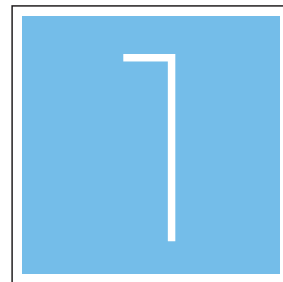
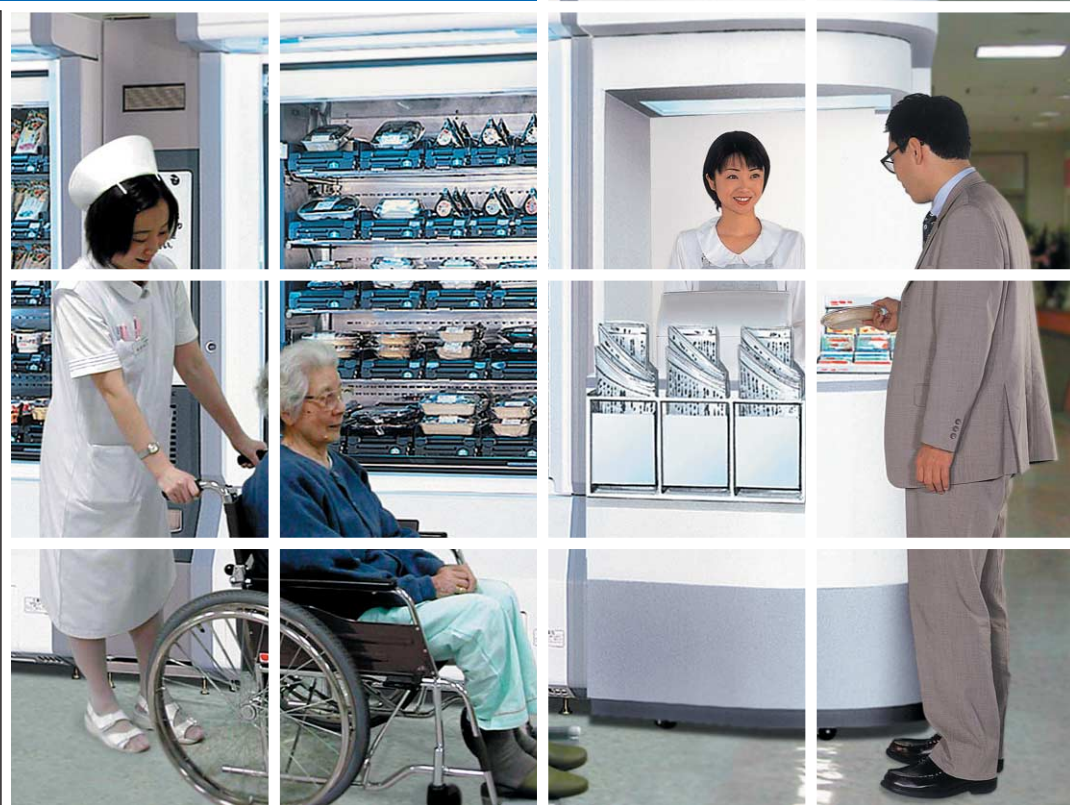


FUJI ELECTRIC REVIEW

Vending Machines
Refrigerated Display Cases



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Integrated ice-heat storage system

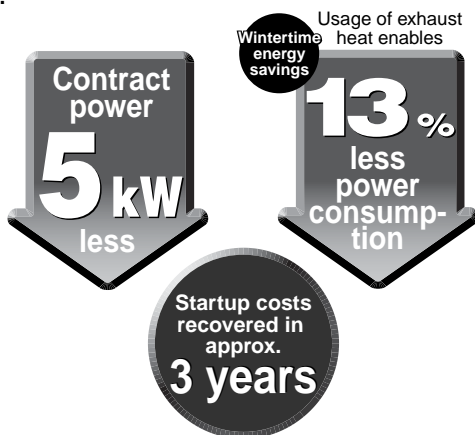
ECOMAXi (ice)

FE
e-Front runners

ECOMAXi is a new integrated thermal storage system.

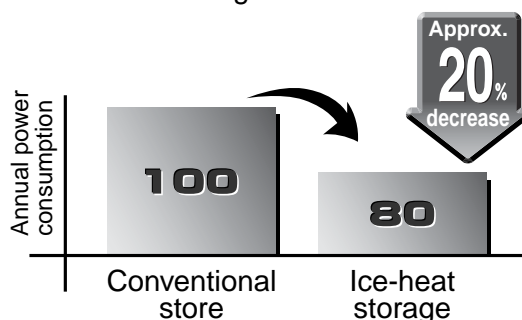
Feature 1 Excellent cost efficiency

Thermal storage enables a 5 kW total decrease in air conditioning and cooling equipment capacity. Startup costs can be recovered in approximately 3 years.



Feature 2 Excellent energy savings effectiveness

20 % reduction in annual running costs achieved due to 30 % peak shift enabled by using ice-heat storage system during summertime and usage of exhaust heat from freezer during wintertime.

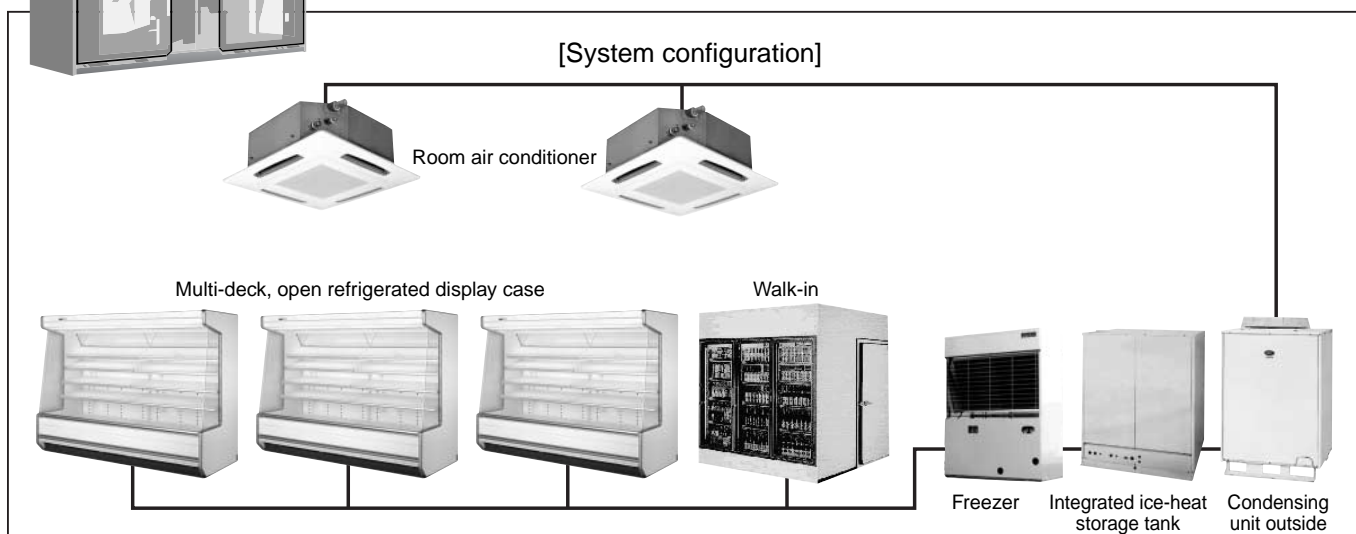


Feature 3 Easy to install

Consolidation of the ice-heat storage tanks for air conditioning- and freezer-use enables easy installation and requires less space.



