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Chirnomas(10) **Pub. No.: US 2006/0186133 A1**(43) **Pub. Date: Aug. 24, 2006**(54) **METHOD AND APPARATUS FOR
POSITIONING AN ARTICLE HANDLING
DEVICE****Publication Classification**(51) **Int. Cl.**
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B65G 59/04 (2006.01)(52) **U.S. Cl.** **221/123; 221/211**(76) Inventor: **Munroe Chirnomas**, Morris Township,
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MORRIS PLAINS, NJ 07950 (US)**(21) Appl. No.: **11/413,264**(22) Filed: **Apr. 29, 2006****Related U.S. Application Data**(60) Division of application No. 10/205,770, filed on Jul.
25, 2002, which is a continuation of application No.
PCT/US01/16894, filed on May 23, 2001.(60) Provisional application No. 60/206,363, filed on May
23, 2000.

An article dispensing device of the type having a housing for defining an internal volume. The internal volume having a dimension along a first axis which has at one end of the dimension an article storage sub-volume, and at an opposing end of the dimension adjacent a dispensing end of the article storage sub-volume, an article dispensing sub-volume. An article storage structure is positioned in the article storage sub-volume and stores therein articles in columns along a plurality of longitudinal axes paraxially aligned with the first axis. An article dispensing mechanism includes a head adapted to engage and secure to an article stored in the article storage structure. The dispensing mechanism includes a substantially non-compressible tube connecting the head to a source of article securing energy. A feeder displaces the tube so as to move the head along the first axis (Z) and a first positioning device moving the feeder along a second axis different from the first axis. All the while, the article storage sub-volume utilizes 75 percent or more of said internal dimension along the first axis of the cabinet.

