are used interchangeably herein as having the same or similar meaning.

In this embodiment, referring to Figure 8A, each instance of the apparatus 100 contains or is otherwise associated with a respective control device 300 (e.g., a computing device). In an alternative arrangement, multiple instances of the

apparatus 100 are connected to and controlled by a single control device 300 via any suitable connection in any suitable topology, such as direct connections (see Figure 8B) or a series or daisy-chain connection (see Figure 8C).

The control device 300 is arranged to: receive the respective prescriptions; control the sources 140, including the respective conveyor belts of the sources 140, to dispatch the drug packages 200 based on the prescriptions for delivery to the intermediate collection stations 130; and operate the transfer mechanism 150 to transfer the drug packages 200 held by the intermediate collection stations 130 to the collection receptacles 110. Operations of some or all components described above may also be controlled by the control device 300.

Other alternative arrangements are described below.

In some arrangements, if a single collection receptacle 110, more particularly a single container 115 therein, has insufficient capacity for receiving drug packages 200 of a corresponding prescription, another receptacle 110, particularly a neighbouring one, may be associated with the prescription.

In one alternative embodiment, the receptacles 110 can be compartments similar to those of a locker. In another alternative embodiment, the receptacles 110 can be containers arranged on, for example, a shelf for prescription fulfilment.

In yet another alternative embodiment, the receptacles 110 are assigned exclusively to receive prescriptions belonging to only one person.

Claims

1. A drug package assembly apparatus comprising:

a plurality of collection receptacles associated with respective prescriptions;

a plurality of intermediate collection stations arranged to receive and hold drug packages delivered from respective sources in association with the prescriptions; and

a transfer mechanism operable to transfer the held drug packages from the intermediate collection stations to at least one of the collection receptacles based on the prescriptions.

2. The apparatus of claim 1, wherein at least one of the intermediate collection stations and the transfer mechanism includes a conveyor belt.

3. The apparatus of claim 2, wherein the conveyor belt has a contact surface with a plurality of protrusions arranged along a plurality of longitudinal axes, wherein the protrusions are spacedly arranged in each axis, and the protrusions in each axis are spaced apart from those in an adjacent one of the axes.

4. The apparatus of claim 3, wherein the protrusions are arranged in a grid formation.

5. The apparatus of claim 3 or 4, wherein each protrusion satisfies at least one of the relationships:

$d \geqslant r$;

$h = r(1 - \sin\theta)$; and

$L \leqslant 0.25 \times C$,

where: 'd' represents a distance between the protrusion and a neighbouring protrusion; 'r' represents a radius of a cylindrical portion of a rollable object to be conveyed by the conveyor belt; 'h' represents a height of the protrusion; 'θ' represents an angle formed by a radial line, which extends through the radius point of the cylindrical portion and a point of contact between the

cylindrical portion and the protrusion, with respect to the contact surface; 'L' represents a length of the protrusion in a conveyance direction of the conveyor belt; and 'C' represents an outer circumference of a pulley associated with the conveyor belt.

6. The apparatus of any one of claims 2 to 5, wherein the conveyor belt is provided with at least one of:

a pair of wall members arranged to restrict movement of drug packages on the conveyor belt past lateral sides of the conveyor belt; and

a gate member arranged at one end of the conveyor belt, and moveable between open and closed positions to permit and block passage of drug packages therethrough, respectively.

7. The apparatus of any one of claim 6, wherein the gate member is formed with recesses matching the protrusions in position and shape.

8. The apparatus of any one of claims 2 to 7, wherein the transfer mechanism further includes a pusher operable to push a drug package into a corresponding one of the receptacles via an opening associated with the receptacle.

9. The apparatus of claim 8, wherein the associated opening partially defines an edge portion arranged at an oblique angle with respect to a vertical axis of the opening, wherein the pusher is inclined at the same oblique angle.

10. The apparatus of any one of the preceding claims, wherein each collection receptacle is provided with at least one of:

a lockable door, which is configured to permit access to the respective collection receptacle if the respective collection receptacle is determined to contain all drug packages associated to the respective collection receptacle;

a sensor operable to detect presence of a removable container for drug packages in the respective collection receptacle; and

a light indicator operable to indicate a status of the respective receptacle for collection.

11. The apparatus of any one of the preceding claims, wherein each intermediate collection station is provided with a sensor arranged to detect presence of a drug package held at the respective intermediate collection station.

12. The apparatus of any one of the preceding claims, wherein the transfer mechanism includes an image capturing device for capturing an image of a visual representation of identification information associated with each collection receptacle and to be association with the respective prescription.

13. The apparatus of any one of the preceding claims, wherein the system is modular.

14. The apparatus of any one of the preceding claims, wherein the transfer mechanism is controlled to perform the method including:

collecting a first drug package held by one of the collection stations;

if a second drug package related to the first drug package satisfies a delay condition,

providing the collected first drug package to one of the collection receptacles corresponding to the first drug package, and

collecting and providing an intermediate drug package to another one of the collection receptacles corresponding to the intermediate drug package, the intermediate drug package being unrelated to the first drug package; and

collecting and providing the second drug package to the collection receptacle of the first drug package.

15. The apparatus of claim 14, wherein, if the second drug package does not satisfy the delay condition, the collected second drug package is provided to the collection receptacle of the first drug package together with the collected first drug package.

16. The apparatus of claim 14 or 15, wherein the delay condition is the second drug package being unavailable for collection at the time of collection of the first drug package.

17. The apparatus of any one of claims 14 to 16, wherein the intermediate drug package and the second drug package are collected from different collection stations.

18. The apparatus of any one of claims 14 to 17, wherein at least one of the intermediate drug package and the second drug package is collected from a collection station different from that of the first drug package.

19. The apparatus of any one of the preceding claims, wherein the drug packages held by each individual one of the collection stations, at any given time, belong to no more than one prescription.

20. The apparatus of any one of the preceding claims, further comprising the drug packages, wherein the drug packages include bottles, blister packs, boxes or bags containing medical items.

21. The apparatus of any one of the preceding claims, further comprising a control device arranged to:

receive the respective prescriptions;

control the sources to dispatch the drug packages based on the prescriptions for delivery to the intermediate collection stations; and

operate the transfer mechanism to transfer the drug packages held by the intermediate collection stations to the collection receptacles.

22. A conveyor belt for conveyance of drug packages, comprising a contact surface with a plurality of protrusions arranged along a plurality of longitudinal axes, wherein the protrusions are spacedly arranged in each axis, and the

protrusions in each axis are spaced apart from those in an adjacent one of the axes.

23. The conveyor belt of claim 22, wherein the protrusions are arranged in a grid formation.

24. A conveyor belt for conveyance of drug packages, comprising a contact surface formed with a plurality of protrusions, wherein each protrusion satisfies at least one of the relationships:

$d \geqslant r$;

$h = r(1 - \sin\theta)$; and

$L \leqslant 0.25 \times C$,

where: 'd' represents a distance between the protrusion and a neighbouring protrusion; 'r' represents a radius of a cylindrical portion of a rollable object to be conveyed by the conveyor belt; 'h' represents a height of the protrusion; 'θ' represents an angle formed by a radial line, which extends through the radius point of the cylindrical portion and a point of contact between the cylindrical portion and the protrusion, with respect to the contact surface; 'L' represents a length of the protrusion in a conveyance direction of the conveyor belt; and 'C' represents an outer circumference of a pulley to be associated with the conveyor belt.