A single ice-heat storage tank links the air conditioner and freezer, enabling energy to be used more effectively.



All figures are in comparison to prior Fuji Electric items.

Fuji Electric's Total Plan Producer for Food Distribution

FUJI ELECTRIC REVIEW

Vending Machines
Refrigerated Display Cases

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Cover photo:

Vending machines are ubiquitous in present day Japanese society and have become essential for the support of our daily lifestyle. Due to work welfare considerations, in facilities such as hospital, hotels, schools, and private companies, the majority of installations employ an attendant. Consequently, there is strong demand for vending machines having lower operating cost and higher profitability, without sacrificing convenience.

The "dual performance store machine" provided by Fuji Electric is a new concept, mini-store that performs the dual role of vending machine and open display case. During busy times, such as lunch-time, the machine can be used attended, and during off-hours such as late night, it can provide unattended services, resulting in efficient operation of the store equipment.

The cover photo depicts an image of a "dual performance store machine" installed in a hospital. Similar to a general concession stand, the "dual performance store machine" enables visual confirmation and purchase of a wide variety of products, and is structured to provide reliable food sanitation.

Present Status and Future Prospects of Vending Machines

Tooru Kajimura
Nobuhiko Kametani
Toshihisa Miyagishi

1. Introduction

According to the Japan Vending Machine Manufacturers Association (JVMA), the number of installed vending machines and automatic service equipment in Japan has exceeded 5.6 million units, and annual sales of a variety of sold merchandise and offered service has exceeded 7.1 trillion yen. On average, there is one vending machine per 23 Japanese people and the per capita sales is 56,000 yen. Vending machines have become very popular among Japanese and have become an indispensable part of our daily life.

On the other hand, the volume of shipments, which after peaking in 1989, had decreased until hitting bottom in 1994 and then increased until 1998, driven by replacement demand. Since 1998, however, demand has been decreasing again, and in the first half of fiscal 2001 year, the actual volume of shipments across the vending machine industry was 89 % of the previous year's figure.

This paper describes the transition of Japan's vending machine industry, Fuji Electric's product development and future prospects.

2. Present Status and Transition of Vending Machine Industry

Figure 1 shows the number of installed vending machines by type, and Fig. 2 shows the percentage breakdown of merchandise sales. Figure 3 shows the transition of the number of installed vending machines and annual merchandise sales. Figure 4 shows the transition of annual shipment volume and shipment value of vending machines.

As shown in Fig. 3, the number of installed vending machines and total annual sales are increasing, although very gradually.

Figure 2 shows that 40 % of sales are from beverages, but as shown in Fig. 5, beverage sales by vending machines are on the decrease and beverage sales by convenience stores and mass merchandisers are on the increase. The sales of beverage by vending machines in fiscal 2000 year was 97.5 % compared to the previous year. With regard to beverages, the

Fig.1 The number of installed vending machines by type (as of the end of Dec. 2000)
(Japan Vending Machine Manufacturers Association)

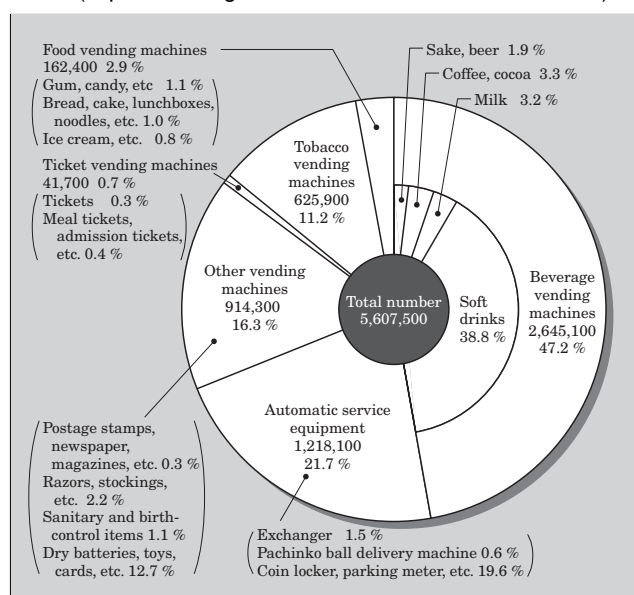
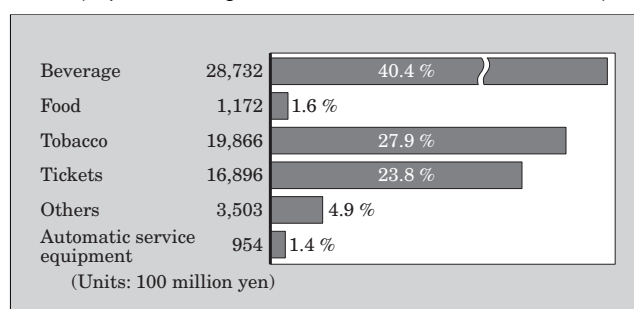


Fig.2 Annual sales and percentage breakdown of merchandise by type (Jan. to Dec. 2000)
(Japan Vending Machine Manufacturers Association)



number of installed machines is increasing but the sales amount is decreasing; that is, per machine sales are decreasing.

Because of reduced sales and profitability, beverage manufacturers are increasingly cutting investment in vending machines.

Thus, as shown in Fig. 4, since 1998, the shipment

Fig.3 Transition of the number of installed vending machines and annual sales of merchandise (Japan Vending Machine Manufacturers Association)

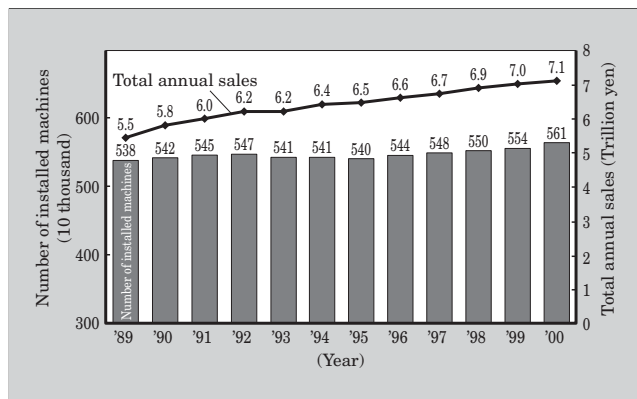
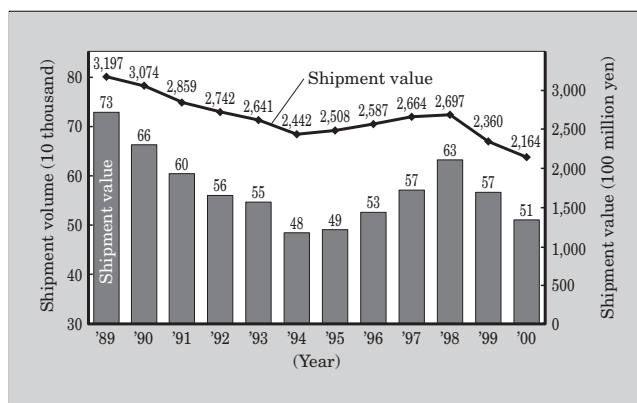


Fig.4 Transition of the shipment volume and value of vending machines (Japan Vending Machine Manufacturers Association)