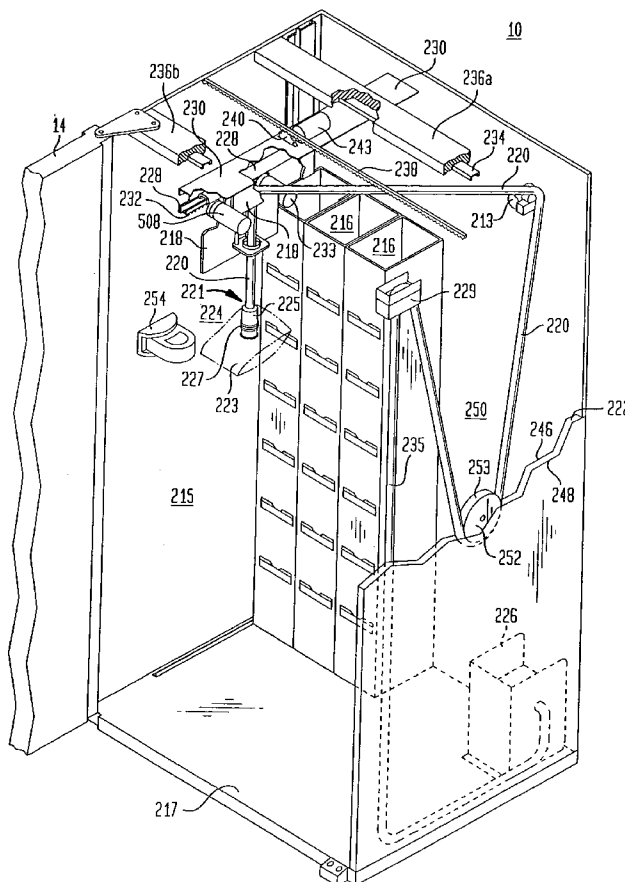


FIG. 1

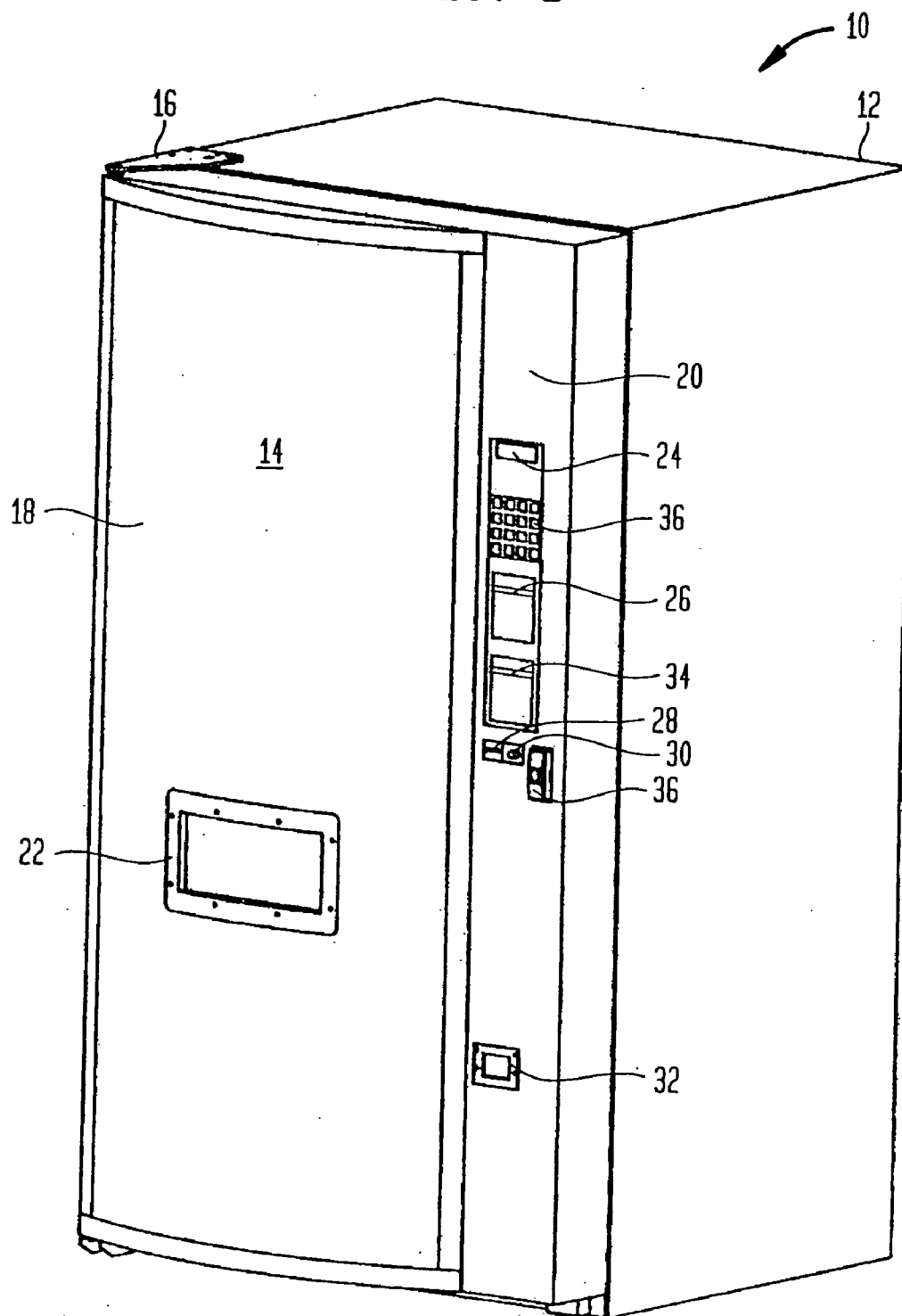


FIG. 2

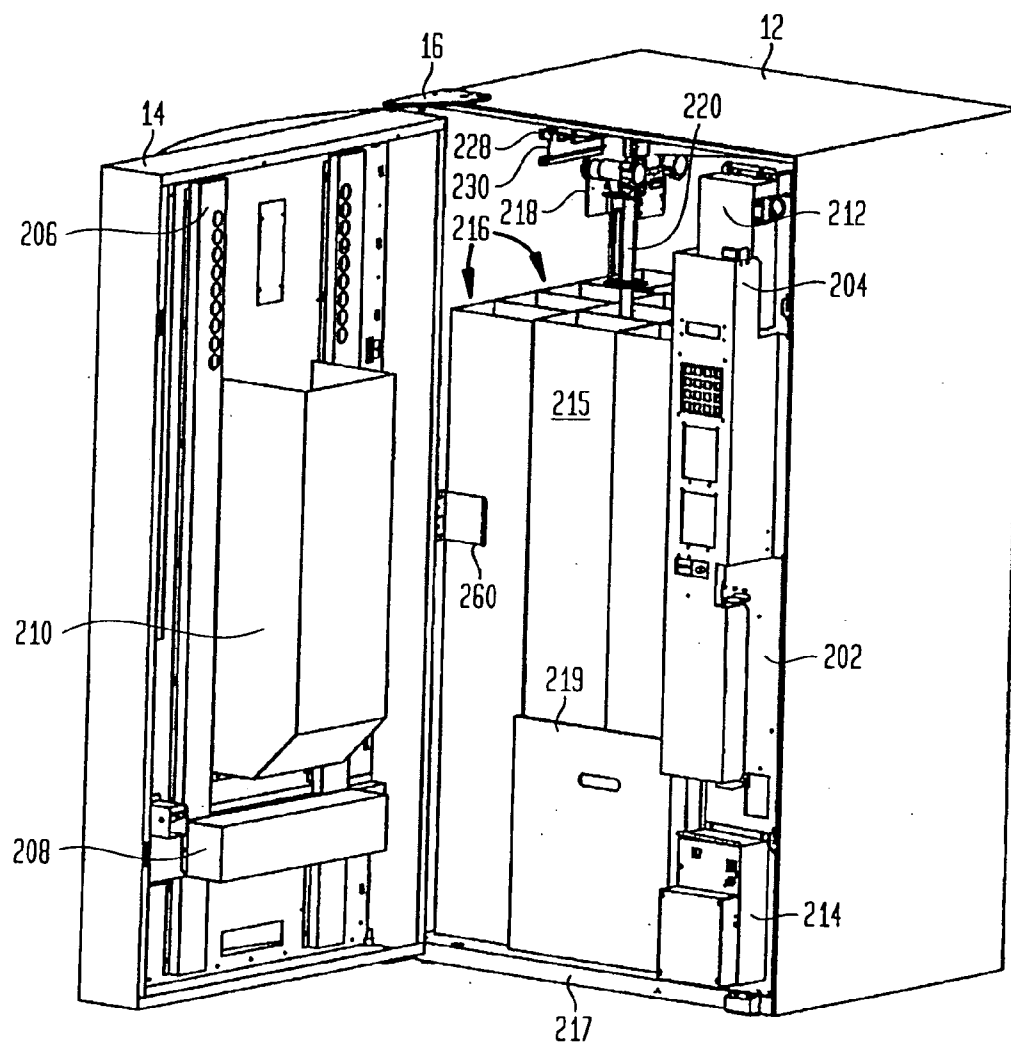


FIG. 3

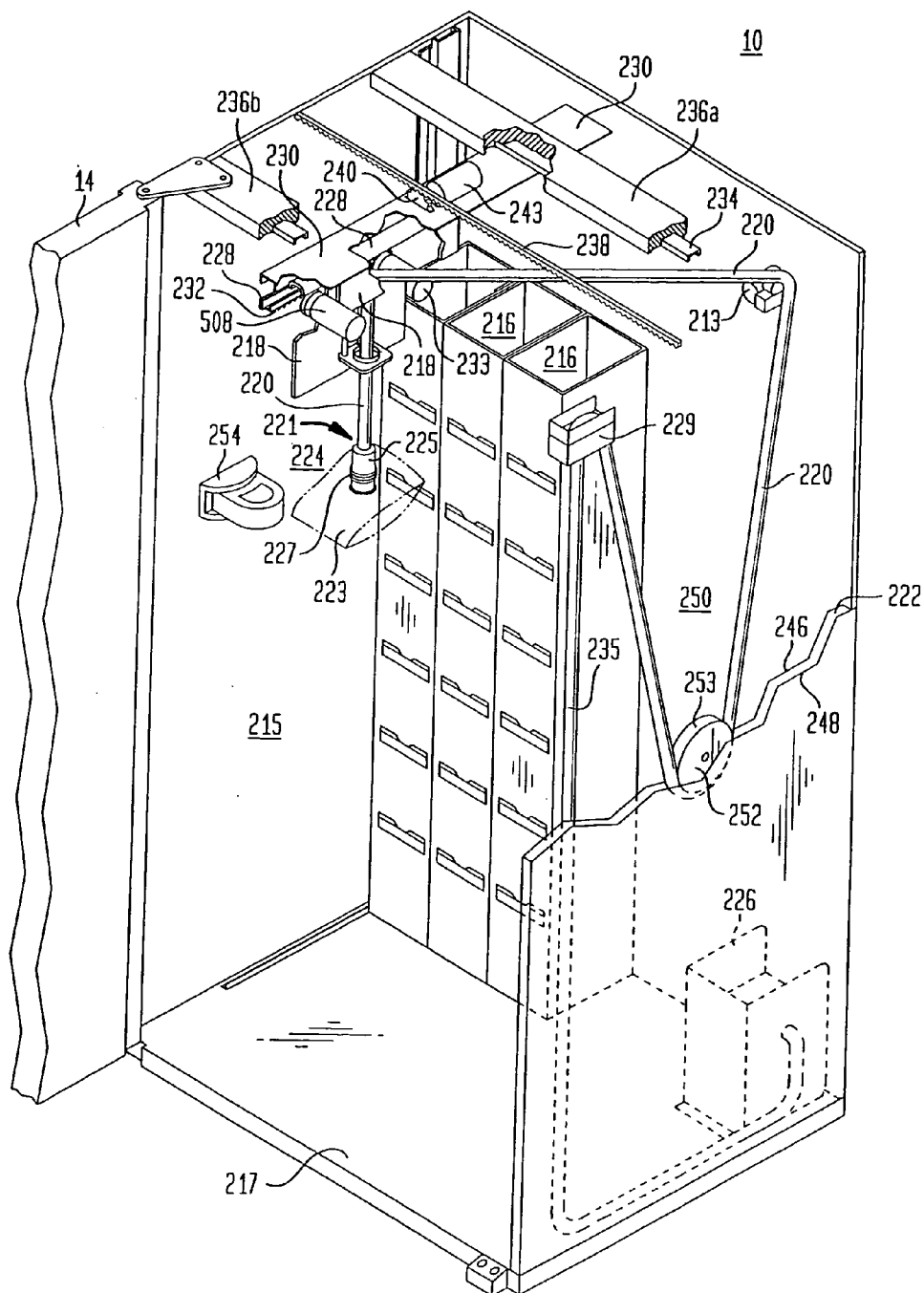


