Multi-purpose Food Vending Machines

Tatsuya Kobayashi
Masahiro Nishi
Takeshi Tamura

1. Introduction

Recently, the need for laborsaving (unattended) vending functions in the work place has increased in response to the call for curtailment of work welfare expenses, and therefore, multi-purpose vending machines that are able to sell various commodities from a single machine are required.

Furthermore, in the mature market of vending machines, in order to increase the number of new installations, which are mostly indoor use, and to improve the sales per machine, a vending machine with novel concept is desired.

In order satisfy such needs, a multi-purpose food vending machine is equipped with a commodity catcher system and is able to sell various commodities such as prepackaged lunches, sandwiches and rice balls, in addition to snacks which were being treated also by conventional machines such as breads and confectioneries. This machine displays the commodity delivering process to the consumers through a glass outer panel, so as to provide sense of security and sense of reliability and enjoyment to the customer. In this paper, the major merits and the construction of the machine are introduced.

2. Merits

The appearance of a multi-purpose food vending machine is shown in Fig. 1, and the merits thereof are described as follows:

(1) Because the rack-mounted commodities are delivered to a delivery port via the commodity catcher system, the commodities are transported gently, which is reassuring to the consumers.

(2) Two types of commodity racks, namely a double spiral type rack and a swappable conveyer belt type rack, enable the machine to adapt flexibly to variations in commodities according to the consumer's needs.

(3) The machine is equipped with a discounting function that operates according to time intervals and an expiration date setting function for each column, so that the loss due to goods that remain unsold or are past their expiration date can be minimized.

Fig.1 Appearance of a multi-purpose food vending machine

3. Specifications

Specifications of the multi-purpose food vending machines are listed in Table 1.

4. Construction

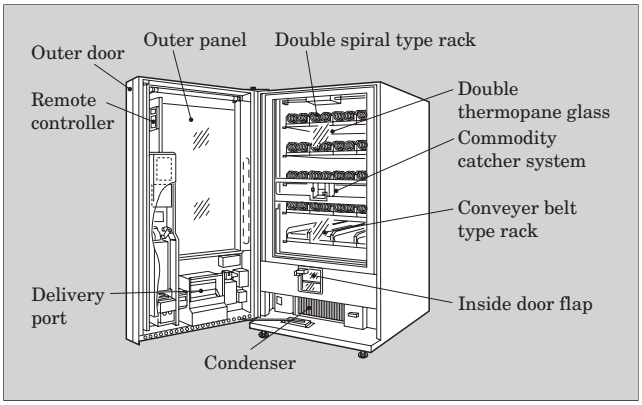
4.1 Overall construction

Figure 2 shows the internal construction of the multi-purpose food vending machine. The commodities are housed in commodity accommodation racks and are stacked in the depth direction. The commodity housing is enclosed by a layer of thermal insulation and the inside temperature is maintained at a temperature set by a remote controller to normal refrigeration (approx. 5°C), weak refrigeration (approx. 18°C), or room temperature. The commodity housing is built with an energy savings construction featuring thermopane glass positioned at the front face of the commodi-

Table 1 Specifications

Item	Specifications
Dimensions	999W×965D×1,832H (mm)
Mass	360 kg
Installation	Indoor installation only
Power supply	100 V AC, 50/60 Hz
Consuming power	501 W/501 W
No. of selections	20 max.
Capacity	300 items
Delivery system	Commodity catcher system
Selection buttons	Ten-digit key
Control system	Distributed system for vending machine
Refrigerant	R-407C
Inner door	Double thermopane glass with film heater
Fluorescent lamp	30 W×1, 32 W×1

Fig.2 Construction of the machine



ty housing so that the consumers are able to observe the desired commodity directly, select it, and then watch the commodity actually being delivered.

The commodity catcher system is positioned at the height of the delivery port during stand-by, and once a selling command is received, the catcher system moves in the X direction (left and right) and the Y direction (up and down) to reach the front of the rack that holds the desired commodity. Once the commodity is delivered from the rack to the catcher system, the catcher system moves to the delivery port to deliver the commodity to the port.

4.2 Commodity catcher system

The construction of the commodity catcher system is shown in Fig. 3. The commodity catcher system is constituted of a commodity bucket mechanism and an X-Y carrying mechanism that moves the bucket mechanism in two dimensions.

4.2.1 Bucket mechanism

The construction of bucket mechanism is shown in Fig. 4. The bucket mechanism performs the following important functions listed below.

(1) Pushes out the bucket gear toward the rack side and connects with the rack gear (Fig. 5).

(2) Transfers torque from the delivering motor to the rack side via coupled rack gear, and delivers the commodity from the rack.