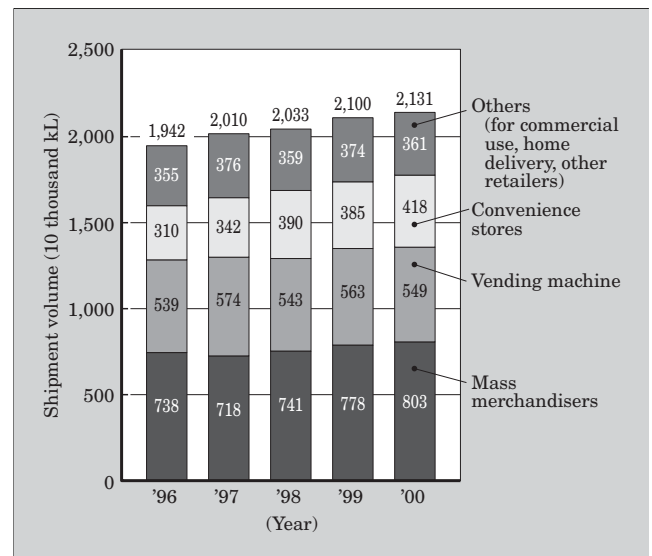
volume of vending machines has been on the decrease, but as shown in Fig. 3, the number of installed vending machines is increasing slightly. The reason for this discrepancy is that vending machines already in operation are being overhauled and their exterior parts such as doors are renewed to elongate their service life, leading to a reduction in investment outlays while maintaining the number of installed vending machines.

Customers are strengthening the drive to purchase as low-priced products as possible through introducing a group purchasing system with participation by several companies and by continuing to use the same-model for several years without upgrading to a new model every year.

Under the market conditions of sluggish per-machine sales, operating companies compete amongst each other to secure good locations for sales. However, because of fierce competition, the fee for reserving a good location and rebates on sales are sharply rising every year, reducing operating companies' profits.

The present harsh market conditions are expected to continue for the next several years. Thus, it will be necessary to increase per-machine revenue and to

Fig.5 Transition of shipment volume of beverage by distribution channel



reduce the operating cost of vending machines. Accordingly, improvement in efficiency of vending machines will be accelerated by using information technology.

On the other hand, there is a promising opportunity arising from compliance with an intensified drive for prohibiting the sale of tobacco to minors, the Tobacco Institution of Japan (TIOJ) is planning to replace present vending machines with machines having a function to identify customers' ages using IC cards not later than 2008.

3. Fuji Electric's Present Status of Vending Machine

Fuji Electric manufactures goods-vending machines such as for food and beverage, food service equipment, peripheral equipment such as coin-and currency-related equipment and POS (point of sales) systems, and vending machines that can accept various cards. This paper describes market needs in these fields including social responsibilities and Fuji Electric's product development to address these needs.

3.1 Social responsibilities and market needs for vending machines

Vending machines in Japan have made unparalleled progress and are providing a great number of people with convenience in the streets. The magnitude of their number, however, requires various social responsibilities and environmental awareness of vending machines.

(1) Environmentally friendly vending machines

Vending machines are specified as designated equipment under the Law Concerning Rational Use of Energy (the Energy-saving Law). It is necessary to develop more energy-efficient vending machines by

benchmarking the machines against the best performer in a top runner approach.

It is also necessary to accelerate the development of vending machines using natural refrigerant having a low global warming coefficient. Greater attention is increasingly given to environmentally friendly vending machines.

(2) Recycling production system

Enhancement of the three Rs (recycling, reduction in size and reuse) of vending machines is required from the viewpoint of prevention of environmental disruption. It is necessary for the vending machine industry to promote and upgrade the recycling system.

(3) Anticrime measures

There seems to be no end to crimes such as theft by forcibly breaking open the door or using counterfeit coin slugs, necessitating a more intelligent coin mechanism and a bill validator to reject slugs and forged bills, and reinforced housings to withstand vandalism. The development of a vending-machine crime reporting network system is now in its testing stage and is expected to be commercialized soon.

(4) Promotion of the application of IT

As part of the application of IT to vending machines, Fuji Electric has developed a Java* platform. In the future, further application of IT to vending machines is strongly desired to address customer needs, to reduce operating costs and to develop new systems for promoting sales of merchandise.

(5) Development for increasing per-machine sales

Fuji Electric was the first in the world to develop cup vending machines that automatically capped the cups in which beverages were served. This type of enhancement to the commercial value of merchandise that leads to increased per-machine sales is strongly desired, such as through giving priority to taste to compete with specialized niche coffee shops.

(6) New fields for vending machines

Fuji Electric has developed vending machines for such locations as booths in workplaces and hospitals, allowing changeover between manned operation during periods of time when there are many customers and unmanned operation during periods of time with few customers, in order to develop a new market for vending machines with a revolutionary idea.

3.2 Present status of Fuji Electric's new product development

3.2.1 Introduction of an information network into vending machines

With the rapid progress of the Internet technology, the introduction of information technology into vending machines is accelerated. The introduction of IT is expected to transform vending machines from machines only selling merchandise to machines capable of providing new services.

As a leading manufacturer in the industry, Fuji Electric was one of the first to start developing vending machines designed for the Internet, and has already developed a machine provided with a message board on its front panel using an LED (light emitting diode) system.

In addition, Fuji Electric has developed a Java mounting system utilizing state of the art technology, and established a platform to support various applications. Java can provide a processor- and OS-independent operating environment that is separate from the basic control unit of the vending machines. Java is a high quality, object-oriented programming language that enables the efficient development of software.

In the past, functions were added or modified by rewriting ROMs, which took a long time and had many restrictions. The development of a Java system allows functions to be dynamically changed and software to be updated from a network or a handy terminal. That is, information acquisition from the Internet using a portable digital assistant (PDA) facilitates real-time communication and route management, such as quality control and preventive maintenance, the reporting of malfunctions, and anticipated sellout. As a result, sales efficiency has substantially been improved, and it has also become possible to broadcast advertising images and emergency information. Furthermore, Fuji Electric is promoting the development and commercialization of new Java applications to various fields, such as cashless shopping and point of sale services, which are accessible from a mobile phone, to increase per-machine sales and marketing support through analysis of demand for merchandise and customers' trends.

3.2.2 Can and bottle vending machines

The primary challenges for can and bottle vending machines is to comply with environmental regulations pursuant to the Energy-Saving Law, to support an increasingly diversifying range of containers, and to reduce life cycle cost.

Since 1995, to help curb global warming, Fuji Electric has been developing energy-saving vending machines. Because vending machines are specified as designated equipment and thus their targeted values are clearly defined, Fuji Electric is now vigorously promoting the development of energy-saving vending machines.

In order to satisfy two conflicting requests from beverage manufacturers, for as much storage capacity as possible and as little power consumption as possible, Fuji Electric is promoting the reduction of environmental impact from the production stage using life-cycle assessment (LCA) in a joint research project with a university, and is promoting optimization of the heat insulation structure and efficiency improvement of the refrigerator system based on thermal conduction analysis.

As for non-Freon vending machines, Fuji Electric has already completed the change to alternative Freon

*: Java is a registered trademark of Sun Microsystems, Inc.

(HFC-407C: zero-ozone-depletion potential), and is promoting the use of natural refrigerant having a smaller global warming coefficient. In addition, Fuji Electric has completed the technological development of an alternative for the blowing agent in hard polyurethane foam, which is now in the preliminary stage for application to products.

PET (polyethylene terephthalate) bottles introduced around 1997 have become more and more widely used, and new products using distinctively shaped PET bottles, such as cylindrical and prism types, are available, mostly in 500 mL bottle sizes. Fuji Electric is developing an adjustment-free merchandise-selling mechanism to provide vending machines that are easy-to-operate and capable of selling a variety of merchandise.