FIG. 4

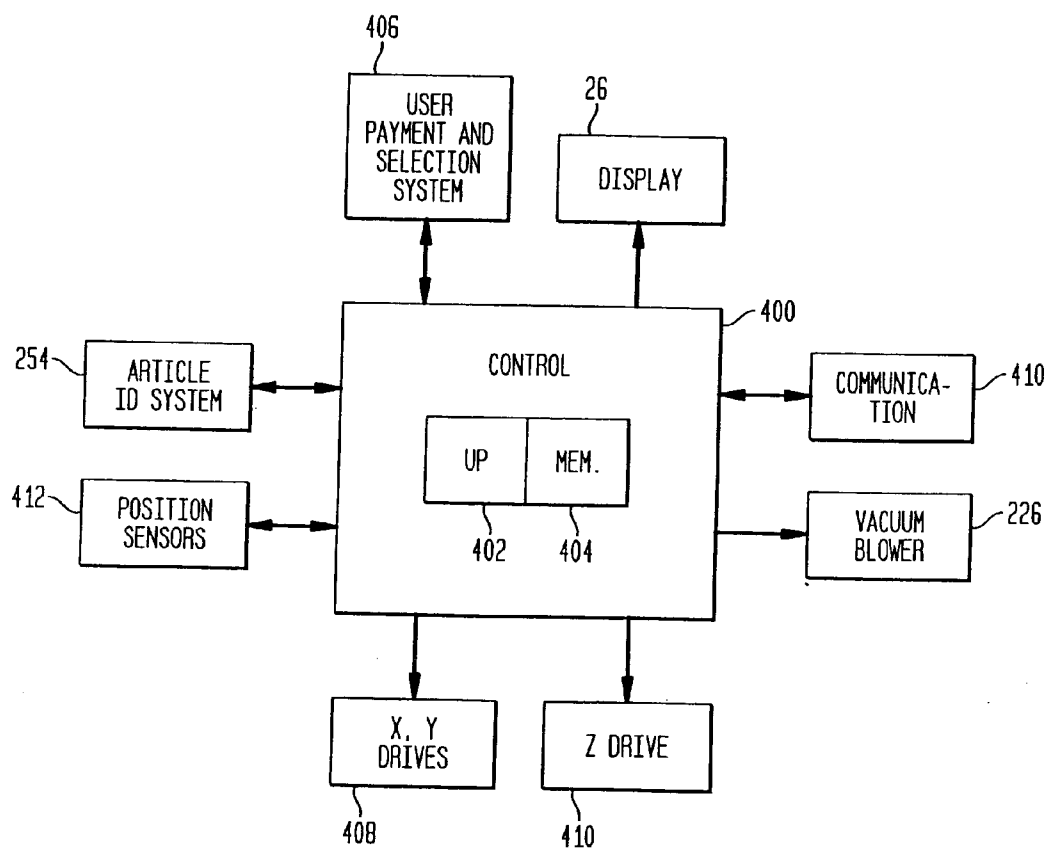


FIG. 5

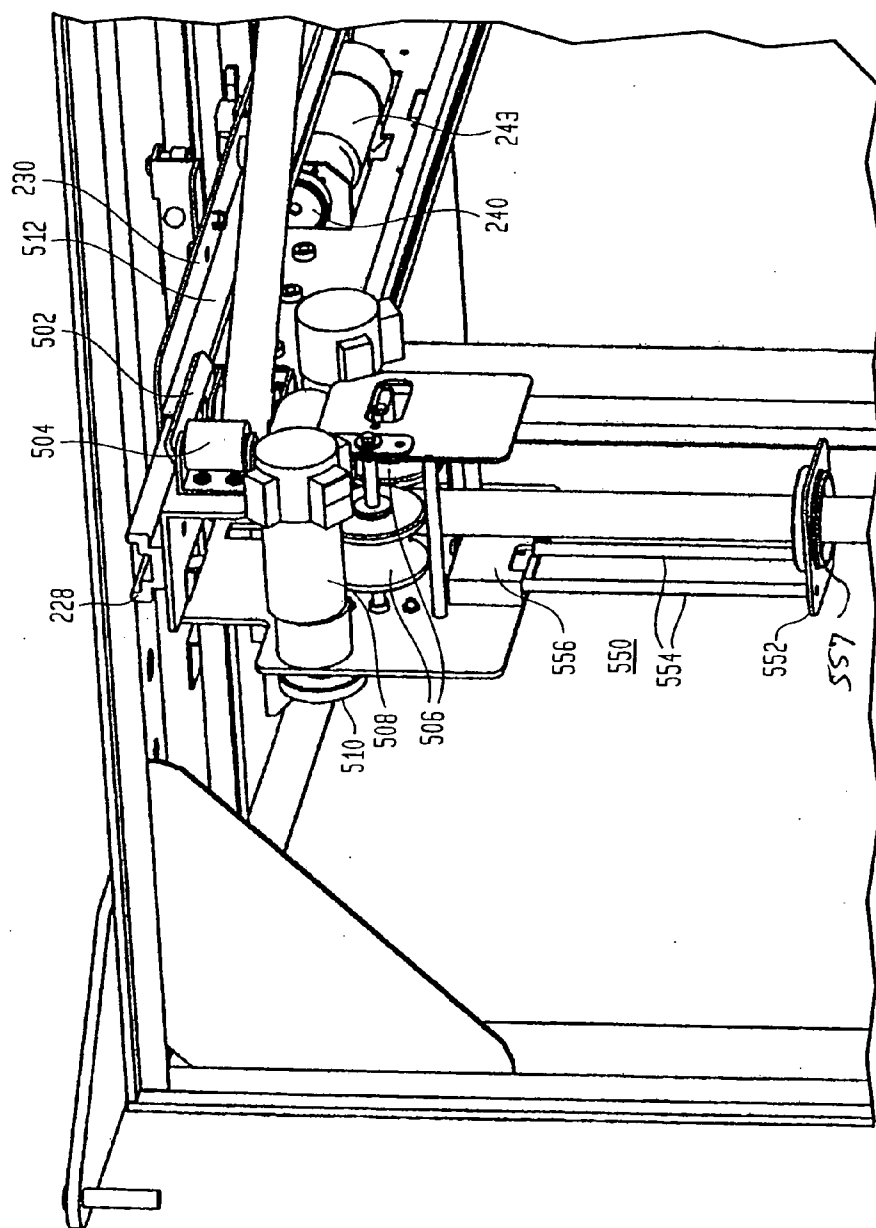


FIG. 6

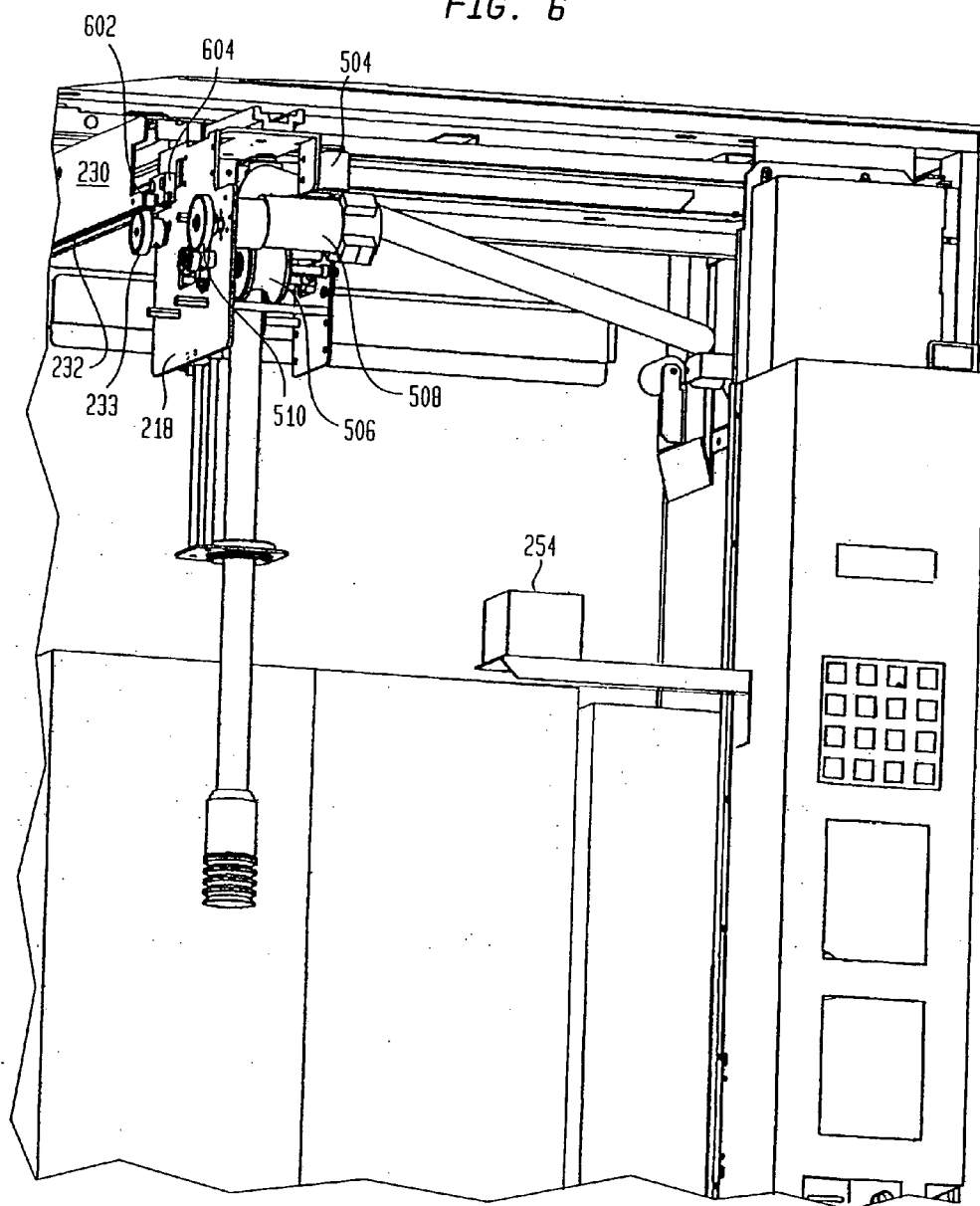
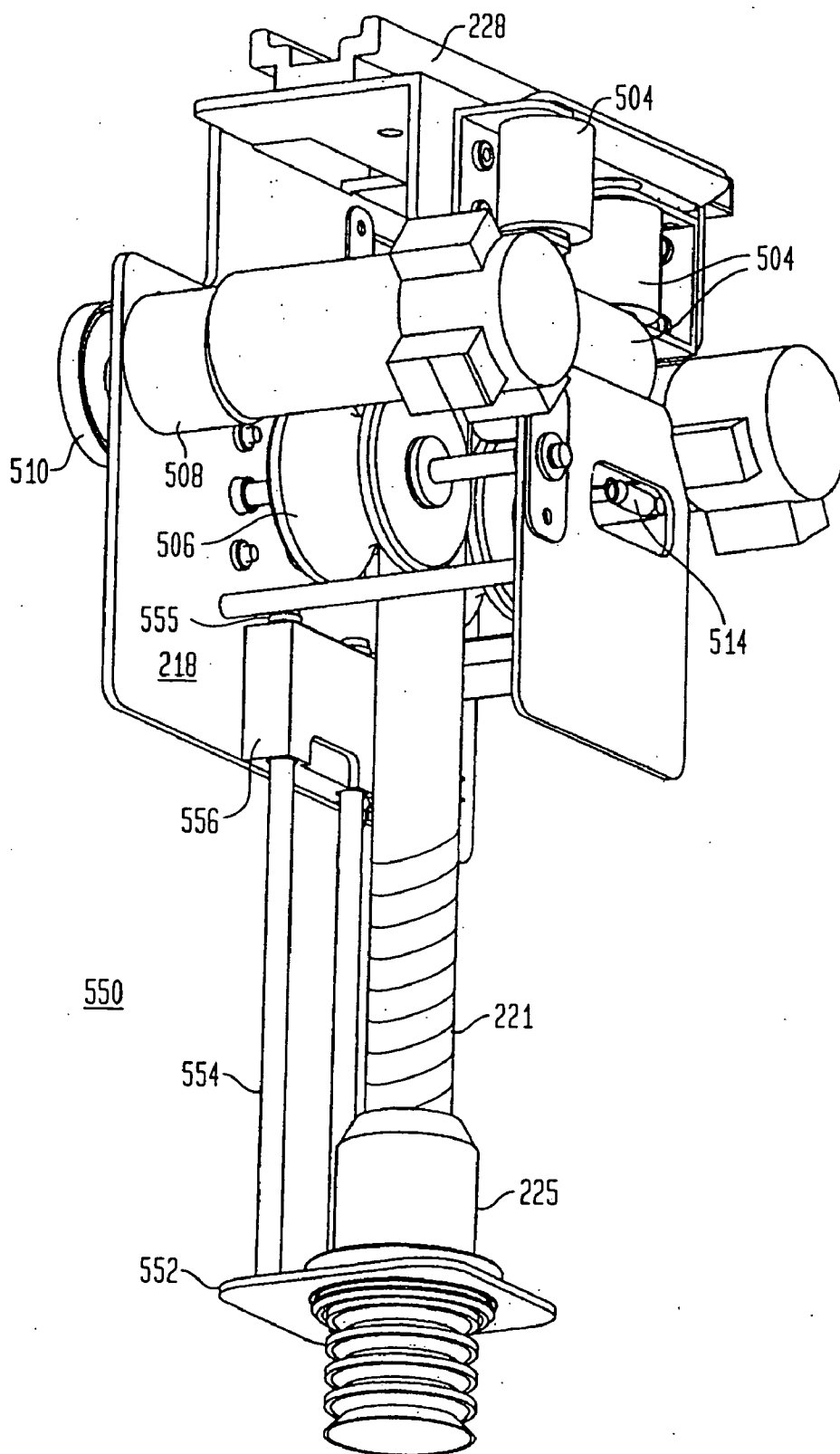