25. A method of assembling drug packages, comprising:

collecting a first drug package from a first source;

if a second drug package related to the first drug package satisfies a delay condition,

providing the collected first drug package to a first destination, and

collecting and providing an intermediate drug package to a second destination, the intermediate drug package being unrelated to the first drug package; and

collecting and providing the second drug package to the first destination.

26. The method of claim 25, wherein, if the second drug package does not satisfy the delay condition, the collected second drug package is provided to the first destination together with the collected first drug package.

27. The method of claim 25 or 26, wherein the delay condition is the second drug package being unavailable for collection at the time of collection of the first drug package.

28. The method of any one of claims 25 to 27, wherein the intermediate drug package and the second drug package are collected from different sources.

29. The method of any one of claims 25 to 28, wherein at least one of the intermediate drug package and the second drug package is collected from a source different from the first source.

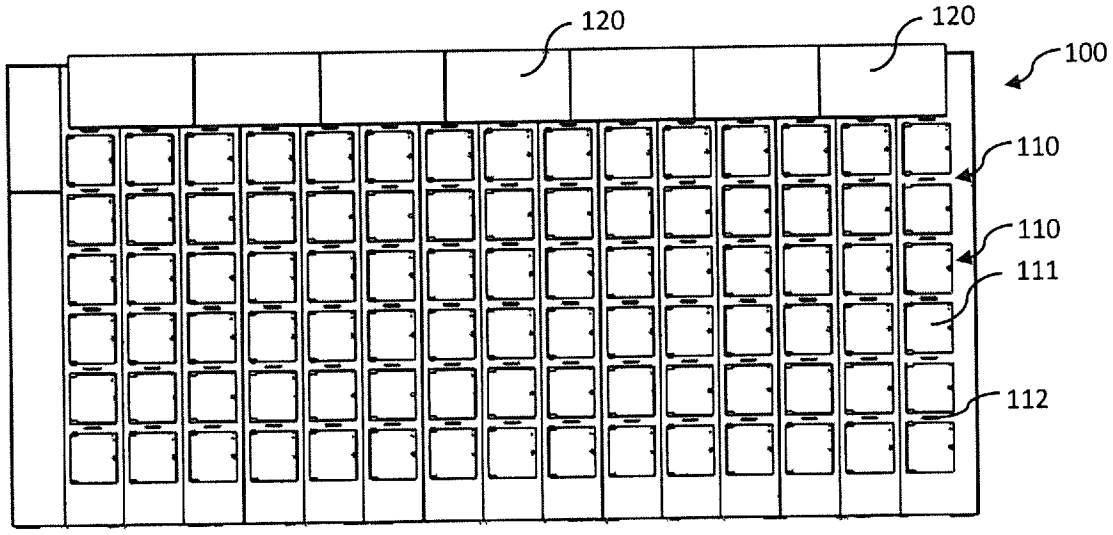

Figure 1A

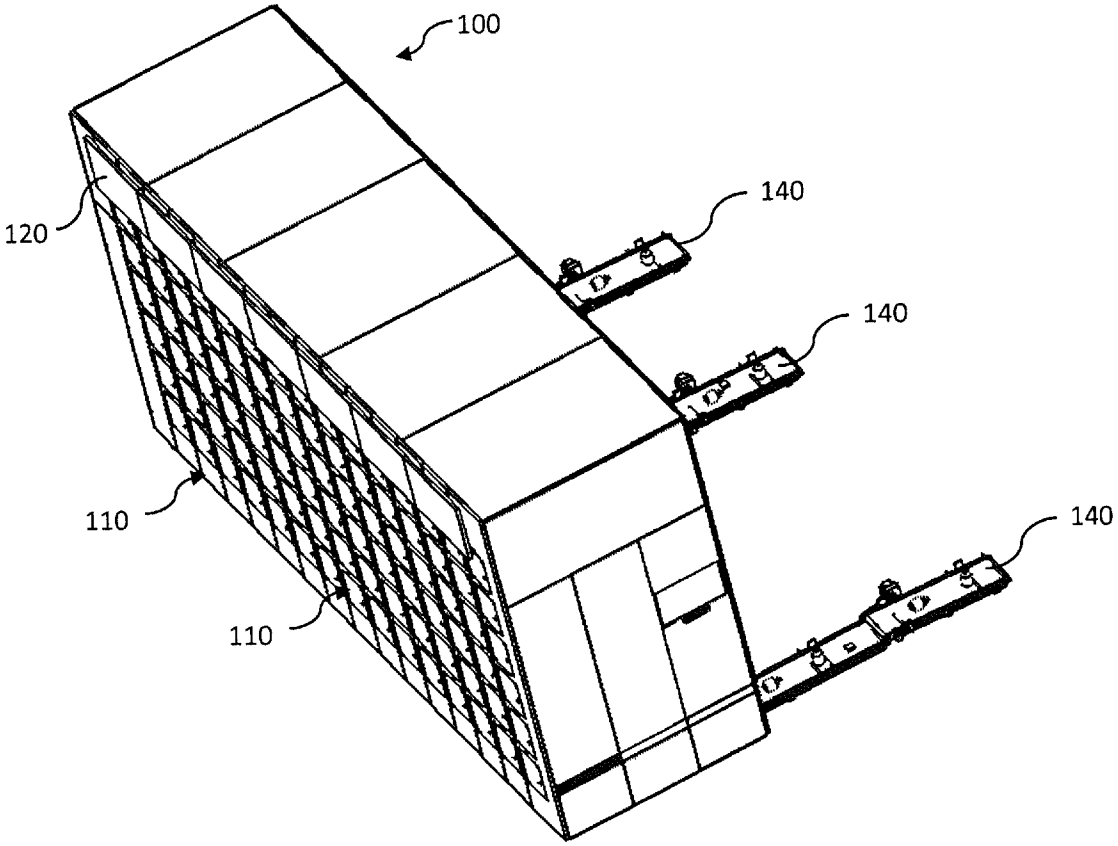

Figure 1B

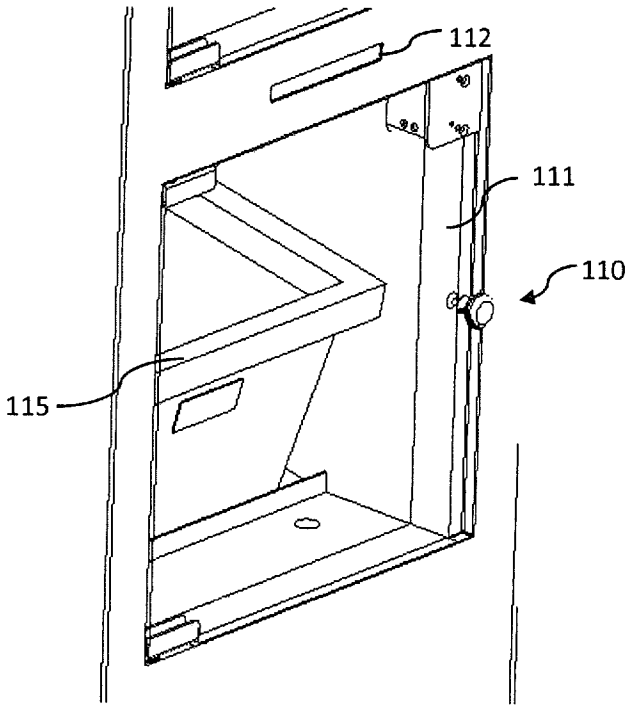

Figure 1C

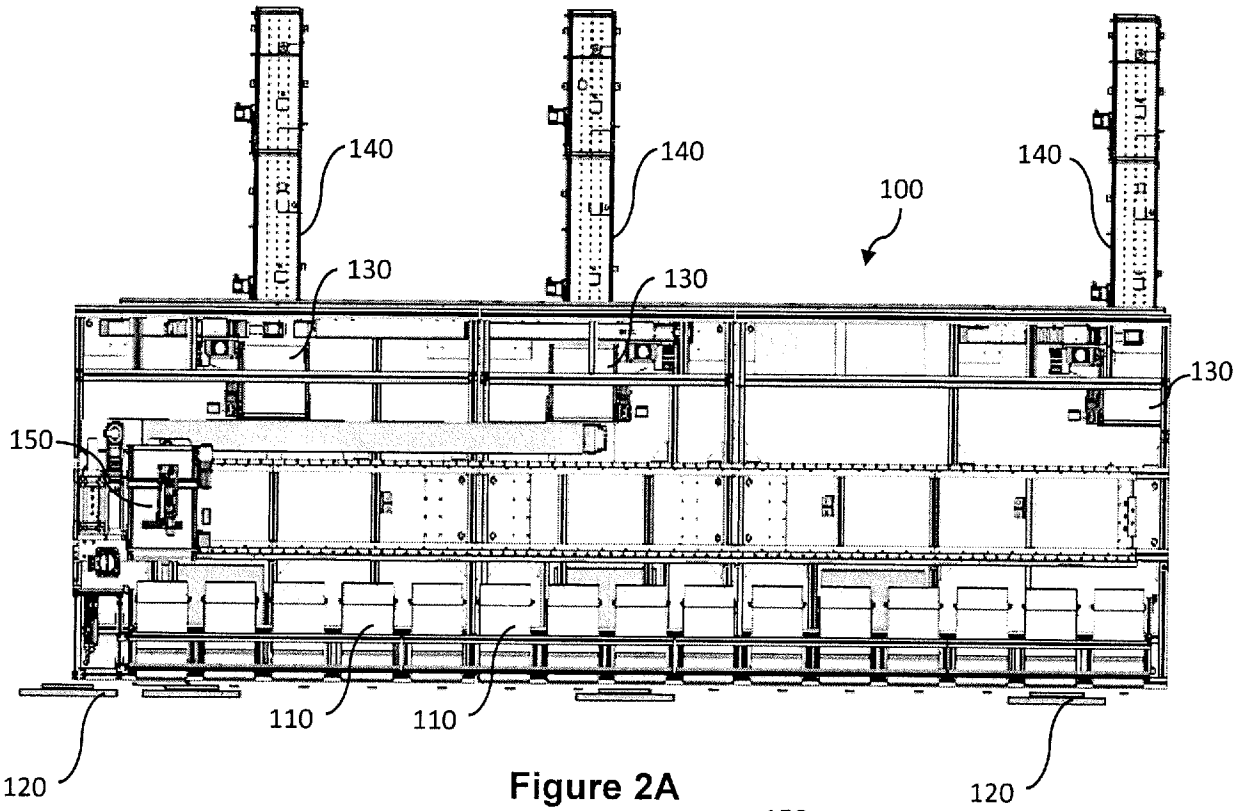

Figure 2A

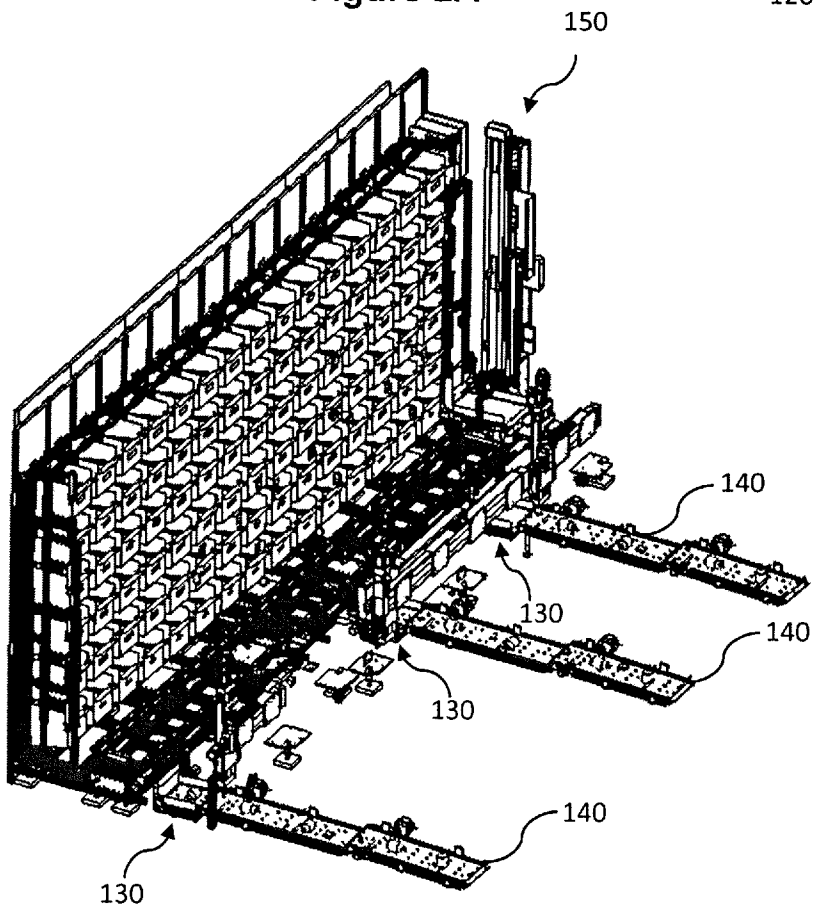

Figure 2B

