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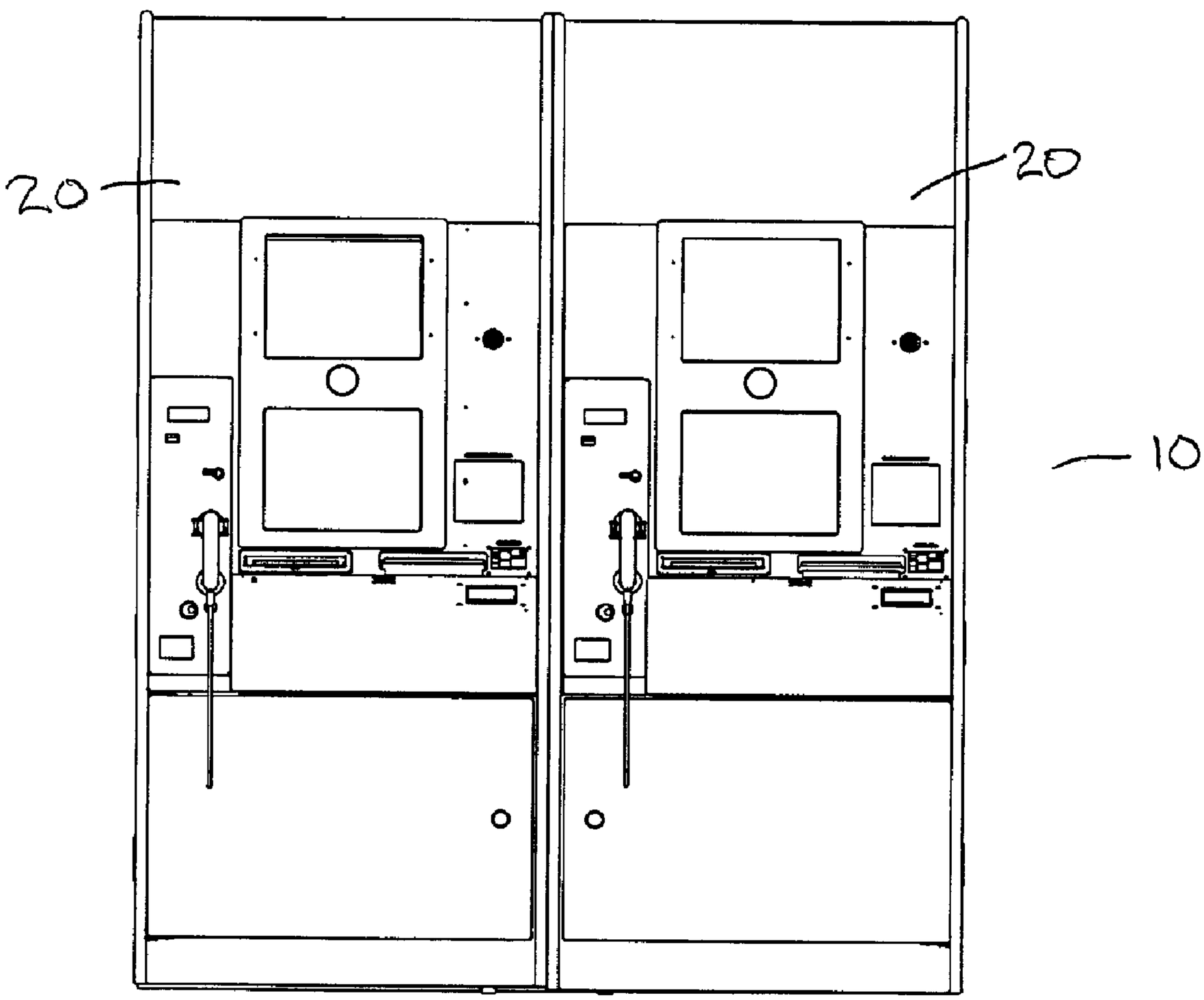

(57) Abrégé/Abstract:
An improved, automated, modular, networked, dispensary apparatus for dispensing a prescribed medicament. A front end user-interface module receives information input by a user and dispenses a requested medicament to a user. A back end drug vault

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(57) Abrégé(suite)/Abstract(continued):
module, interconnected to the front end user-interface module, securely stores a plurality of medicaments. A computer-controlled, intelligent robotic module, using a state machine based on predetermined behaviors, accesses medicaments in the back end drug vault module. A plurality of sensors provide positional feedback information for use with the behaviors by the robotic module for controlling the accessing. The modules enable a modular construction of the apparatus and are dimensionally compatible for interconnectability of multiple front end user-interface modules and back end drug vault modules in multiple combinations. Multiple features of utility are included in the apparatus including refrigeration and means for bulk medication storage and packaging.

ABSTRACT

An improved, automated, modular, networked, dispensary apparatus for dispensing a prescribed medicament. A front end user-interface module receives information input by a user and dispenses a requested medicament to a user. A back end drug vault module, interconnected to the front end user-interface module, securely stores a plurality of medicaments. A computer-controlled, intelligent robotic module, using a state machine based on predetermined behaviors, accesses medicaments in the back end drug vault module. A plurality of sensors provide positional feedback information for use with the behaviors by the robotic module for controlling the accessing. The modules enable a modular construction of the apparatus and are dimensionally compatible for interconnectability of multiple front end user-interface modules and back end drug vault modules in multiple combinations. Multiple features of utility are included in the apparatus including refrigeration and means for bulk medication storage and packaging.

AUTOMATED MODULAR APPARATUS FOR DISPENSING MEDICAMENTS

Field of the Invention

The present invention relates to apparatus for dispensing medicaments (i.e. prescribed drugs, these terms being used interchangeably in the field and herein) and, more particularly, to such apparatus of a modular construction and comprising multiple types of modules.

Background of the Invention

The traditional means of dispensing prescribed drugs involves a doctor meeting with a patient and prescribing a drug (or drugs) based on a particular diagnosis, and then hand writing and signing a prescription for the patient to carry to a pharmacist at a pharmacy location for fulfillment. In recent years, two major advancements have occurred in the field of medicament dispensing. The first is electronic prescription capturing methods, systems and apparatus, which improve the overall accuracy and patient record keeping associated with prescribing drugs. The second is the arrival of automated apparatus, typically configured as kiosks, which automatically dispense medication and are located for convenient patient access (for example, in doctors' offices and medical clinics) and are networked into a central computer system for inventory control and management. In this regard, reference may be made to PCT application no. PCT/CA2007/001220 (published on 17 January, 2008 under no. WO 2008/006203) for a method, system and apparatus for dispensing drugs by, inter alia, two of the same inventors as the subject application.

More specifically, said PCT application describes a system having a server computer, a database of patient information linked to the server computer, a computer input means linked to the server computer operable to generate the script for a drug prescribed to a user, and an automated apparatus for dispensing medicaments (referred to in said PCT application as a robotic prescription dispensary) operable to recognize a human and/or machine readable description in the script, enabling cross-referencing between the description and the patient information to validate dispensing the drug to the user on the basis of the input script. A doctor in a clinic can use the computer input means (for example, a tablet computer) linked to the server to input the appropriate prescription information, or accept certain prescription information from the database as being applicable in the particular case for a particular patient. Further, doctor's tablet computer may display the patient information, e.g., drug history, insurance coverage, etc., and a printer module can print the script as a paper print-out.

The server computer and database enable storing, compiling and retrieval of relevant patient information, for example, the patient's personal information such as name and address, as well as health-relevant information such as diagnostic history and drug history. Access to the database can be provided to both the doctor and the automated apparatus for dispensing medicaments via the server, via a secure connection, or via a link between the system and a clinic's existing clinic management system or patient database.

Said PCT application further describes a method for dispensing drugs including generating a script for a drug prescribed to a user, whereby the script includes data elements in the form of a human readable description of the drug and the user and/or a

machine readable description of the drug and the user. The script is input to automated apparatus for dispensing medicaments (identified in said PCT application as a robotic prescription dispensary) which is operable to do the following: (i) recognize the human and/or machine readable description; (ii) authorize dispensing the drug to the user based on a validation means; and, (iii) dispense the drug to the user. The automated apparatus for dispensing medicaments is linked to the server computer enabling cross-referencing between the machine readable description and the patient information to validate dispensing the drug to the user on the basis of the machine readable description.

The described apparatus also includes a user interface, a teleconferencing or video-conferencing means enabling communication between the user and a human validation agent, and a scanning means for capturing an image of the script so that it, if needed, it can be viewed by a human validation agent, such as a licensed pharmacist communicating in the system and with the apparatus from a remote location to the apparatus, to approve a prescription. The user interface of the dispensary apparatus provides detailed and clear instructions to guide the user.

An authentication means confirms the identity of the patient, for example, by prompting for a personal identification number or by biometric means or by associating certain questions to answers provided by the patient that identify the patient to the apparatus, and cross-referencing this information with the patient information stored on the networked database. Once the patient is recognized, the dispensary apparatus prompts the user for a script and the apparatus processes the user-input script either by the above-mentioned human validation agent or by processing the machine readable

description (which may be a bar code). This information can be verified with the server and the database. The apparatus may also interface with the server to adjudicate an insurance claim and determine the amount payable by the patient. The patient either accepts or rejects the transaction. If the transaction is accepted, the apparatus interfaces with the server to transact a payment, for example, by prompting the patient for credit card information. Prescription labels and receipts are printed. The apparatus confirms that the drug is correct and drops it into a dispensing area for retrieval by the user while retaining the script in a lock box, and verifies that the purchased drug product has been retrieved. Further, the apparatus may also print and/or provide to the user educational materials relevant to the particular prescribed drugs it dispenses to the user.

Said PCT application further describes that an automated apparatus for dispensing medicaments may, for example, be located in a doctor's office or clinic, and electronically linked to a computer input means used by a doctor prescribing a drug to a patient, for example, either directly or via a server so that a patient can obtain prescribed drugs without having to attend a pharmacy or drug store.

To date, however, the utility of such known medicament dispensary apparatus has been restricted by the limited variety of medications that may be remotely stored and robotically dispensed by them. Therefore, patients, especially those requiring non-standard dosing, multiple medications, medications requiring special storage or some form of pre-dispense preparation, are often faced with their medication requirements not being able to be fulfilled at such a known apparatus, thereby requiring a trip to a pharmacy for the balance of the prescription and negating the utility of such a

dispensary apparatus.

In view of these and other user requirements or preferences in the marketplace, an improved automated apparatus for dispensing medicaments is desirable.

Summary of the Invention

In accordance with the invention, there is provided an automated apparatus for dispensing a prescribed medicament. The apparatus communicates with a remote server linking the apparatus to a computer network and it recognizes a script for a prescribed medicament for a user of the apparatus. The apparatus is configured for receiving through the computer network information regarding the user, the medicament and/or other apparatus of the network. A front end user-interface module is configured for receiving information input by a user and for dispensing the medicament to the user. A back end drug vault module is configured for secure storage of a plurality of medicaments and is interconnected to the front end user-interface module. A computer-controlled robotic module is configured for communicating in the network and comprises means for accessing the front end user-interface module and said back end drug vault module, the accessing means comprising a plurality of sensors for providing positional feedback information to the robotic module for controlling the accessing means, picking the medicament from the back end drug vault module and delivering the medicament to the front end user-interface module for dispensing to the user. The front end user-interface module and the back end drug vault module are dimensionally compatible for interconnectability of multiple front end user-interface modules and back end drug vault modules in multiple combinations.

Preferably, the computer-controlled robotic module further comprises a state based machine configured to use a state table comprising states for controlling the robotic module, the states being associated with the positional feedback information provided by the sensors and based on behaviors to be applied by the accessing means to pick the medicament from inventory in the back end drug vault module. The robotic module may apply the behaviors according to increasing levels of aggressiveness to achieve success in picking the medicament from inventory, wherein the success is primarily defined to require no jamming of the robotic module.

The network may be a neural network comprising a dynamic knowledgebase of information, including learned information, pertaining to medicaments in inventory in the apparatus and on-going behaviors, and their results, of robotic modules in the network used for picking medicaments from inventory, and the computer-controlled robotic module may use the knowledgebase information for controlling the accessing means.

The front end user-interface module is preferably configured for staged security level access by a human operator whereby a first level security access is restricted to access of pre-selected components of the front end user-interface module only and a second level security access includes access according to the first level security access and access to the robotic module and the back end drug vault module including the inventory thereof.

The back end drug vault may comprise a refrigerated storage module for storing medicaments in inventory in a controlled refrigerated environment, the refrigerated storage module comprising one or more temperatures sensors for monitoring the refrigerated environment and the apparatus communicates information from the

temperature sensor(s) through the network for centralized action.

The back end drug vault preferably comprises one or more pre-packaged product storage containers for containing inventory pre-packaged medicament product, wherein the storage container(s) is self-loaded into place in storage slots by the robotic module, the position of each loaded pre-packaged product storage container and identification of the medicament product therein being tracked by the robotic module and maintained within the network for use by the robotic module. The back end vault may also comprise one or more bulk pill/capsule and/or bulk liquid product storage containers for containing inventory pill/capsule and/or liquid, respectively, medicament product in bulk form, similarly loaded into place in storage slots by the robotic module with the position of each loaded bulk pill/capsule and/or liquid product storage container and identification of the medicament product therein being tracked by the robotic module and maintained within the network for use by the robotic module. The bulk pill/capsule product storage container may comprise an integrated pill counting module configured for isolating and counting pills/capsules of the bulk pill/capsule product storage container according to the script. The bulk liquid product storage container may comprise an integrated liquid pouring unit configured for measuring and pouring the bulk liquid product according to the script.

The back end drug vault may also comprise one or more reconstitution bulk product storage container for containing a plurality of inventory liquid and/or concentrate medicament product in bulk form and a mixer/agitator, for reconstituting the medicament to be dispensed according to the script integrally within the reconstitution bulk product storage container(s), one or more mixing bulk product storage containers

for containing a plurality of inventory liquid medicament product in bulk form and a mixer, for mixing the medicament to be dispensed according to the script integrally within the mixing bulk product storage container(s) and/or one or more compounding bulk product storage containers for containing a plurality of inventory liquid medicament product in bulk form and a mixer, for mixing and compounding to perform geometric reduction, according to the script, integrally within the reconstitution bulk product storage container(s).

A secure transfer container is provided for secure transfer of medicament product therein from a medicament distribution center to the aforesaid automated modular apparatus. The secure transfer container is configured for receipt by the robotic module of the automated modular apparatus and self-loading by the robotic module of the medicament product from the secure transfer container to placement of the medicament product into inventory in the back end drug vault module. The secure transfer container is configured to restrict access to the medicament product therein to only the distribution center and the robotic module of the automated modular apparatus whereby a common carrier may be used for transporting the secure transfer container. The secure transfer container may be insulated and refrigerated, comprising a solid state cooling device and means for temperature monitoring and configured for powering by means of an external power supply.

The back end drug vault module preferably comprises a medicament packaging module configured for packaging the counted pill/capsule medicaments by a bottle or foil packager of the packaging module. The back end drug vault module also preferably comprises a package labeling module configured for storing a stock of labels and for

labeling a medicament package to be dispensed by the apparatus, whereby the package labeling module uses a suspended label from the stock of labels as an applicator for applying the label to the medicament package and the robotic module transports the medicament package to the suspended label, aligning a front edge of the label with a pre-determined contact start point on the medicament package.

Brief Description of the Drawings

A description of certain embodiments of the invention are provided herein, by way of example only, with reference to the following drawings, in which like reference numbers refer to like elements throughout the description herein:

Figure 1 illustrates a front view of an embodiment of the automated apparatus for dispensing prescribed drugs in accordance with the invention, wherein two, side-by-side front end user-interface modules are shown;

Figure 2 illustrates an example of a z-axis pick head assembly of the automated apparatus of the invention, with product position and z-axis positional sensors used for determining the machine state of the apparatus;

Figures 3A-C illustrate an example of a robotic module of the apparatus of the invention, with robot accessible waste container for placement and storage of suspect or damaged drug product, wherein Figure 3A is a side sectional view of an example of a back end drug vault module with a robotic module therein, Figure 3B is an exploded view of the robotic module portion of Figure 3A and Figure 3C is a sectional view of the robotic module of Figure 3A taken at section B-B;

Figure 4 illustrates a side sectional view of an example of an internal

configuration of a back end drug vault module of the automated apparatus of the invention, with multiple, networked cameras shown at pre-determined locations within the apparatus;

Figures 5A through 5B are perspective views of front end user-interface modules of an embodiment of the automated apparatus of the invention, as per Figure 1, and Figure 5C shows an opened apparatus, together illustrating increasing levels of security for access to the apparatus: Figure 5A shows a first level of access security for which the front of the apparatus remains closed so as to require software controlled function access in order to load inventory, with no physical access into the apparatus being provided; Figures 5B1 through 5B3 show a second level of access security for which the front of the apparatus can be opened via controlled access to gain access to user interface components of the apparatus and to service the apparatus components accessible at this security level; and, Figure 5C shows a third level of access security for which the back end drug vault module of the apparatus, containing medicaments, is opened;

Figure 6 illustrates a side sectional view of an example of a back end drug vault module of the automated apparatus of the invention, with a controlled room temperature top section and a controlled refrigerated bottom section;

Figure 7 illustrates an example of a pill counter module integrated into a bulk storage container for pill/capsule product, for counting pills to be dispensed by the apparatus of the invention;

Figures 8A-B illustrate an example of a packaging module of the automated apparatus of the invention, for packaging drugs to be dispensed to a user in bottles or

foil packs, wherein Figure 8A is a perspective view and Figure 8B is a front view thereof;

Figures 9A-9B illustrate an example of a drug storage module of the automated apparatus of the invention, showing multiple, standard slots for housing bulk storage cassettes therein, and an exemplary bulk storage cassette in one such slot, for retrieval by a robot of the apparatus and transfer to a packaging module, wherein Figure 9A is a perspective view thereof and Figure 9B is an exploded view of portion A of Figure 9A;

Figures 10A-F illustrate a package labelling module of the automated apparatus of the invention, wherein Figure 10A illustrates a top view of a labelling assembly thereof, Figure 10B illustrates a perspective view of the labelling assembly of Figure 10A, Figure 10C is an exploded view of section "C" of Figure 10A, Figure 10D is a sectional view taken at line "D-D" of Figure 10C, Figure 10E is a sectional view taken at line "A-A" of Figure 10A and Figure 10F is a sectional view taken at line "B-B" of Figure 10A;

Figure 11 illustrates a laser marking module of the automated apparatus of the invention, configured for direct marking of label information onto a package to be dispensed by the apparatus to a user;

Figure 12 illustrates, in the front end user-interface module, a manual product load slot for manually loading product, whereby the product passes to the robotic module for automatic self-loading of the product into the drug vault by the robotic module of the apparatus;

Figures 13A-B illustrate an automatic self-loading of a delivered secure transfer container to the automated apparatus of the invention, wherein Figure 13 A shows at section "A" a robotic module receiving a secure transfer container and Figure 13 B is an

exploded view of section "A" of Figure 13A;

Figures 14A-D illustrate an example of a secure transfer container for use with the automated apparatus of the invention, wherein Figure 14A is a perspective view, Figure 14B is a right side view, Figure 14C is left side view and Figure 14D is a top view thereof;

Figures 15A-D illustrate a multiple slot, storage container rack comprising multiple, standard slots for housing bulk storage containers therein, showing one slot thereof containing five bulk storage containers with each container storing a different drug product, wherein Figure 15A is perspective view, Figure 15B is a top view, Figure 15C is a side view and Figure 15D is an end view;

Figure 16 illustrates a perspective view of an embodiment of the automated apparatus for dispensing medicaments in accordance with the invention, wherein two, side-by-side front end user-interface modules share one back end drug vault module;

Figure 17 illustrates a perspective view of another embodiment of the automated apparatus for dispensing medicaments in accordance with the invention, comprising four, side-by-side front end user-interface modules and two back end drug vault modules, whereby each of two side-by-side front end modules share one back end drug vault module;

Figure 18 illustrates an exemplary sub-assembly of two inter-connected back end drug vault modules of the automated apparatus of the invention, each module configured for modular construction of the apparatus;

Figure 19A illustrates a front view of an example of a refrigerated storage module of the automated apparatus of the invention with cooling device, insulated sliding door,

locking unit and air purge means provided by a dehumidifier and pressure control unit, and Figure 19B illustrates a pictorial view of this exemplary module;

Figure 20 illustrates a side view of the module of Figure 19A;

Figure 21 illustrates a top view of the module of Figure 19A;

Figures 22A-B illustrate an example of a refrigerated secure transfer container for use with the automated apparatus of the invention, wherein Figure 22A shows a front view and Figure 22B shows a side view thereof;

Figures 23A-C illustrate an example of a bulk storage container for prepackaged product of the automated apparatus of the invention (one such container shown installed in the apparatus in Figure 9), wherein Figure 23A shows a perspective view, Figure 23B shows a side view and 23C shows a front view thereof;

Figures 24A-B illustrate an example of a bulk storage container for storing pills and/or capsules therein, and having a pill/capsule counter integrated into the bulk storage container, wherein Figure 24A is a front view and Figure 24B is a side view thereof;

Figures 25A-B illustrate an example of a bulk storage container for storing liquid medication, and having an integrated liquid pouring unit, wherein Figure 25A is a front view and Figure 25B is a side view thereof;

Figures 26A-C illustrate an example of a reconstitution bulk storage container for both storing a liquid medication and reconstituting that medication with another liquid prior to dispensing, wherein Figure 26A is a front view, Figure 26B is a side view and Figure 26C is a perspective view thereof;

Figures 27A-B illustrate an example of a mixing bulk storage container for storing

multiple different liquids and mixing them together prior to dispensing, wherein Figure 27A is a front view and Figure 27B is a side view thereof; and,

Figures 28A-B illustrate an example of a compounding bulk storage container for storing multiple different liquids and compounding and mixing them, for geometric reduction with a carrier, prior to dispensing, wherein Figure 28A is a front view and Figure 28B is a side view thereof.

Detailed Description

The invention provides an automated apparatus for dispensing medicaments which advantageously provides improved utility to expand the variety of medicaments that can be stored, prepared and dispensed. Its utility is enhanced by increasing the prescription coverage ratio offered a patient at an autonomous network device or drug dispensary apparatus. This utility of service provided by the apparatus may be viewed from the perspective of a patient (i.e. user) standing at the doctor's office with a prescription in hand and needing immediate medication. The distance the patient must travel and the frictions the patient must overcome to get the medication is the patient's utility function. Utility from the perspective of the drug dispensary, be it a pharmacy or a remote dispensary apparatus as provided by the present invention, means how many items on the patient's prescription could be filled, not requiring secondary actions, such as ordering the medication requiring the patient to return for pick up, or delivering the medication to the patient at a later time. Thus, for both the drug dispensary and the patient, maximum utility is determined by the ability to dispense all medications required, on the spot, at the time of the initial interaction.

Advantageously, the dispensary apparatus 10 of the invention is constructed from a pre-selected number and functional type of modular components, hereinafter referred to generally as modules. These modules include a front end user-interface module 20 (see Figure 1 which illustrates two such modules located side-by-side), a back end drug vault module 200 in which drug product for dispensing is stored and a robotic module 100 (see Figures 3A-C) which is located for operation with both the front end and back end modules. These modules are dimensionally compatible for assembly in numerous combinations, as desired for a particular application, and their internal components are sized and shaped to conform to a grid configuration to enable such compatibility and interconnectability, such that numerous combinations of modules can be assembled and interchanged as desired. This allows an unlimited number of combinations to be configured from an inventory of interchangeable, compatible modules and allows the apparatus to accommodate a wide variety of requirements for a given application.

The front end user-interface module 20 is provided both as a half size and full size module allowing, for example, one large and two small user front ends to be attached to a back end module 200, or two, three or four front end modules to be attached to two back end modules. Within the back end module 200, several optional configurations may be assembled to accommodate product inventory as desired. For example, within a back end module 200 any combination of product storage modules may be selected. A controlled room temperature section 240 may be included together with a refrigerated temperature storage section 250, as shown in Figure 6. Multiple storage container racks 205 may hold any combination of product storage modules, as

shown by Figure 6, including product storage containers 210 for pre-packaged product, bulk medication storage containers 220 for liquid product and bulk medication storage containers 230 for pill/capsule product. If desired, a reconstitution, mixing and/or compounding bulk medication storage container 370, 380, 390 can be added in place of a refrigerated storage module 250 or assembled into a second back end module 200.

The modularity of the components of the apparatus is defined in standardized manner to dictate dimensions, key contact points, power, network configuration points and mechanical features, to ensure interoperability for all components and their associated software, hardware and operational parameters.