(3) Detects the commodity delivered from rack and

Fig.3 Commodity catcher system

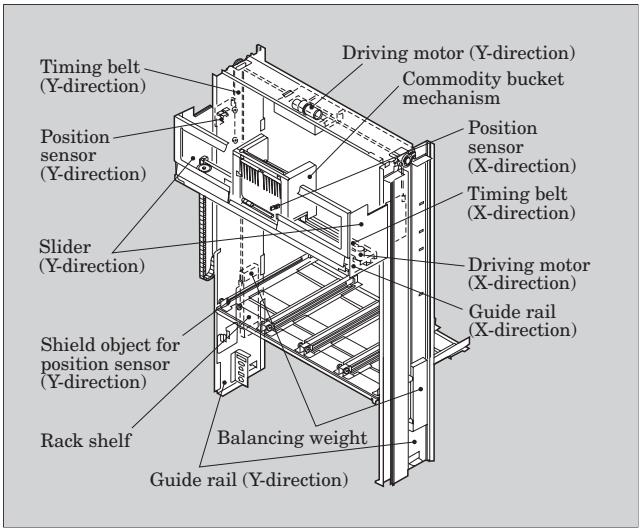


Fig.4 Commodity bucket mechanism

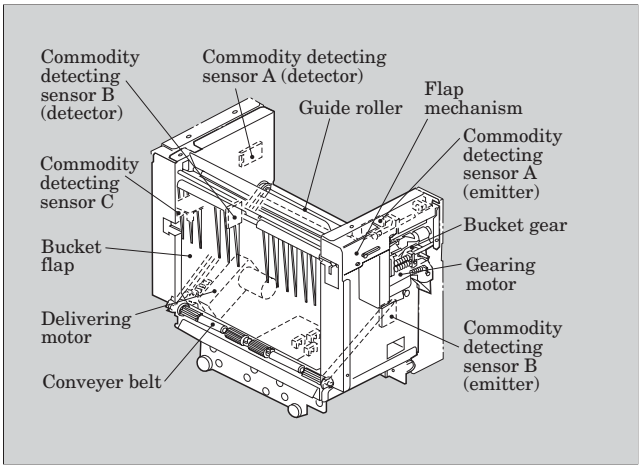
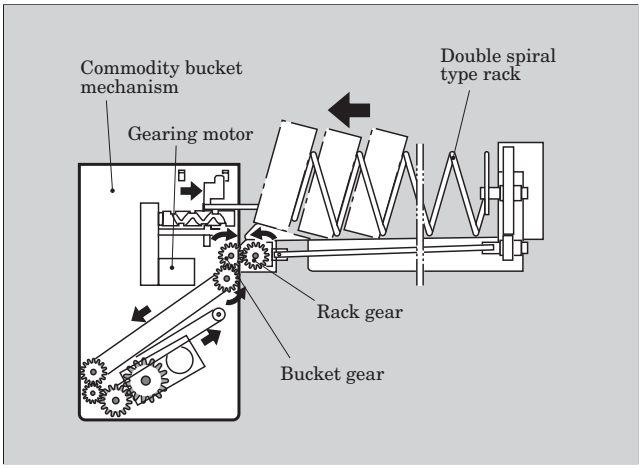


Fig.5 Linking motion of bucket gear and rack gear



houses it in the bucket.

(4) Delivers the housed commodity to the delivery port.

The greatest challenges in this development were how to achieve high reliability and low cost of the commodity detecting section as relating to three of the four functions above, namely functions (2), (3) and (4).

The sensor for detecting that the commodity has been delivered from the rack must be able to detect commodities of various sizes, shapes and mass. Non-contact sensing was studied for this application and finally a transmission type optical sensor was adopted. Because the transmission type optical sensor has a narrow detection range that is limited to the straight line connecting the emitter element and detector element, it is advantageous functionally either to position multiple sensors in close vicinity or to utilize a sensor array; however this causes the problems of misdetection due to interference and of high cost. Therefore, to determine the optimum sensor layout so that the travel path of all commodities is covered with the minimum number of sensors, the delivery motion from the rack to the bucket mechanism was simulated for 10 typical types of commodities. As a result, it was concluded that the commodity detecting section may be constituted from 2 sensors. Figure 6 shows an example of the simulation model.

Delivery from the bucket mechanism to the delivery port is performed by freely dropping the commodity onto a rotating conveyer belt. However, the space between the delivery port and the bucket mechanism is partitioned with two flaps, namely a bucket flap and an inner door flap. This mechanism resulted in a problem for lightweight commodities such as bread, which were trapped by the flaps and not transported to the delivery port. Consequently, in this new machine, the flaps are opened forcibly to clear the commodity path and reliability of the delivery mechanism is improved with low cost through reducing the number of parts by linking this function to the gear coupling motion of the bucket mechanism. Figure 7 shows the opening and shutting motion of the flap mechanism.