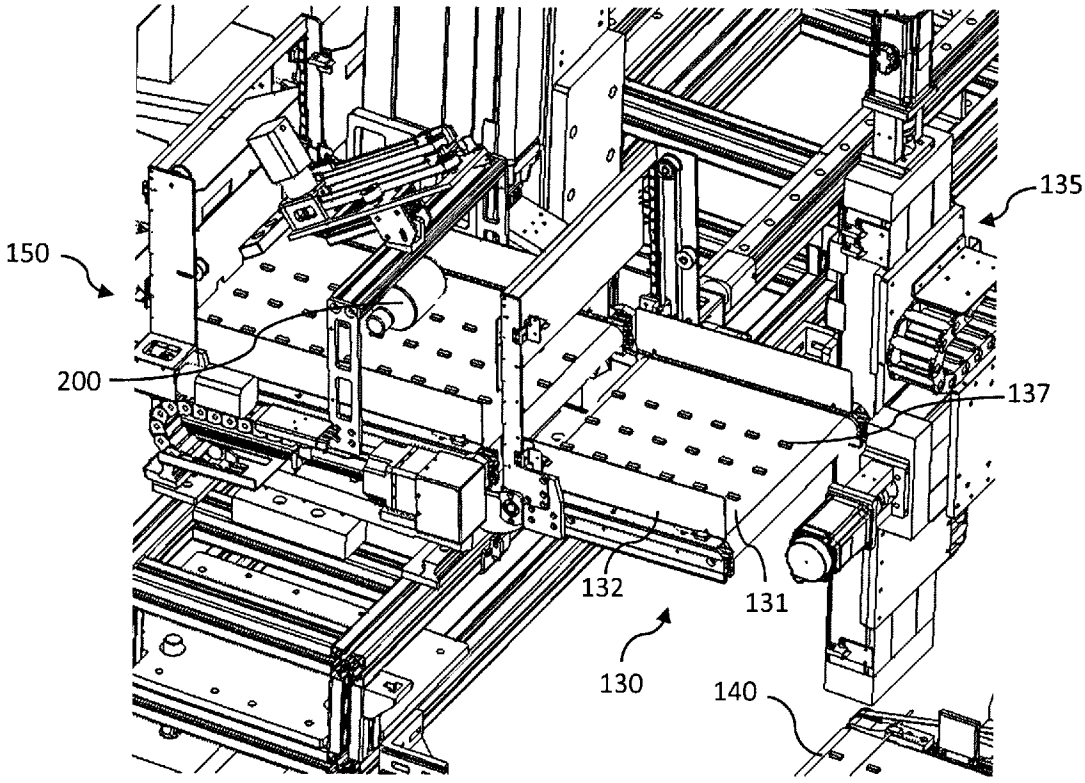

Figure 3A

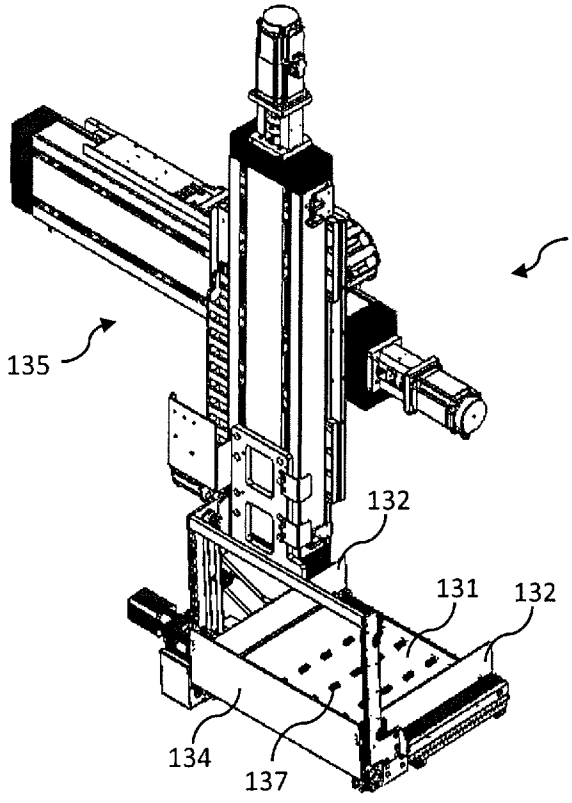

Figure 3B

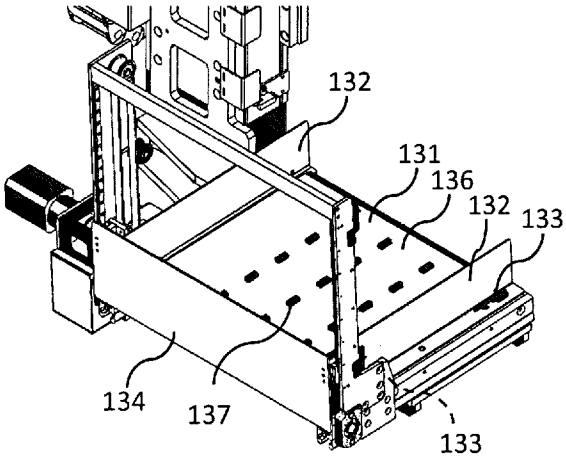

Figure 3C

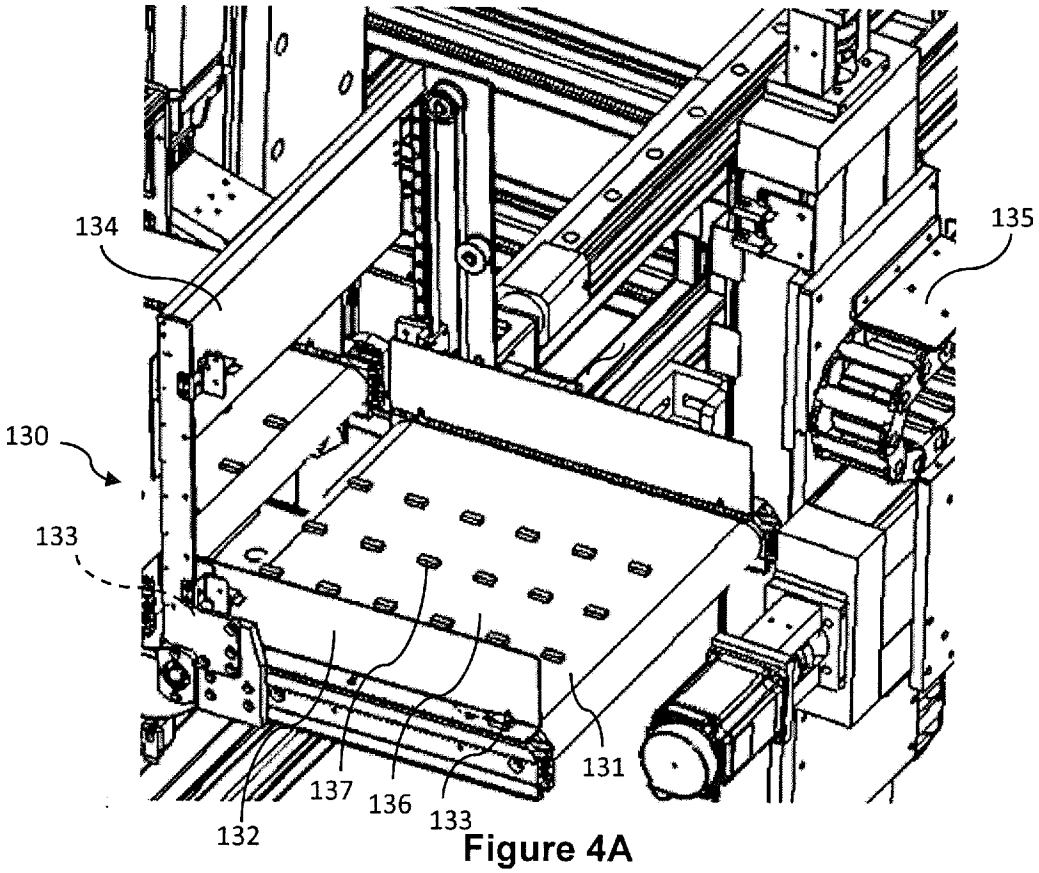

Figure 4A

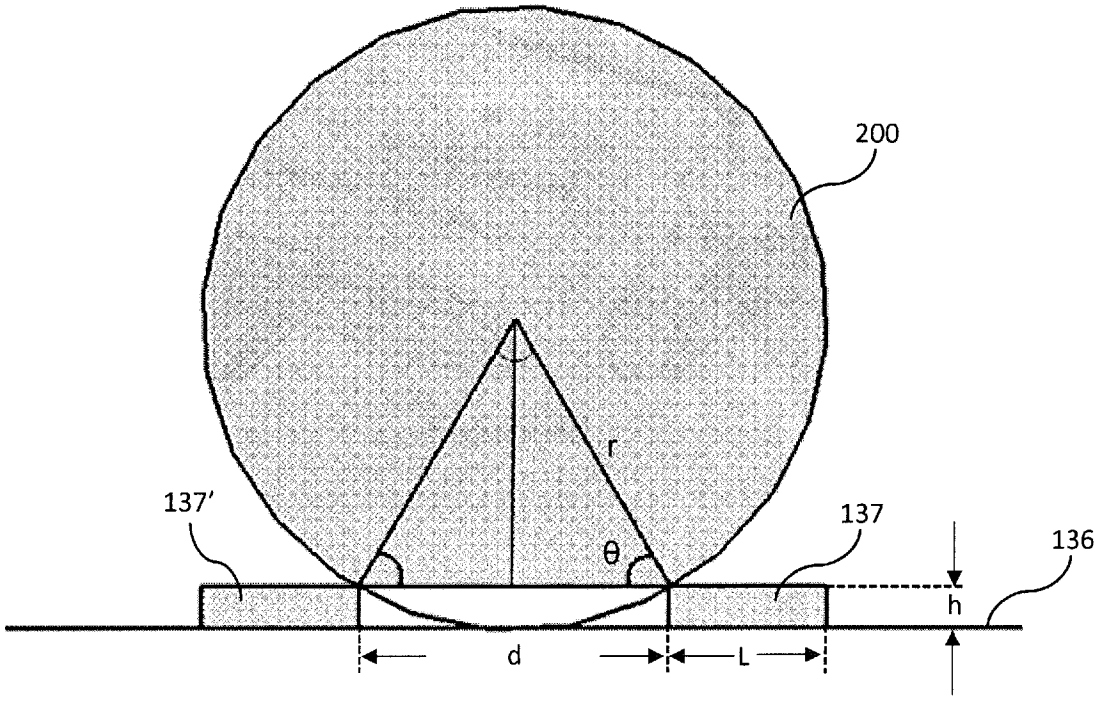

Figure 4B

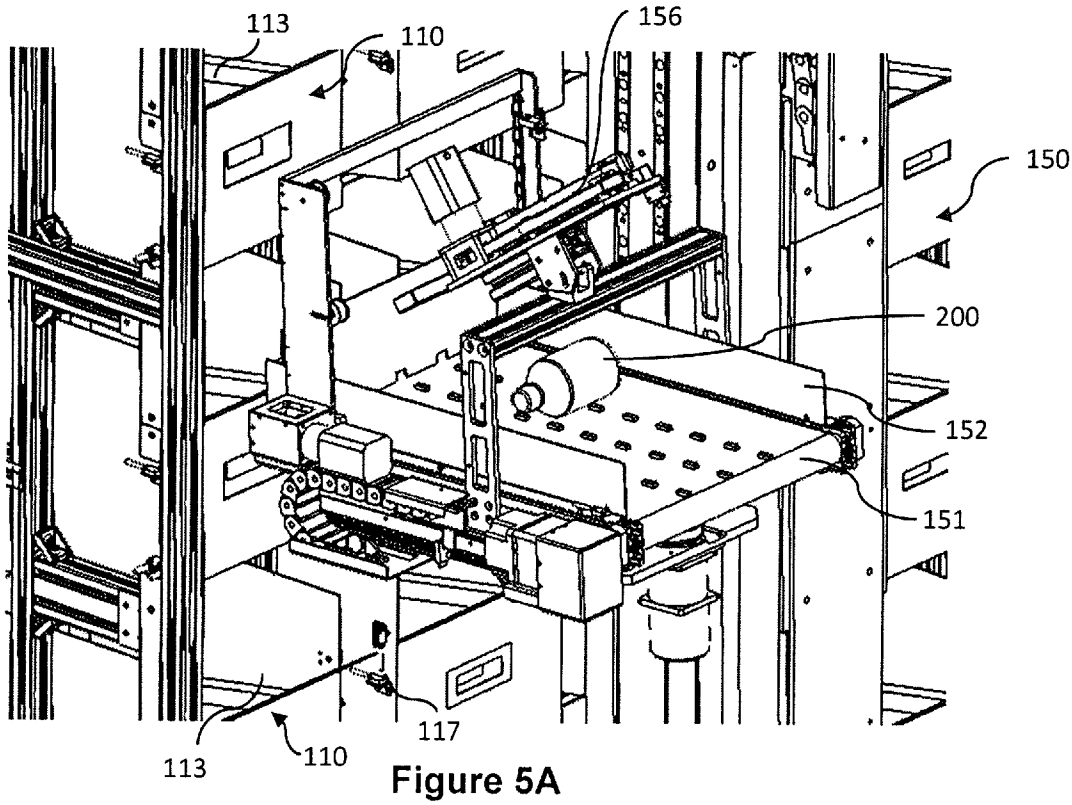

Figure 5A

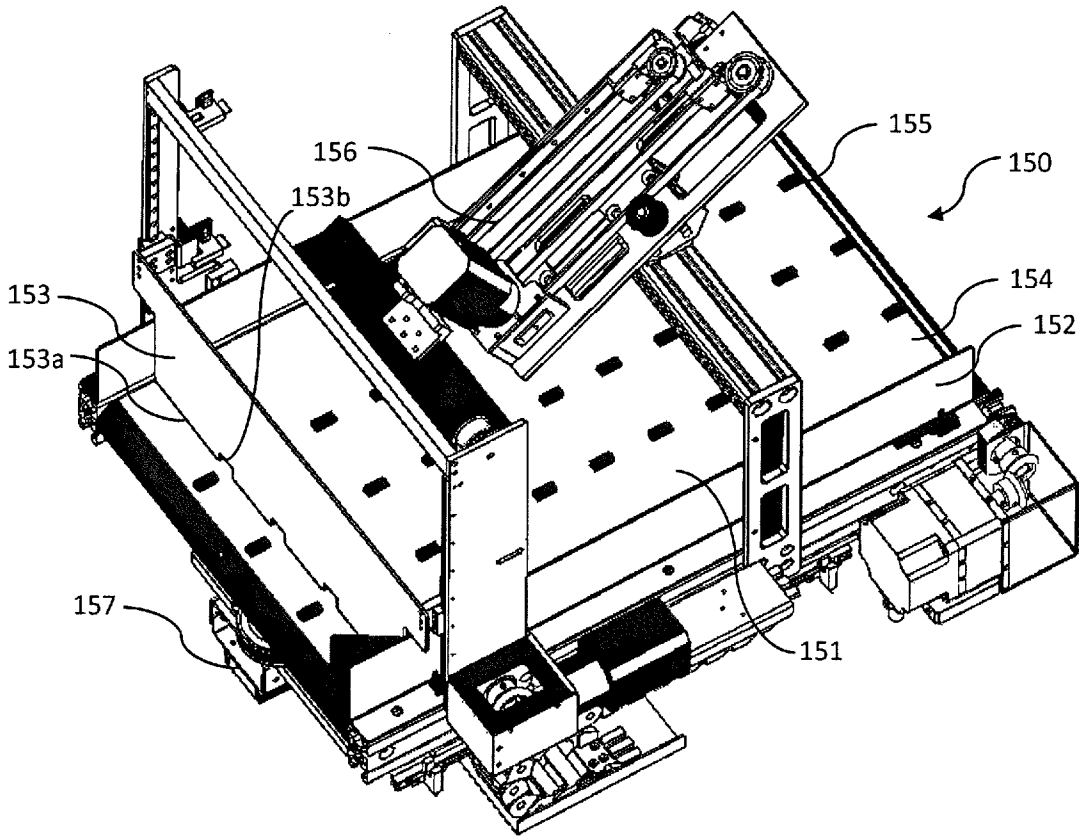

Figure 5B

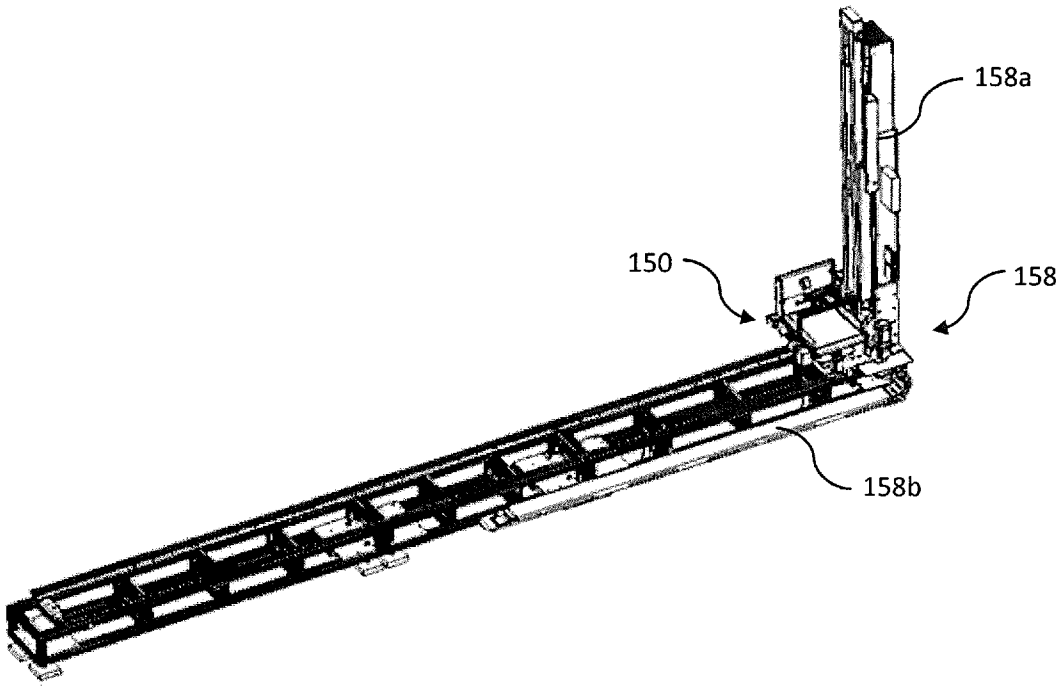

Figure 5C

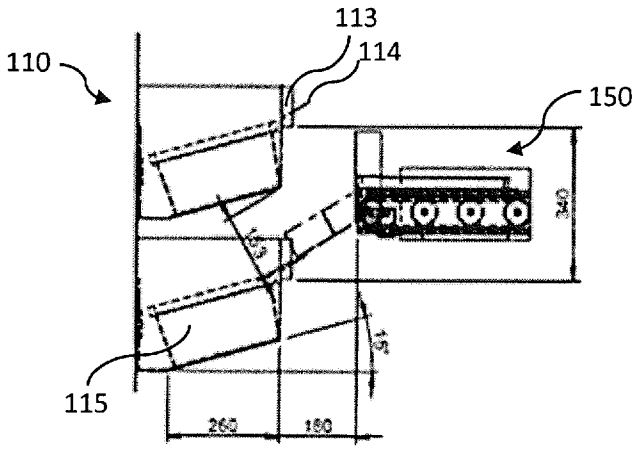

Figure 6A

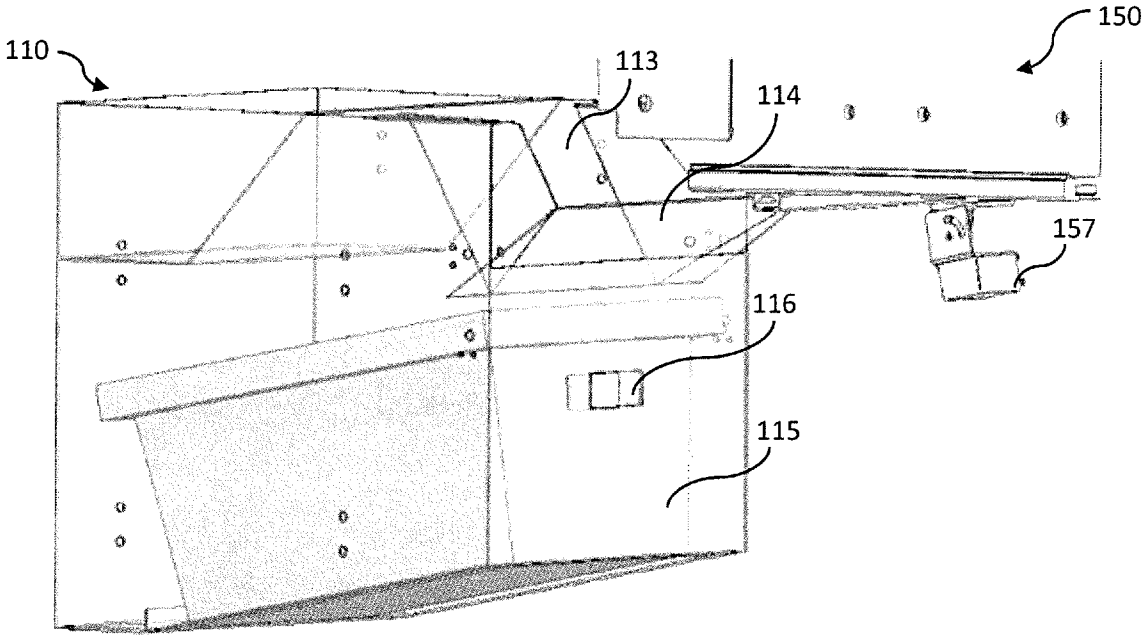