FIG. 7



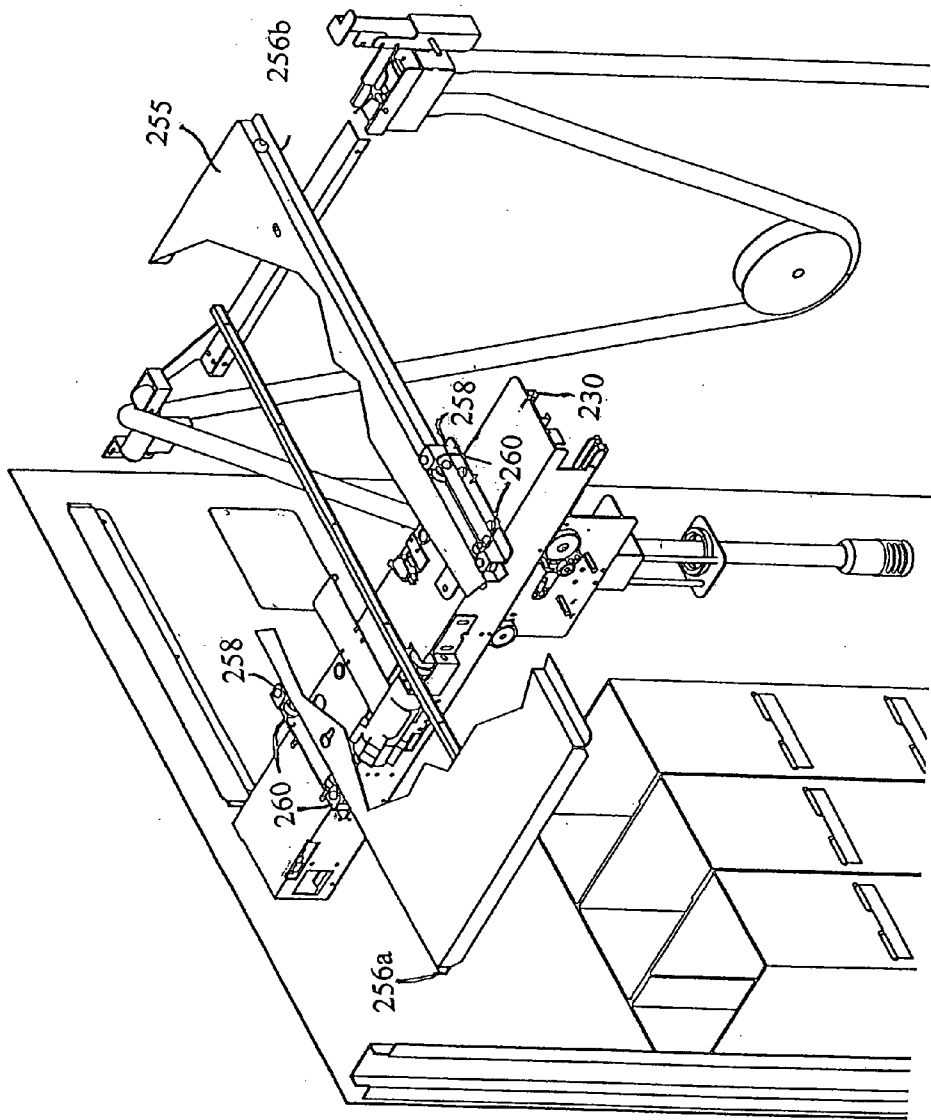


FIG. 8

FIG. 9

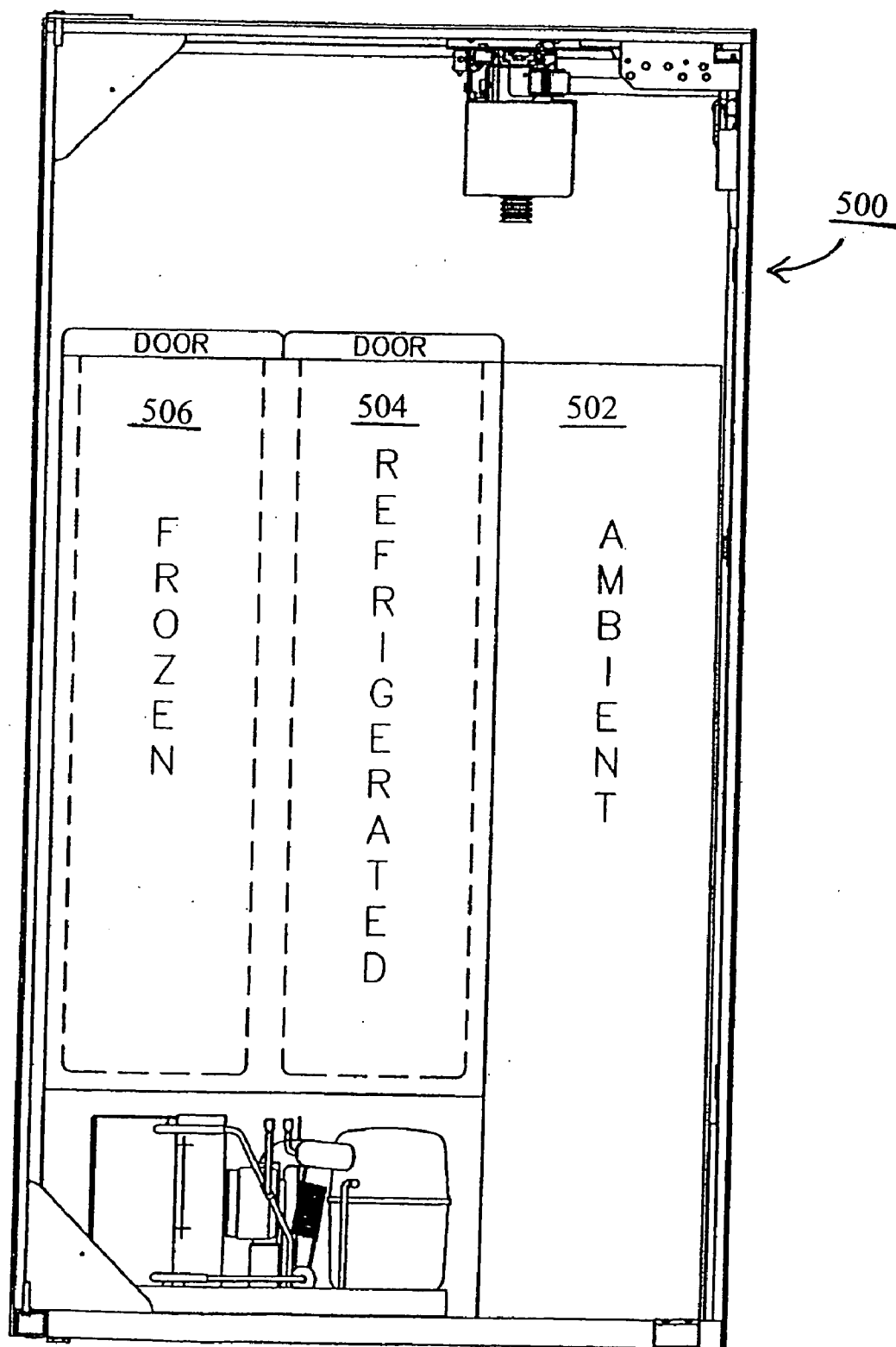


FIG. 10

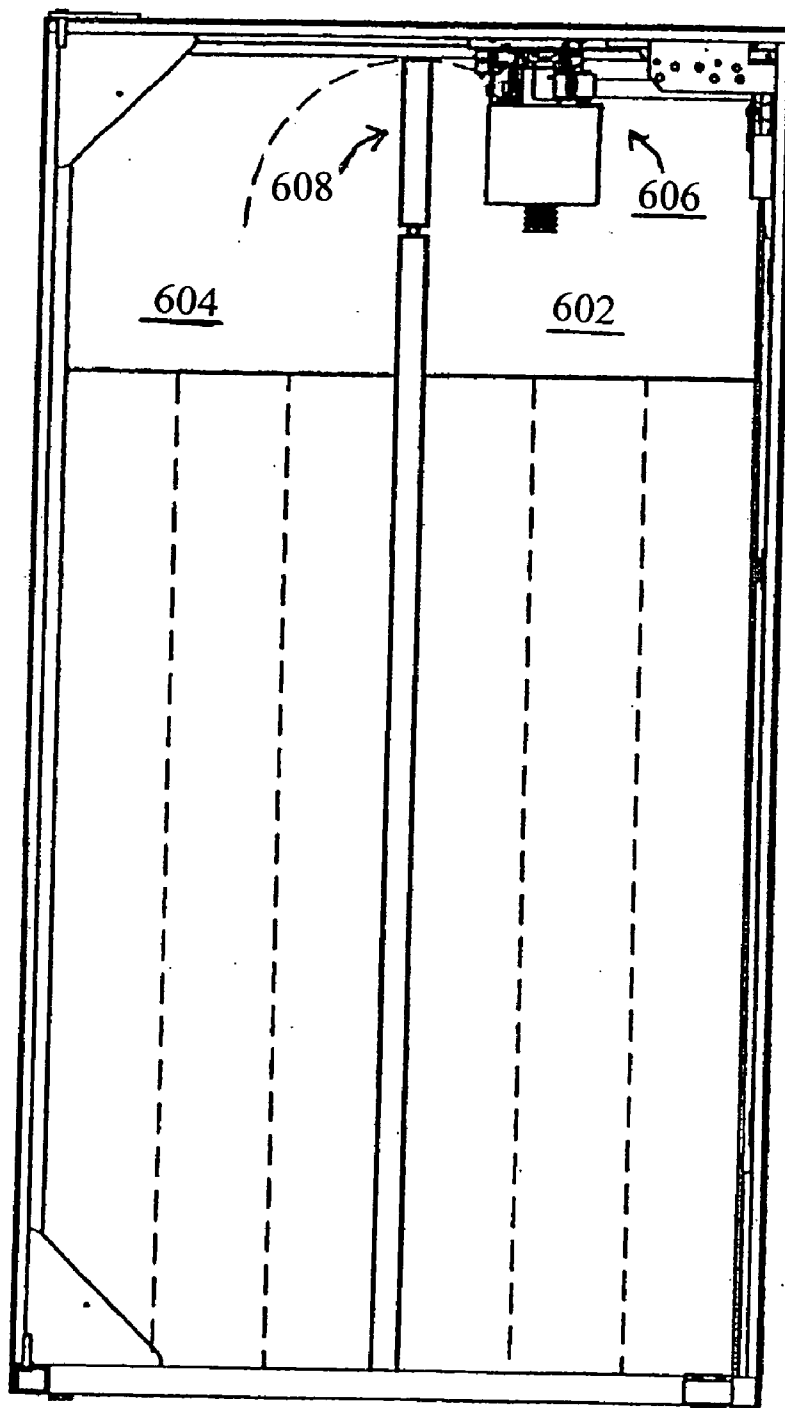


FIG. 11

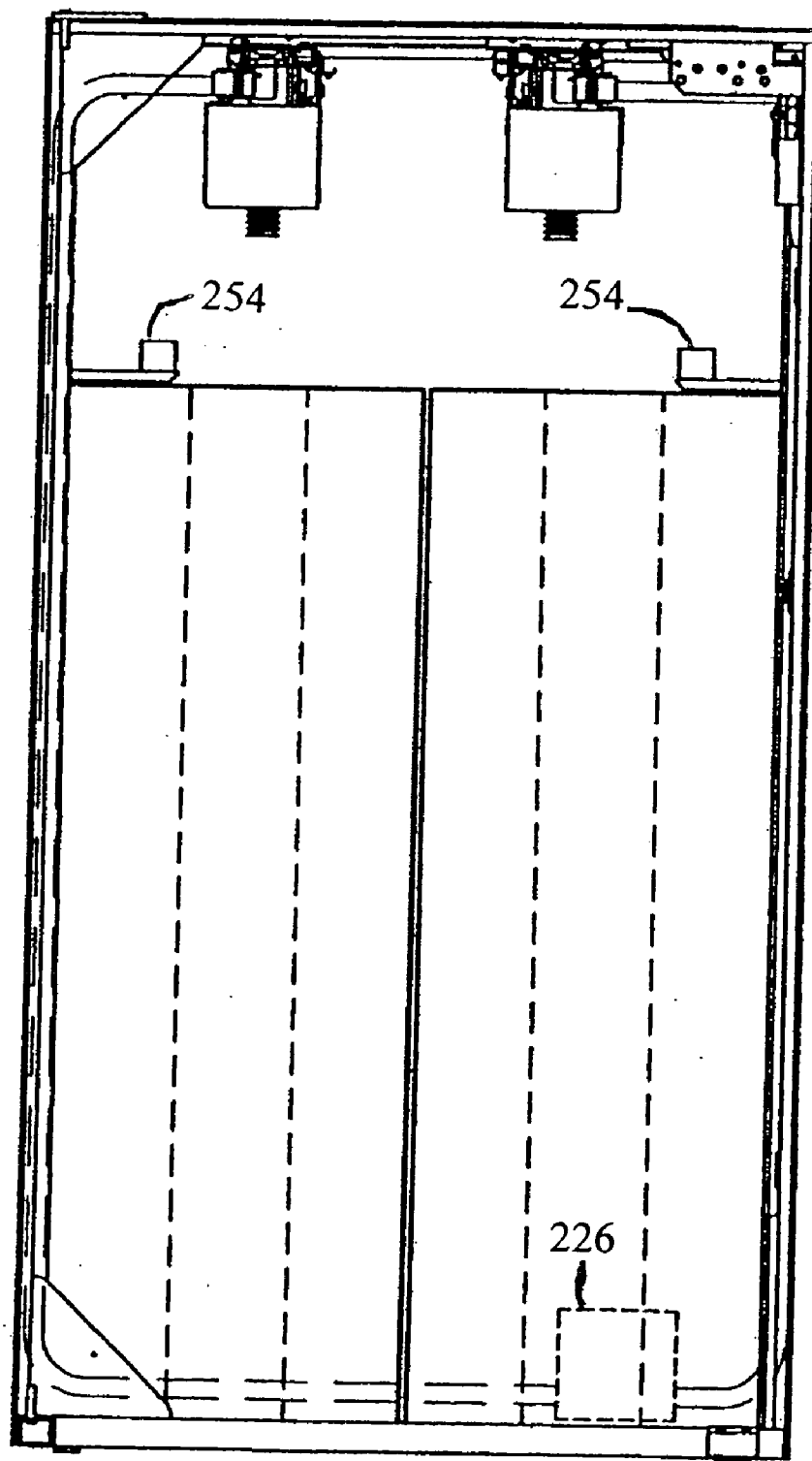


FIG. 12
DOOR FACE CONFIGURATION 2

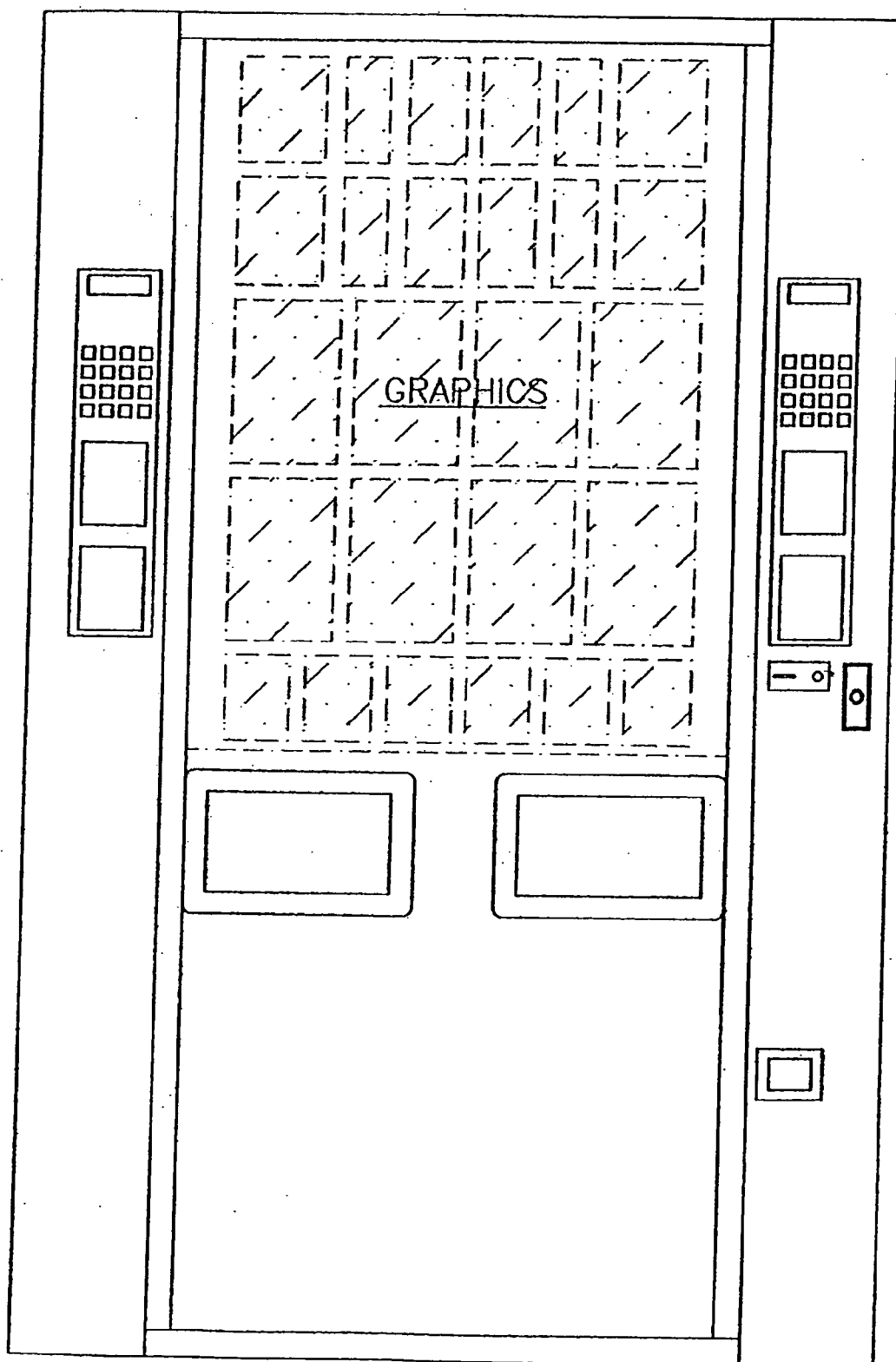
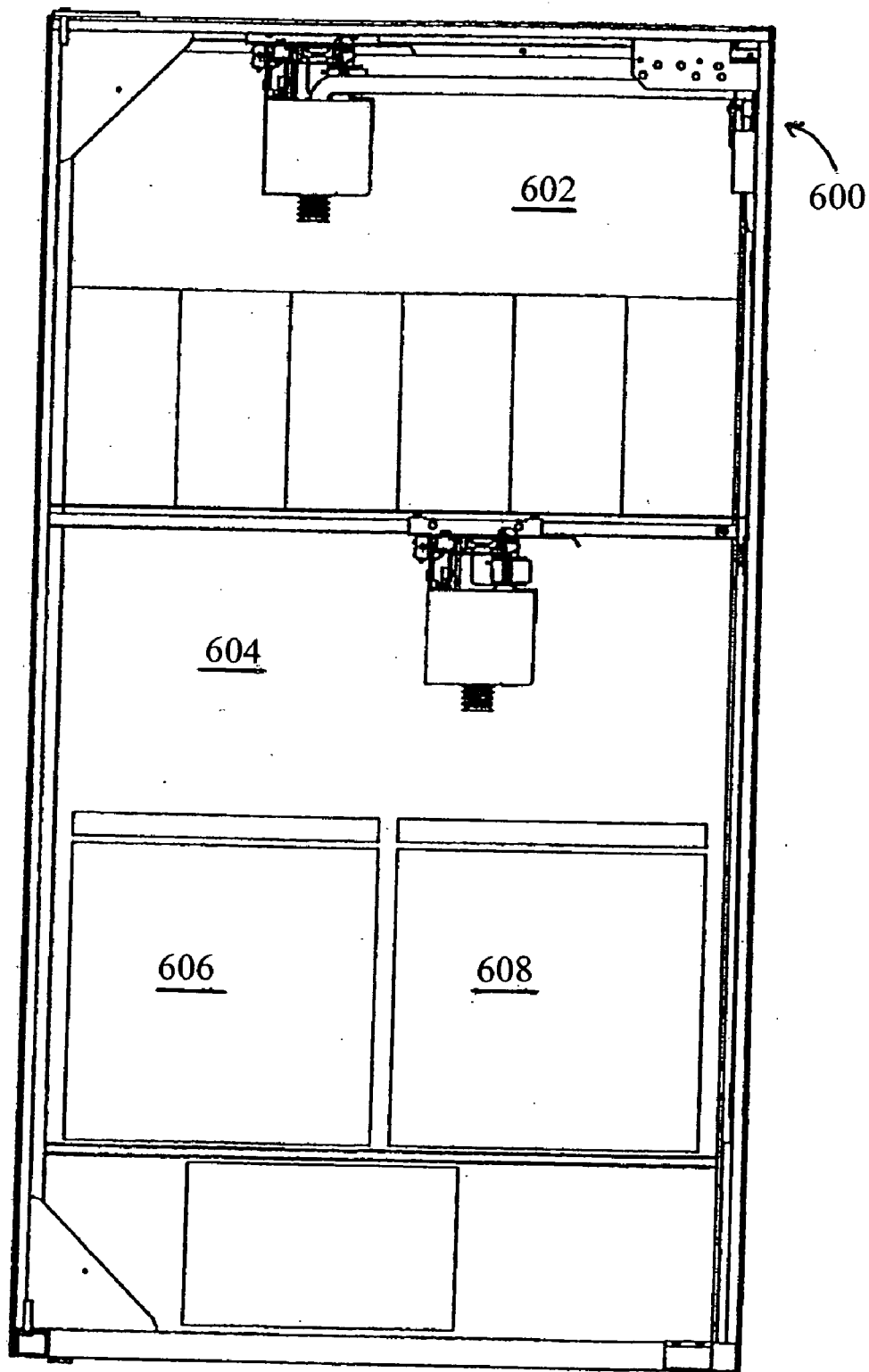


FIG. 13



METHOD AND APPARATUS FOR POSITIONING AN ARTICLE HANDLING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a division of and claims priority under 35 USC 120 of prior U.S. Ser. No. 10/205,770, filed Jul. 25, 2002, entitled METHOD AND APPARATUS FOR POSITIONING AN ARTICLE HANDLING DEVICE, which prior application claims priority under 35 USC 120 of PCT/US01/16894, filed May 23, 2001, entitled METHOD AND APPARATUS FOR POSITIONING AN ARTICLE HANDLING DEVICE, which itself claims the benefit of U.S. Provisional Patent Application No. 60/206,363, filed May 23, 2000, entitled METHOD AND APPARATUS FOR ARTICLE HANDLING, SUCH AS FOR A VENDING MACHINE. The entire disclosure of each of the above patent applications are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to improvements in the design and operation of article handling apparatus and in particular to article handling mechanisms of the type that utilize computer-controlled electromechanical technology, and in the illustrated embodiment a robotically positioned gripper, which uses suction, for example, for grasping and moving a selected article from one area to another, such as from a storage area to a dispensing area.

[0004] 2. Description of the Prior Art

[0005] Most prior art article handling mechanisms, more specifically referred to in the description of the present invention as being in the environment of a point-of-sale (POS) article dispenser, rely on a multitude of motors, switches and solenoids for moving various portions of the handling mechanism, and handling of the articles themselves, such as packaged products. Most such machines require one motor, switch and/or solenoid dedicated for each row, column or type of article or package to be handled or dispensed therefrom. Such machines generally suffer from numerous disadvantages, such as poor reliability due to mechanical failures, as well known by those skilled in this art.

[0006] U.S. Pat. No. 5,240,139 represents a significant improvement in article handling devices. It describes the use of a negative air pressure lifter (i.e., article pickup or handling mechanism), which uses suction, i.e., reduced or so-called "negative" air pressure created by a partial vacuum, for making a secure contact to an article to be retrieved by entering the open top of an article storage bin located in a refrigerated storage area of a vending machine. Although robotic, and specifically suction-type lifting mechanisms are in common use in factory settings, where space limitations are generally relaxed, their use in tight confines, such as an article vending machine, has not gained wide acceptance. Due to the greater reliability and versatility of vending machines of the type which utilizes suction technology for grasping and moving selected articles, it would be desirable to develop new techniques and methods for the operation and control of such machines, as well as for other more generalized article handling mechanisms.