Fuji Electric has developed a super-smart rack that incorporates Fuji's unique "posture control of goods" concept, based on the falling motion analysis of merchandise using CAE (computer-aided engineering), to obviate the necessity for changing thin and thick racks both at the product insert and outlet, and to eliminate blocking and congestion of cans in the storage racks. The super-smart rack is provided with a newly developed solenoid-drive mechanism, enabling fast sales and providing strong resistance to vandalism such as attempts to remove the goods without paying.

In 2002-model machines, anti-vandalism measures are intensified through strengthening the guarding boards and structure of 2001 model machines.

3.2.3 Cup vending machines

Cup vending machines have been introduced chiefly into workplaces, but per-machine sales continue to see sluggish growth. Meanwhile, to meet customers' strong demand for good-tasting coffee, such as espresso coffee, Fuji Electric is helping to revitalize the vending-machine market through providing vending machines which can serve beverages of the customers' desired taste, on the spot and quickly.

To serve good-tasting regular coffee and authentic, strong espresso coffee, Fuji Electric developed and commercialized vending machines featuring a hybrid brewing mechanism that changes the extraction pressure according to each kind of coffee and is provided with an automatic capping mechanism to facilitate carrying after preparation. Since, Fuji Electric developed such a new mechanism to securely mount flammable polyethylene caps one at a time in a cup-dropping system to prevent contents from spilling and to preserve flavor, vending machines equipped with this mechanism are valued by the market as hygienic and easy-to-operate, and can be installed in hospitals and computerized offices. In the future, Fuji Electric intends to develop and serialize this mechanism so as to be able to handle cups with drinking tabs and cups for which a straw can be used, including application to a direct cup mixing system.

Fuji Electric is determined to strive to improve the

operability of vending machines and the flavor of merchandise, from the viewpoint of consumers, for the purpose of revitalizing the cup vending machine market.

3.2.4 Food service equipment

In the field of food service equipment, Fuji Electric is developing vending machines, giving the highest priority to the flavor of food.

Fuji Electric installed a newly-developed automatic valve in a soft drink dispenser, enabling dilution at a fixed rate even if the temperature of the raw materials varies, and developed an optimum mixing method based on the results of analysis of the CO₂ distribution between a carbonator and a mixing nozzle. As a result, Fuji Electric developed and commercialized a carbonator system, which enabled sales of carbonated beverage with high carbon dioxide solubility, superior to that of competitors, and is promoting the application of this system to new-model vending machines for Chu-hi (Shochu mixed with soda water) and a variety of liquors.

As a venture into a new field, Fuji Electric is also developing a coffee machine for commercial use. This machine can serve palatable, full-bodied regular coffee using a newly-developed reduced-pressure extraction system and a paper-filter dripping system using a roll-type paper filter.

Fuji Electric will continue to develop food service equipment as an offshoot of its vending machine business.

3.2.5 New field products

Fuji Electric has developed new field products, for which component technologies can be utilized, such as a "vendor showcase for dual performance store," which allows changeover between attended and unattended services depending on the number of customers and busyness of operation, and a "multi-purpose food vending machine" for bread, rice balls and lunch boxes, which provides a catch mechanism to retrieve merchandise on spiral racks and conveyer racks.

Fuji Electric will continue to develop these new field products, utilizing the acquired mature technology of vending machines. The market for new field products is expected to grow.

4. Future Prospects

Driven by the concept of "convenience anytime and anywhere," nearly the same number of vending machines has been installed in the small area of Japan as throughout the US. With increased public concern about the environment, it is imperative to pursue harmony between environment-friendly and human-friendly products.

Vending machines having growth potential include entertainment-oriented vending machines that provide the pleasure of looking at and of choosing merchandise, in addition to the pleasure of buying, are easy to

operate and feature universal- and barrier-free-design, anti-disaster vending machines which serve free various drinks in case of an emergency, and Java-compatible vending machines which recognize sold out or failure conditions from a remote location and react to realize optimum operation.

Concerning environment prevention, in addition to energy conservation and countermeasures against Freon, the campaign for recycling and reuse of used vending machines will become intensified through the elongation of products' service life, and through the adoption and expansion of policies promoting the reuse of parts.

5. Conclusion

This paper described the present status of Fuji Electric's product development, and presented a general view of the present status and transition of the vending machine industry.

In the past, Fuji Electric has constantly made efforts to become a leading "most valuable service provider." In the future, to response to the so-called three keywords of this era, "humans, spirit and environment," Fuji Electric is determined to do its very best to develop human-friendly and environment-friendly vending machines and systems, with creative ingenuity, to further develop vending machines and to survive the age of structural market change.

In addressing environmental concerns, because the issues of parts reuse and recycling of used vending machines cannot be resolved only by vending machine manufacturers themselves, Fuji Electric is determined to resolve these issues in a joint effort with all the parties concerned, such as industry groups, beverage manufacturers, operators, installation companies, and location owners.

Fuji Electric requests continued assistance and guidance from all concerned parties.



Small-sized, Hot and Cold Cup Vending Machine

Toshio Takagi
Koji Mori
Akitoshi Takano

1. Introduction

Since developing the “combination cup” vending machine in 1981, Fuji Electric has continued to develop new types of machines and new mechanisms in response to the changing needs of the marketplace.

Recently, as the outdoor installation of vending machines has almost reached saturation level, most vending machine operators are attempting to create new demand in schools, business complexes, etc., by installing indoor-type vending machines there.

In response to these changed market conditions, Fuji Electric has developed a new type, small-sized hot and cold cup vending machine requiring only a small installation space.

An overview of this type of vending machine is presented below.

2. Background and Objectives of Development

2.1 Background of development

In the last few years, expansion of the cup vending machine installed base has slowed due to decreasing sales profit per machine. Moreover, the market is beginning to show signs of a shift from large- and medium-sized machines to small-sized machines. This shift is probably caused by the following factors:

- (1) decrease in sales due to prolonged economic stagnation,
- (2) entrance of can vending machines into the indoor installation market and
- (3) diversification of consumers' taste, leading to increased purchases of canned beverages.

In light of these circumstances, Fuji Electric has worked to develop the “FBR151,” a small-sized, hot and cold cup vending machine that aims to invigorate the market for cup vending machines by increasing beverage sales from cup vending machines and creating demand for replacing existing hot cup vending machines with this model due to the savings of installation space.

2.2 Development objectives

- (1) Smallest width of any machine in the industry

that can vend syrup beverages and is equipped with hot and cold functions

- (2) Low price that enables installation in small-scale locations and provides profitability to operators easily
- (3) Good handling performance and easiness to clean to facilitate route service
- (4) Cheerful door design to attract customers

3. Special Features

This newly developed, small-sized, hot and cold cup vending machine realizes the above-mentioned objectives as well as many other functions that satisfy new market demands.

Principal characteristics are as follows:

- (1) Space-saving machine that is only 765 mm wide, the smallest in the industry, with no reduction in the varieties of beverages to vend due to improved construction of the cooling bath and hot water tank.
- (2) Water supply by cartridge tank system requiring no city water system. This is advantageous for installations in small-scale locations where large sales are not expected.
- (3) Syrups are supplied by a BIB (bag in box) system that facilitates syrup replacement operation and improves sanitation.
- (4) Power consumption is reduced compared with the former type of machine due to a newly developed small-sized cooling tank and hot water tank. Moreover, this machine is equipped with a “smart energy saving” function that learns the time intervals when sales increase and controls the operation of the equipment accordingly.
- (5) Machine is equipped with single cup, direct-drop mechanism that can accommodate 500 cups.
- (6) The door contains a coin mechanism cover structure that can be opened through one-touch operation so as to collect money easily and it has a structure that enables a non-kit bill validator to be attached without using parts such as a cosmetic frame.