Figure 6B

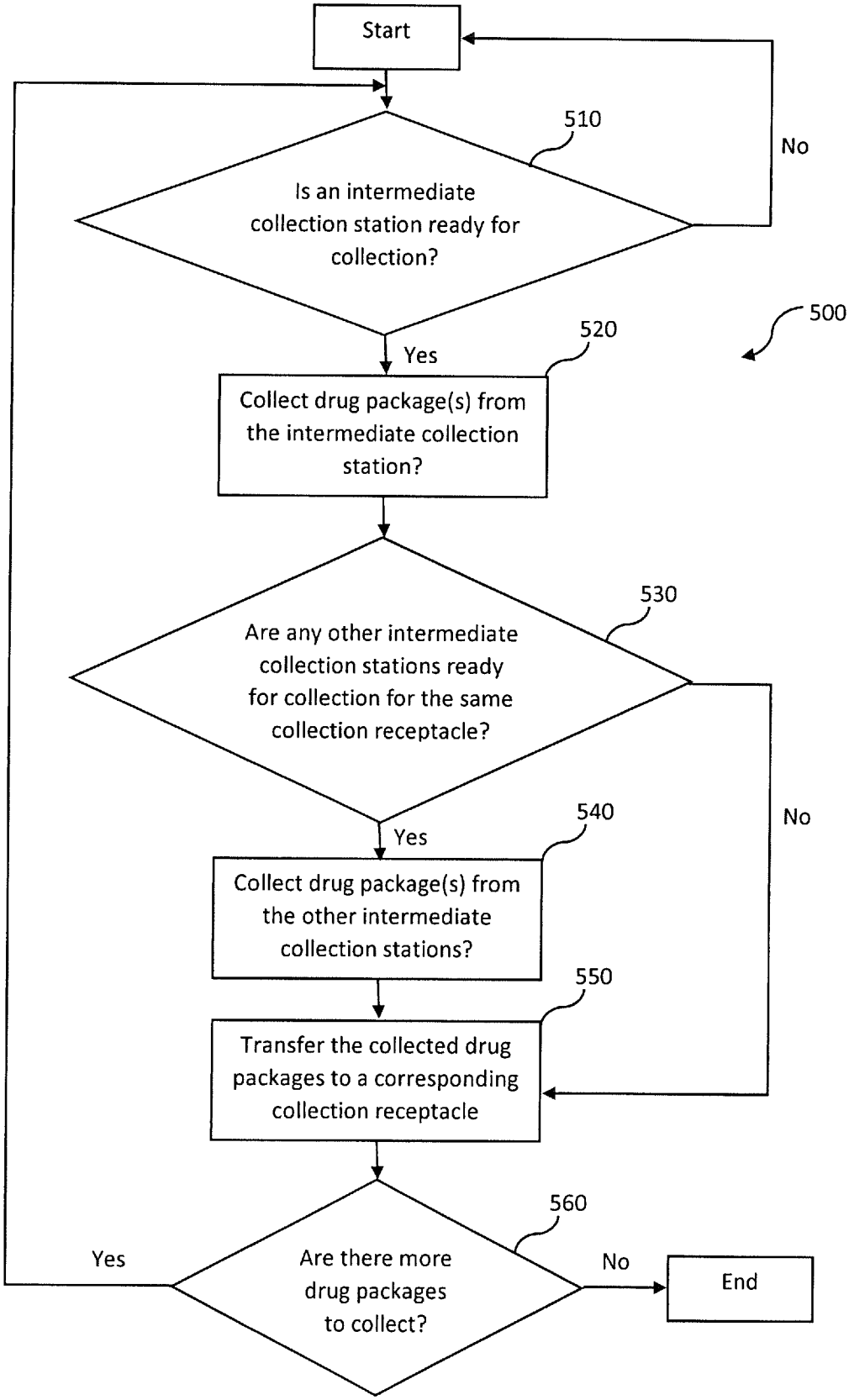
Start
510
Is an intermediate collection station ready for collection?
No
Yes
500
520
Collect drug package(s) from the intermediate collection station?
530
Are any other intermediate collection stations ready for collection for the same collection receptacle?
No
Yes
540
Collect drug package(s) from the other intermediate collection stations?
550
Transfer the collected drug packages to a corresponding collection receptacle
560
Are there more drug packages to collect?