[0007] Hose storage is provided in the forenoted U.S. Pat. No. 5,240,139 by use of a longitudinally compressible air hose having about a 3:1 compression ratio. One end of the hose is connected to a source of negative air pressure which is provided to a support-beam which is moved laterally over the top of the freezer. The other end of the air hose is connected to an article pickup head. Lateral positioning of a compressible hose is satisfactory in the environment of U.S. Pat. No. 5,240,139 since the freezer compartment only occupies the lower half of the interior of the vending machine, leaving the upper half available for the hose and its positioning mechanism. However, since the significant part of the expense of operating a vending machine business comprises servicing (i.e. filling) of the vending machine with products, it would be desirable to be able to provide taller article storage bins, with or without a freezer compartment, in order to maximize utilization of the article storage volume within the interior of the vending machine; cabinet. Prior art article dispensers typically use between 50 and 60 percent of their available height for article storage.

[0008] Due to the above noted disadvantage, it would be desirable to decrease the height requirement for the hose positioning mechanism. One such way would be to consider the use of a non compressible hose. A non compressible hose has the advantage that it can be driven and/or guided by direct engagement with the walls of the hose, a much simpler technique as compared to the indirect hose positioning technique of the forenoted U.S. Pat. No. 5,240,139. Additionally, a non compressible hose has the advantage of maintaining a constant length in spite of being subjected to changes in vacuum. Even furthermore, a non compressible hose has greater structural integrity and reduced leakage, as compared with, for example telescopic tubing. However, two serious problems are presented by the use of a non compressible hose: where can a sufficient length of the hose be stored in order that it's free end can travel the distance from the bottom of the hose positioning mechanism (a position aligned with the top of an article storage bin) to the bottom of the article storage bin; and how can it be simply and reliably be withdrawn and retracted to and from the storage area as needed?

[0009] PCT patent publication WO 99/12132 entitled VENDING MACHINE discloses a vending machine having a folded articulated arm for positioning an article gripping suction hose into a freezer for retrieving articles to be dispensed. The hose is . non-compressible, and continuous from a base area located beneath the articulated arm to its free end, where it is coupled to an article pickup head. A linear actuator and arm mechanism located in the base area is used to drive the hose into and out of the base area, through the articulated arm and into the freezer compartment. The hose positioning arrangement of this PCT patent publication has a similar disadvantage as the forenoted U.S. Pat. No. 5,240,139, in that a significant volume within the vending machine cabinet is required for the mechanism which positions the hose over and into the storage bins during a package dispensing cycle (i.e., a height almost equal to the height of the article storage bins themselves). Additionally, it is noted that only a relatively small length of hose is required to be stored, corresponding to the amount of hose required to move the article pickup head in the Z direction (i.e., into and out of the freezer), since a significant length of the hose is already stored in the folded articulated

arm. Even furthermore, it is noted that this patent publication teaches a relatively complex mechanism for hose positioning, storage and drive.

[0010] German patent DE 2455673 by G. Lucas, published May 26, 1976 and entitled VENDING MACHINE FOR ICE CREAM-USING SUCTION HEAD TO PICKUP WRAPPED BLOCKS OF ICE CREAM FROM STACK IN REFRIGERATOR discloses an ice cream vending machine wherein a movable carriage is mounted inside a freezer and laterally positionable over the article storage bins. The carriage includes a drive mechanism for lowering an electric cord having a suction motor at its free end into the article storage bins for retrieving the ice cream packages. This type of positioning mechanism for an article handling device avoids the problem of hose storage by actually lowering the suction motor into the bin. It's is particularly disadvantageous since the repeated bending and flexing of the electric cord can lead to reliability/failure problems. Additionally, the diameter of the suction motor places severe limitations upon the dimensions of the article storage bins.

[0011] U.S. Pat. No. 5,957,326 entitled APPARATUS FOR RETRIEVING RANDOMLY ORGANIZED ARTICLES, describes a vending apparatus including carriage mounted for being laterally positionable over an article storage bin, and includes a drive mechanism for lowering, into the storage bin a pickup head having a plurality of suction cups mounted thereon. Each suction cup is individually connected to a substantial length of hose which leads back to a manifold which supplies suction thereto. This type of positioning mechanism for an article handling device is particularly disadvantageous since the plurality of suction hoses connected to the pickup head are not provided in a hose storage area, and instead are coiled/dragged beneath the carriage during its repositioning thereby protruding significantly into a space which could more advantageously being used for the storage of articles to be vended/dispensed.

[0012] U.S. Pat. No. 4,557,659 the entitled DEVICE FOR SUPPORTING AND HANDLING LOADS BY MEANS OF VACUUM OPERATED SUCTION PADS, describes an article lifting and transport device wherein an electric motor slidably mounted along a raised and rotatable I beam, is used to lower an electrical cord towards an article to be handled. The electrical cord has at its free end a pickup head including a plurality of suction cups mounted thereon. A suction providing hose, which is continuous from a suction generator to the pickup head, is loosely supported between its ends by a series of slides connected to the rotatable I beam. This type of positioning mechanism for an article handling device is disadvantageous for substantially the same reason as the forenoted U.S. Pat. No. 5,957,326, due to the fact that the suction hose is dragged alongside and behind the carriage during its repositioning, thereby protruding significantly into a space which could more advantageously being used for the storage of articles to be vended/dispensed.

OBJECTS OF THE INVENTION

[0013] Accordingly, one of the objects of the present invention is to provide new techniques and methods for the design, operation and control of article handling mechanisms.

[0014] It is a further object of the present invention to provide new techniques and methods for the design, opera-

tion and control of article handling mechanisms of the type that utilize computer-controlled electromechanical technology, and in the illustrated embodiment a robotically positioned suction-type gripper, for grasping and moving a selected article from one area to another, such as from a storage area to a dispensing area.

[0015] It is also an object of the present invention to provide new techniques and methods for such mechanisms which improve the speed and accuracy of the article handling operation while still handling the articles to be dispensed in a careful manner so as to prevent any damage thereto.

[0016] It is a more specific object of the invention to provide an article handling mechanism of compact height, so as to maximize the article holding capacity of the storage area.

SUMMARY OF THE INVENTION

[0017] An article dispensing device of the type having a housing for defining an internal volume. The internal volume having a dimension along a first axis which has at one end of the dimension an article storage sub-volume, and at an opposing end of the dimension adjacent a dispensing end of the article storage sub-volume, an article dispensing sub-volume. An article storage structure is positioned in the article storage sub-volume and stores therein articles in columns along a plurality of longitudinal axes paraxially aligned with the first axis. An article dispensing mechanism includes a head adapted to engage and secure to an article stored in the article storage structure. The dispensing mechanism includes a substantially non-compressible tube connecting the head to a source of article securing energy. A feeder displaces the tube so as to move the head along the first axis (Z) and a first positioning device moving the feeder along a second axis different from the first axis. All the while, the article storage sub-volume utilizes 75 percent or more of said internal dimension along the first axis of the cabinet.

BRIEF DESCRIPTION OF THE FIGURES

[0018] FIG. 1 is a front perspective view of a vending machine constructed and operating in accordance with the principles of the invention.

[0019] FIGS. 2 and 3 are front perspective views of the vending machine of FIG. 1, with the front door opened, so as to illustrate the main mechanical and electrical components therein.

[0020] FIG. 4 is a functional block diagram illustrating the cooperation of the main mechanical and electrical components in the vending machine of FIG. 1.

[0021] FIGS. 5 and 6 illustrate details of the carriage portion of article handling mechanism shown in FIGS. 2 and 3.

[0022] FIG. 7 illustrates details of the hose guidance mechanism shown in FIGS. 2 and 3.

[0023] FIG. 8 illustrates an alternative embodiment of the hose positioning mechanism shown in FIG. 3.

[0024] FIGS. 9, 10, 11, 12 and 13 illustrate combinations/orientations of various article handling mechanisms and storage areas.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0025] **FIG. 1** illustrates an environment for the invention described herein, in the form of an article dispenser, such as a point-of-sale (POS) dispenser. Although throughout the following description, reference is made to implementation of the invention in a vending machine environment, it is intended that the term “vending machine”, and in fact the environment for the present invention, include more general purpose article handling, retrieval and/or dispensing apparatus, as well as POS equipment. Such equipment, if embodied as a portable device may comprise and be about the size of a traditional vending machine or as large as a tractor-pulled trailer, and if embodied as a non-portable device may comprise and be embodied as an automated dispensing room or an area located in a permanent structure, such as in a building (aboveground or underground, and with or without interior walls or an enclosing cabinet). Furthermore, it is intended that the term “articles” or “products” include in at least some of the embodiments of the invention described herein, not only goods, but also services and/or information, in either a permanent or temporal form.

[0026] Accordingly, **FIG. 1** illustrates a perspective view of a vending machine **10**, comprising one embodiment for an apparatus which is constructed and operates according to the present invention. Vending machine **10** includes a main cabinet **12** and a front door **14** mounted on a hinge **16** for providing access to the interior of the vending machine for servicing (filling it with articles, maintenance, etc.). Note, in a further vending machine embodiment, a service door or port could be positioned anywhere on or as a part of cabinet **12**. In **FIG. 1**, front door **14** is shown in a closed position, forming an enclosure with main cabinet **12**, within which various components of vending machine **10** are housed, as explained in more detail below.

[0027] Front door **14** includes a convex-shaped section **18** adjacent a flat section **20**; however, these particular shapes are not necessary to the invention. The convex-shaped section **18** comprises a translucent plastic display panel **18**, which typically has brand name and/or logo graphics displayed thereon, and may even include graphics which illustrate the individual articles that are vendible by vending machine **10**, as well as the price and/or selection information for the articles. Panel **18** is typically back-light using fluorescent bulbs, not shown.

[0028] A customer retrieval area **22** is formed in the panel **18** on door **14** so that articles stored therein can be discharged to a user of vending machine **10**.

[0029] Various user interface features are mounted on flat section **20** of door **14**. A customer display **24** may be a conventional fluorescent or LED display panel for displaying various items of information to a user of machine **10**, such as feedback to the user of the selection made, the amount tendered, and if the product is sold out or being vended. For accepting payments, a bill acceptor slot **26** accepts paper money into a conventional bill acceptor mechanism (mounted inside machine **10** so as to have its user interface portion extend through an aligned opening in flat section **20**) for purchasing articles or for making change. A coin insertion slot **28** accepts coins into a conventional coin changer (also mounted inside machine **10** so as to have its user interface portion extend through an aligned opening

in flat section **20**) for purchasing articles or for making change. A coin return actuator **30** comprises a conventional push-button mechanism for activating a coin return portion of the coin changer mechanism which, upon actuation returns coins inserted by the current user, to a coin return well **32**. The coin return portion of the coin changer mechanism also provides change to the coin return well **32** either in response to the purchasing of articles or for making change for paper money or larger coins. A credit/debit card slot **34** accepts a plastic credit/debit card inserted into a conventional card reader mechanism (also mounted inside machine **10** so as to have its user interface portion extend through an aligned opening in flat section **20**) for allowing a user to pay for purchases via credit/debit cards. A door lock mechanism **36** enables front door **14** to be secured so that it cannot be opened without a key. For allowing user selections, display panel **18** may include graphics, as noted above, which indicates the various articles vendible by the machine, as well as their associated price and unique selection number. Alternatively, flat section **20** could include a group of graphic article displays and their associated price. A conventional keypad push-button mechanism **38** is provided for enabling a user to select a desired article from vending machine **10**. Alternatively, push-button mechanism **40** could include individual push buttons for each article selection, as well as an associated price display; and even furthermore, a user operated touch screen could replace pushbutton mechanism **40** and display **24**. Although not shown in **FIG. 1**, machine **10** also includes a conventional telecommunications component that can be, used for authenticating credit card purchases, as well as other uses relating to machine control and reporting the inventory and operational status of machine **10** to a remote location, as more fully described later on. Although vending machine **10** is illustrated to include the above described user interface components, in a more minimal embodiment of the invention, most, if not all, of these user interface components could be omitted, and the dispenser could in fact be controlled from a remote location, with or without a local payment system.

[0030] **FIG. 2** is a front perspective view of the vending machine of **FIG. 1**, with the front door open, so as to illustrate the main mechanical and electrical components therein. **FIG. 3** is a somewhat idealized version of the main components of the article handling mechanism portion of vending machine **10**, and is useful for understanding its general operation. Note, some portions of vending machine **10** are shown in these FIGURES cut away in order to better illustrate the interior components.

[0031] Referring first to **FIG. 2**, it is noted that the right portion of the front of cabinet **12** includes a vertically mounted support panel **202** which is used for mounting most of the user interface components. More specifically, a hinged mounting bracket **204** is mounted on panel **202** and aligned with an opening in door **14** so that the user interface components, such as the selection button keypad **40**, coin insertion slot **30**, bill acceptor slot **28**, coin return **32**, and customer display **24**, are all accessible to the user from the front side of door **14**. Mounted on the interior of front door **14** are two fluorescent bulb light sources (which are behind protective covers **206**. Other numbers of light sources can be used) which emit light for backlighting panel **18**. A ballast **208** for the fluorescent bulbs and a product delivery chute **210**. Note, the product delivery chute **210** is unconventional

in that it is extremely tall, and therefore serves as a security measure to prevent unauthorized access into the machine by insertion of an arm or other grasping mechanism into the customer retrieval area **22** from outside the machine. In typical prior art vending machines, a swinging security door is usually found at the top of chute **210**, which swings into a vandal blocking position when the customer pushes in the swinging door at the entrance to the product retrieval area **8**. In a further embodiment of vending machine **10**, such a security door could be used in conjunction with product delivery chute **210**, especially if chute, **210** is not as tall as the one illustrated in **FIG. 2** and also if the product retrieval area **8** is located higher up on machine **10**. Mounted behind hinged mounting bracket **204** is a conventional bill acceptor mechanism for causing paper money inserted into bill acceptor slot **28** to be drawn into vending machine **10**, a conventional coin changer supplies coins to coin return slot **34** and is located behind panel, a coin guide guides inserted coins into the coin changer, and a conventional bill validator ascertains proper insertion of paper money into bill acceptor slot **28**.