The front end user-interface module 20 is independent from the back end drug vault module 200, whereby they may be co-located in a single chassis as a unified apparatus, or located in appropriate multiples to meet a particular service location requirement. Most commonly, multiple front end modules 20 are co-located with a single back end module 200 and both front ends (or multiple front ends) are serviced by a single robotic module 100 and back end drug vault 200. This is shown by Figures 16 and 17, in which Figure 16 shows two, side-by-side front end user-interface modules share one back end drug vault module and Figure 17 shows four, side-by-side front end user-interface modules and two back end drug vault modules, whereby each of two side-by-side front end modules share one back end drug vault module. Multiple back ends can also be linked to extend storage capacity to serve a front end user-interface cluster. Figure 18 illustrates a sub-assembly of two inter-connected back end drug vault modules. A further configuration, which may be desirable to service remote communities with low transactional volumes and long times between inventory

replenishment, is multiple back end modules 200 serving a single front end module 20.

The robotic module 100 is improved to, *inter alia*, provide dispensing reliability of pre-packaged drugs which have a range of sizes, shapes, weight and weight distribution (e.g. a heavy dense glass vial on one side and light weight dropper on the other side of a package renders an uneven weight distribution for the package), slipperiness of packaging, tabs, stickiness, moisture (e.g. from absorption by cardboard), all of which create a plurality of handling problems for robotic systems. Also, drug companies frequently change packaging, so control algorithms may become ineffective when a package change alters an SKU (StockKeeping Unit) which may be used by the robot to identify the package. Therefore, a robotic control algorithm that prescribes a handling method based on pre-recorded product package information (weight, size, etc) is subject to errors, simply because the packaging was not intended for automated dispensary, and there are currently more than four thousand package variants for common medications, that vary by region, manufacturer, re-packager, or distributor. To try to deal with this problem, some known systems create uniform over-packaging to assist in robotic dispensary reliability, but this adds additional handling and expense to the dispensary process, a significant increase in the opportunity for error, and additional waste stream burden to products already notorious for over packaging.

The robotic module 100 overcomes the foregoing problems of the prior art by using a “state based machine” based on controls, behaviours and sensors on a robotic pick head 50 (see Figure 2), wherein the pick head assembly 50 provides means for accessing the front end user-interface module and the back end drug vault module. Current medicament packaging is generally designed for handling by personnel, not

automated machines or robotic machines. Humans can compensate instantly and intuitively to variations, changes and anomalies. Machines such as robotic dispensaries are not smart, and require a refined set of behaviors to compensate for common anomalies. As shown in Figure 4, several networked video cameras 150 are installed inside the apparatus 10 to view what is taking place in the apparatus, and this visual information is used by the robotic module 100 as well as remotely, if needed, by a human agent. To compensate for the fact that machines, unlike humans, do not intuitively compensate for gripping items, the robotic module 100 is computer-controlled by a state machine (being firmware), associated software and a z-axis encoder 80 (for positional feedback control) to react to what happens and read the values of the various sensors, which include product position sensors 60 and z-axis positional sensors 70. For example, if a drug product being picked from inventory by the robotic module 100 is fully registered to be positioned at the back of a platen of the pick head assembly 50, then the robotic module 100 knows that was a successful pick and a tractor of the assembly can then feed it off correctly. A computer of the robotic module 100 knows the length of products so the module determines from the sensors 60, 70, being simple light beam sensors, where a product should be located. The array of sensors 60, 70 enables the robotic module 100 to determine what state it is in at any given moment. The robotic module 100 operates, for example to pick a product out of the back end drug vault module 200, by using "state tables" of approximately 385 states, each state functioning as a rule.

Intelligence is provided to the dispensary apparatus 10 to solve problems, this

being achieved by pick head sensors 60, 70, product information, machine states, behaviors and behavior results. A state determination is made from sensors and product knowledge, determination of a state leads to a selection of behaviors, behaviors are executed in order of success and success of behaviors for particular states increases the intelligence (knowledge learned) of the apparatus and system.

The hardware of the robotic module 100 operates at a first layer of control, while the state machine operates at second layer. The hardware includes a set of behaviors, including jiggle pick, shelf recovery, and others. The state machine drives which of the behaviors the robot is to apply and a series of states are provided with a score. The states know whether one state is better than another. For example, an optimal state would be registered where a product is located at the correct identifier number with the sensors identifying it to be fully registered at the back of pick head measured against product specific information out of the system's database. At the time of a product pick by the robotic module 100, the product is known because it was measured and its length was recorded when the product was serialized and put into inventory in the apparatus. Also known by the robotic module 100 is the size, the weight, the shape, the moment arm, and other particulars pertaining to the location of the product to be picked. The software driving robot knows what it is supposed to expect and the robot deduces what states should occur in order to be successful. It also deduces when it gets into a state relative to what the product is and by combining the product information and sensor information it deduces what to do next be successful. The robotic module 100 is controlled to do anything it can deduce to be successful.

A neural network is used by the system and each networked robotic module 100 to allow it to learn from previous actions and results. State transitions may provide learning knowledge to the robotic module 100. For example, if the robot achieved a particular state and used a particular behavior to get to that state, this is learned knowledge which is maintained by the robotic module 100 for future use. A collection of 25 different behaviors is applied by the robotic. If the robot is in a similar state as it was previously, and it previously tried a behavior which did not succeed, then it will not try the same behavior and, instead, will try another behavior. The robotic module is controlled to apply behaviors on the basis of risk levels, to become progressively more aggressive to achieve success. In a state table the states reflect this progression for control of the robot so that, for example, it will attempt 1 for, say, shift recovery, then attempt 2 for aggressive shift recovery, and then attempt 3 for maximum shift recovery.

The robotic module 100 is also controlled to do anything in its power to get unstuck, so it doesn't jam (since the apparatus is unattended). The primary rule applied by the robot is that it must not jam. For the robot, to not a make an error is a lesser rule (having lower priority) because the robot has access to a waste container 115 and a waste arm 110 which it uses to direct damaged product. If the robotic module 100 detects an error it transfers the product to the waste container. The robot applies it hardware, then state machine behaviors to achieve its primary directive of no jamming. If after three attempts to pick a product it is not successful, it reverts to remote control mode by invoking a call center screen for a human agent who is alerted that an error occurred and manual recovery is required. The human agent can look at the screen through the network and can summon a technical person to commence a remote control

application over the network which pilots the robot in real time, enabling the robot to service a user who is standing at the apparatus 10.

The control software of the robotic module 100 acts to try to correct errors when they occur. The robot picks a product from its storage location by bringing the pick head 50 to the storage location slot 207. The slot 207 has a gap in front to allow the pick head 50 to insert a tongue into the slot under the product. The pick head 50 has multiple belts (or wheels or fingers) to pull the product forward as the pick head moves up and onto a shelf of a storage container rack 205 while lifting the product up. This action picks up the first product on the storage shelf location, separating it from the remaining inventory, which is to (ideally) remain on the shelf. The pick head 50 then senses the size, shape, weight of the product it has picked to determine that it has picked a single product unit and determine that it has overcome three common errors, namely, a stuck pick (where the product sits in place due to slipperiness), double pick (where two products are either in close proximity, tangled together or stuck together) and multi pick (usually due to labels sticking together). The state machine, using sensors and a tables of information about the inventory product being dispensed, determines the error based on the physical parameters of dimension and weight and, for product containing RFID (Radio Frequency Identification) tags, by scanning and detecting the presence of more than one RFID tag, or more that one bar code if bar codes are presented in such a configuration as to make them visible.

Based on the foregoing information, the robotic module 100 determines with a high degree of accuracy whether the product is present, whether an error exists and, if so, the state of the error. Upon occurrence of an error, using the error state information

the robot implements an escalating series of interventions in an attempt to resolve the error. If no product is present in the pick head 50 and the robot knows there is product in the slot 20, then machine state is a stuck pick. In this state, the robot implements a first level stuck pick resolution action called "Jiggle Pick", for which a software control loop causes the robot to oscillate up and down within a range of motion and velocity determined to be appropriate for level one resolution range. With "Jiggle Pick", distance is important for effectiveness and to minimize damage to the robot, storage shelf and product. Sensors on the pick head determine penetration into the shelf and maintain a safe distance from the surfaces to minimize the possibility of contact damage. "Jiggle Pick" causes the stuck product to unstick from the shelf, in much the same way that a vibratory conveyer overcomes friction to move goods.

Two products may stick together causing two products to be loaded into the pick head rather than one product. In the storage bin, the mean angle between the panels of each product box is shallow and this may cause two package boxes to mate when sitting next to each other with pressure or if cardboard and subject to humid conditions. This increases the chance that when the pick head lifts one box, it may actually lift both, creating a double pick error. To resolve this, an escalation to a level two remedial action is implemented by the local control software creating a shift higher on the control head, to alter the angle the product is held at, thereby reducing the contact area between the first and second product, to create a separation angle, and create the contact point that disallows mating, therefore only pick one box.

A third common pick problem is multi pick, where several products are stuck together, typically due to the label or label glue affixing several packages together. The

sensors and machine operating software are able to determine a multi pick error based on weight, moment arm of the load, dimensions of the load and load behaviour measured by parameters of acceleration and deceleration lag. If the multi pick error cannot be resolved by the foregoing resolution one or two, the local operating software escalates to resolution three, whereby an edge of a pick bin is used as a guillotine to wipe the redundant products from the picked product. As the wiped product may have been damaged or compromised by a level three intervention wiping action, any wiped product is placed in the waste container 115 and is not dispensed without prior confirmation of integrity.

A drug dispensary apparatus must be reliable, measured primarily in terms of availability for service. The ideal machine would be one that never fails, but the very nature of integrated communications, software and hardware, and variety of products and packaging that must be handled, invariably lead to an error rate greater than zero. However, errors are probable and, therefore, error management, isolation and recovery are paramount to prevent failure.

A core reliability algorithm used by the apparatus 10 of the invention is defined in terms of absolute parameters or edicts. Each edict overrides subordinate edicts, with edict one overriding all others. The edicts are the following:

- Edict One: Patient Safety - No activity can compromise patient safety.
- Edict Two: Protection of Assets - No activity can compromise in order, the security of the drug inventory or the security of the machine.
- Edict Three: Maintain Operability.

Edict One is described in detail in the above-identified published PCT application (WO

2008/006203). Edict Two requires escalating procedures that do not require the machine or the drug vault to be opened. Edict Three requires that the escalating procedures be as succinct as possible to maintain an in service status and core utility of the apparatus.

The dispensary apparatus 10 is networked to a computer system so that any error occurring at the apparatus with respect to product (SKU) becomes a shared network experience and part of a common error record contributing to the accumulated knowledgebase of the system. Error parameters forming trends can be analyzed, such as, errors common to a specific machine, or specific machine configurations, or specific conditions, or specific packaging or product variants. As components of a neural network, each software controlled robot has pre-programmed autonomous actions, and being a state machine is able to adapt to changes to deliver the desired result under the control of a strictly applied rule set.

As stated, the robot's state machine in effect learns to recognize conditions and acquires knowledge in the form of a recorded history of the result of various solutions, thereby adding to the collective operation knowledgebase, to allow the robots of each of the networked dispensary apparatus 10 to learn from a successful outcome. For example, a product jam that entraps the pick head is a common reason for a dispensary apparatus to be out of service. The robot has a set of procedures to unstick itself. It knows its slot location and it knows the product SKU on the platen, but it may find that its X and Y axis movements are arrested.

If the database has no prior occurrence of this specific problem, the software begins the following resolution sequence, starting with the least destructive behavior:

jiggle gently, yes/no resolution; escalate to jiggle intensely, yes/ no resolution; escalate to jiggle intensely while pulling back the platen, reversing the pickup belts and while applying X axis up, to force the product free, sacrificing the product to the discard bid (this action will discard one product SKU), yes/ no resolution; escalate to ramming the platen forward into the slot and elevating the contents of the slot, then dropping them into the waste container (this action will discard all remaining product SKU's in the slot, but if successful, frees the robot to pick and dispense from the remaining slots), yes/no resolution; revert to shut down, call for help center technical intervention, open a remote pilot session, whereby the multiple cameras within the apparatus allow a technician at a remote repair center location to see inside the apparatus and to take over remote piloting of the robot to resolve the issue (this action avoids on site intervention and the apparatus is not opened so no security issues arise with this intervention), yes/no resolution; escalate to local call out whereby a qualified local technician who is certified to enter security level one (front of machine) is dispatched to the site, opens the front of the machine and can repair the problem if it is external to the drug vault, yes/no resolution; lastly, escalate to truck roll whereby a senior technician is called out, and the senior technician is authorised to security level two (drug vault access) and can resolve the issue by opening the back end drug vault module(s).

The foregoing staged error resolution process, by which the dispensary apparatus 30 determines when an error state occurs and is able to resolve the error which has been detected, serves to maximize the in-service time of the apparatus, maximize patient utility, provide a rapid response to an error, provide a low service cost structure and optimize security for the machine and the drug inventory.

The physical security of the dispensary apparatus 10 is enhanced by a staged access configuration of the apparatus as illustrated by Figures 5A through 5C. Access level one is illustrated by Figure 5A and Figures 5B1 through 5B3 and provides access at locations 160, 170 to the front part of the apparatus which houses the user interface components, waste section, pick head garage and regular dispensary service items. Access level two is illustrated by Figure 5C and provides access to the drug vault module including its refrigerated section (if any) and its bulk storage containers which controlled and isolated. Two types of security are applied to these access levels. The technician must have a valid ID badge to allow entry to the front end of the apparatus. A network video camera confirms the identity of the technician, that the technician's credentials are current and authorize the technician to access the machine at that time and that there is a work order created to track time and activity at the dispensary apparatus. In the event that a network connection cannot be established by the apparatus due to network interruption or prolonged power failure beyond the hold up time of an internal UPS, a controlled access key can be used for access to the level one interior space to restore power or network connectivity. Access to the level two controlled regions of the apparatus, such as the drug vault module, can only be achieved with network confirmation.

To optimize the user's utility in relation to the dispensary apparatus and serve a high traffic level, the apparatus must provide a high level of prescription coverage. An obstacle to doing so is that some medications, like insulin for diabetics, eye drops for glaucoma and several pediatric medications, require refrigeration for storage and such medications can be rendered ineffective if stored outside of their temperature range

(e.g. if outside such range by two to eight degrees Celsius). On the other hand, some medications such as syrups require room temperature storage which is defined as fifteen to twenty-nine degrees Celsius. Advantageously, the dispensary apparatus 10 of the invention overcomes this obstacle by providing an isolated refrigerated section 250 in the drug vault module 200 that can store medications at controlled refrigerated temperatures in combination with a controlled room temperature section 240 in the drug vault module 200 to store medications at room temperature, as shown by Figure 6. The apparatus also contains monitoring sensors (not shown) within the storage areas to sense internal temperature for the purposes of control of temperature, as well as to monitor temperature to report to a log file for correct temperature storage verification for a drug pedigree file and to report any temperature fluctuations in the form of high or low temperature alarms to the network for remedial action. Any drug that has been exposed to a temperature, or time and temperature beyond its allowable range is tagged to identify this via a drug pedigree established by the system and is removed from accessible inventory for disposal.

As in the known medication dispensary apparatus, the apparatus 10 of the invention is able to dispense only pre-packaged product, being single unit items referred to as "standard dosage" items or packages. Pre-package products indicate that the items are appropriate for use in the dispensary and for dispensing to users but the actual number of pills, capsules, etc., contained in a given standard dosage package will vary based on the drug and dosing regimen. This regimen is derived from information provided by the drug manufacturer and the common dosing practices for the drug in question. However, from the perspective of utility function for the user, the

dispensary apparatus is non-functional if the prescription requires 10 pills and the apparatus only stocks 8 pills standard dosage packages. The apparatus 10 solves this common problem by providing in its back end drug vault module 200 a bulk medication storage area 215 and pill counters 270 integrated into bulk storage containers for pill/capsule products 230.

A common problem encountered in autonomous pill counting is reliable, secure and clean handling of medication without cross contamination. The apparatus 10 includes a larger bulk pill/capsule storage container 230 that allows medication to be securely stored in bulk and sealed, and only touched by dedicated handling equipment until dropped into a dispensary package and dispensed to the user. This conforms to a no touch technique SOP to eliminate the possibility of cross contamination. The storage container 230 has specific dimensions to allow it to be stored in a standard storage slot, and specific features to enable reliable handling by robot. It also has specific security features to make it tamper resistant in transit.

The bulk pill/capsule storage container 230 is shown in Figures 24A-B and allows the robot to select and cause pill/capsule medication to be delivered to a counting unit comprising a pill singulator 260 and counter 270 which are integrated into the container 230 as shown by Figure 7. Tablets or capsules are stored in hopper of the container 230. A vibratory scroll feeder (not shown) aligns the medication from the hopper, before it passes to the counting unit which counts the number of pills or capsules directed by the robot. When the product count is reached, a flap mechanism (not shown) diverts the pill flow back to the bulk storage container 230. The prescribed medication is then transferred to a medication packaging module 280 (see Figures 8A-B) via a vibratory

scroll feed conveyer mechanism (not shown). Alternatively, the apparatus could be configured for placement of the medication packaging module at the counting unit's discharge port. The bulk pill/capsule storage container 230 is sealed and secured. Optionally, the apparatus 10 may be configured so that the bulk pill/capsule storage container 230 can only dispense medication when inserted into a dispensary module under control of the robot. Such a configuration allows for tight batch and inventory control and maintenance of the drug pedigree.

The prescribed counted medication is loaded into a hopper 290 of the packaging module 280 and is packaged by a bottle or foil packager 300, 310 of the packaging module 280. Optionally, the medication count may be verified optically during the transfer between the counter unit and the packaging module. The hopper 290, vibratory conveyer and counting unit (and optionally the transfer port) are optically inspected to confirm that no medication remains at those locations (i.e. no medication was left behind), before the bulk medication container 230 is cleared for the next use.

The mediation packaging module 280 is configured for packaging medication in two ways. Firstly, it can bottle medication, insert sterile bulking material and apply a cap. A cap spinner (not shown) applies a known torque, the removal torque is tested to verify cap function and re-torqued to the original torque setting. A drug pedigree certificate produced by the system adds to the pedigree a "cap good" notation. Secondly, the medication packaging module 280 can load medication into sterile foil seal pouches, apply a foil seal and verify seal via visual inspection.

Standard dosage packaging also presents an obstacle for liquid medications, especially paediatric medications and maintenance drugs where dosage can vary

widely. To resolve this obstacle the dispensary apparatus 10 of the invention provides a bulk storage container for liquid product 220 with an integrated pouring unit 226 as shown by Figures 25A-B. This bulk liquid medication container 220 is operated by the robot to pour a measured amount of medication into liquid dispensing containers (not shown).

Some medications require reconstitution generally with another liquid prior to dispensing. A reconstitution bulk storage container 370 is shown in Figures 26A-C and includes a mixer/agitator 32 and a liquid/concentrate storage section 34 for adding liquids to concentrates and pass them to a mixing cell for stirring or agitation. Similarly, some medications require mixing of two or more components prior to dispensing. A mixing bulk storage container 380 is shown by Figures 27A-B. The mixing container 380 includes liquid storage sections 382, a mixer 384 and mixing valves and piping 386 for measuring and dispensing mixed medication to a liquid dispensing container according to any number and amount of liquid components by weight, volume or percentage. Further, some medications require geometric reduction of one or more components in a carrier. A compounding bulk storage container 390 is shown in Figures 28A-B and includes liquid storage sections 391, a mixer 394 and mixing valves and piping 396 for performing geometric reduction of one or more components in a carrier.

A problem which has not been overcome by prior art dispensary apparatus is a failure to provide means for reliably applying standard flat labels to the dispensed medication product. Labels are typically applied by the conventional means of running pressure sensitive adhesive back coated labels on a peal away carrier through a label

printer and transferring the printed label to a bottle or box, but achieving reliability of good placement and adhesion reliability has been a problem. Labels must be a standard shape and size to pass through the printer, and must contain critical patient and medication information, conforming to industry standards offering little creativity in shape, size or materials. Several transfer methods have been previously disclosed including sponges, vacuum, sponges and vacuum in combination, transfer media, transfer roller and pressure pads.

The apparatus 10 of the invention solves this problem in a novel and simple way by using the label itself as an applicator. A package labeling module 330 of the apparatus is shown in Figures 10A-F. The label stock is paper or plastic stiff enough to support the label without sagging from edge to edge along its longest side. The label is ejected from the printer and attached to a continuous release liner. The release liner wraps around a small diameter roller, causing the label to separate from the release liner. The release liner advances to the point where 7/8 of the label is detached from the release liner. The robot's pick head 50 picks a product to be dispensed by the apparatus and brings the product to the suspended label, aligning the front edge of the label with a pre-selected contact start point on the product package. The robot's pick head 50 rotates the product away from the small diameter roller, rolling the label onto the product, and dislodging the remaining 1/8 of the label from the release liner. The product, with label attached, is then transported and pressed label-side down, onto a conformal sponge contact patch that applies adequate pressure to contact the label to all parts of the package with sufficient pressure to activate the contact sensitive adhesive. Because the size and shape of the package of the product is known to the

robot, accurate placement is possible with this method, with high reliability and repeatability, and without the adhesive residue problems of the prior art. A parts description listing for the parts shown in Figures 10A-F is provided by the following table:

Item no.	Description
L01	Nema 23 Stepper Motor
L02	Nema 23 Reducer 10:1
L03	Stepper controller
L04	Banner miniature polarized retro reflective sensor
L05	Banner square reflector 60mm x 40mm w/ mounting holes
L06	8mm, NO, PNP Inductive Prox w/ 8mm Quick Disconnect
L07	M8, Inductive Prox w/ 8mm Quick Disconnect
L08	ABS Resin Conveyor Roller 20mm OD x 99mm lg.
L09	XL Timing pulley 15 teeth
L10	XL Timing pulley 30 teeth, 10mm bore w/setscrews
L11	XL Timing Belt, 105 teeth, 533.4mm long (Poly w/ Kevlar)
L12	10mm double bearing housing
L13	Knurled lock nut M20x2.5
L14	2mm E-Clip
L15	Large diameter knurled screw M5 tapped
L16	Linear bearing rail 135mm Lg, 2 bearing carriages
L17	M5 Threaded Stud, 95mm Long
L18	5mm Pivot Pin, One end Threaded with Flat, 85mm Long
L19	3mm Shaft x 112lg with 2x E-Clip grooves
L20	6mm Shaft x 81lg with tapped M3 End
L21	10mm Shaft x 60lg with 2x Retaining Groove
L22	Resin Pipe, 5mm OD, 3mm ID x 100lg.
L23	Constant Force Spring, 0.1 kg force
L24	5mm E-Clip
L25	6mm Hexagonal Base Cantilever shaft, 100mm Lg with 2mm Base, M6 Thread
L26	6mm Hexagonal Base Cantilever shaft, 100mm Lg with 20mm Base, M6 Thread
L27	Resin Pipe, 8mm OD, 6mm ID x 100lg.
L28	6mm shaft, 101mm Lg. Threaded M4 both ends
L29	6mm shaft x 112 mm Lg, with 2x E-Clip Grooves
L30	Polyurethane Foam Rod 2"

L31	Polyurethane Foam 2 1/4" Square
L32	Seiko Thermal Label Printer
	Seiko CAP9000 USB Board
	Seiko - Control Cable
L33	10mm External Retaining Ring
L34	DC Gear motor, 187.68:1 reduction ratio
L35	XL Timing Pulley, 12 Teeth
L36	XL Timing pulley 20 teeth, 10mm bore w/setscrews
L100	Labeler Plate
L101	Label Stock Trap Plate
L102	Label Take-up plate
L103	Take-up Spindle
L104	Label Backing Back Guide Plate
L105	Label Backing Front Guide Plate
L106	Label Take-up Drive Shaft
L107	8mm Prox Mount Angle
L108	Label Stock Collar
L109	Constant Tension Spring Mount
L110	Banner Sensor Bracket
L111	Labeler Mount Plate
L112	Foam Mount Bracket
L113	DC Gear Motor Mount
L200	5mm x 25mm, Shoulder Screw

In addition, the apparatus 10 provides a further improvement for product labeling in the form of an optical scribe 330 that writes directly to a product package (container) to be dispensed. Figure 11 shows a laser marking module 330 directly marking (labeling) a product container 335 positioned on the robot's pick head 50. By the addition of a light sensitive coating on the container 335 the laser marking module 330 writes readable information directly onto the container 335 without the requirement for a transfer label and the associated complications of label transfer, placement and adhesion.

Loading a dispensary apparatus with medication is a time consuming, tedious, laborious, highly repetitious task, and as a result, is subject to error. Removal of these human factors at the loading point is important for reducing errors in a drug supply chain. The known loading methods have relied on RFID tags to verify the drug, requiring a human operator to flash each product against an RFID sensor which verifies the drug and identifies (e.g. by a light) the appropriate storage slot to direct the operator to the location of correct placement. Apparatus using such known methods display, on an inside screen, a picture of the drug with data, DIN, lot, etc., and then says the name of the drug using a text speech generator. The downfall of those prior methods and apparatus is the amount of time required to verify each product, and the additional cost in the apparatus of an the indicator light system with related software and hardware to drive the lights, in addition to the cost of an RFID tag in each and every product.