Yes
No
End

Figure 7A

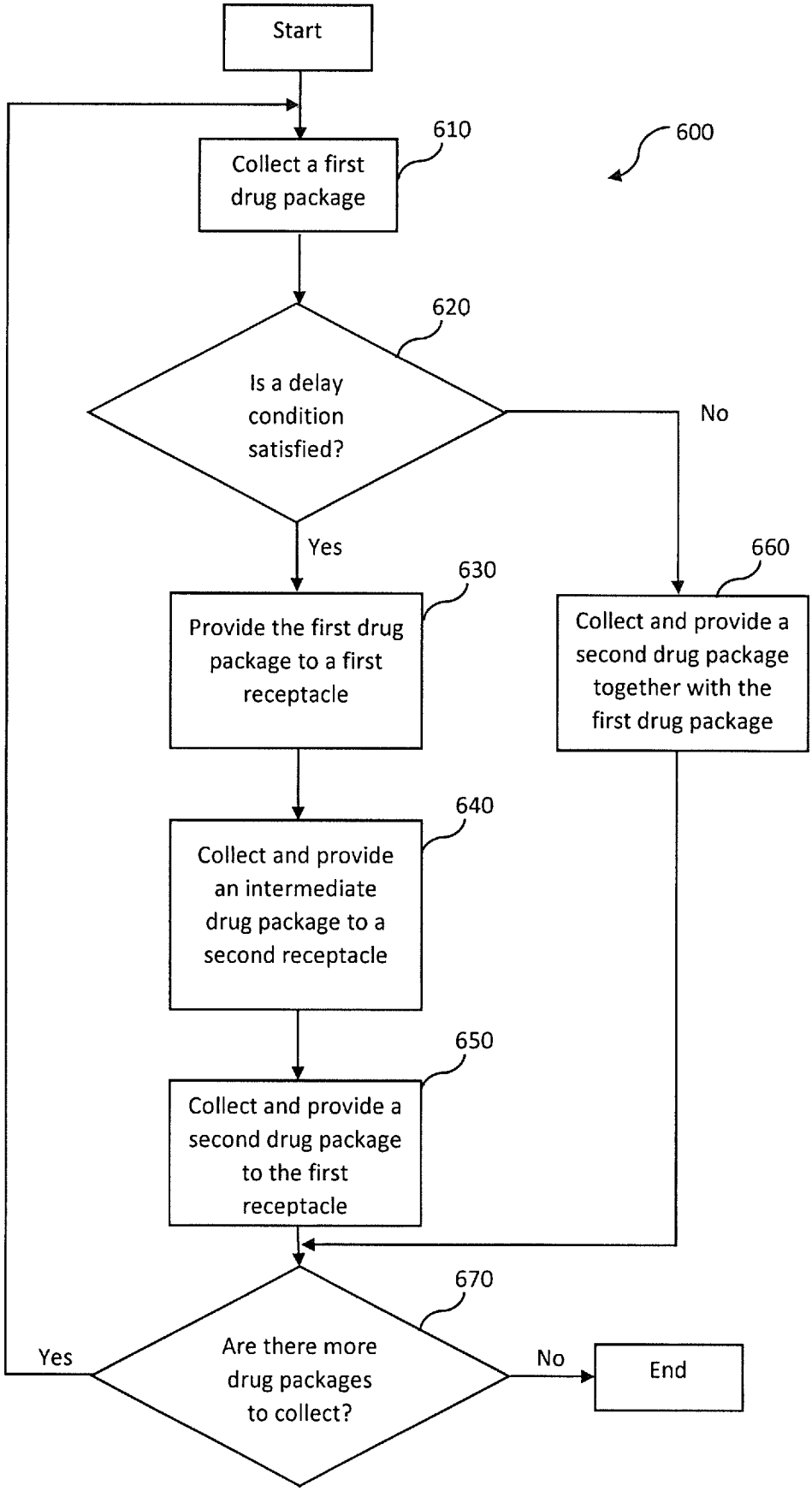
Start
610
Collect a first drug package
600
620
Is a delay condition satisfied?
No
Yes
660
630
Provide the first drug package to a first receptacle
Collect and provide a second drug package together with the first drug package
640
Collect and provide an intermediate drug package to a second receptacle
650
Collect and provide a second drug package to the first receptacle
670
Are there more drug packages to collect?
Yes
No
End