[0032] A control board **212** comprises a printed circuit board on which circuitry is formed and to which integrated circuit chips are attached. Control board **212** includes a microprocessor that is electrically connected to various sensors, motors, the above described user interface elements, as well as other devices within vending machine **10**, to control the operation of vending machine **10** as described herein. When reference is made in this description to performance of specified functions by control board **212**, it is to be understood that these functions are controlled by the microprocessor and the associated circuitry formed on control board **212**. A power supply **214** is mounted on panel **202** and supplies power for the electrical components of vending machine **10**.

[0033] Referring now also to **FIG. 3**, it is apparent that the bulk of the interior of cabinet **12** is available as an article storage area **215**. In the illustrated embodiment, a plurality of vertically aligned article storage bins **216** are arranged on the interior floor **217** of cabinet **12**, for storing articles **223** to be vended by machine **10**. In a refrigerated environment for the present invention the bins could be arranged to sit on a shelf positioned above the refrigeration system.

[0034] An opened-top container **219** can be dimensioned to hold a plurality of article storage bins **216** therein, and used, for example to facilitate the simultaneous handling (i.e., removal, installation and transportation) of the plurality of bins **216** into/out of the article storage area **215**. Container **219** also facilitates rapid and accurate positioning of a plurality of the article storage bins into the storage area of the article handling apparatus. A carriage **218** (which may be more generally referred to as an X-Y or planar positioning mechanism) is coupled to the interior topside of cabinet **12** and adapted for being controllably positioned by the control board portion **212** of machine **10**, to a location centered over (so as to be aligned with) the open top-end of a selected one of article storage bins **216**.

[0035] Although vertical (Z-axis) alignment of the article storage bins **216** is shown, non-vertical, i.e., slanted or even horizontal (X or Y axis) alignment may also be possible (such as found in the well known glass front vending machines of the type using a "spiral wire" type of dispensing

apparatus). In the event of substantially horizontal alignment of the storage bins, the planar positioning mechanism will be appropriately changed so as to position carriage **218** for movement in the X/Z or Y/Z plane. In fact, a curvilinear plane, such as a cylinder, is also considered to be within the scope of the present invention. The combination of substantially horizontally aligned stacks of products with a robotically controlled article transport mechanism which moves in a vertical plane adjacent to dispensing ends of the stacks of products, is known, for example in U.S. Pat. No. 6,230,930 issued May 15, 2001 and entitled METHOD AND APPARATUS FOR VENDING PRODUCTS, and in U.S. Pat. No. publication US 2001/0000609 published May 3, 2001. Use of a curvilinear plane for article transport is known, for example, in the videocassette vending art, wherein the videocassette's are stacked in an outwardly facing manner in a central storage carousel, and a robotic gripper encircles the carousel. Furthermore, although article storage bins **216** are shown to be an ambient environment, bins **216** could in fact be positioned in a refrigerated environment, such as a freezer located in the bottom of storage area **217**, and the article transport mechanism enter the bins from a top opening the freezer, such as shown and described in the forenoted U.S. Pat. No. 5,240,139. Alternatively, in the event the refrigerated environment is of the type including a substantially horizontal alignment of the storage bins, a vertically oriented opening could be used to provide access to the dispensing end of the article storage bins.

[0036] In the environment of the present invention, an air hose **220** is continuous from a point before it's exit from a hose storage area **222** over orthogonally positioned rollers **213**, to its free end **221**. Free end **221** includes a weighted portion **225** in combination with a bellows extension tip portion **227**. Depending upon the physical characteristics of the articles to be dispensed, article pickup head **224** may comprise only the weighted portion **225**, or this portion in combination with a fitting specifically adapted to the type of packages to be dispensed, such as the bellows tip **227** or a compliant tip without a weight. Hose **220** has one end coupled to a source of negative air pressure, i.e., suction, which source of suction comprises in the preferred embodiment a blower motor **226**, and a free end coupled to the article pickup head **224**. In the present invention, the word continuous is intended to mean a hose which is connected and acts between it's end points, in order to accomplish the functions required by it, as a unitary/single hose. An air hose portion **235** provides suction from blower motor **226** to one port of an air junction box **229**, while continuous hose **220** is connected to a second port of air junction box **229**. Air junction box **229**, included at a top portion of hose storage area **222**, includes an airflow sensor and vacuum breaker assembly. The airflow sensor is used to develop a signal which is applied to the controller of the vending machine and is representative of the airflow through air hose **220**. The vacuum breaker assembly is used to quickly bring the air pressure in hose **220** to the ambient pressure, thereby facilitating a "quick-release" of an article transported by the article pickup head, into the dispensing chute **210**. It is noted that a quick release of the products does not have to occur at the top of dispensing chute **210**, and in the event that it is desirable to avoid subjecting the article to forces which result from jarring or dropping, the article pickup head could proceed to the bottom of the dispensing chute **210** before providing the quick release of the article. In one embodi-

ment, the airflow sensor arrangement may comprises a two-part switch, a first part includes a reed switch mounted on a top portion of box 229, and a second part includes a magnet mounted at the free end of a swinging arm mounted inside box 229. As the arm swings inside box 229 due to changes in airflow, the switch is “toggled”, thereby indicating changes in airflow. The use of this airflow signal will be described in greater detail later.

[0037] In accordance with one aspect of the present invention, a novel hose positioning arrangement is provided. As shown generally in FIG. 3, and more specifically in FIGS. 5 and 6, alignment of carriage 218 with a selected one of bins 216 is accomplished in the front/back (Y) direction using a front/back linear slide 228 (shown in a cut away view) mounted to an “L” shaped front/back beam 230 so that carriage 218 can be controllably positioned therealong using slide 228. A bottom edge portion of beam 230 includes a rack portion 232 and carriage 218 includes an electric motor 233 that drives a gear (633 of FIG. 6) which engages rack portion 232. Application of forward and reverse motor control signals from control board 212 to motor 233 causes carriage 218 to be driven in the front/back directions. Alignment of carriage 218 in the left/right (X) direction is accomplished in a similar manner, using a left/right linear slide 234 which slidably couples the top side of front/back beam 230 to the underside of each of spaced apart left/right beams 236a and 236b. Beams 236a and 236b are rigidly attached to the inside top portion of cabinet 12. A rack 238, also rigidly attached to the top inside portion of cabinet 12 and in parallel with beams 236, is engaged by a gear 240 driven by a reversible motor 243 mounted near the inside corner of beam 230. Application of forward and reverse motor control signals from control board 212 to motor 243 causes a rotation of gear 240 and a corresponding movement of beam 230, and hence carriage 218, in the left/right (X) directions.

[0038] In accordance with a further aspect of the present invention, as the hose positioning arrangement causes an article 223 to be moved by pickup head 224 from a storage bin 216 to chute 210, it is positioned past an article identification (ID) device 254 mounted within cabinet 12. A specific type of article ID device is not required for the present invention, and depending upon system constraints, such a device may comprise, for example, a bar code scanner or other optical image/pattern recognition system, or even a non-optical system, such as a radio frequency identification (RFID), or magnetic-based system mounted within cabinet 12, for uniquely identifying and confirming that the article being dispensed is in fact the article that was selected. The construction operation of such article identification devices are well known to those of ordinary skill in this technology, and therefore further description in this regard is not necessary.

[0039] It is noted that article ID device 254 is mounted within cabinet 12 at a relatively fixed location, the mounting being such that some controlled movement in the orientation of article ID device 254 may be facilitated, in order to help ensure a good “view” of the article being transported, and a high confidence of the transported articles being identified. One way to provide such controlled movement for ID device 254 would be to mount it on a piezoelectric substrate, and control board 212 could provide a voltage to the substrate so as to shift the “view” of ID device 254. It is noted that by

using an appropriately positioned article ID device 254, only a single article ID device 254 is needed. This is particularly useful for a robotic type dispenser, since the robotic apparatus can controllably position, and re-position if necessary, the article in the vicinity of the article ID device 254, thereby helping ensure a reliable ID of the article.

[0040] A bin holder 260, shown in FIG. 2, comprising a pair of rectangular brackets secured in a spaced manner to opposed interior side walls of cabinet 12, is used to maintain the bins situated therebetween in a predetermined position relative to the interior of the vending machine cabinet. This is required in view of the pre-programming of control board 212 which controls the robotic structure for retrieving a selected article from one a selected one of bins 216.

[0041] Note that although carriage assembly 218 only moves in a single plane, it is responsible for precisely positioning pickup head 224 in each of the X, Y and Z directions. More specifically, in accordance with a further aspect of the invention as shown in FIGS. 5 and 6, in a preferred embodiment, the hose positioning carriage 218 includes a roller arrangement 502 which comprises three orthogonally positioned rollers 504 at the point where hose 220 enters carriage 218, for redirecting the movement of hose 220 from a substantially horizontal direction along the top interior portion of machine 10 (i.e., in the X,Y direction), to a direction perpendicular thereto (i.e., in the Z direction). Movement of carriage 218 will not only move the free end 221 of hose 220 so that it can be axially aligned with a selected one of bins 216, but it will also automatically withdraw hose 220 from the hose storage area 222. Thereafter, a hose drive mechanism which may comprise a set of conventionally operated “pinch rollers” 506 driven by a reversible motor 508 via gear set 510, which in the illustrated embodiment are mounted in carriage 218, but in a further embodiment motor 508/rollers 506 (or some other drive mechanism, such as the one shown from the forenoted PCT publication WO 99/12132) could be mounted somewhere else along the length of hose 220, are used for driving pickup head 224 into/out of the selected bin 216 in order to retrieve articles stored therein. The event that hose 220 includes structural spiral corrugations along its length, pinch rollers 506 could include matching corrugations thereon for assisting the driving of hose 220.

[0042] This arrangement, where hose 220 travels in the same X,Y plane that carriage 218 travels, facilitates a compact hose positioning and drive mechanism embodiment for the present invention. Furthermore, since movement of the carriage is responsible for supplying most of the force needed to withdraw hose 220 from storage area 222,, the Z drive motor is only needed to drive the hose for causing its free end to travel into/out of bins 216 for article retrieval. It is noted that the pinch rollers 506 should comprise a soft rubber material so as to provide a good friction contact to hose 220, and if hose 220 includes structural spiral corrugations along its length, pinch rollers 506 could include matching corrugations for providing a more positive driving force to hose 220. In the illustrated embodiment, it has been determined that two drive rollers are not needed, and accordingly only one of the pinch rollers is driven by motor 508, while a spring (514) is used to urge the other roller towards the driven roller, thereby pinching and driving hose 220 therebetween. Furthermore when using corrugated hose, in

some applications it may be possible to replace pinch rollers **506** with a linear screw mechanism adjacent hose **220**, for driving the hose.

[0043] In the vending machine environment, having a compact hose positioning and drive mechanism is significant. The present arrangement of inventive features provides a very compact robotic structure which maximizes the ability of the carriage to position the hose within the interior of cabinet **4**. Additionally a compact robotic structure maximizes the article storage capacity of vending machine **10** and increases the ability of the robotic positioner to maneuver within the maximized storage area. Consider a cabinet having a height of 72 inches: a prior art hose positioning mechanism, such as provided by the forenoted U.S. Pat. No. 5,240,139 or the PCT patent publication WO 99/12132 typically occupied approximately 40 percent of the height dimension inside the cabinet, thereby leaving 60 percent or less for the storage of articles to be vended. With the arrangement of the present invention the hose positioning and drive mechanism comprises less than 25 percent of the interior height of the enclosure, a very desirable result. Additionally, it is noted that the compact hose positioning and drive mechanism of the present invention is extraordinary in that in the illustrated embodiment it occupies approximately only 15 percent of the interior height of the enclosure. What is even more remarkable is that this very compact hose positioning and drive mechanism can position the free end of the hose into alignment with a bin of articles, and then have the ability to drive the hose all way to the bottom of the bin. In the present invention the hose is able to be driven a distance which is greater than three times the height of the hose positioning mechanism and in fact, in the illustrated embodiment the hose is driven approximately five times the height of the hose positioning mechanism.