The dispensary apparatus 10 of the invention uses either an RFID tag, if any, or the optical product coding which is already in place on pre-packaged product, which is read by the robot and used by the robot to automatically place the products in inventory in the apparatus, without requiring an operator to open the machine. The robot and the networked computer system then know, with absolute certainty, the location of all products in the machine and the state of the inventory, without the possibility of human placement error. Product loading occurs in two modes. Firstly, the apparatus provides means for manual loading of product by an operator, after the operator has passed a security test to place the apparatus in a manual load mode. Product is placed in a manual load slot 350 for robotic self-load as shown in Figure 12. When product is manually placed in the load slot 350 it is accepted by the robot, read and placed in

inventory in the apparatus. The cycle completes until inventory storage of the product load is complete.

Secondly, the apparatus provides means for automatic loading of product as shown by Figures 13A-B. A secure transfer container 360 is used for secure transport of drugs and automated loading into the apparatus. In the automatic load mode, the operator places the secure transfer container 360 into the apparatus in a receiving port and the robotic module 100 automatically loads the products into inventory while not required for other tasks. When full loaded, the empty secure transfer container 360 is used for receiving waste to be returned from the apparatus to the distribution center so the transfer container 360 also serves as a waste container 115 in this mode.

The secure transfer container is shown in Figures 14A-D and is configured on the basis of its contents, with several types being provided including a refrigerated type, a non-refrigerated type, a pre-packaged product type, a bulk liquid type and a bulk pill type. A universal type secure transfer container 360 is also provided. The refrigerated type secure transfer container 365 is shown in Figures 22A-B. It is insulated and refrigerated with an external power supply hook up 368 to provide active refrigeration during transport or storage on route, and it contains a Peltier effect type solid state cooling device 366 and a temperature monitoring system. The secure transfer container 360 is a secure device that can only be opened by the robot once it is inside the apparatus or at the distribution center and provides a secure transfer vessel for the drug products as they travel between the apparatus and the distribution center, whereby a common carrier may be used for transporting the products.

As stated, a measure of utility for the apparatus is that a drug requested by a

user must be available from the apparatus from which it is requested. A back end drug vault module 200 of the apparatus 10 has a fixed number of storage slots 207 for product. As shown by Figures 15A-d, each storage slot 207 can store up to five units of the same product SKU. In locations such as a busy primary care clinic or hospital emergency room, this may not be adequate storage to meet the demand for high demand medications to be in stock all of the time with a reasonable restocking cycle time, making it possible to run out of a high demand medications before the next restocking visit, especially during epidemic seasons or events. In such locations, multiple modules of the apparatus can be co-located to duplicate or multiply the number of user interfaces present, allowing more than one patient to be served at a time. Further, the apparatus 10 is configured to allow for the inventory product of one drug vault module 200 to be picked and securely transferred by a robotic module 100 to another co-located drug vault module 200.

A patient may be served by a first apparatus 10 for which some components of the medication requested may be out of stock within that apparatus but available and in stock at a second apparatus 10. The first apparatus 10 queries the second apparatus 10 for availability, if the product is available, the first apparatus requests a secure transfer of the medication. The robot of the second apparatus is instructed to carry out a product pick, scan and verification that the product is correct, then deliver it to a left or right side secure transfer slot of the apparatus (not shown). The robot of the first apparatus travels to a right or left side secure transfer slot of that apparatus and, when in correct position, a transfer order handshake is exchanged between the first and second apparatus, allowing the transfer ports to open and the requested product to be

passed from a platen of the robot of the second apparatus to a receiving platen of the robot of the first apparatus. After the transfer is complete, the second apparatus retracts its robot platen, verifies that the transfer was completed and closes its transfer door. The robot of the first apparatus verifies the product received, confirms identity of the product against the drug record, and continues the dispense cycle in the same manner as if the drug had been located within the drug vault module of the first apparatus.

Multiple apparatus 20 can be co-located, for example in a three apparatus co-location installation, a first apparatus can request medications from the third apparatus whereby the second apparatus is instructed to act as an intermediary and pass the medication through that apparatus.

Further, from the user's perspective of utility, there is no such thing as an obscure medication. If a medication has been prescribed, it is what is wanted and needed immediately to commence healing. The user does not accept that a particular medication it needs is rarely sold, so seldom stocked. To the patient, the utility value of the dispensary apparatus is its ability to dispense the medication needed as and when requested. For example, there are many medications for tropical diseases that are necessary, but dispensed infrequently. The apparatus 10 of the invention applies a method with enabling hardware and software to designate specific storage slots 207 as multiple product SKU garages.

The slots 207 are vertically oriented, and operated on a first in-first out inventory control rule. This is accomplished by picking product from the bottom of the slot and placing new product on the top of the slot. In a garage-type designated slot containing

five different individual product SKU's, the desired product may be the third product in the slot. The robot travels to the slot location and picks item one, picking from the bottom. The robot returns item one to the top of the same slot for restocking. The robot returns to pick item two, again returning it for restocking. The robot then picks item three, the desired item, verifies it and proceeds to a dispensary preparation cycle. The system's product inventory location register is corrected to show that former product one is now in position three, that former product two is now in position four, that former product three is now in position one and that former product four is now in position two, with the slot able to accept one additional product SKU on restock.

The refrigerated storage module 250 of the apparatus 10 is shown by Figures 19A-B, Figure 20 and Figure 21. It has an insulated perimeter and an insulated, sliding door 252 which can be opened in a low clearance environment by means of a sliding mechanism or track such that it opens to expose its internal contents to the robot, and moves out of the way on a plane perpendicular to the X-Y axis of motion of the robot pick head 50. Its track has a shape or the door has a mechanism whereby the door is sealed at the perimeter when closed, and moves away from the seal, or the seal collapses or moves away to provide clearance for the door to operate. The door is operated by a linear actuator, pulley, cable, cogged belt system, or by a latch that can be engaged by the robot head to open and close the door. The refrigerated storage module 250 also communicates to an external vacuum pump 258 (or may contain a pump), capable of providing a reduction in barometric pressure within the refrigerated storage cell immediately after the door is closed, to set the door seal and to remove ambient air and moisture that was introduced into the refrigerated storage module while

open. The refrigerated storage module 250 contains Peltier effect type solid state cooling devices coupled to heat absorbing aluminum thermo sink arrays to remove heat from within the refrigerated module without the requirement for a compressor, condenser and evaporator.

What is claimed is:

1. An automated apparatus for dispensing a prescribed medicament, configured for communicating with a remote server linking said apparatus to a computer network and for recognizing a script for a prescribed medicament for a user of said apparatus, said apparatus further configured for receiving through said computer network information regarding said user, said medicament and/or other apparatus of said network, said apparatus comprising:

(a) a front end user-interface module configured for receiving information input by a user and for dispensing said medicament to said user;

(b) a back end drug vault module configured for secure storage of a plurality of medicaments and interconnected to said front end user-interface module; and,

(c) a computer-controlled robotic module configured for communicating in said network and comprises means for accessing said front end user-interface module and said back end drug vault module, said accessing means comprising a plurality of sensors for providing positional feedback information to said robotic module for controlling said accessing, picking said medicament from said back end drug vault module and delivering said medicament to said front end user-interface module for dispensing to said user;

wherein said front end user-interface module and said back end drug vault module are dimensionally compatible for interconnectability of multiple said front end user-interface modules and back end drug vault modules in multiple combinations.

2. An apparatus according to claim 1 wherein said computer-controlled robotic module further comprises a state based machine configured to use a state table comprising states for controlling said robotic module, said states being associated with said positional feedback information provided by said sensors and based on behaviors to be applied by said assessing means to pick said medicament from inventory in said back end drug vault module.

3. An apparatus according to claim 2 wherein said robotic module applies said behaviors according to increasing levels of aggressiveness to achieve success in picking said medicament from inventory, wherein said success is primarily defined to require no jamming of said robotic module.

3. An apparatus according to claim 2 wherein said network is a neural network comprising a dynamic knowledgebase of information, including learned information, pertaining to medicaments in inventory in said apparatus and on-going behaviors, and their results, of robotic modules in said network used for picking medicaments from inventory, said computer-controlled robotic module using said knowledgebase information for controlling said accessing means.

4. An apparatus according to claim 2 wherein said front end user-interface module is configured for staged security level access by a human operator whereby a first level security access is restricted to access of pre-selected components of the front end user-interface module only and a second level security access includes access according to

said first level security access and access to said robotic module and said back end drug vault module including said inventory thereof.

5. An apparatus according to claim 1 wherein said back end drug vault comprises a refrigerated storage module for storing medicaments in inventory in a controlled refrigerated environment, said refrigerated storage module comprising one or more temperatures sensors for monitoring said refrigerated environment and said apparatus communicates information from said temperature sensor(s) through said network for centralized action.

6. An apparatus according to claim 1 wherein said back end drug vault comprises one or more pre-packaged product storage containers for containing inventory pre-packaged medicament product and said storage container(s) is self-loaded into place in storage slots by said robotic module, the position of each loaded pre-packaged product storage container and identification of the medicament product therein being tracked by said robotic module and maintained within said network for use by said robotic module.

7. An apparatus according to claim 1 or claim 6 wherein said back end drug vault comprises one or more bulk pill/capsule product storage containers for containing inventory pill/capsule medicament product in bulk form and said bulk pill/capsule product storage container(s) is loaded into place in storage slots by said robotic module, the position of each loaded bulk pill/capsule product storage container and identification of the medicament product therein being tracked by said robotic module and maintained

within said network for use by said robotic module.

8. An apparatus according to claim 7 wherein said bulk pill/capsule product storage container comprises an integrated pill counting module configured for isolating and counting pills/capsules of said bulk pill/capsule product storage container according to said script.

9. An apparatus according to claim 1 or claim 6 wherein said back end drug vault comprises one or more bulk liquid product storage containers for containing inventory liquid medicament product in bulk form and said bulk liquid product storage container(s) is loaded into place in storage slots by said robotic module, the position of each loaded bulk liquid product storage container and identification of the medicament product therein being tracked by said robotic module and maintained within said network for use by said robotic module.

10. An apparatus according to claim 7 wherein said bulk liquid product storage container comprises an integrated liquid pouring unit configured for measuring and pouring said bulk liquid product according to said script.

11. An apparatus according to claim 1 or claim 6 wherein said back end drug vault comprises one or more reconstitution bulk product storage containers for containing a plurality of inventory liquid and/or concentrate medicament product in bulk form and a mixer/agitator, for reconstituting said medicament to be dispensed according to said

script integrally within said reconstitution bulk product storage container(s), and said reconstitution bulk product storage container(s) is loaded into place in storage slots by said robotic module, the position of each loaded reconstitution bulk product storage container and identification of the medicament product therein being tracked by said robotic module and maintained within said network for use by said robotic module.

13. An apparatus according to claim 1 or claim 6 wherein said back end drug vault comprises one or more mixing bulk product storage containers for containing a plurality of inventory liquid medicament product in bulk form and a mixer, for mixing said medicament to be dispensed according to said script integrally within said mixing bulk product storage container(s), and said mixing bulk product storage container(s) is loaded into place in storage slots by said robotic module, the position of each loaded mixing bulk product storage container and identification of the medicament product therein being tracked by said robotic module and maintained within said network for use by said robotic module.

14. An apparatus according to claim 1 or claim 6 wherein said back end drug vault comprises one or more compounding bulk product storage containers for containing a plurality of inventory liquid medicament product in bulk form and a mixer, for mixing and compounding to perform geometric reduction, according to said script, integrally within said reconstitution bulk product storage container(s), and said compounding bulk product storage container(s) is loaded into place in storage slots by said robotic module, the position of each loaded compounding bulk liquid product storage container and

identification of the medicament product therein being tracked by said robotic module and maintained within said network for use by said robotic module.

15. A secure transfer container configured for secure transfer of medicament product therein from a medicament distribution center to an automated modular apparatus according to claim 1, said secure transfer container configured for receipt by said robotic module of said automated modular apparatus and self-loading by said robotic module of said medicament product from said secure transfer container to placement of said medicament product into inventory in said back end drug vault module, wherein said secure transfer container is configured to restrict access to said medicament product therein to only said distribution center and said robotic module of said automated modular apparatus whereby a common carrier may be used for transporting said secure transfer container.

16. A secure transfer container according to claim 15 wherein said secure transfer container is insulated and refrigerated, said secure transfer container comprising a solid state cooling device and means for temperature monitoring and configured for powering by means of an external power supply.

17 An apparatus of claim 8 wherein said back end drug vault module comprises a medicament packaging module configured for packaging said counted pill/capsule medicaments by a bottle or foil packager of said packaging module.

18. An apparatus according to claim 1 wherein said back end drug vault module comprises a package labeling module configured for storing a stock of labels and for labeling a medicament package to be dispensed by said apparatus, whereby said package labeling module uses a suspended label from said stock of labels as an applicator for applying said label to said medicament package and said robotic module transports said medicament package to said suspended label, aligning a front edge of said label with a pre-determined contact start point on said medicament package.

Application number / numéro de demande: 2639239

Figures: 15A 15B 15C 15D 26A 26B 26C
27A 27B 28A 28B

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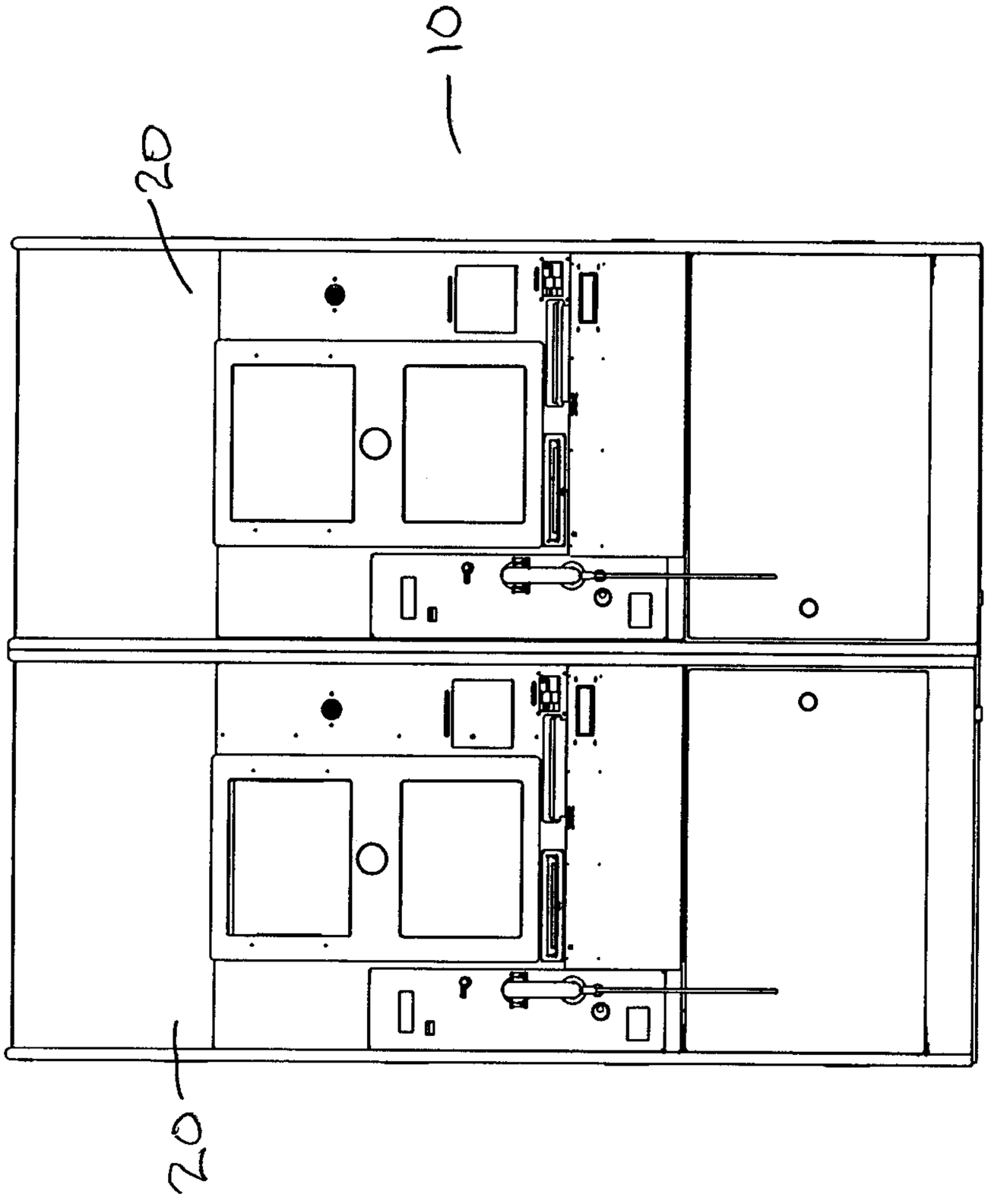


Figure 1

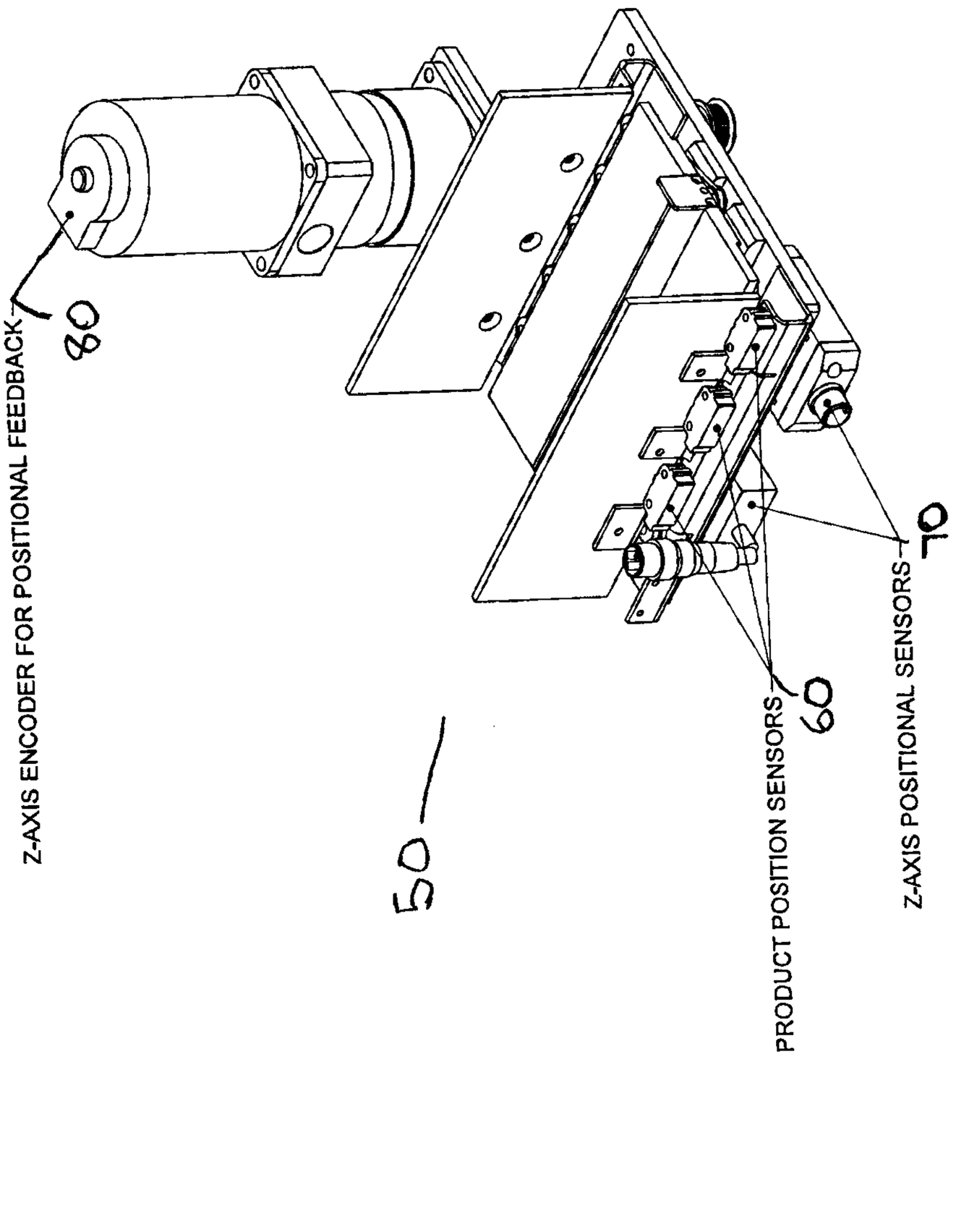

Z-AXIS ENCODER FOR POSITIONAL FEEDBACK
80
50
PRODUCT POSITION SENSORS
60
Z-AXIS POSITIONAL SENSORS
70

Figure 2

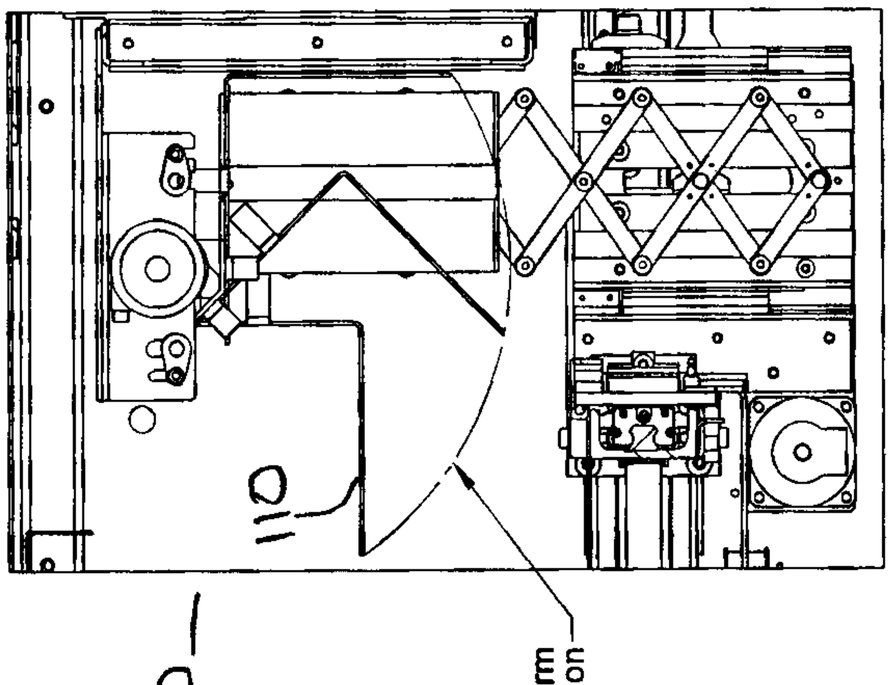
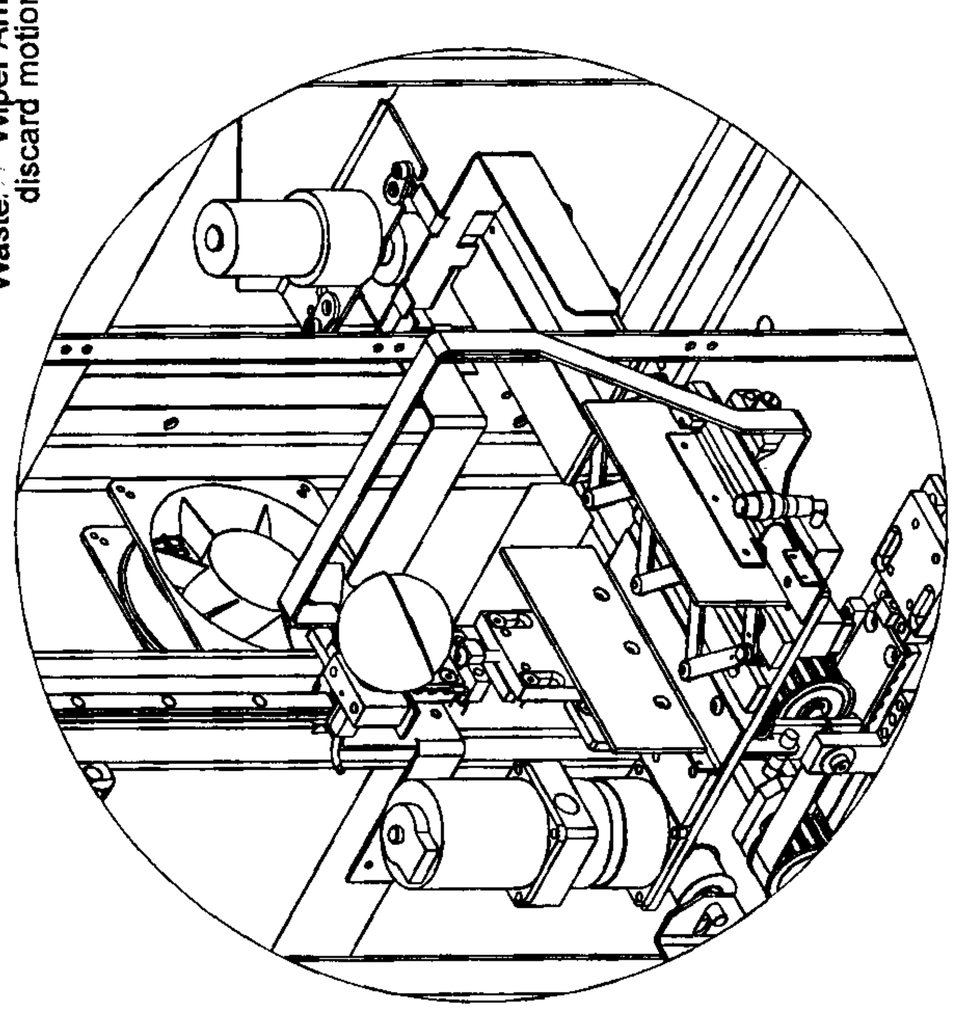