Figure 7B

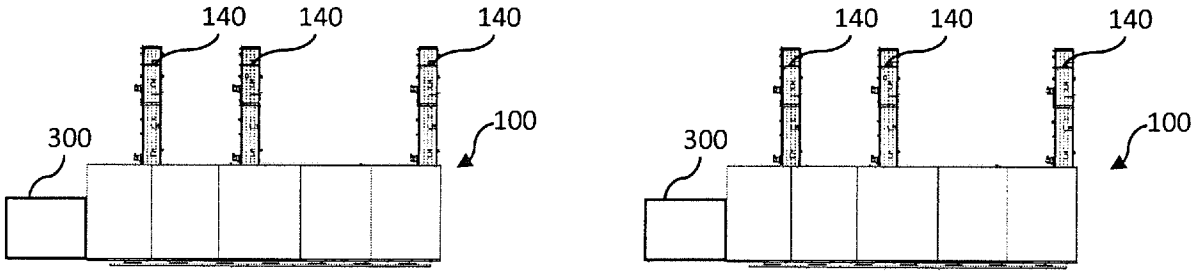

Figure 8A

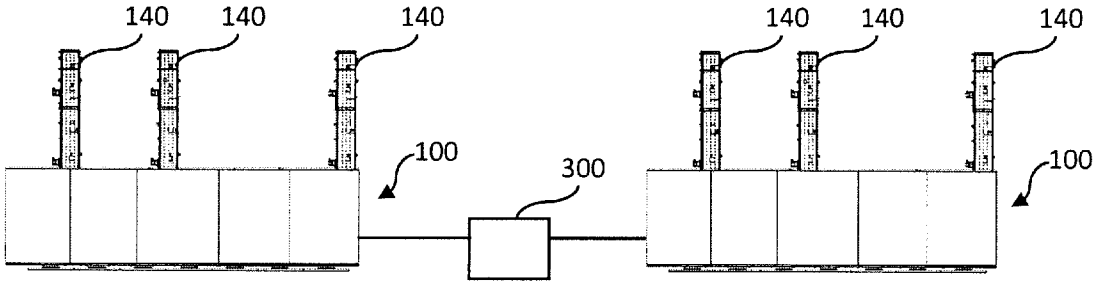

Figure 8B

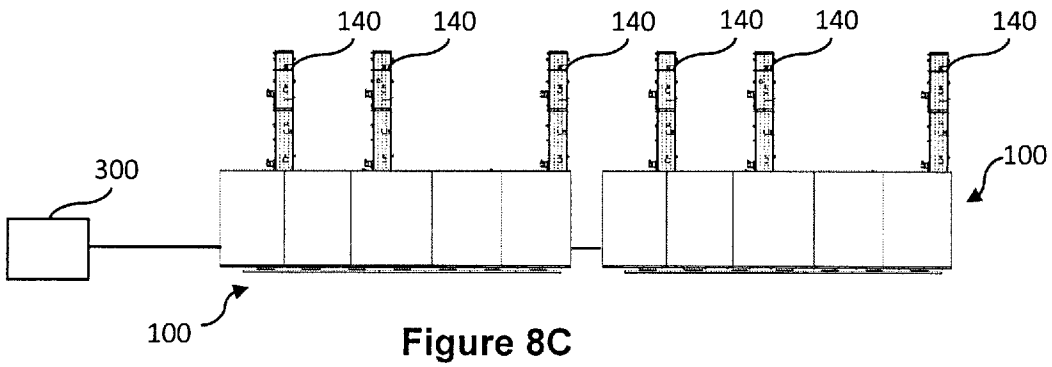

Figure 8C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2018/050186

A. CLASSIFICATION OF SUBJECT MATTER

B65G 47/46 (2006.01) *G07F 11/00 (2006.01)* *B65G 15/00 (2006.01)*

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B65G, G07F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

FAMPAT: drug, pharmaceutical, medicine, medicament, prescription, assembly, package, receptacle, box, bin, basket, container, collection station, collection point, conveyer, belt, protrusion, projection, delay, lag, destination, location, sequence, grouping, 药物, 药品, 药, 药方, 处方, 输送带, 容器, 筐, 自动化, 自动, 包装, 配药, 延迟, 顺序, 分组 and related search terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2015/0274422 A1 (HELLENBRAND C.) 1 October 2015 paragraphs [0008], [0013], [0024], [0027], [0029], [0032], figures 1-3	1-4, 6-13, 19-21 5, 14-18, 25-29
X	CN 204737277 U (SHENZHEN KOKOON MEDICAL CO. LTD.) 4 November 2015 paragraphs [0004], [0015]-[0017] and figure 2 of the original non-English language document (a machine translation is enclosed **only** for your reference)	1-4, 6-13, 19-21
X A	CN 206384449 U (GUANGZHOU YOUCARE BIOPHARMACEUTIS CO. LTD.) 8 August 2017 paragraph [0020] and figure 1 of the original non-English language document (a machine translation is enclosed **only** for your reference)	22 and 23 24

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

*Special categories of cited documents:

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

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05/11/2018 *(day/month/year)*	09/11/2018 *(day/month/year)*

Name and mailing address of the ISA/SG

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2018/050186

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 106315111 A (MENG LING) 11 January 2017 paragraphs [0013], [0036] and figure 1 of the original non-English language document (a machine translation is enclosed **only** for your reference)	22 and 23

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG2018/050186

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015/0274422 A1	01/10/2015	PT 2719641 E	03/06/2015
		US 2017/0267453 A1	21/09/2017
		CN 104781164 A	15/07/2015
		EP 2719641 A1	16/04/2014
		WO 2014/056761 A1	17/04/2014
		DK 2719641 T3	04/05/2015
		ES 2536685 T3	27/05/2015
CN 204737277 U	04/11/2015	NONE	
CN 206384449 U	08/08/2017	NONE	
CN 106315111 A	11/01/2017	NONE	