4. Specifications

A summary of specifications of this type of machine is listed in Table 1.

5. Structure

5.1 Appearance and inner structure

Figure 1 shows the appearance of this small-sized hot and cold cup vending machine. The machine's layout allows easy selection of commodities and the

Table 1 Specifications of the hot and cold cup vending machine

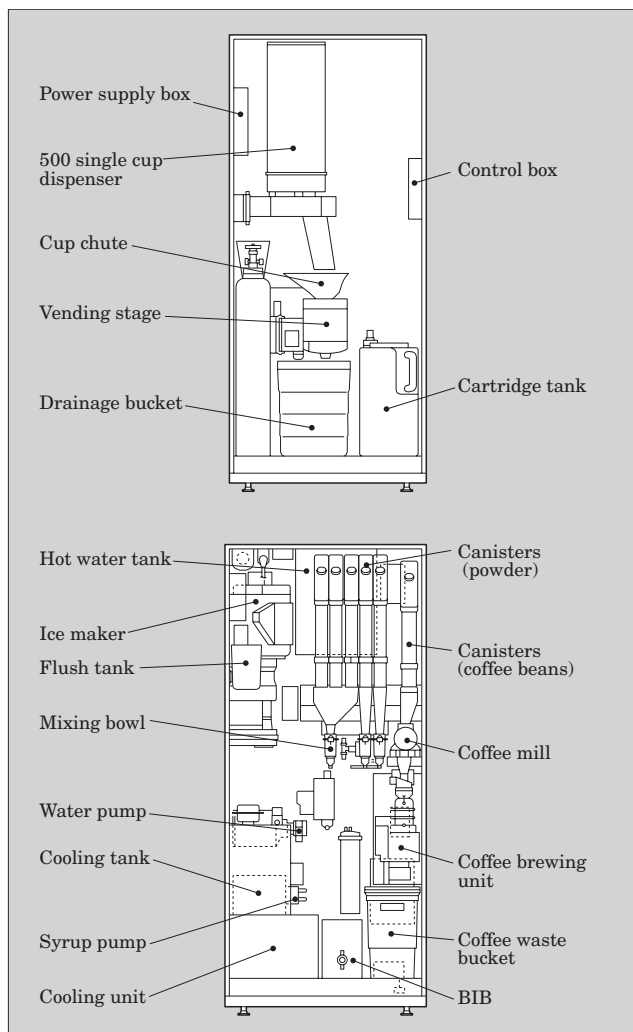
| | | |
|-----------------------------|---|-----------------------------|
| Model | FRB151 (M) | |
| Outer dimensions | Width 765 mm×depth 749 mm×height 1,830 mm | |
| Mass | 240 kg | |
| Power supply | Single phase 100 V, 50/60 Hz, 15 A | |
| Beverages to be vended | 71 kinds/24 buttons | |
| | Syrup | 1 kind |
| | Powder | 1 kind (instant coffee) |
| | | 2 kinds (cocoa, juice e.g.) |
| | Regular | 1 kind (regular coffee) |
| Function button | Increase/decrease buttons for sugar, cream, coffee Buttons for without sugar, without cream Buttons for with/without ice | |
| Materials holding capacity | Syrup | 2.5 gallons |
| | Coffee beans | 4.6 L (1.6 kg) |
| | Cream | 3.6 L (1.8 kg) |
| | Sugar | 3.6 L (3.2 kg) |
| | Instant coffee | 3.6 L (0.7 kg) |
| | Cocoa, juice | 2×3.6 L (3.0 kg) |
| Materials taking-out system | Syrup | Variable pump system + BIB |
| | Powder | Screw taking-out |
| | Coffee beans | Screw taking-out + mill |
| Hot water tank | Tank capacity: 6 L Heater capacity: 950 W | |
| Cooling system | Power: 175 W, Refrigerant: R134a Mass of refrigerant encapsulated: 170 g Compressor: rotary compressor (common to ice maker and water bath) | |
| Cooling tank | 11 L | |
| Ice maker | Ice capacity: 2.1 kg | |
| Coffee brewing unit | Air agitation, air press, paper filter | |
| Cup dispenser | 500 single cup dispenser up to 500 cups×9-oz cup | |
| Water supply system | City water system or cartridge tank system (19 L) | |
| Display and monitoring | LCD display, monitoring for various operations, sell-out, fault detection | |
| Sanitary functions | Sanitation of hot drink system: cold water, hot water rinsing Automatic rinsing: once a day (can be set up for every day) or for preset number of cups vended Automatic rinsing of brewer: once a day (can be set up for every day) | |

handling performance is well suited for use in a wide range of installations, from offices to general-use locations. The illuminated sign has an integral

Fig.1 Appearance of the hot and cold cup vending machine



Fig.2 Inner structure of the hot and cold cup vending machine



construction, which gives a sense of sophistication. Attractiveness and cheerfulness are the basis of our design.

The inner structure, shown in Fig. 2, is designed to have a layout that facilitates the routine replenishment of beverage materials and cups, and enables maintenance inspections to be performed easily. Thus, handling performance is improved.

5.2 Downsizing of mechanisms

Each mechanism has been downsized to develop a small-sized hot and cold cup vending machine requiring about 10 % less installation space than the former type vending machine.

Major improvements are as described below.

5.2.1 Water cooling unit

In order to realize the appropriate width of a machine equipped with hot and cold functions that support with syrup beverage vending, it was important to reduce the volume of the water cooling tank by 30 % compared to former machines.

Additionally, it was necessary to comply with beverage regulations concerning beverage temperature, number of cups continuously vendible, etc., without altering significantly other performance characteristics such as preparation time for cooling (pull-down time) as compared to former machines.

Accordingly, it was necessary to develop a water cooling tank and a cooling unit having performance suitable for use in small-scale locations.

Therefore, the following items were calculated to obtain the required cooling capacity of a motor-driven compressor (which serves to take in the vaporized refrigerant and compress it to raise vapor pressure of the refrigerant so as to facilitate liquefaction in the condenser).

- (1) Heat quantity required to lower the temperature of water in the water cooling tank from 32°C to 0°C
- (2) Heat quantity that must be stored for continuous vending (heat required to generate ice bank)
- (3) Heat input from outside (heat loss)

As a result, downsizing was realized by developing a new 175 W motor-driven compressor instead of the former 300 W compressor, a 3-row 7-stage small-sized condenser in place of the former 3-row 8-stage small-sized condenser (which functions to perform liquefaction by releasing heat obtained by the evaporator and the compressor), a 16-stage 100 mm square water tank evaporator in place of the former 16-stage 135 mm square water tank evaporator (which functions to remove heat from surrounding matter to be cooled using low pressure refrigerant). Figure 3 shows the outer dimensions of this newly developed water cooling device together with those of the former cooling device.