Figure 3C



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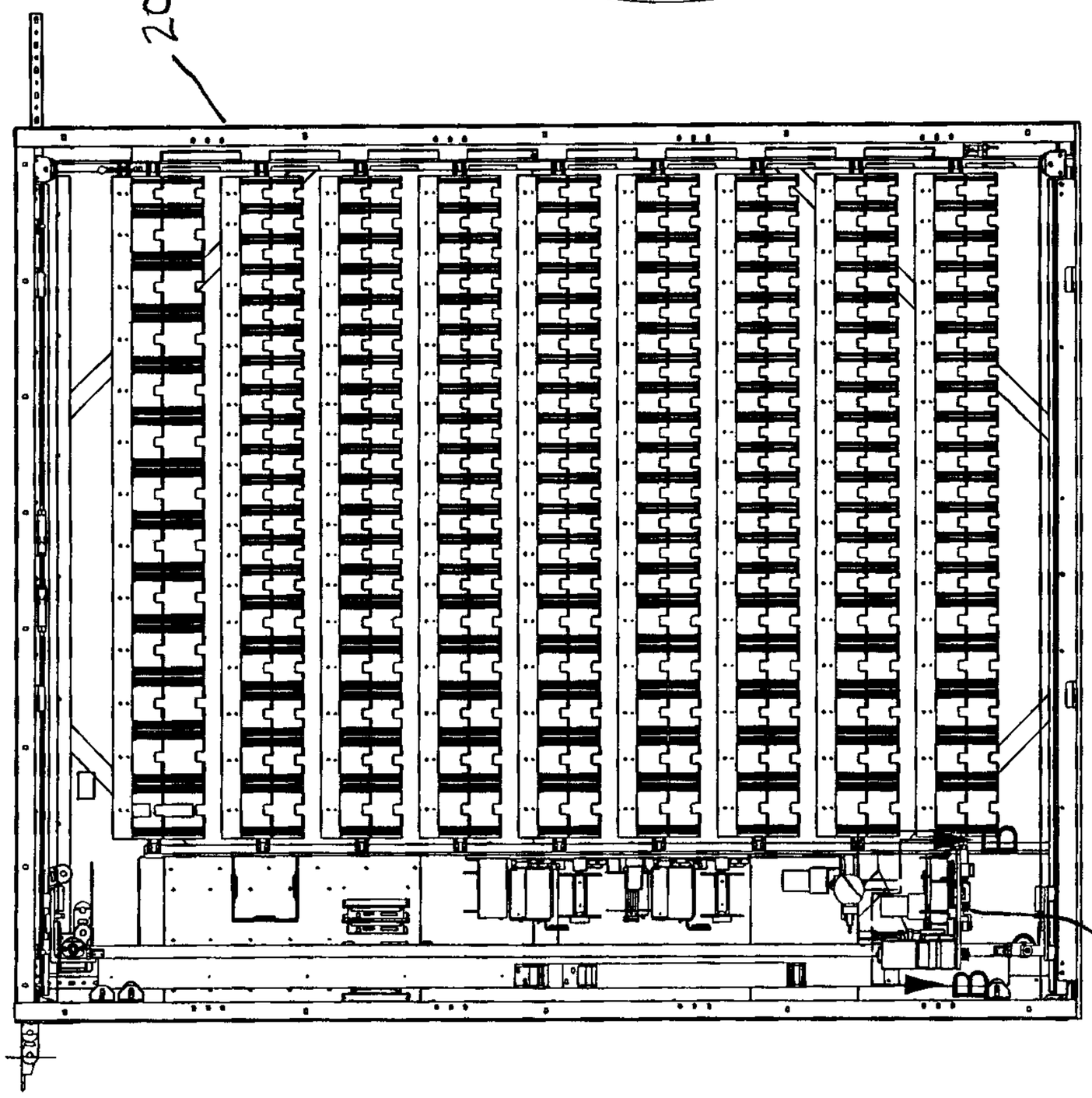

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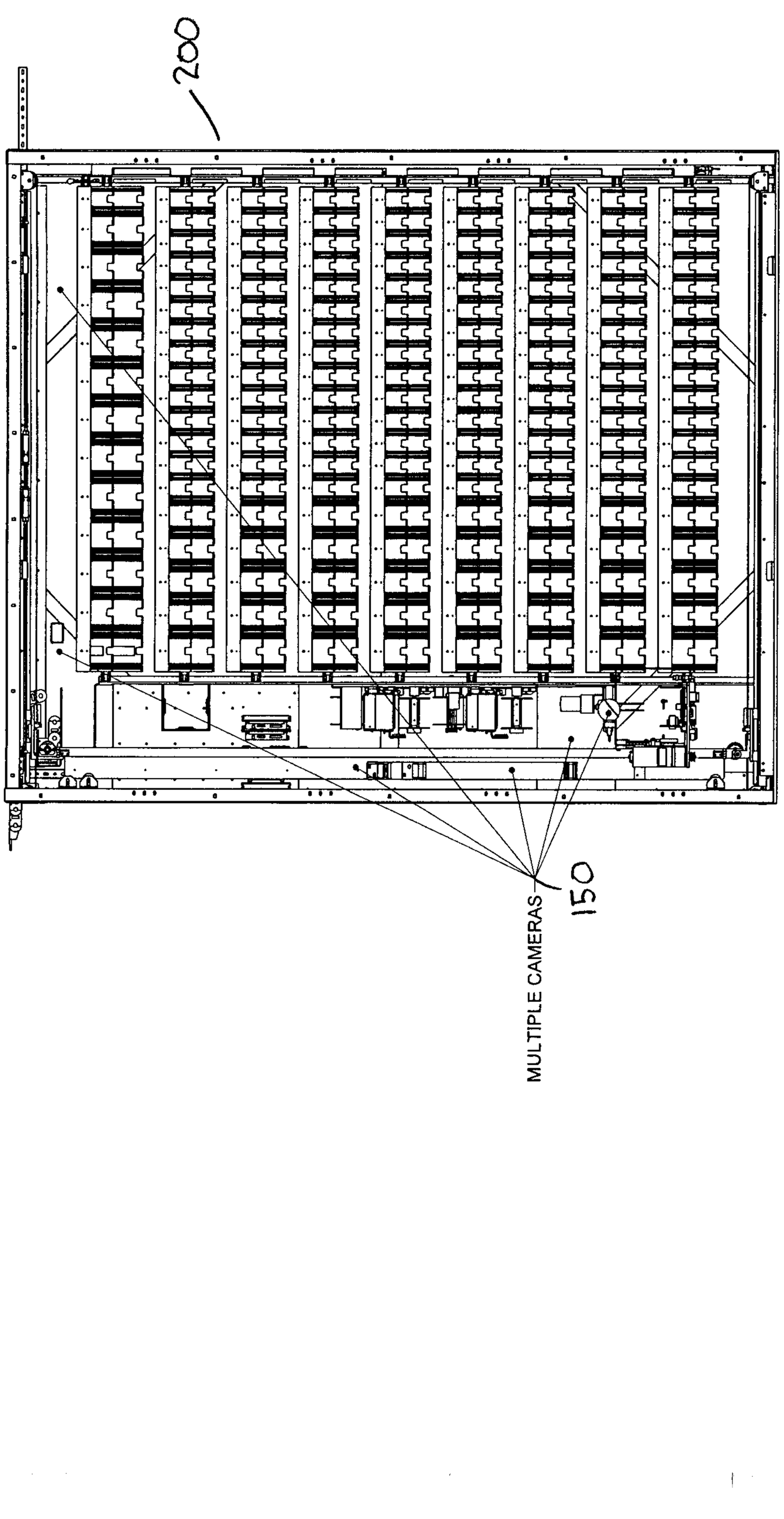

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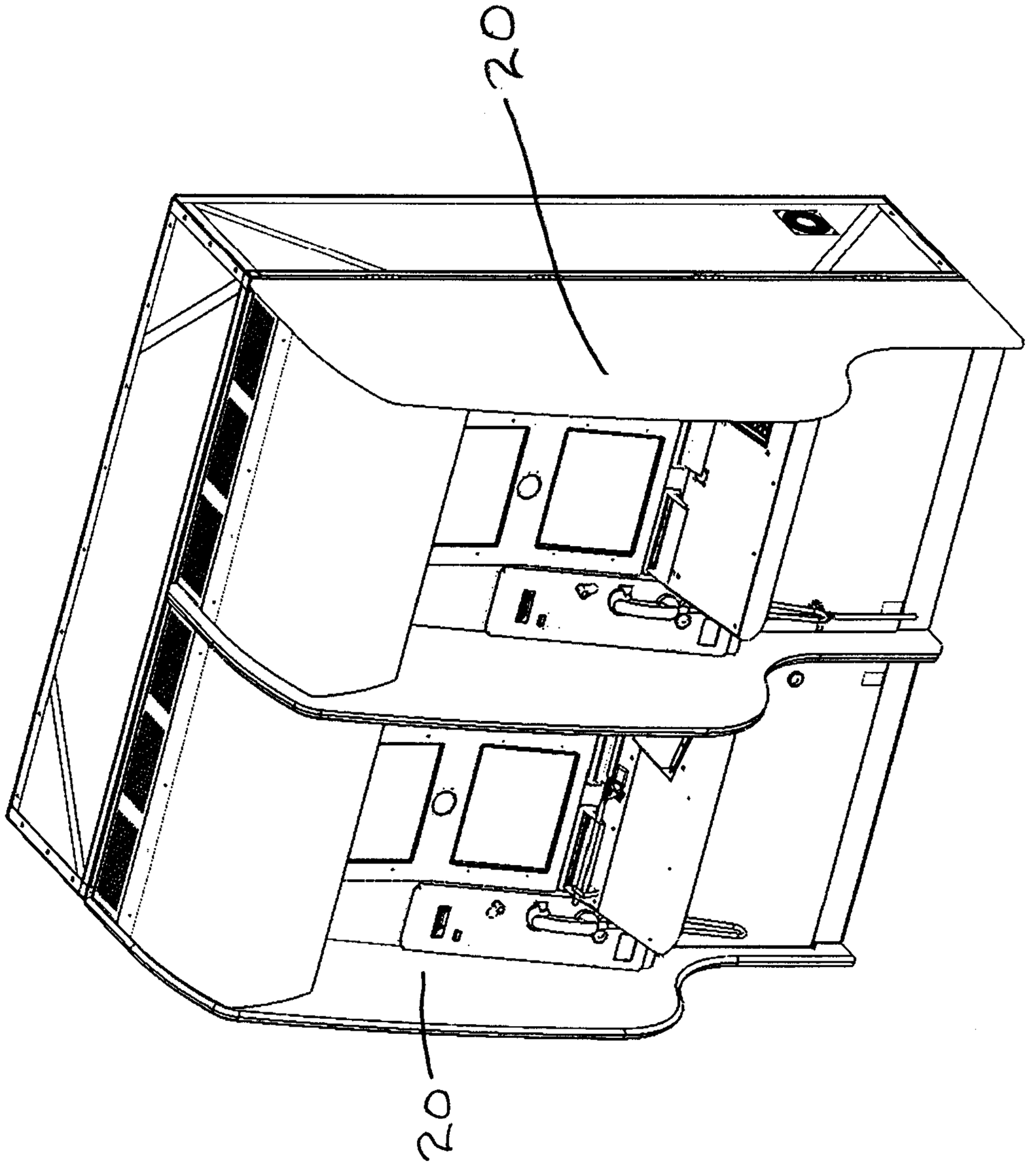
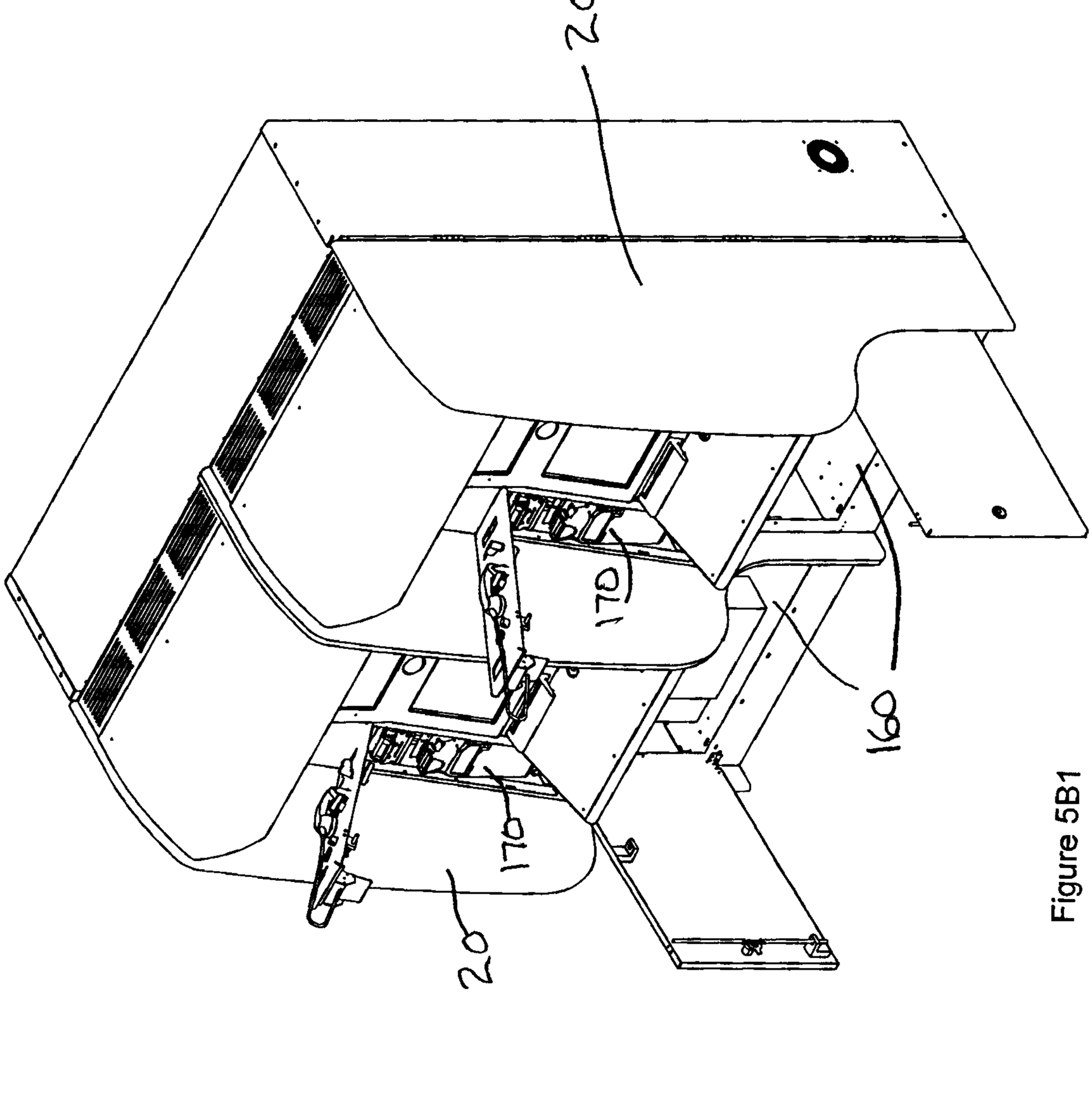


Figures 5A



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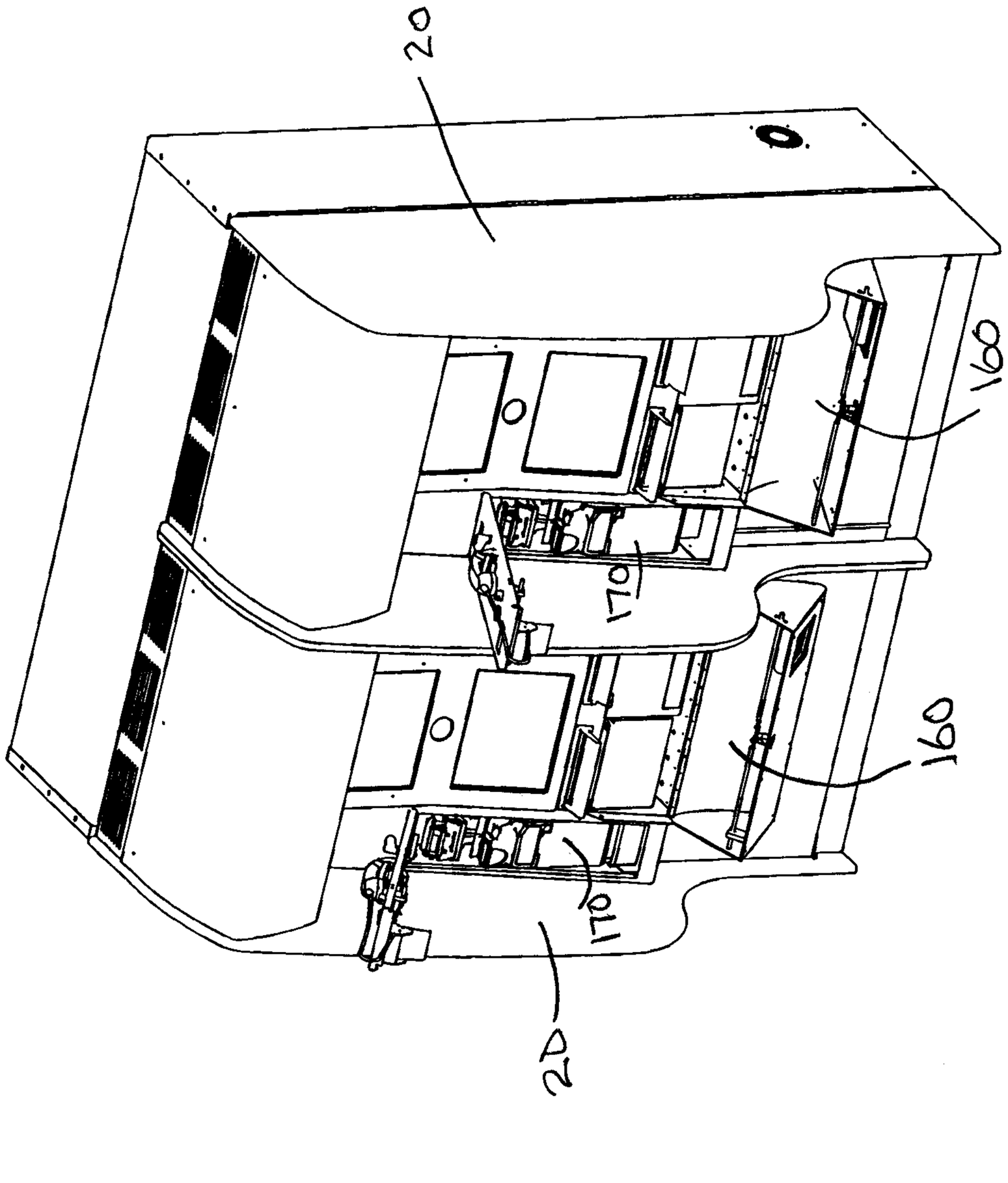

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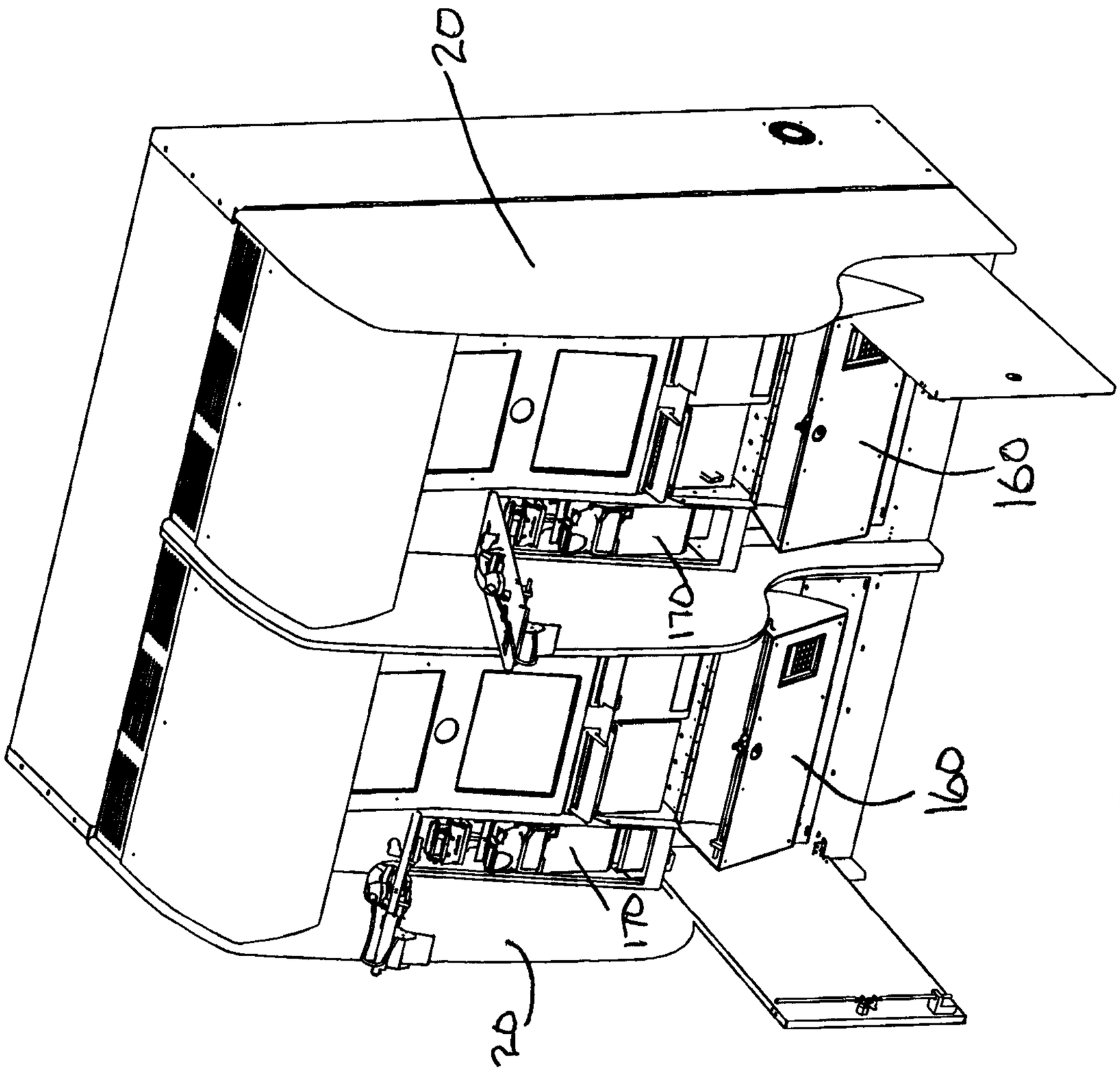