[0044] Also shown in FIGS. 5, 6 and FIG. 7, is a telescoping guide mechanism **550** for ensuring that when picker head **224** is lowered by the drive mechanism in carriage **218** into the storage area, it drops into the desired one of bins **216**. For example, depending upon the material used for constructing hose **220**, it is possible that during long time periods when hose **220** is not repositioned, the 90° turn in the direction of the hose which takes place in carriage **218** can form a significant “kink” in hose **220**. Thereafter, as hose **220** is lowered into a selected bin **216**, the kink may cause picker head **224** to swing as the hose kink moves past drive rollers **506**. In order to prevent such undesired swinging or movements of picker head **224**, guide mechanism **550** is provided and comprises a guide plate **552** affixed to the end of two sliding support bars **554**. As shown more clearly in FIG. 7, support bars **554** slide through holes in a plastic (PVC, i.e., poly vinyl chloride) block **556** secured to a wall portion of carriage **218**. Plate **552** is constructed so as to have a hole in the center thereof which is dimensioned to be slightly greater than the diameter of the body portion of picker head **224**, yet less than the diameter of a shoulder portion thereof. Accordingly, in operation when picker head **224** is lowered into a desired bin, support rods **554** allow support plate **552** to drop, due to gravity, at the same speed as picker head **224** is lowered away from carriage **218**. At a height above the top of bins **216**, and as determined by the length of support rods **554**, plate **552** no longer moves away from carriage **218** and the hole in the center thereof merely provides guidance for the remainder of the descent of picker head **224** into the selected bin **216**. As picker head **224** is

retracted from the bin, after having a package secured thereto due to the suction force created within hose **220**, picker head **224** eventually contacts guide plate **552** and then for the remainder of its upward travel, retraction of hose **220** also provides for retraction of guide plate **552**.

[0045] As also shown in FIGS. 5 and 6, the movement of carriage **218** is somewhat stabilized by the cooperative action of a bracket **512**, positioned on the underside of a top portion of support beam **230** through which slide **228** is constrained to follow, and a “U” shaped lip portion **602** which protrudes from a lower side portion of support beam **230**. An upwardly pointing portion of the lip **602** is engaged (and in fact “trapped”) by a downward facing slot a slide mechanism **604** attached to carriage **218**. It is believed that the cooperative action of the diagonally opposed supports provided by the combinations of bracket **512** and slide **228**, as well as lip **602** and slide **604**, which are fixed to the two legs of “L” shaped support beam **230**, provides for superior stability of carriage **218** during its travel along beam **230**.

[0046] As shown more clearly in FIG. 7, support rods **554** comprise rods having a threaded hole at each end, in which a machine screw can be inserted. At the top portion of rods **554** the head **555** of the screw forms a shoulder portion that prevents rods **554** from falling completely through the holes in block **556**, and at the bottom of rods **554** the screws secure plate **552** to the rods. As also shown in FIG. 14b, plate **552** includes a protective grommet **557** about the hole therein, for preventing damage and reducing wear of hose **220** as it travels through plate **552**. It is noted that the height of grommet **557** is preferably greater than the spacing between adjacent turns of the spiral support structure of hose **220**. Furthermore, it is noted that hose **220** is preferable constructed of a strong, flexible spiral portion functioning as the spine to form the shape of the hose, formed co-extensively with a flexible and air-tight plastic material which spans adjacent turns of the spiral portion.

[0047] Alternative constructions for guide mechanism **132** are also contemplated. For example, a series of telescoping tubing sections, attached to the underside of carriage **218**, and through which hose **220** passes, could be used in place of rods **136** and plate **134**.

[0048] As previously noted, since hose **220** is formed of a continuous material from its connection to the source of suction at one end to the pickup head **224** at its other end, means are necessary for providing hose storage and/or retraction during travel of the pickup head **224** in the X, Y and Z directions, as appropriate during the article dispensing operations.

[0049] Accordingly, as shown in FIG. 3, placing an interior wall **246** parallel and adjacent to an exterior wall **248** of cabinet **12** is used to form the hose storage area **222** there between. Hose storage area **222** has a cross-sectional area which is slightly greater than the cross-sectional area of the hose loop formed therein. Walls **246** and **248** are shown partially cut-away so as to illustrate a gravity feed self-retracting loop tensioner/ retraction mechanism **250** formed in hose **220**. Loop tensioner **250** is constrained for movement within hose storage area **222**, and made somewhat self-retracting by comprising a rolling weight **252** having a groove **253** along its periphery in order to provide constant centering of the weight within hose storage area **222** and for providing a constant “loop forming” tension on hose **220**.

Furthermore, centering of the grooved rolling weight 252 within hose storage area 222 results in centering of hose 220, thereby preventing hose 220 from rubbing with the walls of hose storage area 222 during X, Y and Z repositioning of pickup head 224. In order to prevent binding of hose 220, rolling weight 252 is dimensioned so as to be slightly larger than the diameter of hose 220 and the width dimension of hose storage area 222 is dimensioned to be only slightly larger than the width dimension of rolling weight 252. The specific amount of weight used for rolling weight 252 is a matter of design choice, and depends upon various factors, such as the weight of the articles to be moved, the strength of the motors used to drive the hose in the Z direction, etc. In a further embodiment, it may be desirable to couple weight 252 to a lower portion of cabinet 12 using a spring, for adding further tension to loop tensioner 250.

[0050] It is also noted that this gravity-based retraction/hose storage technique meets the storage requirements needed for both the X and Y movements of carriage 218 (left/right and front/back), as well as for the Z movement of pickup head 224. Of course this gravity-based retraction/hose storage technique would work equivalently well in an embodiment wherein the robotic hose positioning mechanism used a rotary type device (R, θ), an articulated arm, telescoping or scissor system, or other technique. Furthermore, the illustrated gravity-based retraction/hose storage technique is not necessary for the present invention, and in fact a fully or partially motorized retraction technique could also be used. Furthermore, in other embodiments, it may be desirable to place hose storage area at another location, such as parallel to the top or rear portion of cabinet 12.

[0051] Even furthermore, although only a single storage area 215, hose 220 and carriage 218 are shown in the illustrated embodiment, the invention described herein could also be used in a dispensing apparatus/article handler of the type having multiple storage areas and/or robotic article handling mechanisms, such as two robotic mechanisms (both positioned vertically or horizontally or mixed, and one vertically and one horizontally) each one serving a different storage area. Furthermore, when multiple article handling mechanisms are provided, each can be tailored for a particular operation. For example, one may have a relatively large diameter pickup head and use a high airflow/modest suction vacuum supply device, while the other may have a relatively small diameter pickup head and use a low airflow/high suction vacuum supply.

[0052] In this regard, FIG. 9 illustrates a multiple storage area arrangement 500, where a single article handler of the type previously noted serves 3 adjacent storage areas. In one embodiment each area may be for storing stacks of articles aligned in the same direction as in the other areas. One storage area 502 may have an ambient environment, while the other storage areas may be cooled, e.g., one area 504 being refrigerated and one area 506 being frozen. This arrangement may typically find use for dispensing in a compact, reliable and efficient vending structure: salty snacks (such as bags of potato chips) from the ambient storage area, cooled drinks (such as soda) from the refrigerated storage area, and frozen snacks (such as ice cream) from the frozen storage area. Furthermore, an arrangement of this type may be particularly advantageous in that the frozen compartment can be used for maintaining the quality of the stored articles until they are close to being needed for

dispensing, as determined by an intelligent controller. At a predetermined appropriate time before dispensing, a certain amount of articles can be moved from the frozen area to the refrigerated area. This technique also finds particular advantage in the event that the third storage area is in fact a temporary storage area which is used for individually heating/cooking the articles, such as, e.g. frozen pizzas, using an oven or microwave. In this case the quality/shelf life of the frozen pizza is maintained by not moving them to the refrigerated area until the refrigerated area has been depleted to the point that it needs replenishment, at which time they are sequentially moved from the frozen area to the refrigerated area. This technique substantially reduces the time needed for heating the pizza while the customer is waiting, while at the same time allowing for storage of the pizza in a frozen manner, thereby substantially increasing its shelf life and reducing the labor costs involved in stocking the machine. In this arrangement, the refrigerated storage areas can include thermal separators at their top portions, such as an air curtain or sliding thermal panels.

[0053] FIG. 10 illustrates an arrangement where the single article handling mechanism services two horizontally aligned in article storage areas, area 602 being an ambient environment and area 604 being a refrigerated environment. The article handling mechanism 606 can be constructed in a manner such as previously described using support beam 230 and carriage 218 so that mechanism 606 can "live" in the ambient area 602, and travel into the refrigerated area 604 through swinging door 608 as needed. Areas 602 and 604 can each include their own article ID device 254 or share a common ID device.

[0054] Additionally, separate hoses and hose positioning mechanisms can also be useful in order to speed up retrieval and delivery of stored articles to a customer. FIG. 11 shows such as a rapid article dispenser, of the type having two horizontally displaced storage areas. Although separate hoses and hose positioning mechanisms are used, they may share a single source of suction (e.g., blower motor 226), airflow sensor and vacuum breaker. A single hose, hose positioning mechanism and hose storage area could be used in a further embodiment where the single hose services more than one article storage area, such as the refrigerated and non refrigerated storage areas shown in FIG. 11, wherein support beam 230 and carriage 218 is positionable between the two storage areas having different ambient environments. Each robotic article handling mechanism could have its own article ID device 254, or they could share a single article ID device 254.

[0055] FIG. 12 illustrates a vending machine having a single article handling mechanism with dual customer interface areas (each including a product selection apparatus such as a keypad or touch screen, payment system, and product retrieval door), for example, one on the left side and one on the right side, with a common graphics display therebetween. This machine can service two purchasers at substantially the same time since customer selections and payment typically take a substantial amount time compared to the actual time needed for the dispenser to deliver the selected product.

[0056] A further one of such arrangements is shown in FIG. 13, where cabinet 600 includes therein an upper area 602 which is non-refrigerated (and may even be heated) and

a lower area **604** which is refrigerated (and may even be divided into, e.g., two additional sections, one area **606** being frozen and another area **608** being merely cooled). This arrangement is particularly advantageous since hot air tends to rise and cool air tends to sink. Alternatively, one storage area may be oriented for vertical storage of products and the other one, or even multiple ones, arranged for horizontal storage. In this case a separate hose, hose positioning mechanism and hose storage area may be required for the differently oriented storage areas.

[0057] In the above arrangements it is noted that the article handling mechanism can have other configurations such as the forenoted telescopic tubing, scissors, or R, theta arrangement. Additionally, the articles can be consumer goods, such as office supplies, printer cartridges etc.

[0058] In the embodiment illustrated herein, blower motor **226** provides a relatively high volume of airflow but a relatively modest negative air pressure. As a matter of design choice, blower motor **226** could comprise a vacuum pump, so as to provide a much more substantial degree of negative air pressure, but, due to size and cost limitations, a correspondingly reduced amount of airflow. In this latter case, the diameter of the air hose **220** would be reduced from the diameter illustrated in FIG's **2** and **3**, which may be particularly important in some applications of the present invention. The illustrated embodiment is particularly useful for picking up flexible packages since a momentary or even sustained leak in the coupling to the packaging to the article will generally not result in dropping of the package, while at the same time offering extreme versatility due to the ability to pick up a wide variety of shaped objects of varying weight and size. In the event that blower motor **226** comprises a vacuum pump, it could be used alone or in combination with a storage tank coupled to the suction hose via a valve and air hose, in order to provide a greater volume of airflow. Alternatively a compressor could be used in combination with a venturi device to create a vacuum.

[0059] FIG. 4 illustrates a functional block diagram of the general operation of the various aspects of the invention described herein, as embodied in an article dispenser of the type comprising, for example, vending machine **10**. A control system **400** including a microprocessor **402** and associated memory circuits **404**, is constructed on control board **212**. Control system **400** may also include the electronic parts of other portions of vending machine **10**, as appropriate. Memory circuits **404** include ROM for storage of operating programs (embedded software, as well known, for accomplishing the described herein control of vending machine **10**), as well as RAM cache for temporary storage of operational data during system operation as well as other data as may be needed. Control system **400** is responsive to user operation of the user payment and selection system **506** (including the coin and bill mechanism **28** and **30** and the selection buttons **40** of FIG. 1) for operating the user interface and article handling apparatus of vending machine **10** so as to dispense the article desired by a user. More specifically, upon proper payment for a selection made by the user using payment and selection system **506**, control system **400** operates the XJY (left/right and front/back) drive motors **508** so as to position pickup head **224** to be in alignment with a bin **216** which holds the article selected by the user. Control system **400** then engages a hose drive motor **410** (Z-motor) mounted within and carried by carriage

218, so that hose **220** is driven in a direction towards the top article in the aligned bin. At an appropriate time before head **224** contacts the article to be removed (and in an embodiment of the invention where cabinet **12** does not include refrigerated air, an appropriate time may be just before head **224** enters bin **216**, but if the air is refrigerated, just before contact with the desired article is expected, in order to minimize removal of refrigerated air), control system **400** activates blower motor **226** so as to provide lifting suction at pickup head **224**. Upon position sensors **412** determining that pickup head **224** has contacted and become secured to the desired article, control system **400** causes hose drive motor **410** to reverse its direction so as to retract hose **220** from the aligned bin **216** and thereby lift out from the bin **216** the selected article. Carriage **218** is then driven to a position in alignment with the article delivery chute **210**. As the desired article **223** is moved along its way from a storage bin **216** to chute **210**, it is positioned past the article ID device **254** for uniquely identifying and confirming that the article being dispensed is in fact the article that was selected. Upon sensors **412** sensing alignment of carriage **218** with chute **210** (in this case sensor **202** may comprise a reed switch mounted on a front wall of the cabinet, and a magnet mounted at a leading edge of carriage **218**), control system **400** turns off blower motor **226** and the resulting loss of vacuum causes the selected article to drop into the customer retrieval area **22**. As previously noted, in the event that the articles are so fragile that they should not be dropped or subjected to such impact forces, hose **220** can be driven to the bottom of chute **210** before the article is released.