5.2.2 Hot water tank

The hot water tank, shown in Fig. 4, has 40 % less volume than former machines in order to secure the

Fig.3 Water cooling tank of the hot and cold cup vending machine

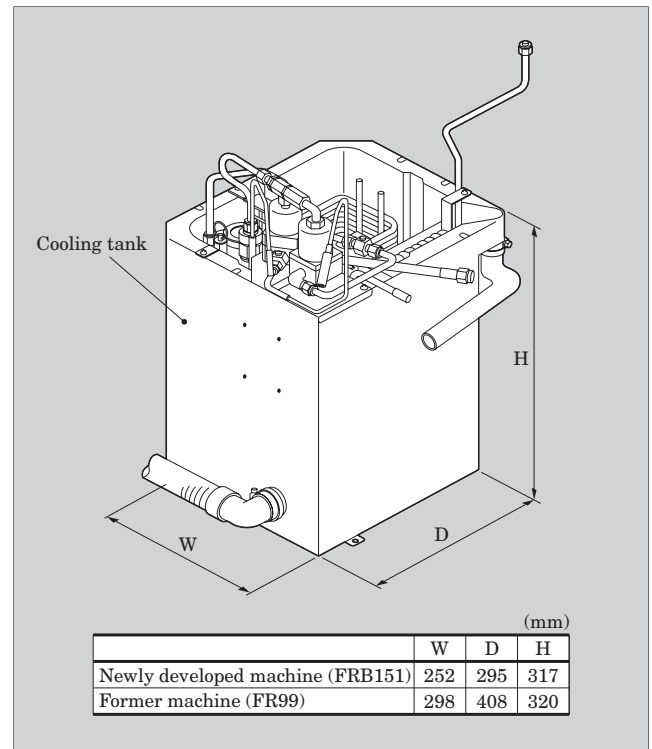
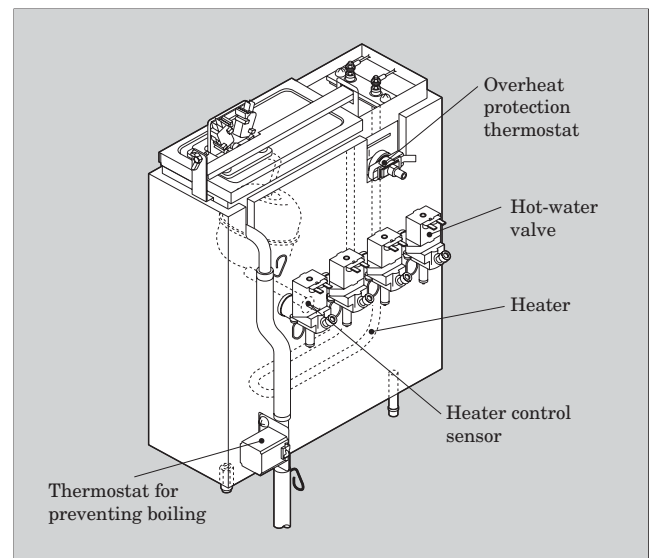


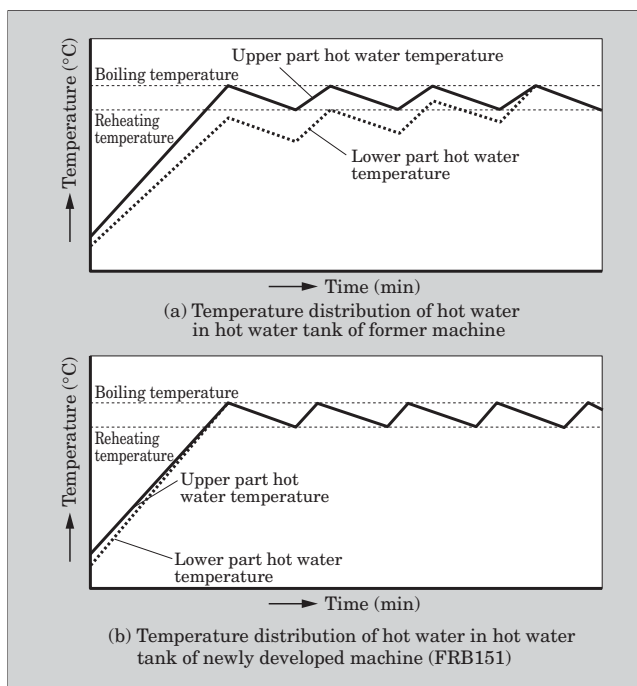
Fig.4 Hot water tank of the hot and cold cup vending machine



necessary effective space within the machine, and moreover, it has a single-heater heating and control system instead of the dual-heater heating and control system of the former machine in order to realize downsizing and cost reduction.

The challenge in complying with beverage regulations concerning beverage temperature, number of cups continuously vendible, etc., by means of a single-heater heating and control system was to achieve a uniform temperature distribution of the hot water in the hot water tank at the time of boiling. This

Fig.5 Temperature distribution in the hot water tank of hot and cold cup vending machine



challenge has been successfully overcome by selecting the heater configuration and position of the heater control sensor. Figure 5 shows the temperature distribution in the hot water tank together with that of the former machine.

Moreover, the on-time ratio has been reduced to 1/3 that of the former machine due to adoption of single-heater heating and control (at an ambient temperature of 10°C), and accordingly, energy saving has been accomplished.

Hot water discharge valves are arranged in a row in front of the machine instead of on the side as in the former machine. Accordingly, handling performance and exchangeability are improved.

5.2.3 Cup dispenser mechanism

A 500 single cup mechanism was developed utilizing the full effective volume within the machine to accommodate a quantity of cups suitable for a machine at a small-scale location. Thus, downsizing is achieved and the route service efficiency is improved.

Recently, the cups' paper quality has been changed to reduce cost, and as a result, cup strength is sometimes degraded. This leads to failure in cup delivery due to the cup being pinched by the conventional spring-driven cup mechanism. Sudden separation of the cups by spring force is the cause of this problem. Accordingly, a cam-driven cup mechanism has been developed to improve the reliability of cup separation. Figure 6 shows the principle of this mechanism. A driving cam attached to a cup motor turns the lever of a cup dropping mechanism to a predetermined position and at the same time, a spring is stretched and fixed to a position determined by the

Fig.6 Principle of motion for cup mechanism of the hot and cold cup vending machine

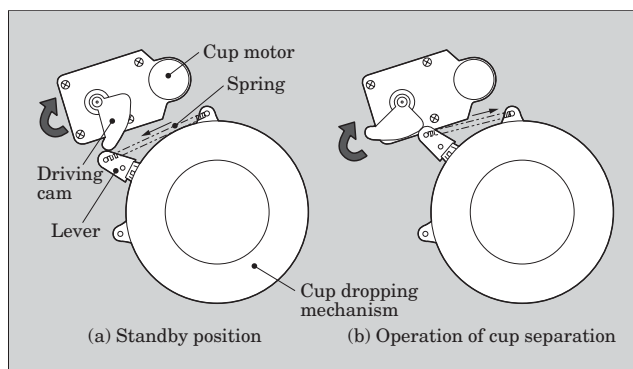
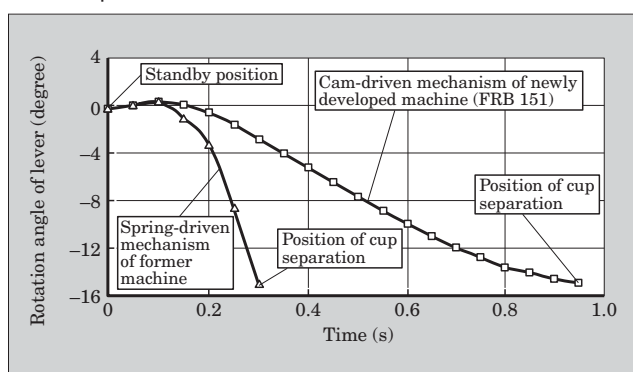


Fig.7 Relation between rotation angle of lever and cup separation time



lever. The spring is held in that position. When a cup vending request occurs, the driving cam turns and the lever is pulled back gradually along the outer contour of the driving cam by means of the spring force. Thus, the cup separating operation is performed and the cup is delivered successfully. In Fig. 7, the relation between rotation angle of the lever and cup separation time is shown in comparison with that of the former machine.