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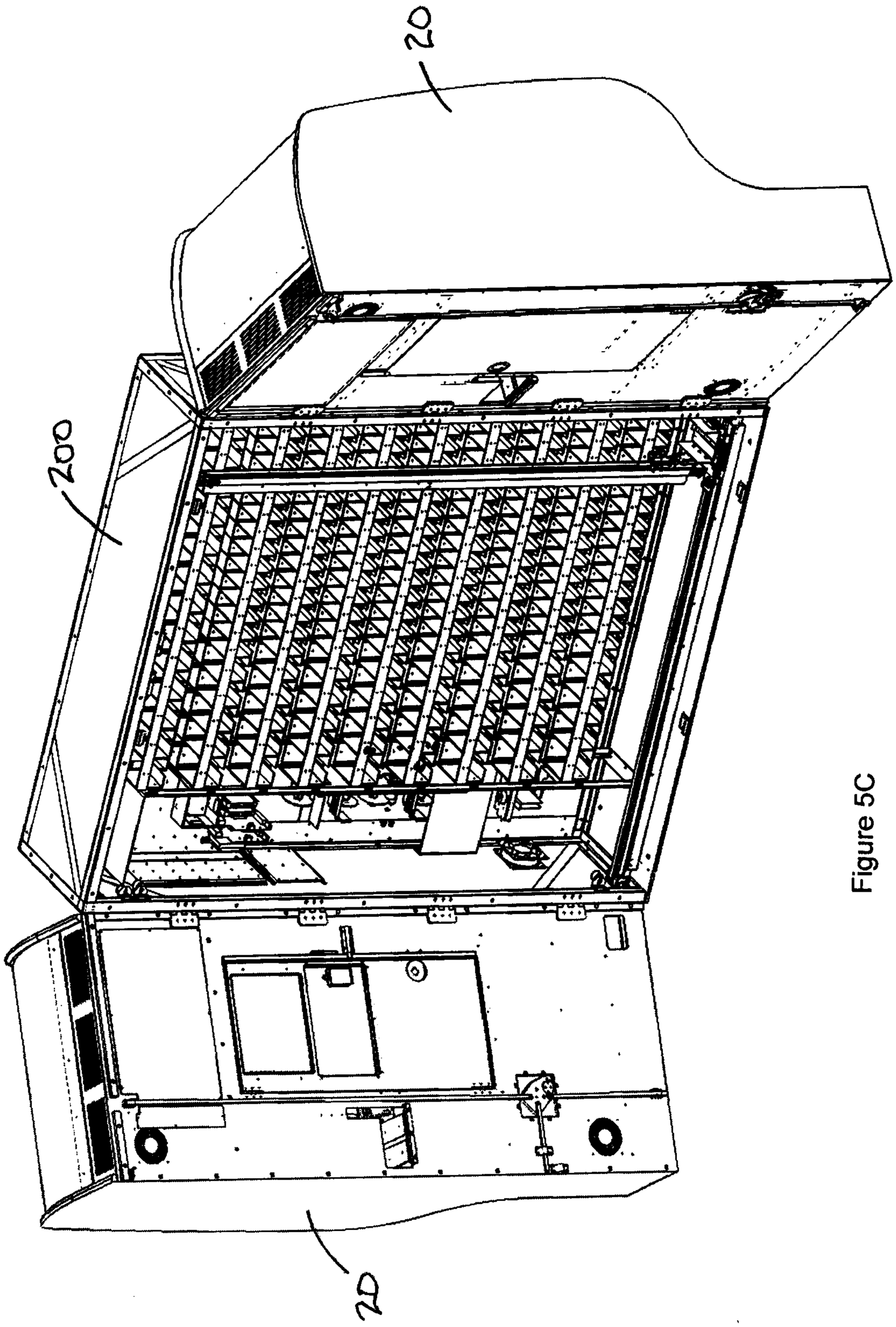


Figure 5C

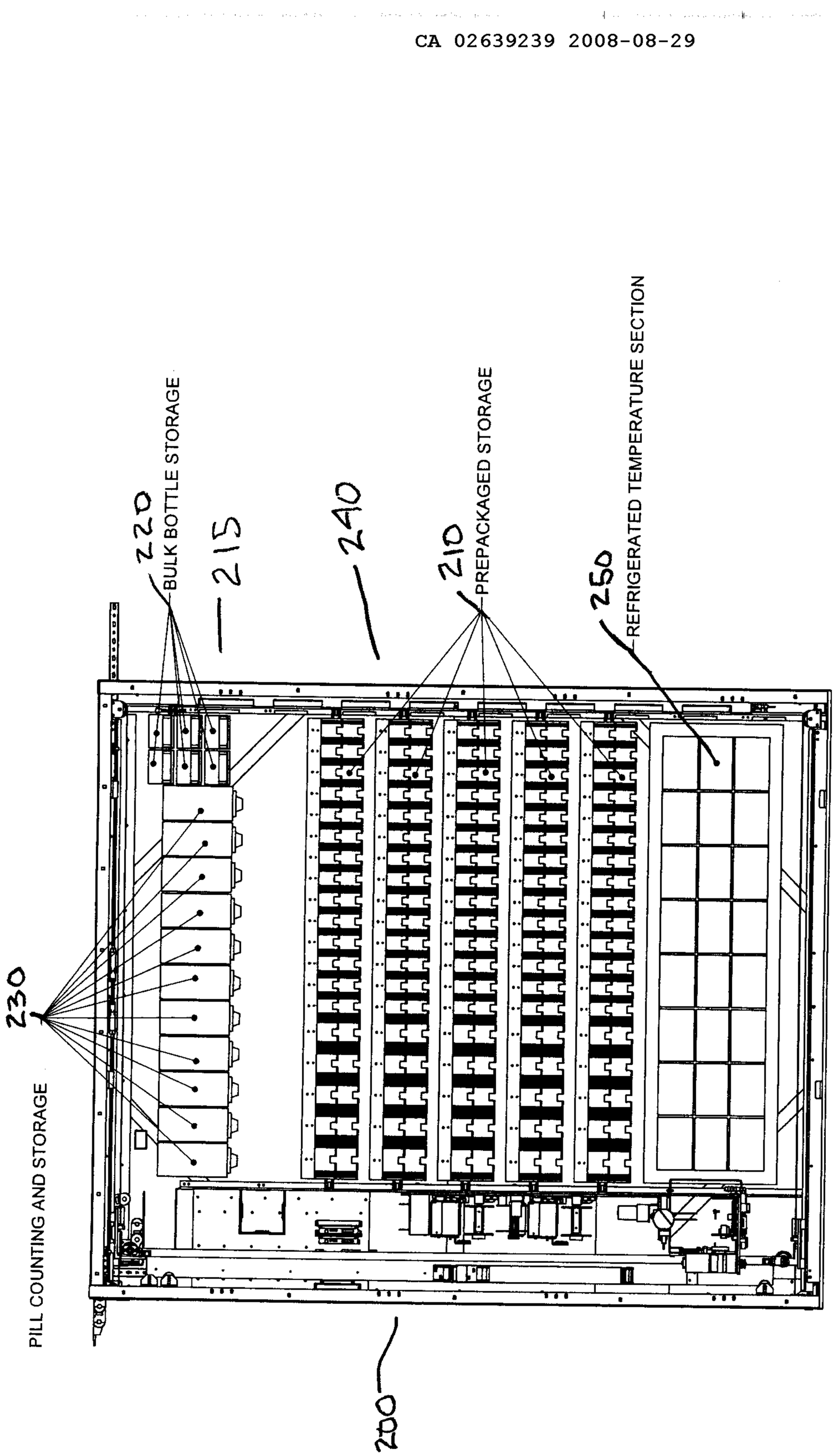

220
BULK BOTTLE STORAGE
215
240
210
PREPACKAGED STORAGE
250
REFRIGERATED TEMPERATURE SECTION
230
PILL COUNTING AND STORAGE
200

Figure 6

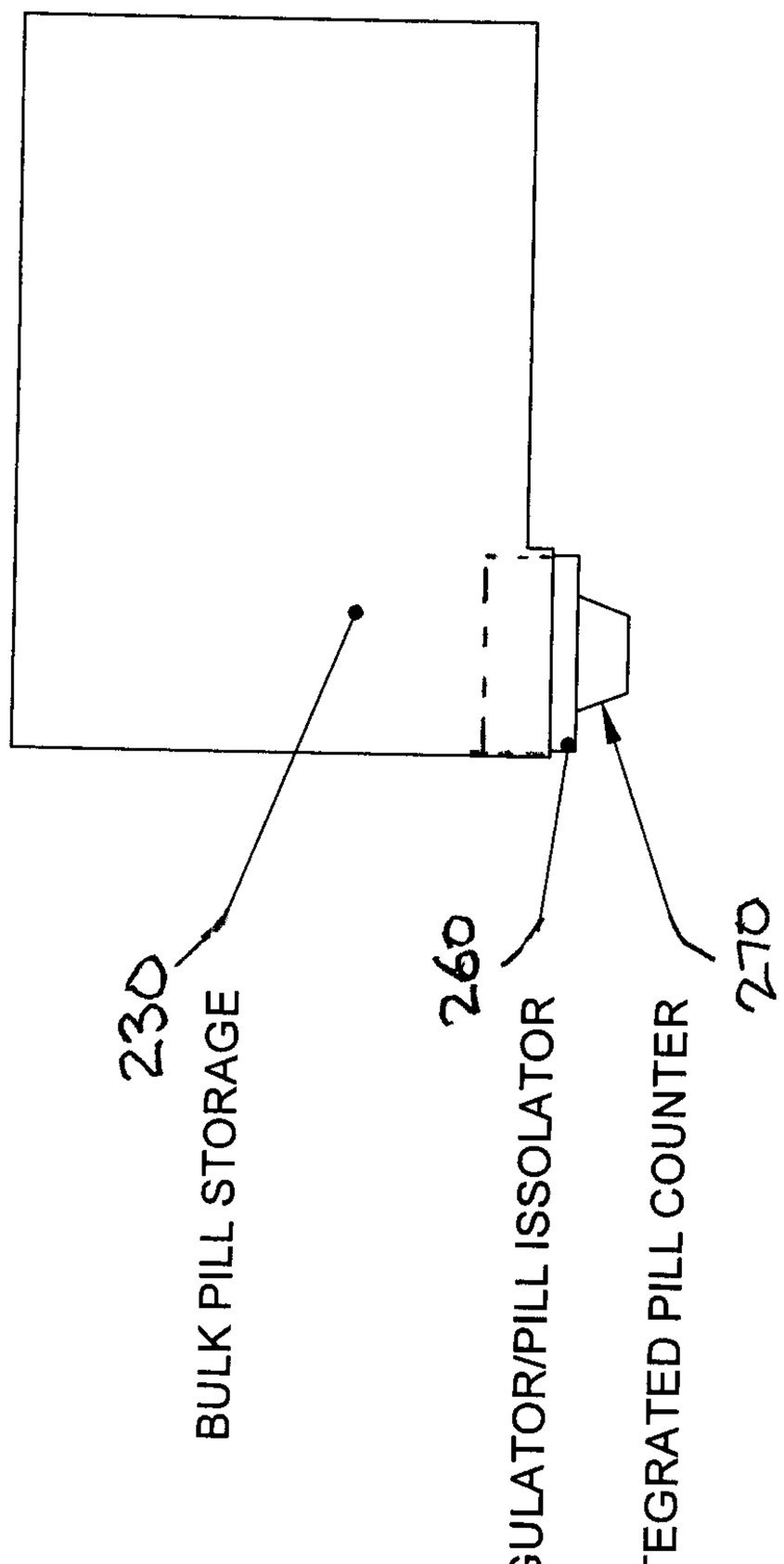

230
BULK PILL STORAGE
260
SINGULATOR/PILL ISSOLATOR
270
INTEGRATED PILL COUNTER

Figure 7

Figure 8A

Figure 8B

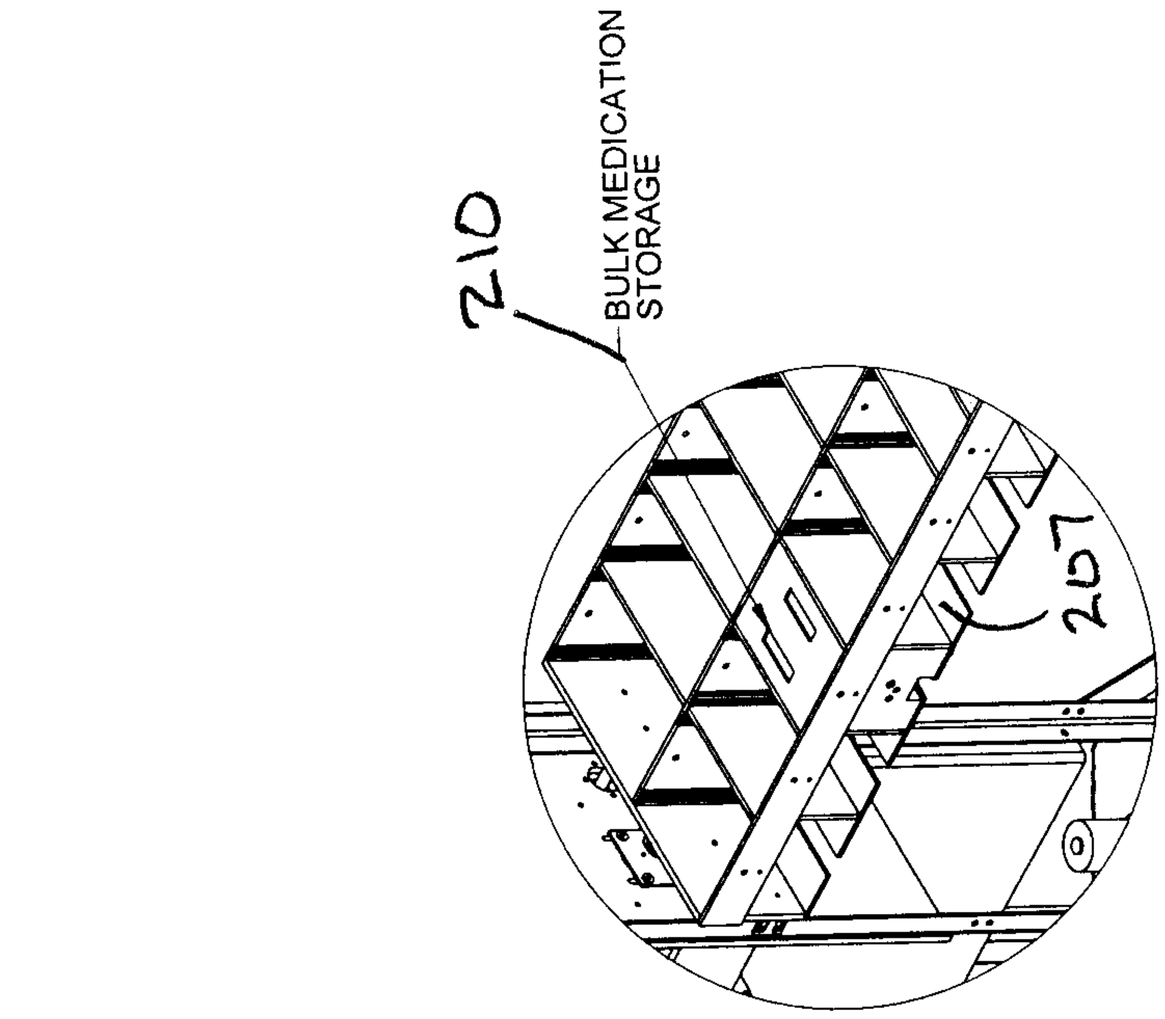


Figure 9B

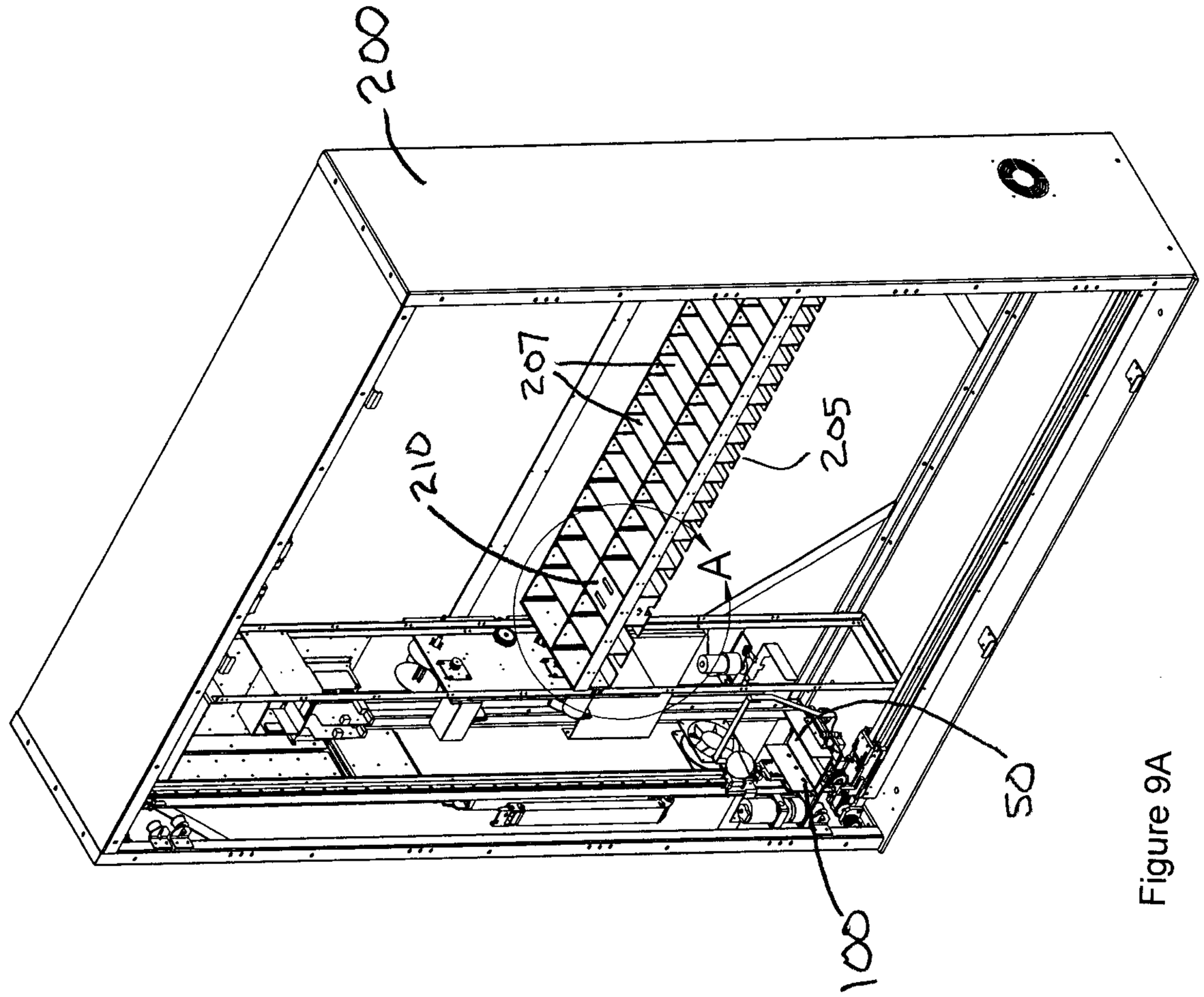
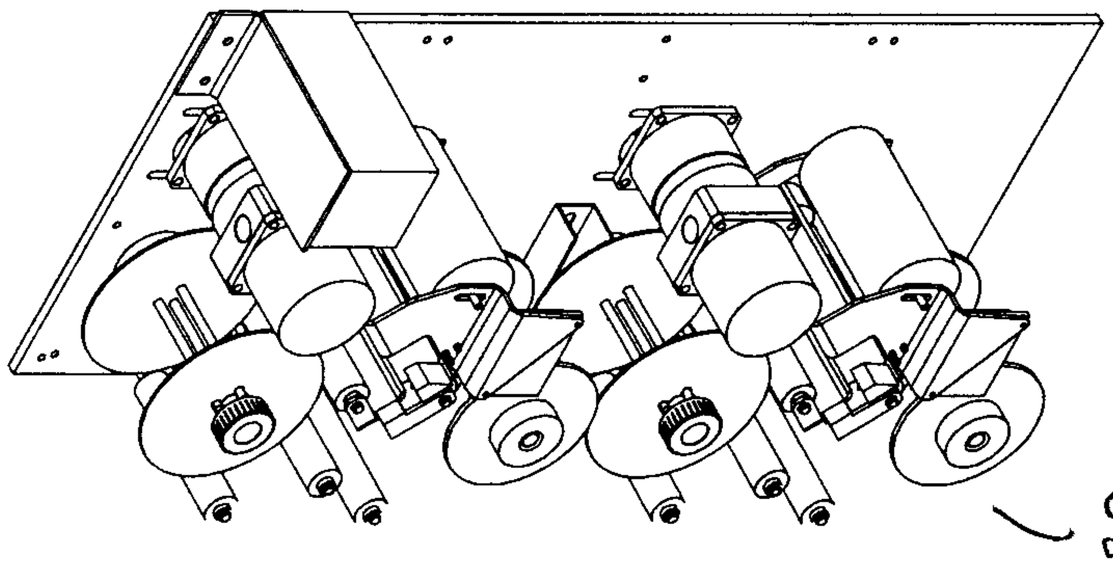


Figure 9A



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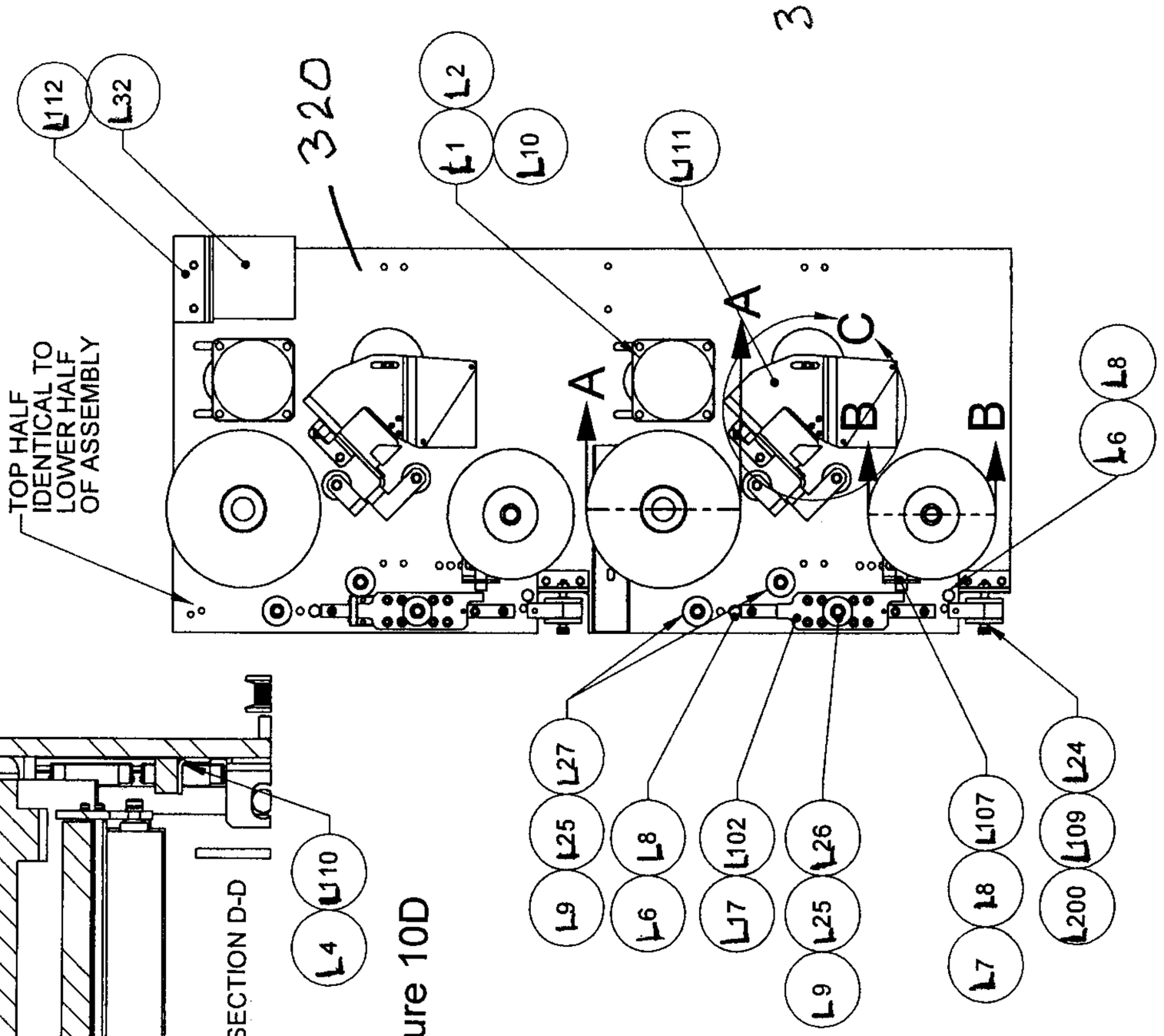
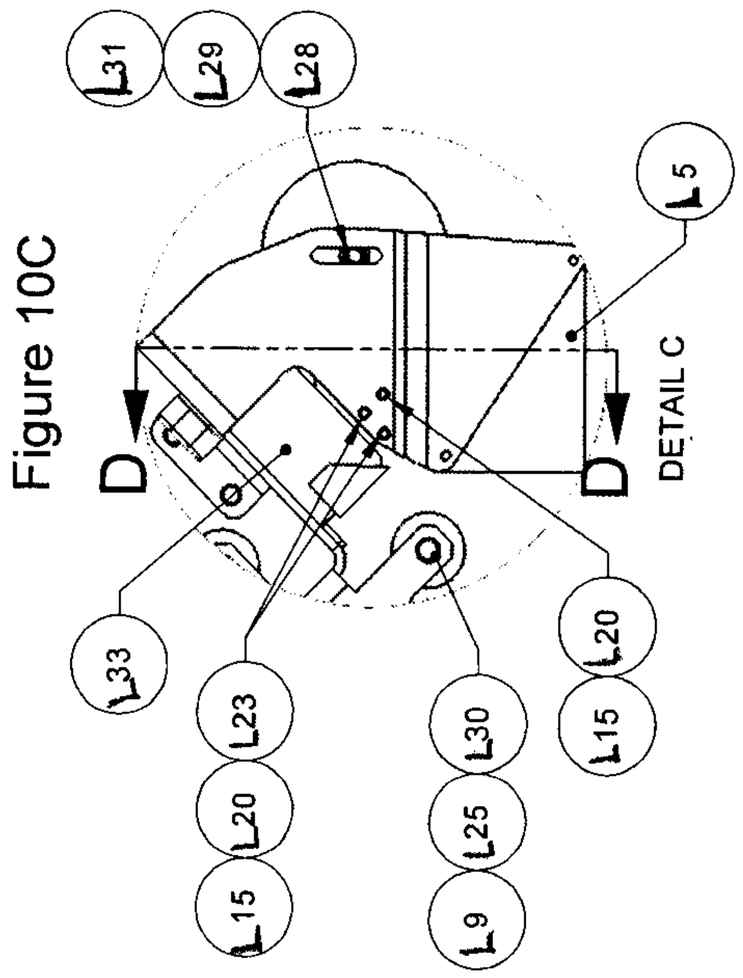