4.2.2 X-Y conveyance mechanism

The positioning control of the X-Y conveyance mechanism is performed using an optical sensor. A shield for the sensor is provided along the X-Y rails at a location corresponding to the position of the rack and delivery port. This shield is read out by optical sensors located in moving mechanisms in the X and Y directions (the bucket mechanism moves in the X direction and the slide mechanism moves in the Y direction). The signals thus obtained are counted to determine the position. The Y-direction sensor shield is connected to a shelf on which rack is mounted, and the shelf position and the number of the shelf are recognized by sensing the Y-direction sensor shield in the initial setting mode prior to the start of sales operation. Through this mechanism, commodities that could not be sold with the initial setting due to their large height are now able to be handled by changing the position of the rack shelf without complicated setting (refer to Fig. 3).

Fig.6 Modeled simulation of delivery

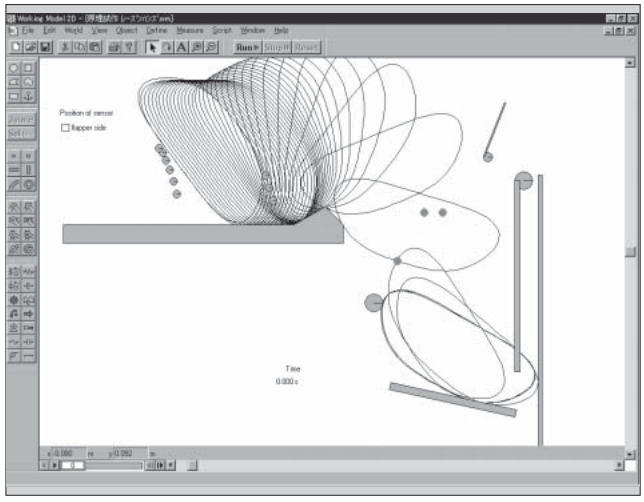
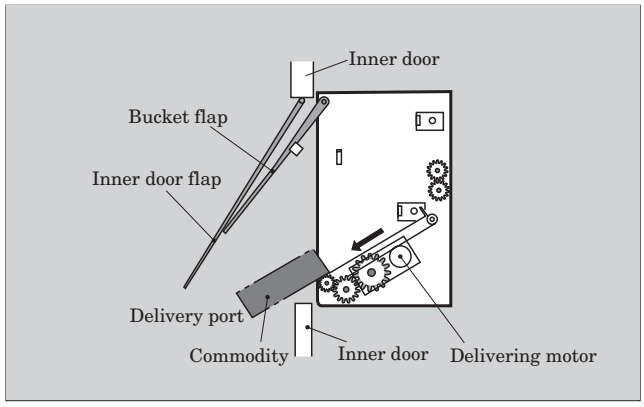


Fig.7 Motion of flap mechanism



4.3 Commodity housing rack

Figures 8 and 9 show the construction of the conveyer belt type rack and double spiral type rack, respectively.

The conventional rack is equipped with a commodity delivering motor and delivery detecting switch, and thus has the disadvantages of high cost and unfavorable handling ability due to heavy weight. In this new machine, since the driving power source as well as the commodity delivery and sold out detecting functions are mounted on the bucket mechanism and no electrical device is mounted on the rack side at all, the rack is lightweight, which provides favorable operating ability with racks that are easy to pull out or exchange, are easy to clean up and have superior maintainability. In addition, through the exhaustive concentration of functions, the number of parts has been reduced and low cost realized.

4.3.1 Conveyer belt type rack

The conveyer belt type rack was developed to sell

Fig.8 Conveyer belt type rack

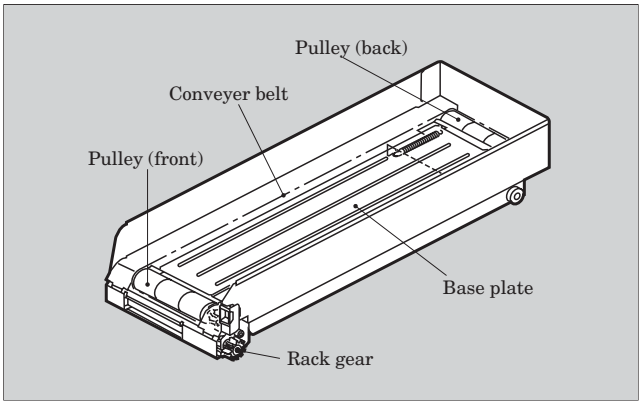
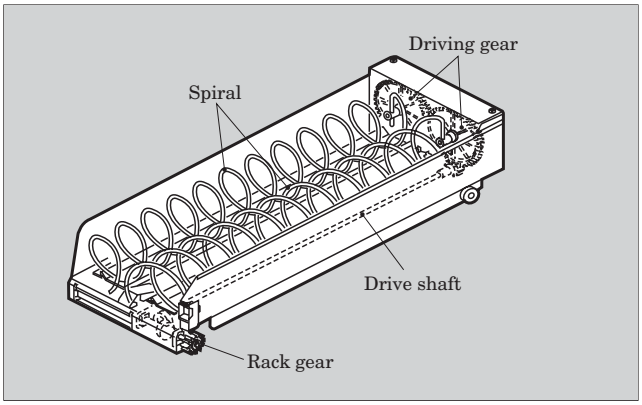