6. Conclusion

An overview of the hot and cold cup vending machine has been presented.

Requirements of cup vending machines from the consumers' standpoint are improvement of taste and diversification of beverage types, and operators' side requirements are the ability to attract customers, and sanitary and low-cost machines suited to highly efficient route service.

In order to keep up with market demand, Fuji Electric intends to continue making efforts to develop cup vending machines acceptable to all consumers and operators that are concerned with cup vending machines.

Lastly, we would like to thank all persons involved for their ongoing guidance and assistance in the development of these machines.

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

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



unsold or are past their expiration date can be minimized.

3. Specifications

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

4. Construction

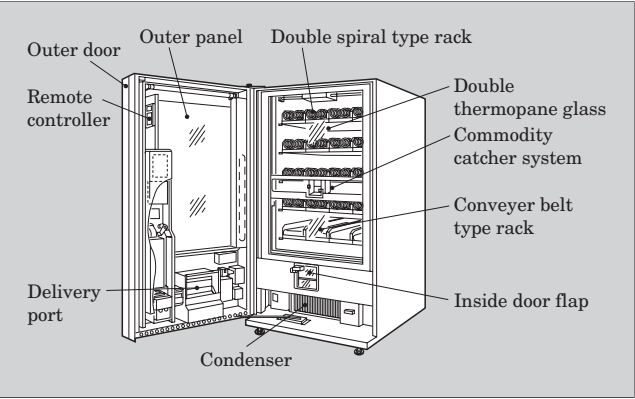
4.1 Overall construction

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 thermo-pane glass positioned at the front face of the commo-

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

Fig.3 Commodity catcher system

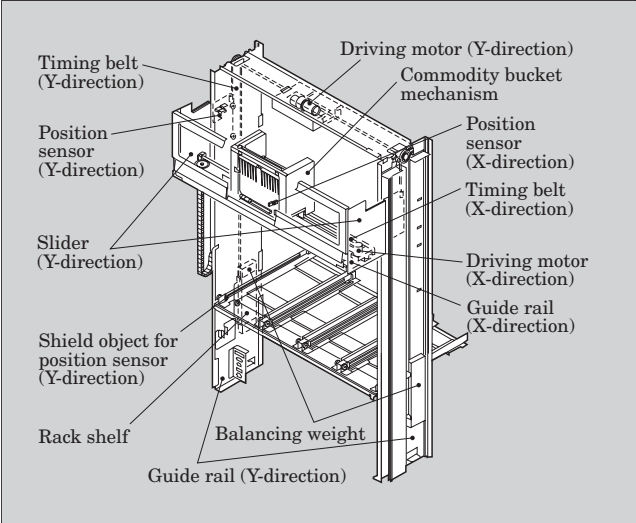


Fig.4 Commodity bucket mechanism

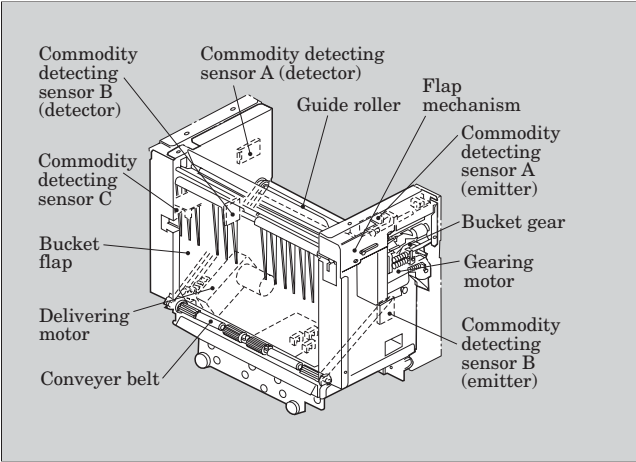
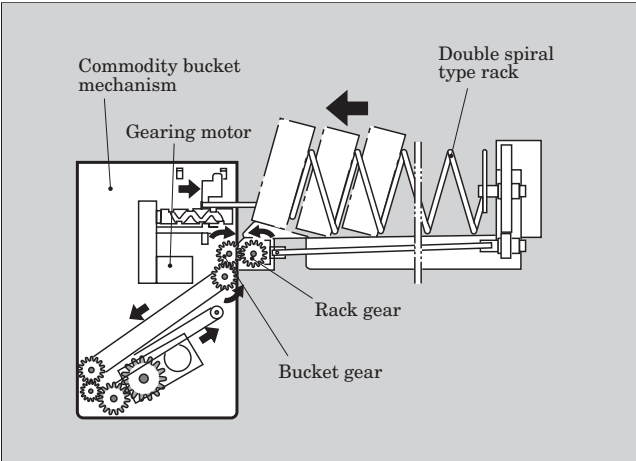


Fig.5 Linking motion of bucket gear and rack gear



- 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

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

Fig.6 Modeled simulation of delivery

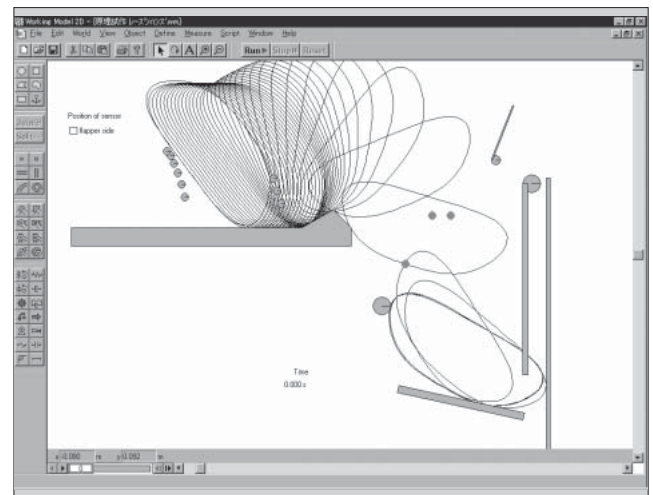
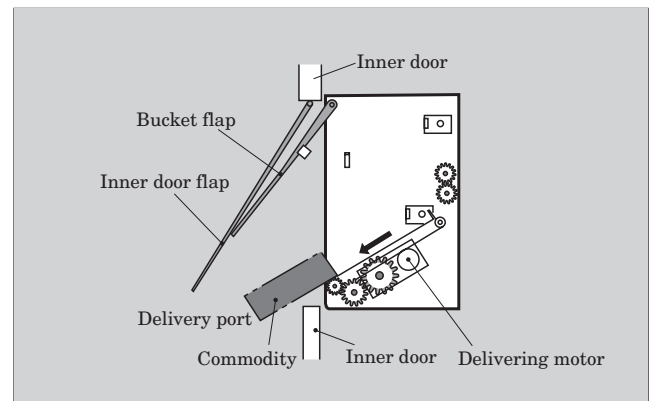


Fig.7 Motion of flap mechanism



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).