Figure 10A

Figure 10D



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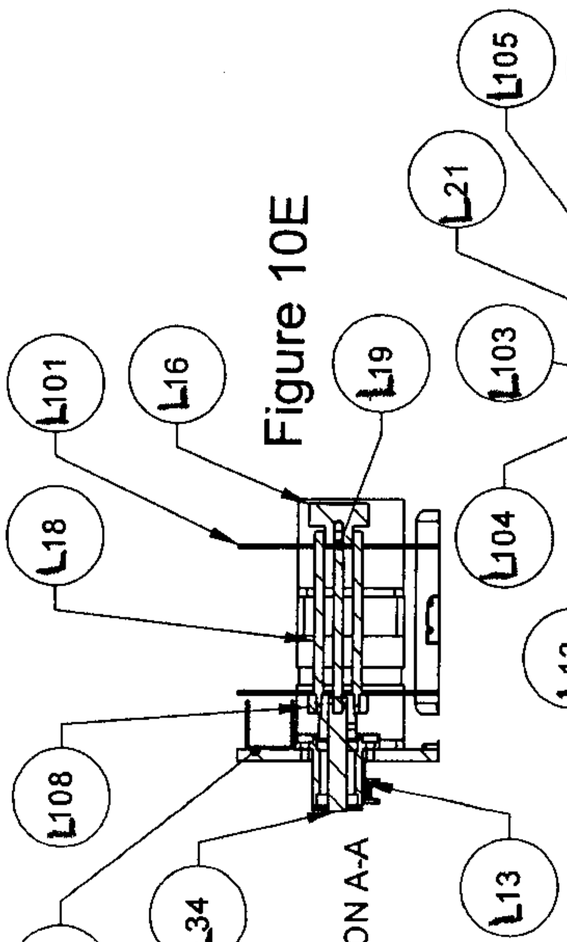

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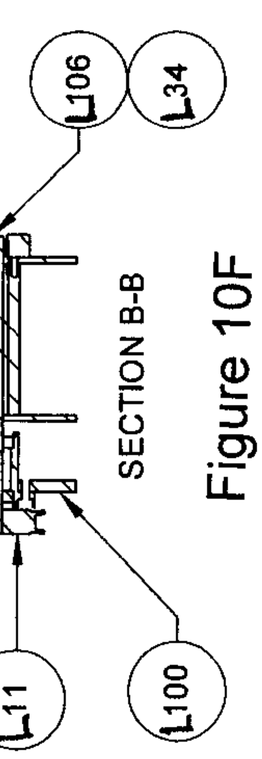

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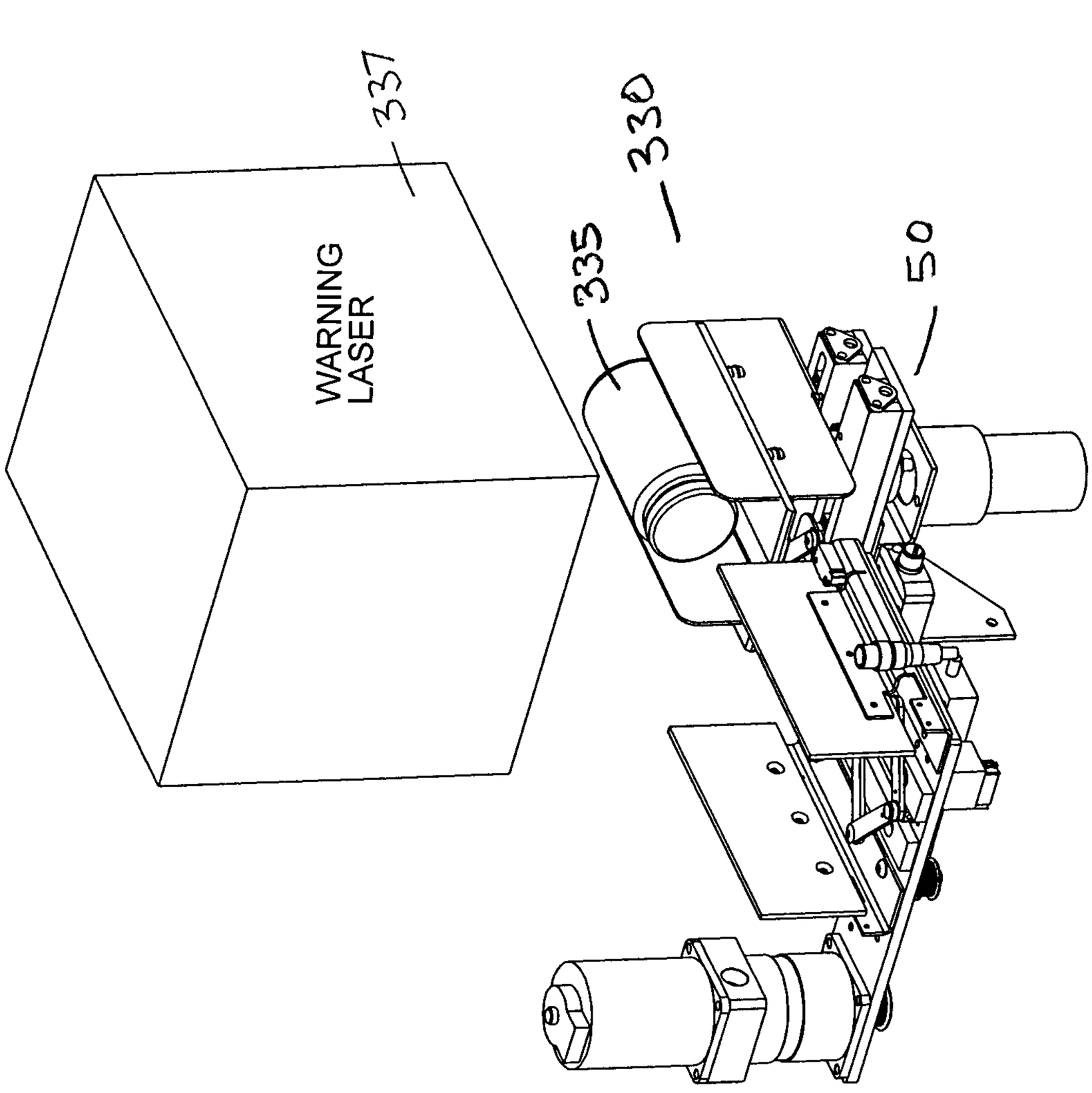

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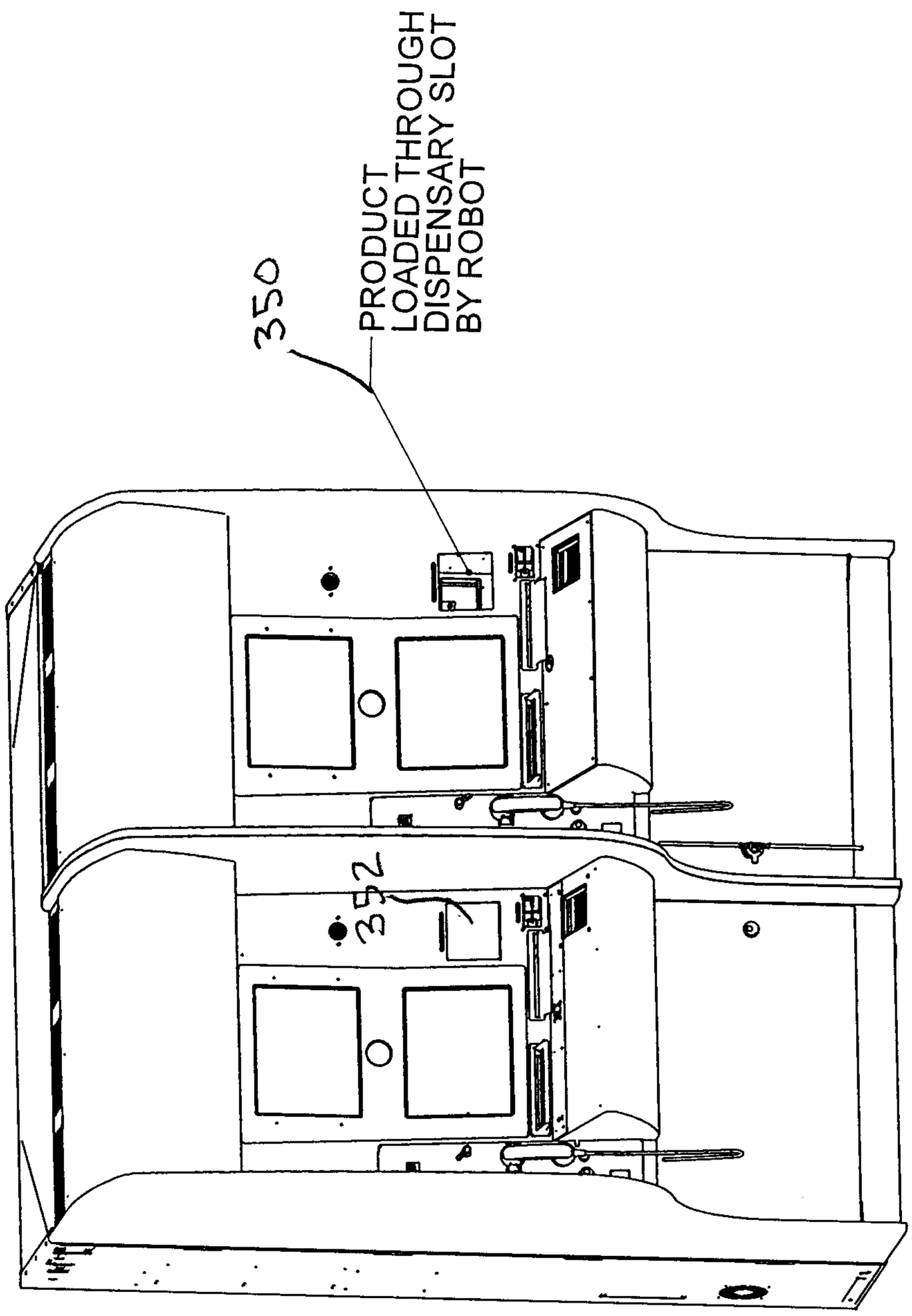

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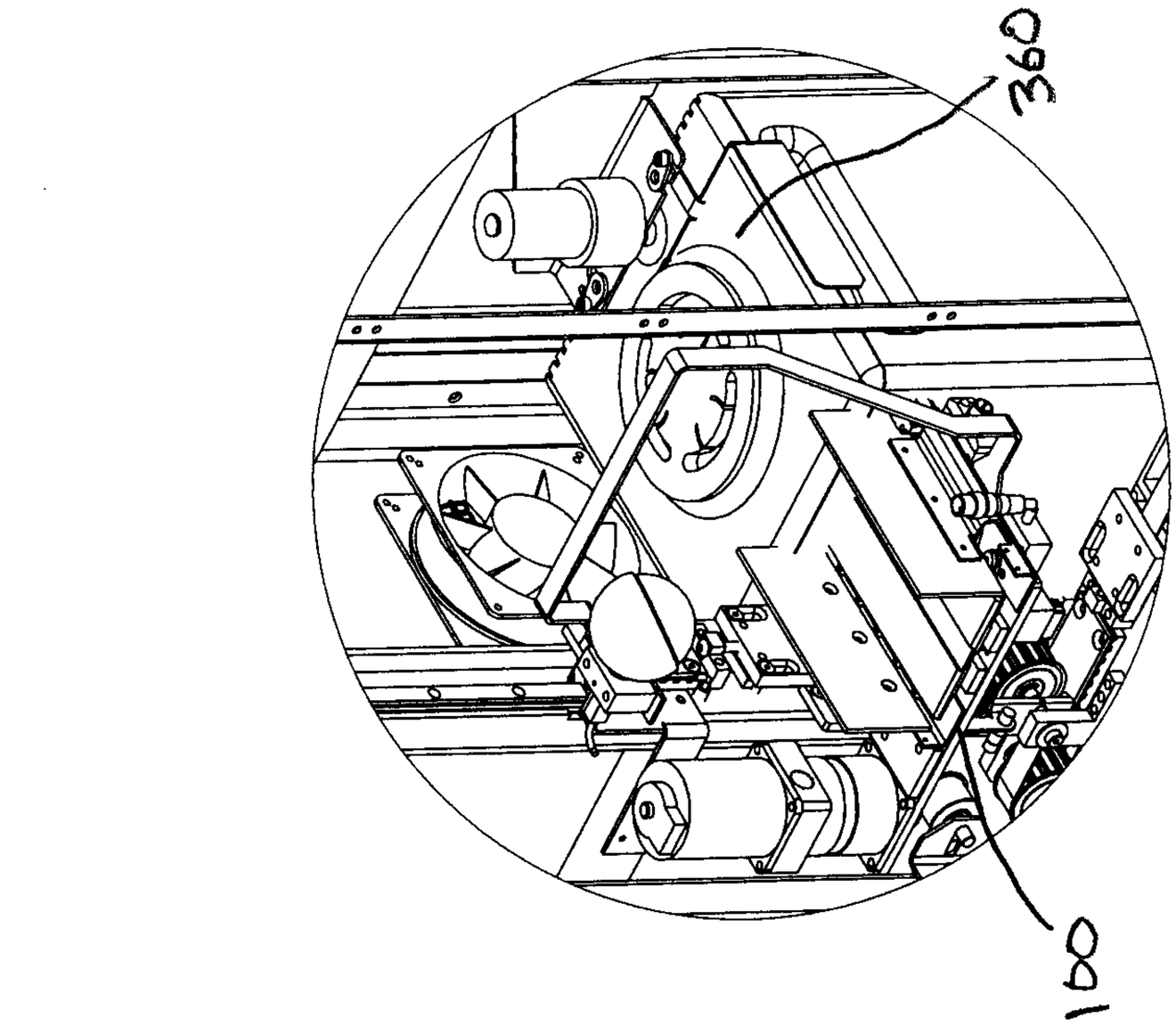

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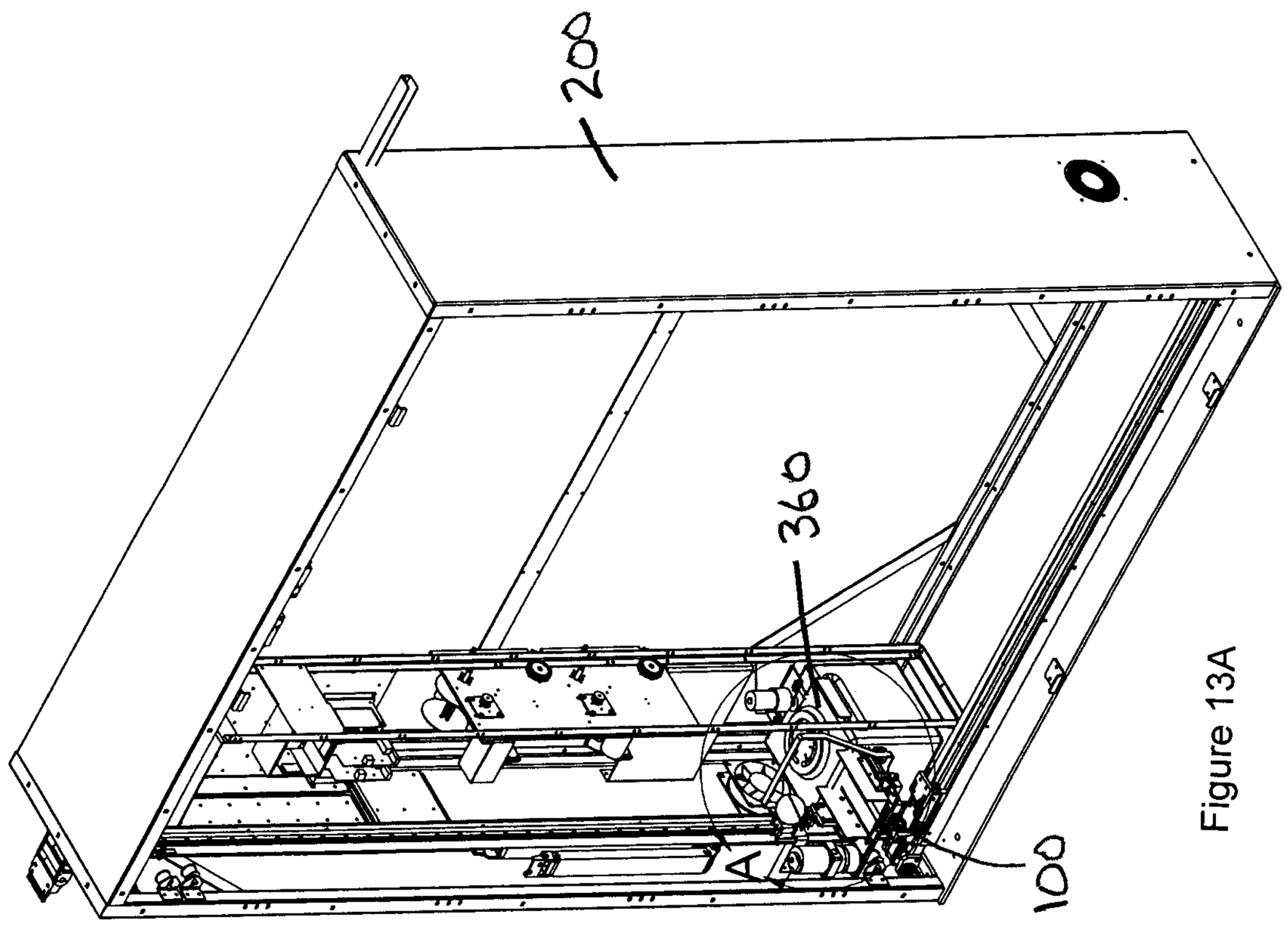

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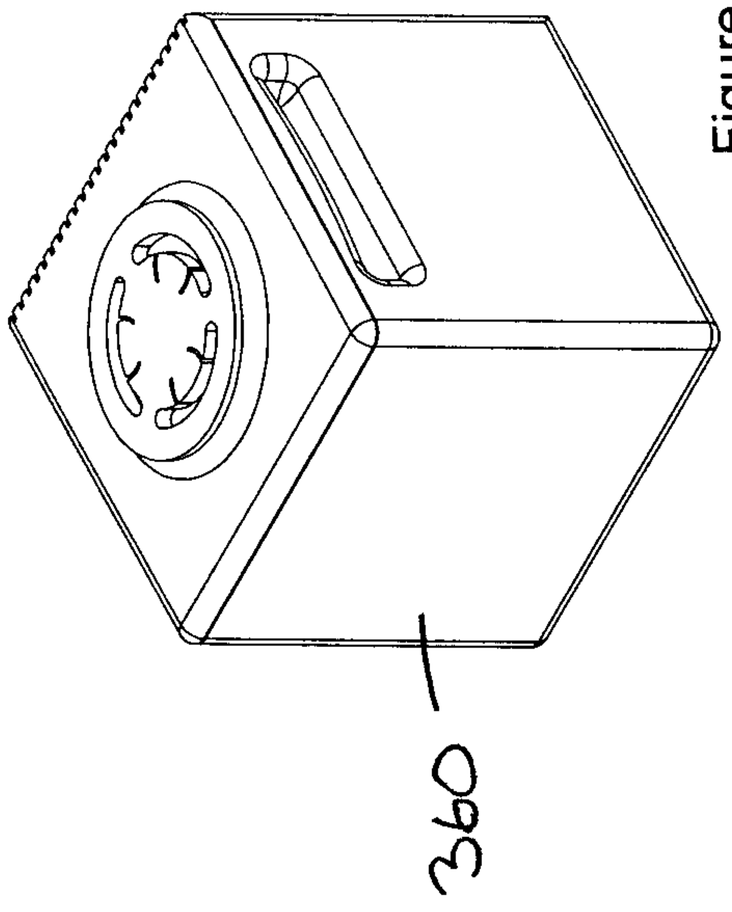

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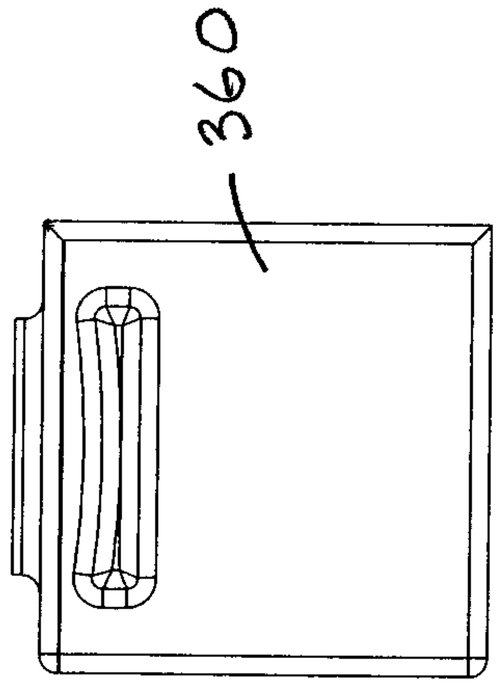

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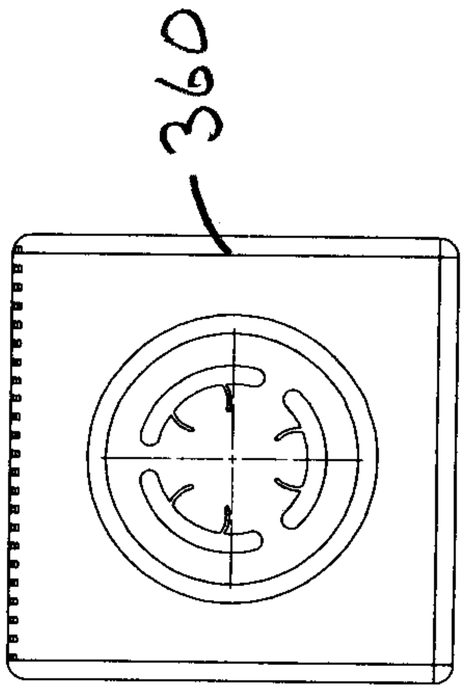