Fig.9 Double spiral type rack



those particular commodities that could not be accommodated in the double spiral type rack, such as prepackaged lunches in a plastic case or triangular-shaped sandwiches, or commodities whose commercial value is spoiled due to damage of their shape at delivery even if they were able to be accommodated in the double spiral type rack.

The commodities are laid flat on an endless belt spanning from the front to back of the rack. The belt rotates, driven by rotation of a rack gear, and the commodity on the belt is conveyed forward and delivered to the bucket mechanism. In the case of a commodity with heavy mass such as a prepackaged lunch, excess frictional force between the belt and the base plate caused the problem of overloading the delivery motor of the bucket mechanism that drives the rack. To solve this problem, ribs are provided at the base plate to decrease the contact area between the belt and the base plate and reduce the frictional force by exchanging the base plate material with other material having good lubricity, so that the allowable total mass of commodities per rack of 2.5 kg is realized.

Because the function for detecting commodity delivery is not provided on the rack side, belt rotation is suspended when a detection signal is received from the commodity detecting sensor of the bucket mechanism. However, the position on the suspended rack of the commodity to be sold next time is not constant, in particular, a commodity having long length will be suspended at the rear of the rack and therefore consumers will have difficulty in observing it. By making it possible to set the time interval between commodity detection and belt suspension from a remote controller, the position of the commodity to be sold next time can be controlled and the commodity recognition improved.

4.3.2 Double spiral type rack

The double spiral type rack is appropriate for those commodities in which the commodity accommodating efficiency is lowered if they are laid flat due to their small height, or cannot be laid flat due to an irregular shape. Since the left and right spirals are constructed symmetrically, commodities that are accommodated between the spirals are pushed out one-by-one by the forward rotation of the spiral and delivered to the bucket mechanism. Four types of spirals having different sized accommodating sections are provided, and the spiral appropriate to the commodity to be sold is mounted in the rack and used. The configuration of component parts is simplified so that spirals can be replaced with half the work required of conventional machines, and ease of handling is also improved. In addition, functions have been thoroughly concentrated and the number of parts is reduced by 72 % compared with conventional technology.

4.4 Value added functions

In businesses handling daily delivered commodities such as breads or prepackaged lunches, the handling of commodities close to their expiration date has been challenging from the perspective of The Food Sanitation Law, and in some cases, commodities are being discarded even before reaching their expiration date. Reducing the number of commodities past their expiration date is important for securing profit, and the same applies to the operation of food vending machines. Taking this fact into account, the following functions can be set easily by the remote controller and realized to reduce loss due to commodities past their expiration dates.

4.4.1 Discounting function according to time interval

The discount rate and time interval can be set so that remainder commodities can be minimized by discounting the commodities as they approach their expiration date or by applying discounts outside normal working hours.

4.4.2 Setting function of appreciation limit according to column

Any column can be set to suspend selling at a fixed time on a fixed day of the week, and the subjected commodities will not sold even if their expiration date has passed by while in the vending machine.

4.4.3 Function for indicating quantity sold per time interval

In order to reduce the number of remainder commodities having short expiration time limits such

as prepackaged lunches, it is important to understand the selling trends of each time interval when restocking these commodities. In this machine, in order to realize this function with low cost, the quantity of each commodity sold per hour of the past 24 hours can be printed using a printer connected to the vending machines.

5. Conclusion

An overview of the multi-purpose food vending machine equipped with a commodity catcher system has been presented.

These machines have been favorably received in the marketplace as novel vending machines providing a convenience-store-like experience and their installed base is expanding.

A commodity delivery system able to handle an even greater diversity of sellable commodities will be developed in the future and Fuji Electric will endeavor to develop a series of vending machines that incorporate this delivery system to establish the indoor market as a new frontier.

Finally, we offer our heartfelt thanks to our customers and other concerned people who provided guidance and cooperated in the development of this machine.