[0060] It is noted that position sensor **412** may include the airflow sensor of junction box **229**, or in a further embodiment, comprise a mechanically operated plunger-type position sensor associated with pickup head **224**. Even furthermore, position sensors **412** may also include a reed switch mounted on a front wall of the cabinet, and a magnet mounted at a leading edge of carriage **218**.

[0061] In accordance with a further aspect of the present invention, since the control system keeps track of the movement of hose **220** and carriage **218** (for example, by sensing pulses from a shaft encoder or other distance measuring device on each of their respective drive motors), the signal generated by the airflow sensor at the time carriage **218** reaches the virtual home can also be used as a check to ensure that control system **400** accurately counted the motor drive pulses, and can re-calibrate the positioning system based on the virtual home, if necessary.

[0062] It is noted that the above described carriage **218** and robotic hose positioning and drive mechanism, are particularly advantageous in the environment of a cabinet, such as in a vending machine, in that it facilitates improved utilization of the interior storage volume of the cabinet. More specifically, in the event that, for example non-storage related components are mounted or reside inside the cabinet, leaving "pockets" of storage area behind or in front of the components, the carriage is easily positionable so as to reach these pockets and make them usable for article storage.

[0063] A communication system **414** is connected to control system **400** so as to provide article inventory and vending machine operation information to a remote location, as well as to allow, for control of the operation of the vending machine from a remote location. In this regard,

communication system **414** may include a connection to means for making a wire-line and/or wireless transceiver interface through which a communication link with a remote computer can be established. Additionally, the communication system **414** may communicate with a plurality of other similarly connected vending machines in the same general area and communicate therewith using the wire-line interface or wireless communication. Even furthermore, communication system **414** can provide for communication with multiple vending machines and/or a local server/controller, in a local site along a LAN (local area network), LAWN (a local area wireless network) or a WAN (wide area network). The remote computer may comprise a database which receives and/or accumulates the operational data from one or more vending machines, which data is then accessible (via, e.g., the Internet, using a wired or wireless connection) using appropriate encryption, to others, such as route drivers, machine operators, machine owners, product suppliers, etc. Furthermore, the remote site may give feedback to the vending machines, such as authorization information, which can control its operation, such as allow its continued operation.

[0064] Further embodiments for the robotic hose positioning mechanism described above are contemplated to be within the scope of the present inventions. For example, instead of using a combination of left/right slides **234** and support beams **236a** and **236b**, a roller/guide rail combination as shown in **FIG. 8** could be used. Support beams **236a** and **236b** may comprise a support plate **255** having two outwardly facing, i.e., opposed, L-shaped rails **256a** and **256b** along its longitudinal edges. In this embodiment, the function of slides **234** is accomplished by fixing a pair of brackets **258** to opposed ends of beam **230**, each bracket **258** including a pair of spaced apart and inwardly facing rollers **260** which engage and follow the opposed rails **256** on the support plate **255**. Furthermore, the spaced apart and inwardly facing rollers **260** could each comprise a set of rollers positioned to be angled **90** degrees with respect to each other, so as to engage or follow the two orthogonal surfaces of the L-shaped rails **256a** and **256b**. Such arrangement may result in a coupling of carriage **218** to beam **230** which needs less adjustment for proper operation. Furthermore, as previously noted, the event of substantially horizontal alignment of the storage bins, the robotic hose positioning mechanism can position carriage **218** for movement in a vertical plane which is substantially flat (i.e., in the X/Z or Y/Z plane) or in fact a vertical curvilinear plane. Additionally, as previously noted, in some aspects of the invention, it may be desirable for the robotic hose positioning mechanism to include a rotary device (R, θ) of the type including an I beam of fixed length (or telescopic sections), for establishing the “R” movement of the gripper/pickup head, which pivots for establishing the “ θ ” movement. Alternatively, in other environments for the invention the robotic hose positioning mechanism may include an articulated arm or scissor system, or other technique.

[0065] Accurate control of energization of blower motor **226** is particularly advantageous in the event that the inside of the cabinet, or a portion thereof, is refrigerated, since accurate control, would decrease the amount of refrigerated air being displaced by blower motor **226**. In the preferred embodiment, the microprocessor **402** will energize blower motor **226** as the pickup head **224** approaches the desired article, and in fact only when it is in the immediate proximity

of the desired article (and not earlier), due to control system **400** maintaining updated information about the height of the stack of articles in each bin **216**. The height is assumed to be at a predefined level upon article filling of the vending machine **10** by the operator. Control system **400** may confirm the assumed height by moving the pickup head **224** at a reduced speed towards an article at the top of a bin **216** on the first retrieval attempt after the storage area has been refilled, and then compare the assumed height to the actual height. Memory **404** can be pre-programmed with specific article heights in advance, or the heights can be learned by control system **400** by comparison of prior vend heights in each bin. Once the height of the top article is known, control system **400** is also able to always know the height of the next “top” article in that bin. Furthermore, control system **400** is also able to cause the pickup head **224** to approach the articles in that storage area at a higher speed, and only slow down when in the immediate proximity of the next “top” article in that bin. The technique to slow down upon the pickup head **224** approaching the next article also helps ensure that the stored articles will not be damaged by the pickup head **224**.

[0066] When a “reset” switch (not shown) is activated by the machine operator, control system **400** automatically defaults to using the above height detection technique since it can be assumed that the operator may have changed the product load levels and consequently the product heights in each bin.

[0067] It is noted that in an alternate embodiment, a simpler way of controlling operation of blower motor **226** and the approach of pickup head **224**, without knowing the specific article height, would be to turn on the blower motor **226**, or slow down the pickup head **224** just prior to the learned stack height of the prior vend.

[0068] For the embodiments described herein, it is assumed that energization of the blower motor or other suction creating device (or alternatives thereto, such as a valve operated source of vacuum), is meant to be equivalent to the appearance of a prompt package securing force, i.e., suction, at the pickup head **224**.

[0069] In accordance with a further aspect of the present invention, since the control system keeps track of the movement of hose **220** and carriage **218** by sensing pulses from a shaft encoder or other distance measuring device on each of their respective drive motors, the signal generated by the switch in airflow junction box **229** at the time carriage **218** reaches the dispensing chute **210** can also be used as a check to ensure that control system **400** accurately counted the motor drive pulses, and can re-calibrate its positioning system based on the virtual home, if necessary.

[0070] In the event that the stored articles could be easily damaged, and delicate handling is required, e.g., the stored articles comprise soft plastic bags of potato chips, further modifications to the above-described apparatus may be desirable. For example, in accordance with a further aspect of the present invention, the pickup tip **227** (shown in **FIG. 2B**) includes pleated or “bellows” type sides and is constructed of a soft compliant rubber or plastic, so that when tip **227** contacts a package to be removed, the sudden increase in negative air pressure inside hose **220** causes the length of tip **227** to suddenly decrease. This effect tends to rapidly and momentarily contract the gripping end of pickup

head **224** from the article and might even apply a slight lifting to the package. This hose contracting/package lifting can be important, since weight portion **223** of pickup head **224** may be significant. Such weight may have a tendency to crush or otherwise damage a delicate package in the storage area if it makes a forceful contact with the package. The length of tip **227** and the aggressiveness of its “pleats” is a matter of design choice, and should be determined so as to provide a hose contraction by an amount which is equal to or greater than the expected downward travel of pickup head **224** due to time delay/lag in effecting a braking and stopping of the z drive motor (**310** of **FIG. 3**), by control system **300**, and its associated sensors, and the mechanical linkages associated therewith.

[**0071**] Alternatively, or in addition to the hose contraction provided by compliant tip **227**, a sufficiently compliant hose **220** may be designed to provide a desired amount of lift.

[**0072**] In accordance with a further aspect of the invention, although speed is important, and generally the hose **220** is driven at a maximum allowable speed, when handling delicate articles, the speed at which pickup head **224** is driven by control system **400** towards a package to be retrieved, is reduced as pickup head **224** approaches the stored package. Since control system **400** maintains updated information about the height of each stack of stored articles in the storage bins **10**, appropriate speed control, i.e., slow-down, during the approach of pickup head **224** towards a stored article can be accomplished. Such slow down provides some tolerance in the downward travel and reversal of pickup head **224**, so as to prevent the weight associated therewith from “crashing” into and thereby crushing a delicate package. A similar type of speed control can also be used on the upward direction of pickup head **224**, so as to prevent it from crashing into the underside of carriage **218**, as well as at the ends of the left/right and front/back travel of carriage **218**.

[**0073**] Additionally, wherein slide **228** has extended beyond the front edge of beam **230**, the above-described mechanism for positioning carriage **218** is particularly advantageous in that it allows for a support beam, such as **22** which is limited in length so that it can travel within the full extent, i.e., wall-to-wall, within the cabinet of the vending machine (and behind corner support gussets, brackets and partitions such as partition **208** of **FIG. 8**, yet still allow for carriage **218** to extend beyond its front so that a desired article can be positioned into a customer retrieval area which is outside the interior confines of the vending machine cabinet.

[**0074**] Many of the benefits of the inventions described herein could also be particularly useful in an article dispensing apparatus of the type having a refrigerated compartment, such as a chest freezer including various doors thereon (such as described for the ice cream dispenser in U.S. Pat. 5,240,139), in combination with the forenoted controls for creating and/or maintaining suction at the gripping end of the suction hose

[**0075**] While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. In fact, many such

changes are already noted in this description. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described specifically herein. For example, although a suction providing air hose **220** has been disclosed in the described preferred embodiments, in fact a solid element having a gripper at its free end, such as a mechanically operated claw (or an electromagnetic device or even a self-contained suction generator), could also be used. Such equivalents are intended to be encompassed in the scope of the appended claims.

1. An article dispensing device, comprising:

a housing for defining an internal volume therein, said volume having a dimension along a first axis which has at one end of the dimension an article storage sub-volume, and at an opposing end of the dimension adjacent a dispensing end of the article storage sub-volume, an article dispensing sub-volume;

an article storage structure positioned in the article storage sub-volume, said article storage structure storing articles in columns along a plurality of longitudinal axes paraxially aligned with the first axis; and

an article dispensing mechanism, including,

a head adapted to engage and secure to an article stored in the article storage structure;

a substantially non-compressible tube connecting the head to a source of article securing energy;

a feeder displacing the tube so as to move the head along the first axis (Z); and

a first positioning device moving the feeder along a second axis different from the first axis; wherein

the article storage sub-volume utilizes 75 percent or more of said internal dimension along the first axis of the cabinet.

2. The device of claim 1, wherein said tube comprises a suction-conducting tube, and said source of article securing energy comprises a source of suction.

3. The device of claim 1, further including a second positioning device for moving the first positioning device along a third axis (X).

4. The article handling device of claim 3, wherein movement of the head with respect to the first, second and third axes corresponds to movement in a Cartesian (X, Y, Z) coordinate system.

5. An article dispensing device, comprising:

a housing for defining an internal volume therein, said volume having a dimension along a first axis which has at one end of the dimension an article storage sub-volume, and at an opposing end of the dimension adjacent a dispensing end of the article storage sub-volume, an article dispensing sub-volume;

an article storage structure positioned in the article storage sub-volume, said article storage structure storing articles in columns along a plurality of longitudinal axes paraxially aligned with the first axis; and

an article dispensing mechanism, including,

a head adapted to engage and secure to an article stored in the article storage structure;

- a substantially non-compressible tube connecting the head to a source of article securing energy;
- a feeder displacing the tube so as to move the head along the first axis (Z); and
- a first positioning device moving the feeder along a second axis different from the first axis; wherein

the article dispensing sub-volume utilizes 25 percent or less of said internal dimension along the first axis of the cabinet.

6. The device of claim 5, wherein said tube comprises a suction-conducting tube, and said source of article securing energy comprises a source of suction.

7. The device of claim 5, further including a second positioning device for moving the first positioning device along a third axis (X).

8. The article handling device of claim 7, wherein movement of the head with respect to the first, second and third axes corresponds to movement in a Cartesian (X, Y, Z) coordinate system.

9. An article dispensing device, comprising:

- a housing for defining an internal volume therein, said volume having a dimension along a first axis which has at one end of the dimension an article storage sub-volume, and at an opposing end of the dimension adjacent a dispensing end of the article storage sub-volume, an article dispensing sub-volume;

an article storage structure positioned in the article storage sub-volume, said article storage structure storing articles in columns along a plurality of longitudinal axes paraxially aligned with the first axis; and

- an article dispensing mechanism, including,
- a head adapted to engage and secure to an article stored in the article storage structure;
- a substantially non-compressible tube connecting the head to a source of article securing energy;
- a feeder displacing the tube so as to move the head along the first axis (Z); and
- a first positioning device moving the feeder along a second axis different from the first axis; wherein

when the first positioning device moves the head along the second axis, the positioning device including the head moves at all times in a portion of said internal dimension that is less than a given percentage of said internal dimension, and the feeder is able to displace the head along the first axis by an amount that is greater than three times the given percentage.

10. The device of claim 9, wherein said tube comprises a suction-conducting tube, and said source of article securing energy comprises a source of suction.

11. The device of claim 10, wherein said source of article securing energy comprises a blower motor.

12. The apparatus of claims 9, further including a second positioning device for moving the first positioning device along a third axis (X).

13. The article handling device of claim 12, wherein movement of the head with respect to the first, second and third axes corresponds to movement in a Cartesian (X, Y, Z) coordinate system.

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