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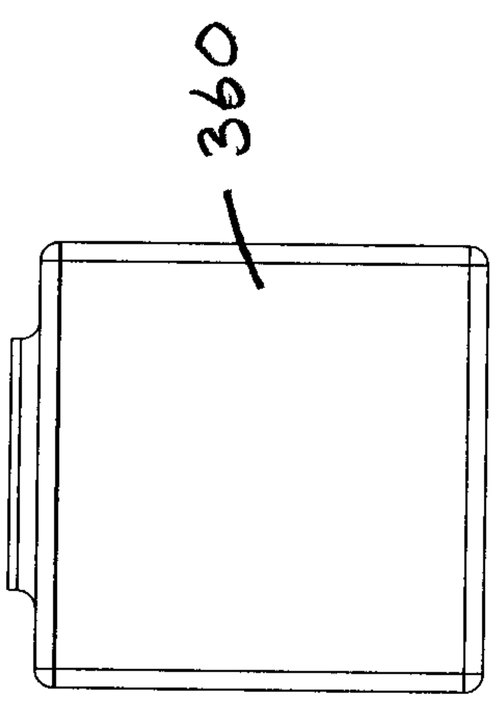
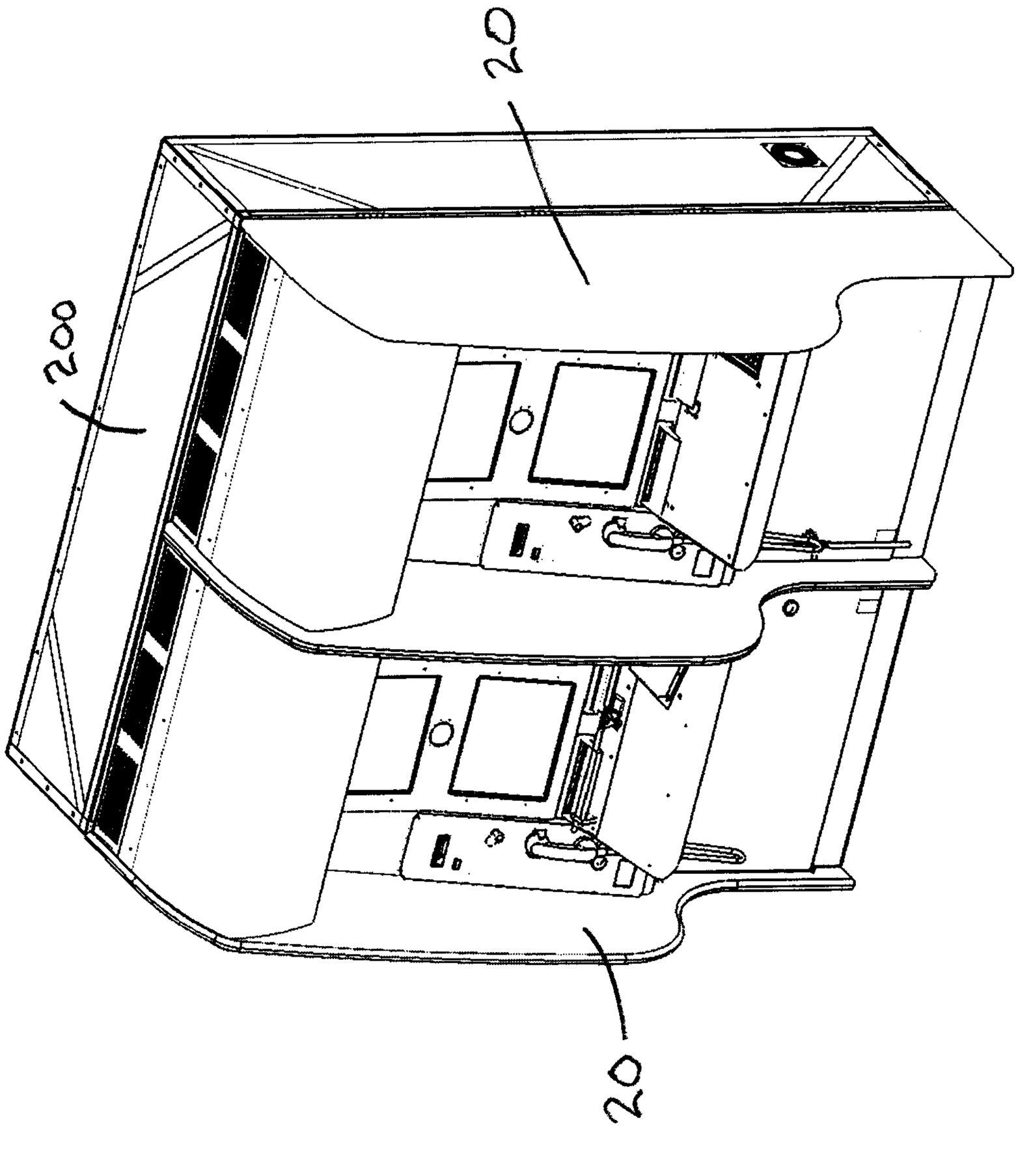


Figure 14C



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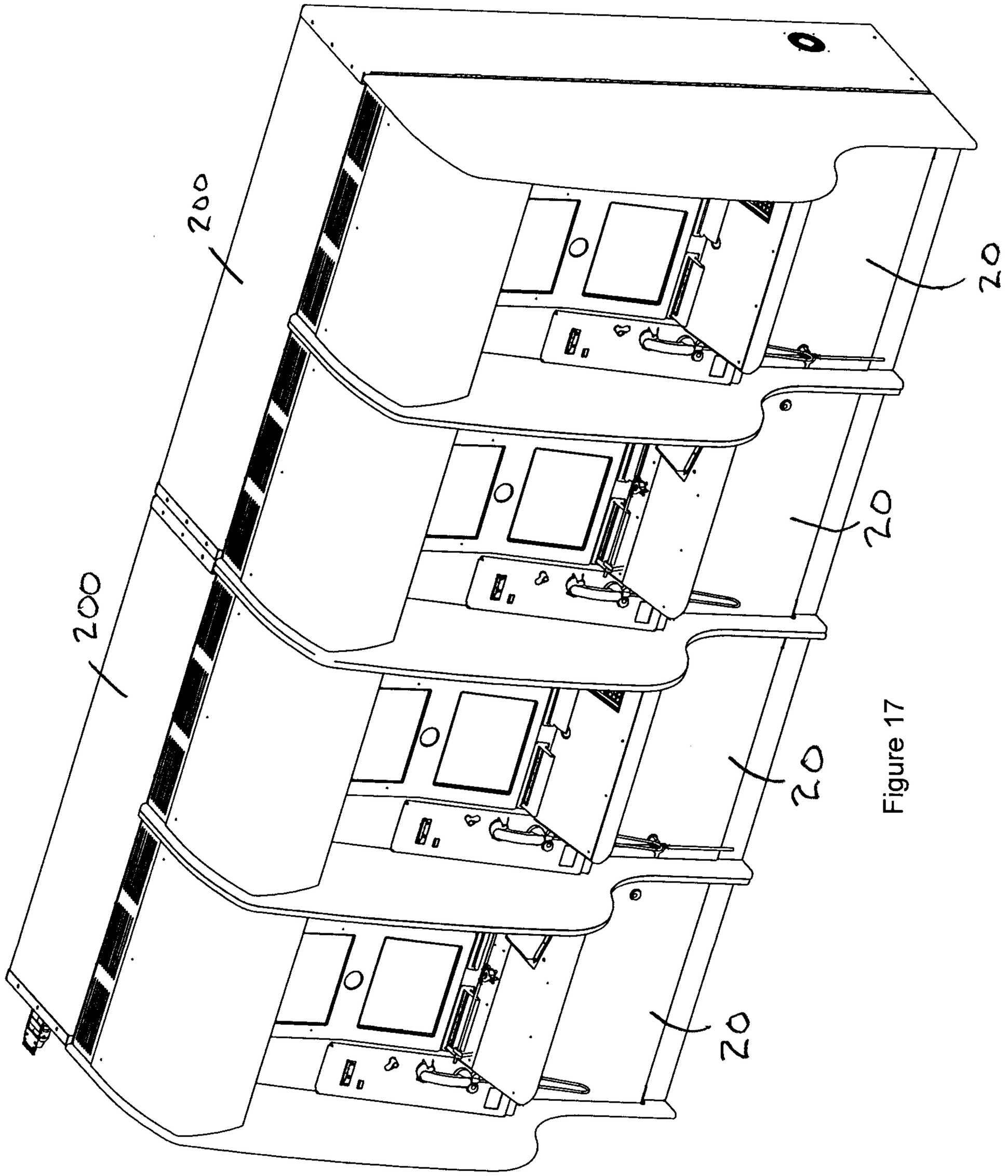

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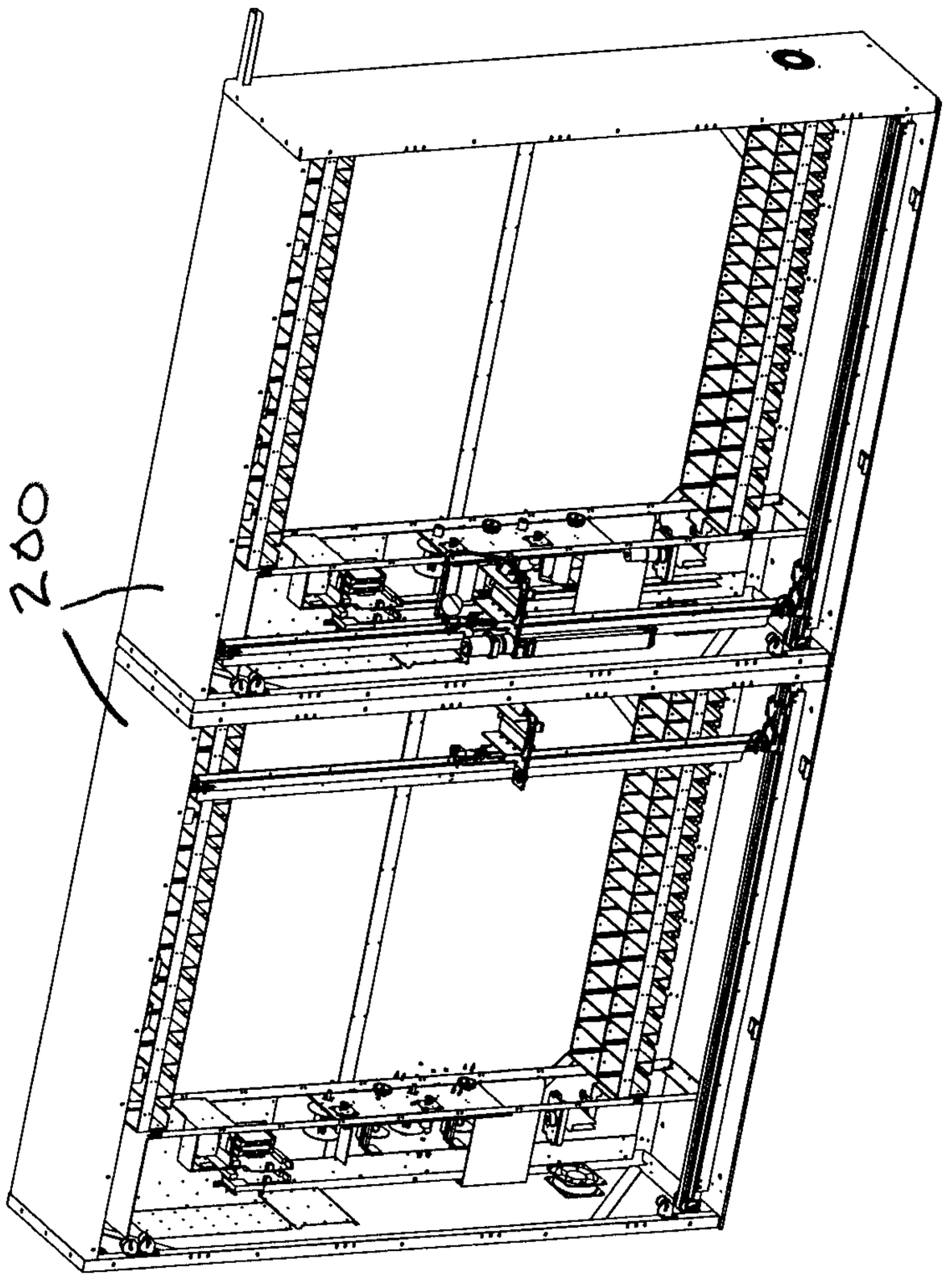

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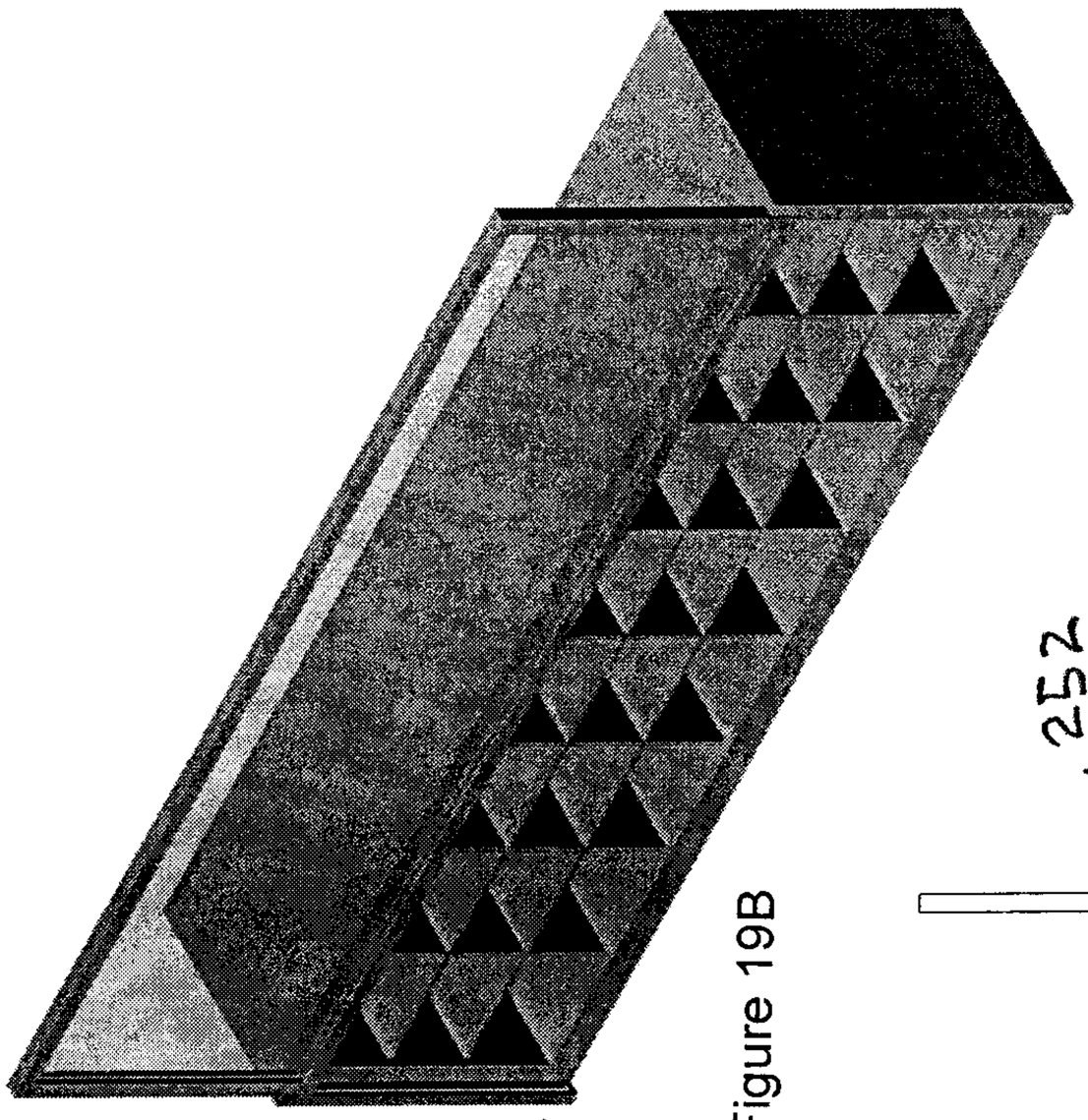
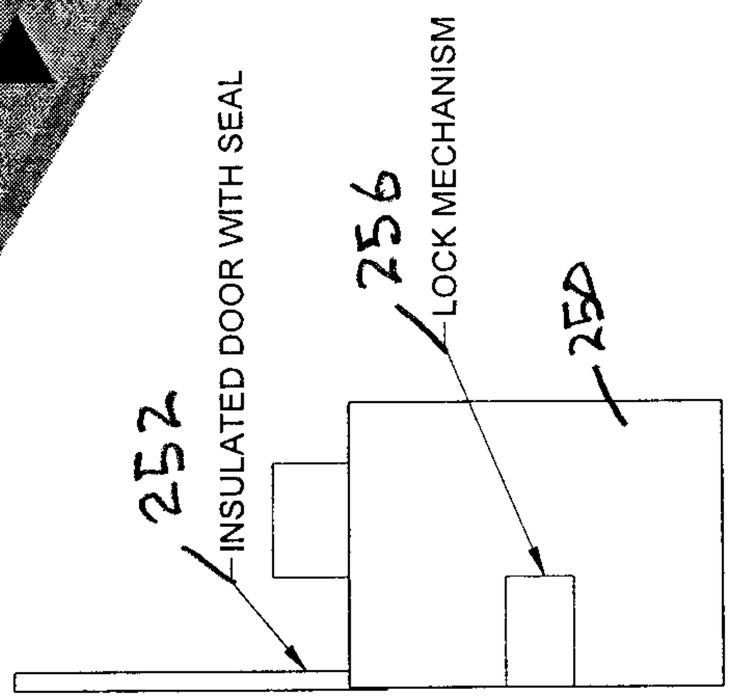


Figure 19B



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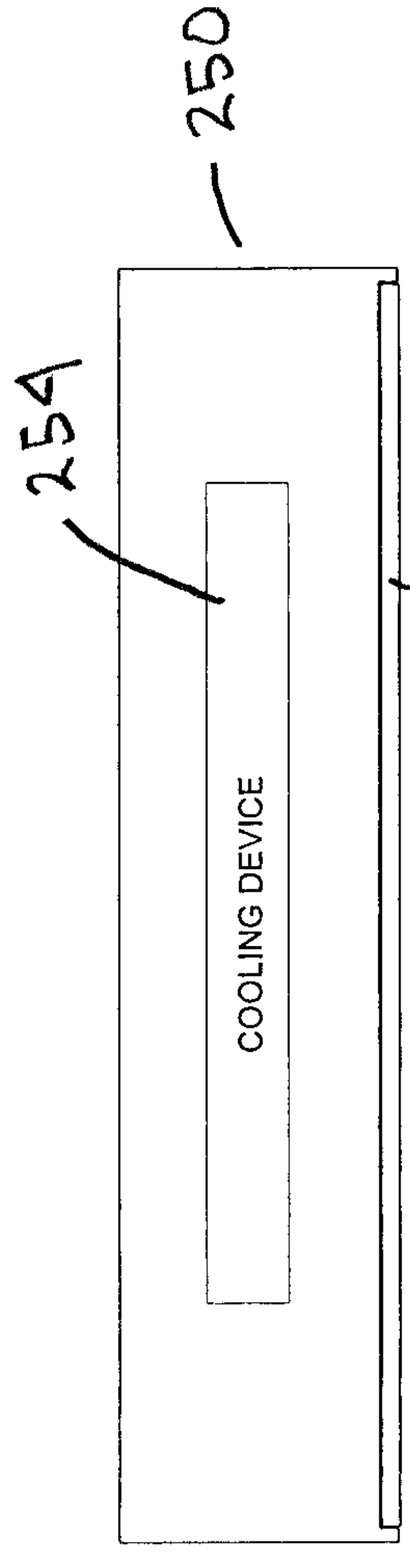

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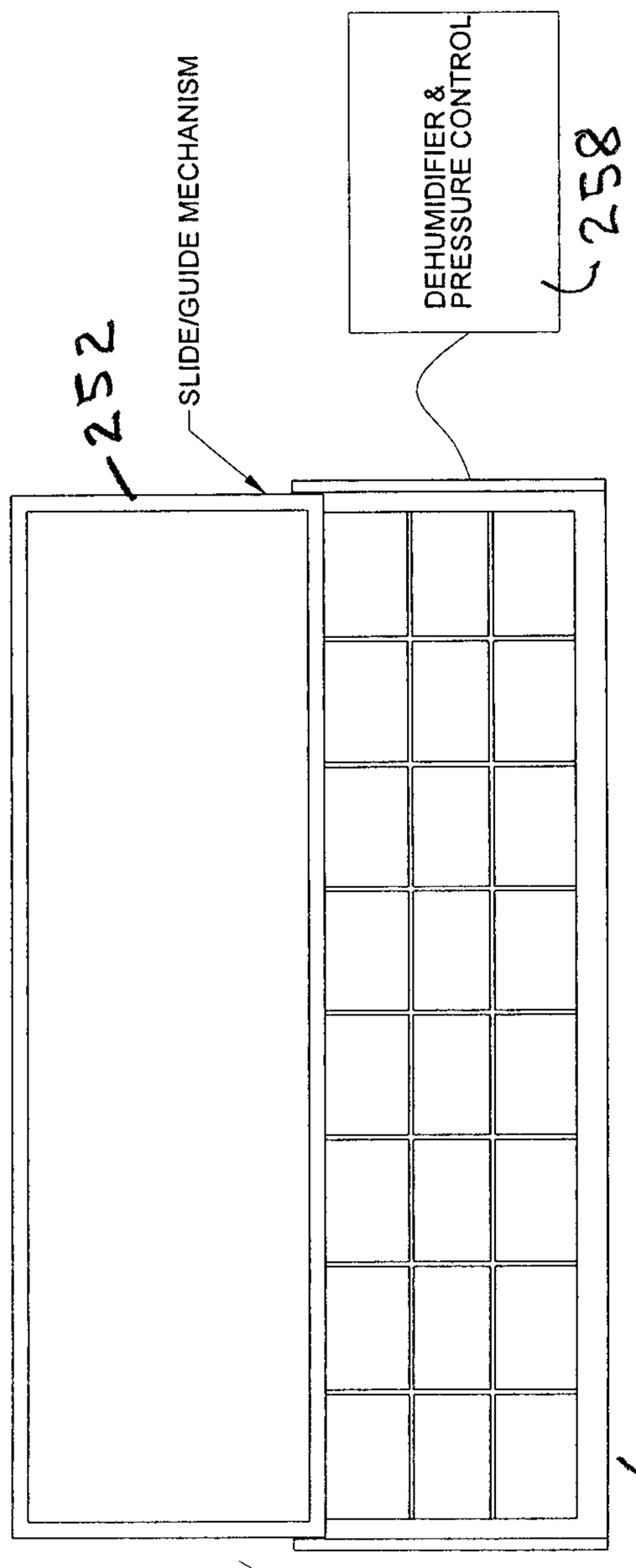

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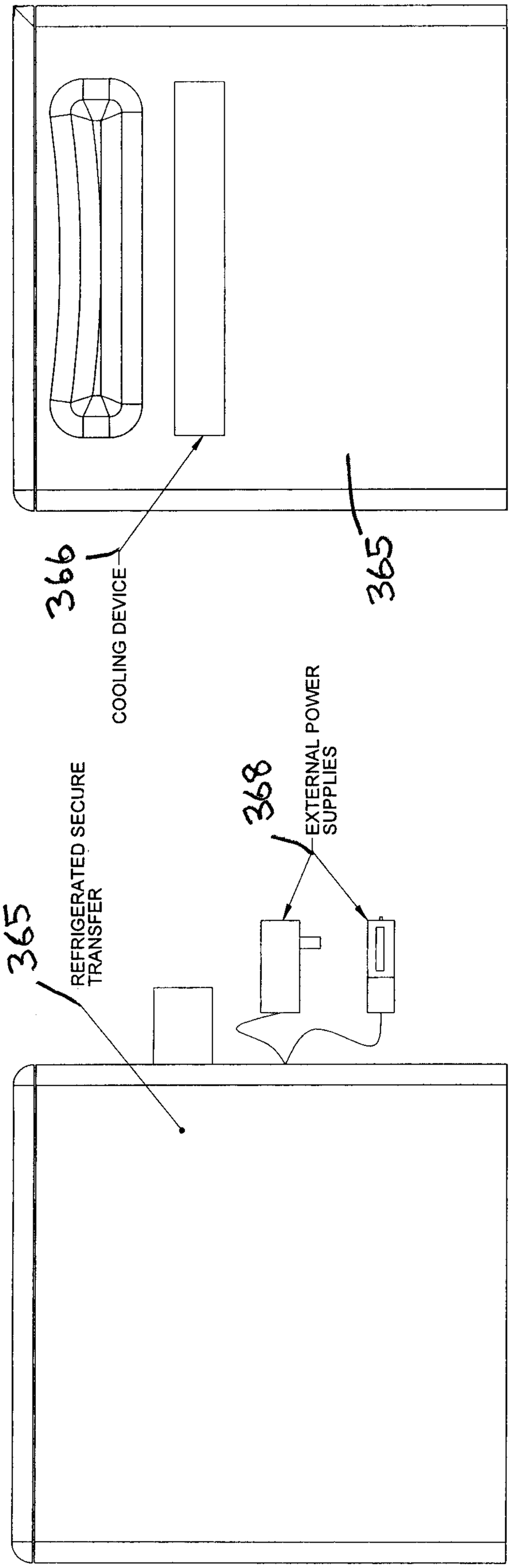
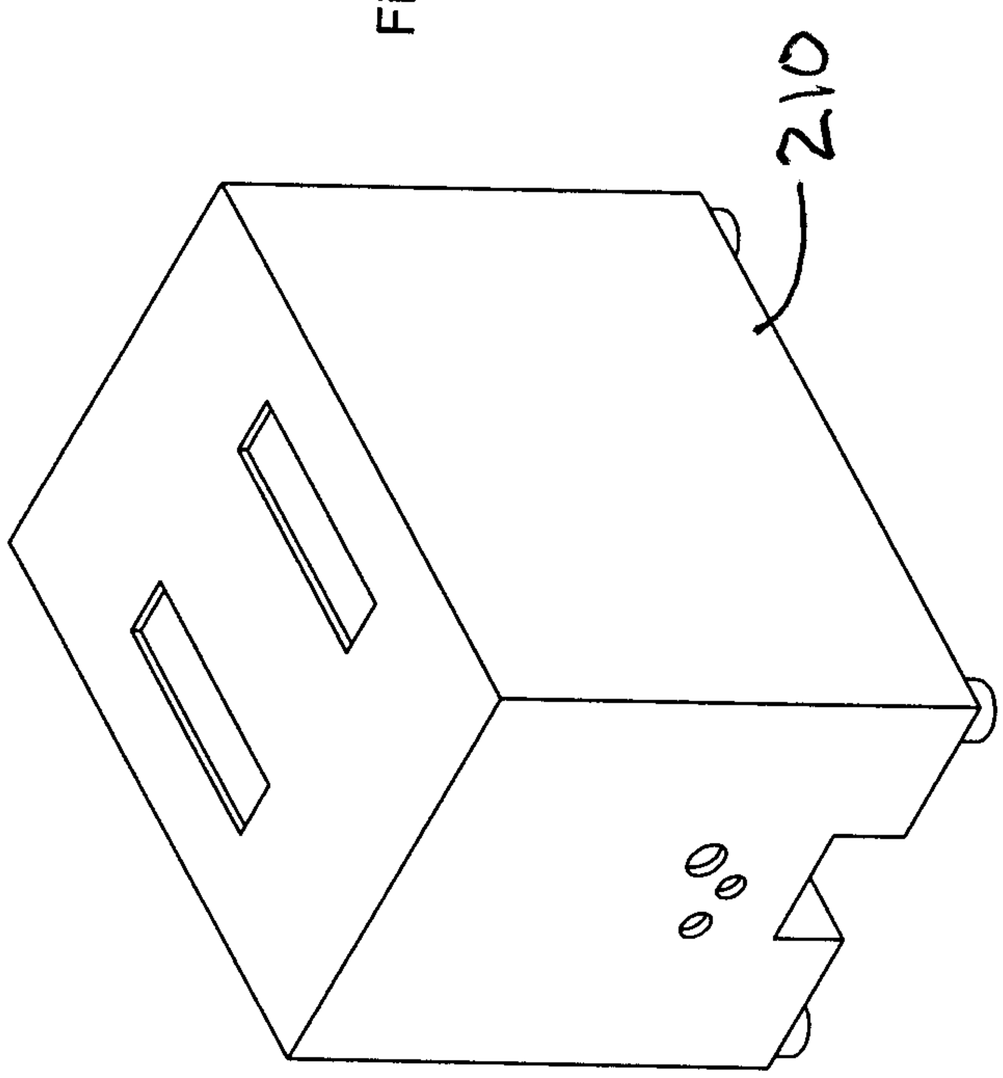


Figure 22B

Figure 22A



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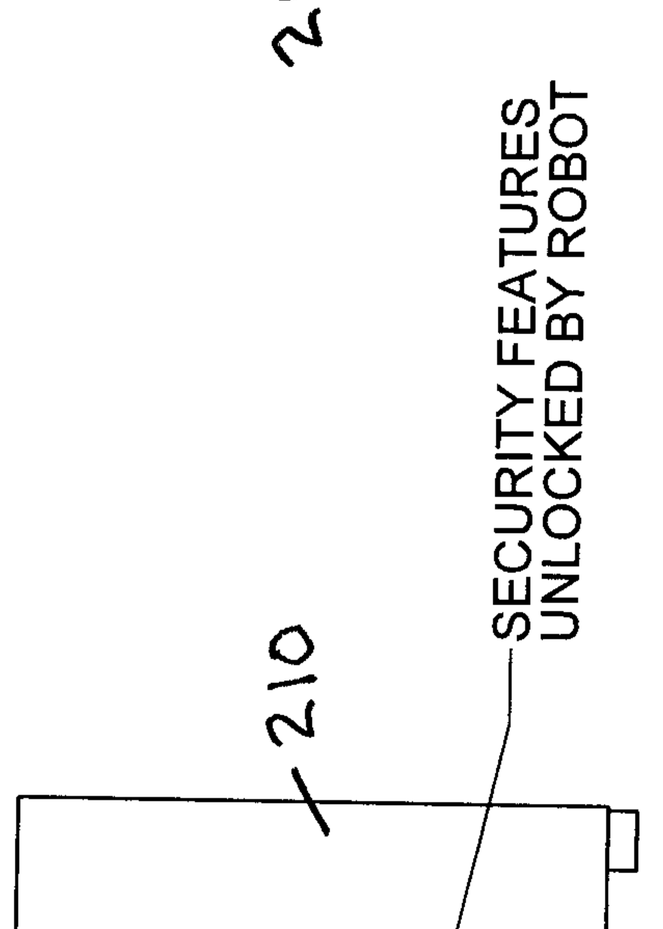

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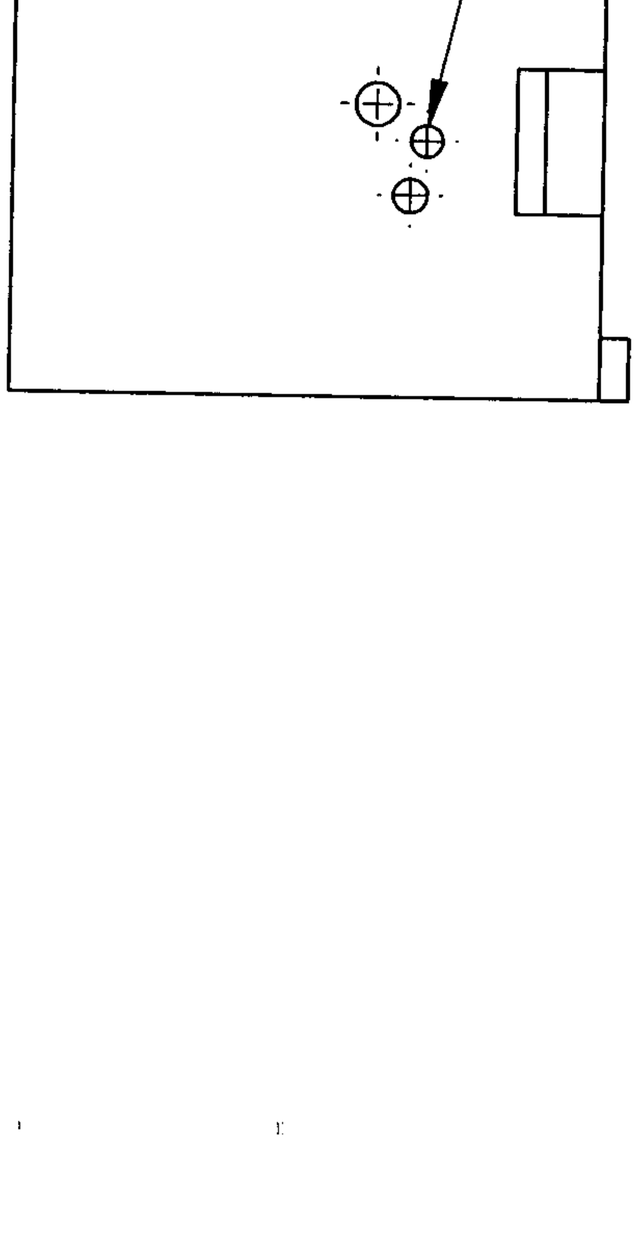

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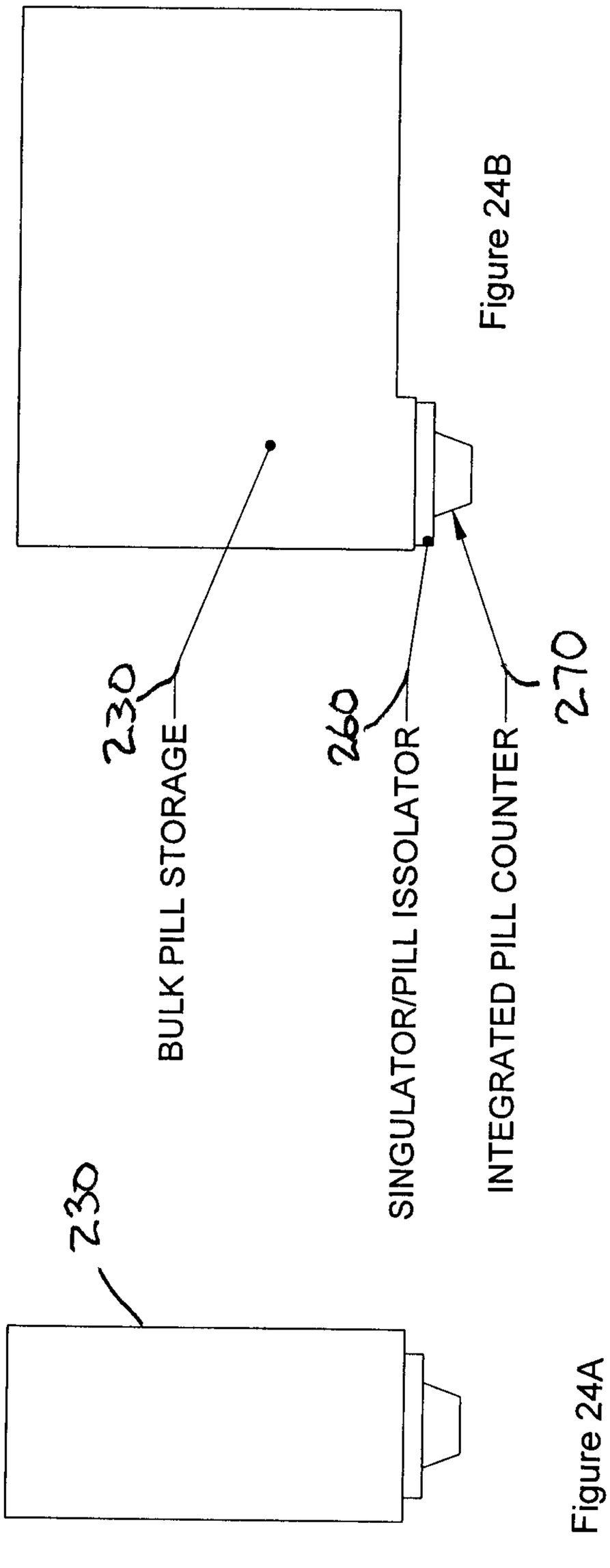
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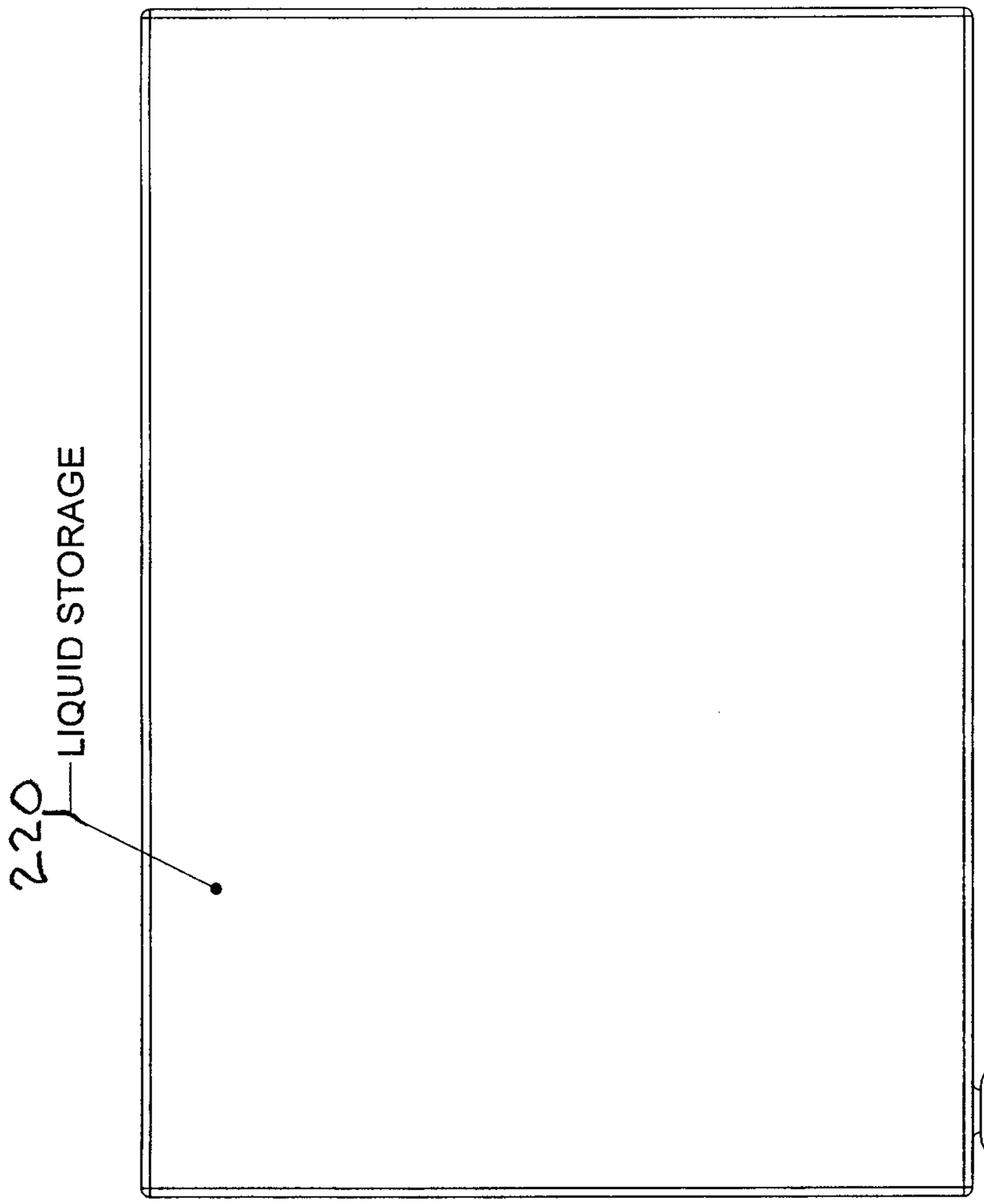
BULK PILL STORAGE
260
SINGULATOR/PILL ISSOLATOR
270
INTEGRATED PILL COUNTER
230

Figure 24A



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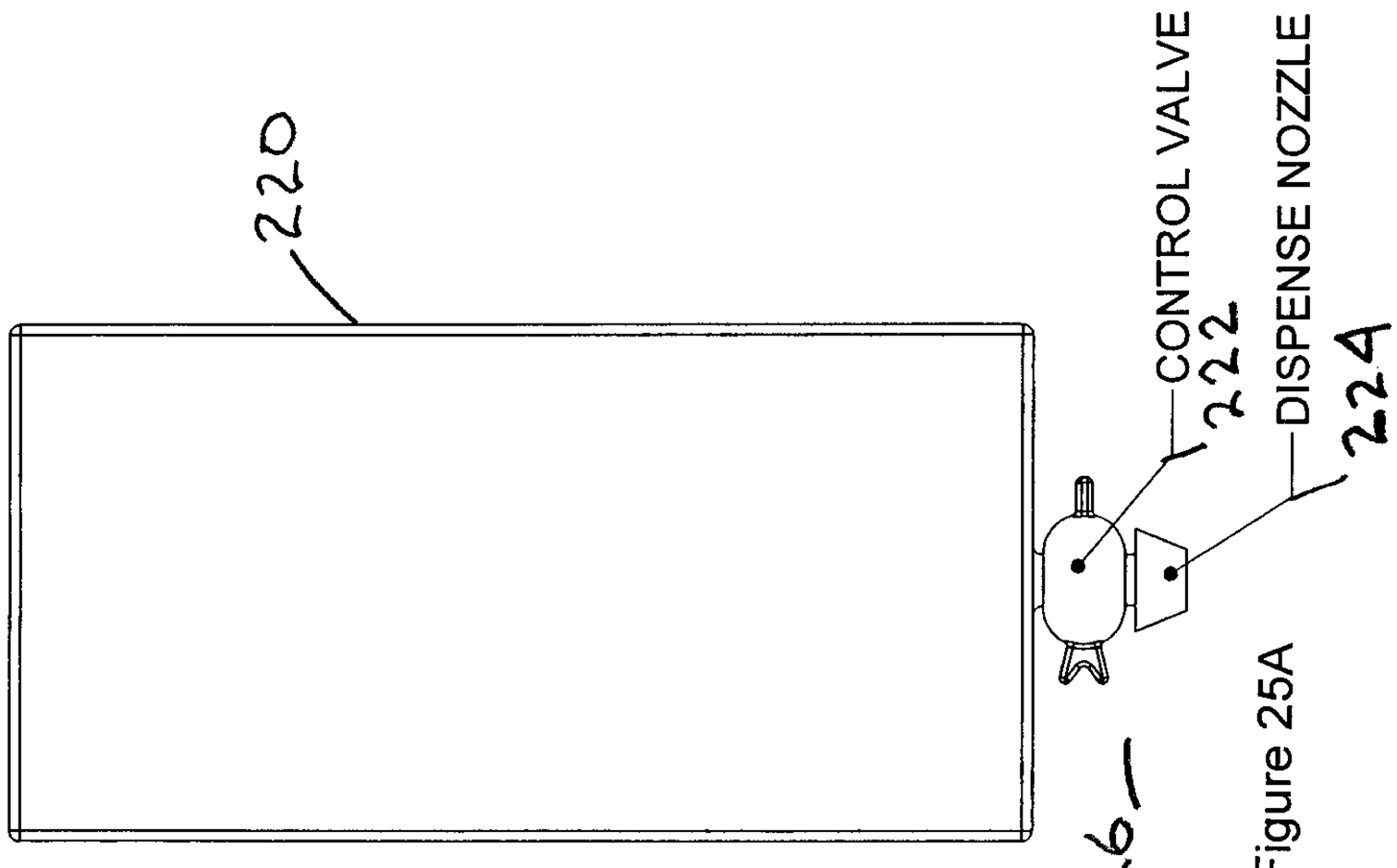

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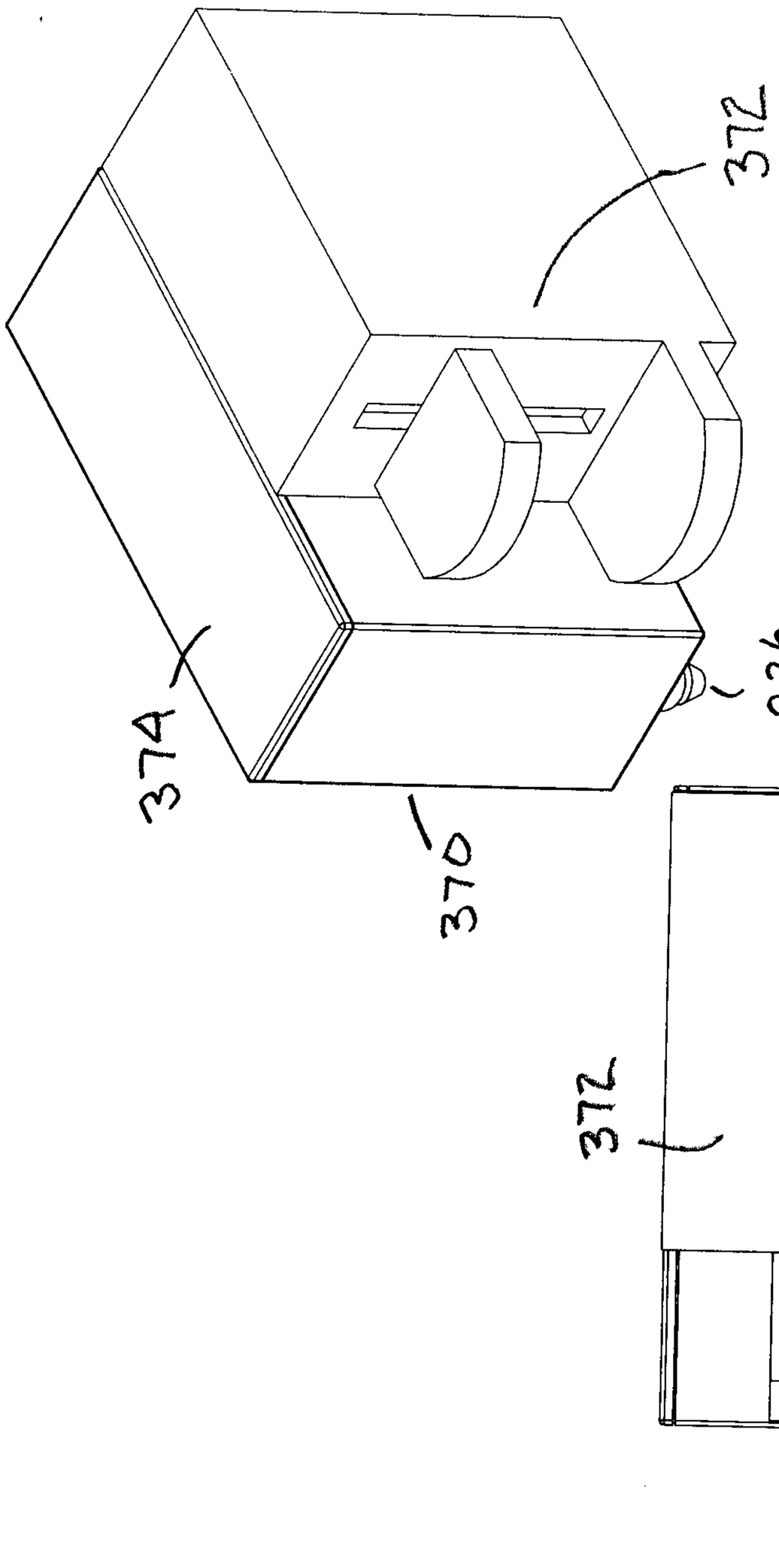
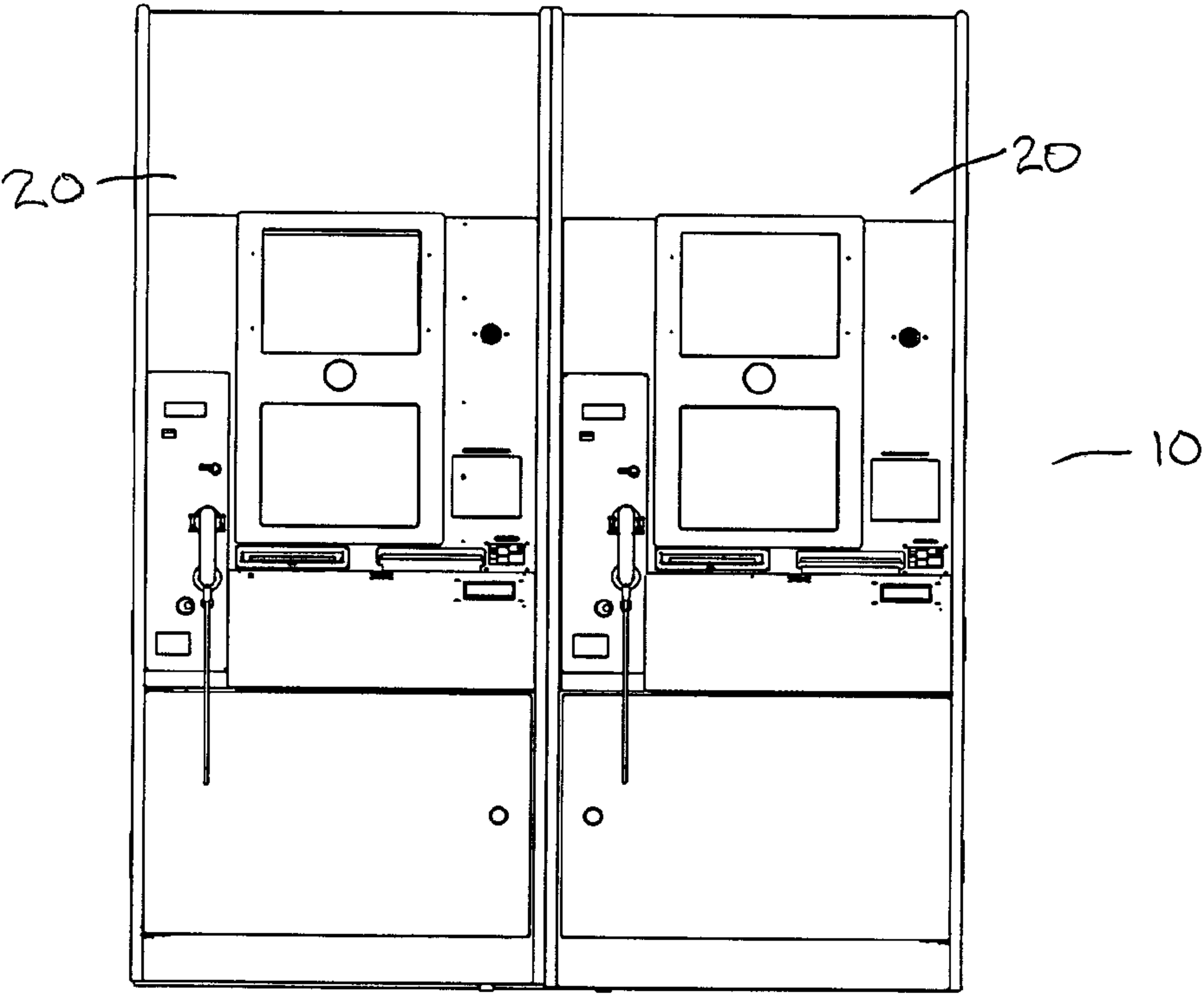


Figure 26C

Figure 26B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