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 Conveyor belt type rack

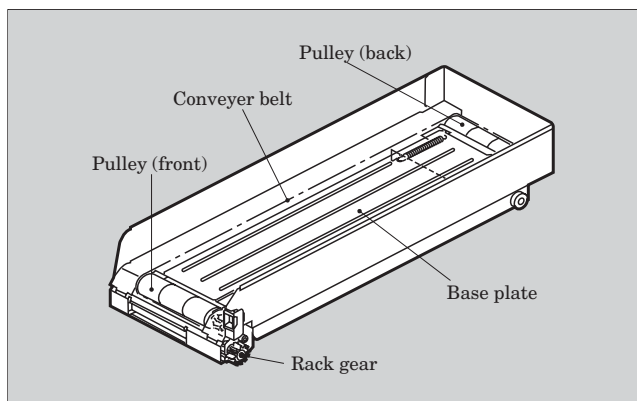
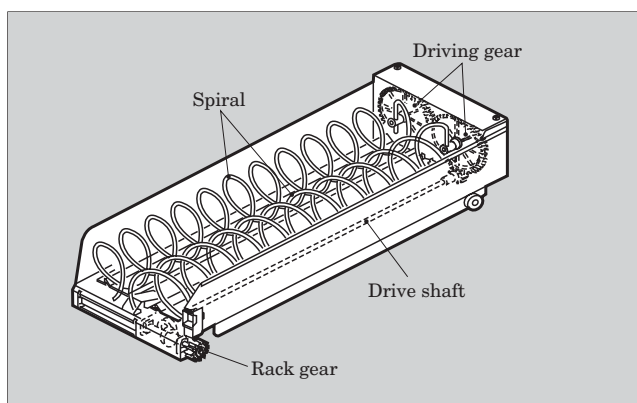


Fig.9 Double spiral type rack



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.



New Series of Can Vending Machines

Haruyuki Ueda
Yoshikazu Saito

1. Introduction

As of December 2002 in Japan, about 2.17 million can vending machines are installed in indoor and outdoor locations. The operators use these can vending machines to sell soft drinks, coffees and teas in PET (polyethylene terephthalate) bottles, cans and bottles in cooled and warmed conditions. Beverage suppliers introduce new products one after another into the market every year and increase the diversity of their containers. Route men and staff employees of beverage suppliers restock and exchange the products being vended and collect and replenish cash reserves. Can vending machines have been traditionally discarded after 6 to 7 years, but today they are used for 7 to 8 years or longer, the longer useful life being supported by overhauling and other types of maintenance.

2. Challenges for Can Vending Machines

2.1 Vending of new products

Such new containers as lightweight containers and containers for small quantity products are put out on the market one after another, and can vending machines must be capable of accommodating them to the extent possible.

2.2 Ease of use by consumers

Can vending machines are widely used by children and adults. In order to be easy to use for all consumers, it is required that the display be easy to understand, money can easily be inserted, products are easy to take out, and that the machine be sanitary.

2.3 Reduction of operation costs of can vending machines

The operators search for cost reduction opportunities in all processes – from purchase, to operation, until disposal of the vending machines. During operation, much cost is required in restocking products, changing of the racks due to product changes, removing jammed products and servicing the doors and cooling units. Accordingly, the construction has been completely redesigned to develop a new series of can

Fig.1 Appearance of new series can vending machines

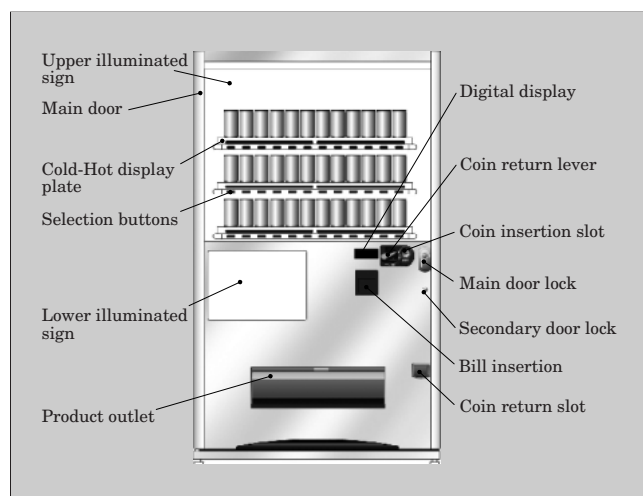
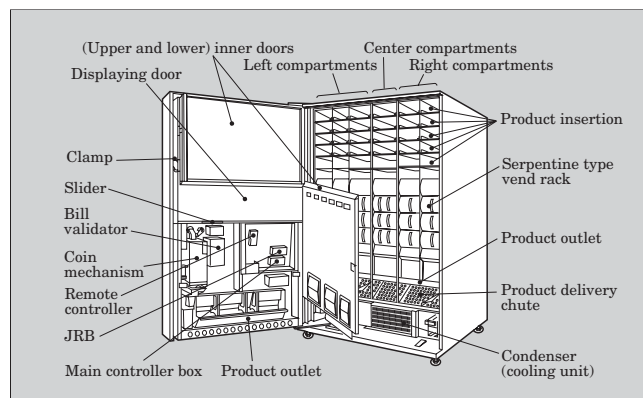


Fig.2 Internal component descriptions



vending machines that are easy to use for users and easy to operate for operators. Figure 1 shows the appearance of the new series of can vending machine. An overview of this new series is presented as follows.

3. Construction and Features of the New Series of Can Vending Machines

The can vending machine construction is grouped into the four blocks of: (1) a door block for displaying products, this block faces consumers, accepts inserted

cash, delivers products and returns change; (2) a rack block for accepting and delivering products; (3) a cabinet block for cooling and warming products; and (4) an electric control block unit for controlling the vending and temperature of products. Figure 2 illustrates the names of internal components with the door opened.

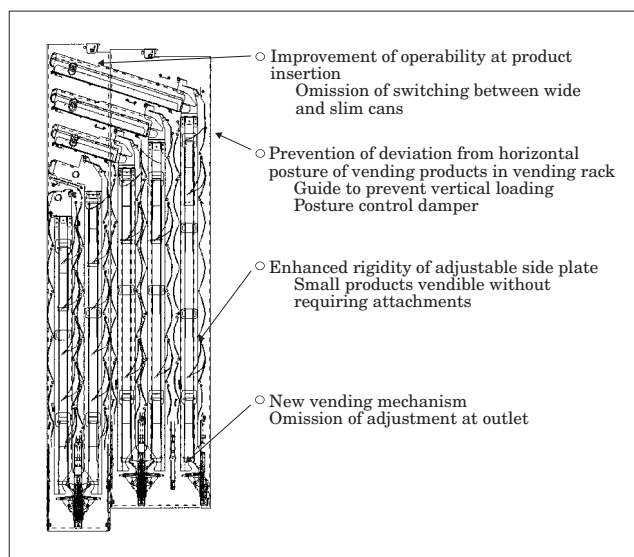
3.1 Rack

Serpentine type vending racks, which have been conventionally installed in vending machines, are said to be easy to use as they enable products to be rolled along the rack from the top. But these serpentine racks always had to be changed whenever the external shape of the product (outer diameter and height) changed. In the newly developed series of can vending machines, no setting change is required at the product outlet and, furthermore, the installed rack does not require any setting for narrow cans at product insertion. The side view of the new rack is shown in Fig. 3 and its features are explained below.

3.1.1 Product outlet

In conventional racks, if products smaller than $\phi 53$ mm are conveyed along a path intended for products wider than $\phi 69$ mm, the products will slip or become jammed. To avoid such troubles, the product path in a vending mechanism (delivery unit) at the rack outlet had to be narrowed so as to fit slim products. Outlet width adjusters (regulating plates) must be operated or attachments (separate components) must be mounted for adjusting the path dimensions. The product paths of a rack are arranged from front to back in rows inside the vending machine. As the number of product paths is increased from 4 to 5, 6 and 7, the location of adjusters or attachments become maximally about 800 mm away from the front side, which makes setting difficult to implement and requires special skills and much cost. To resolve these

Fig.3 Side view of new rack



problems, racks requiring no outlet setting when vending wide products and/or slim products were developed. Figures 4 and 5 show the vending operation of conventional racks and Fig. 6 shows that of new

Fig.4 Vending behavior of conventional rack (wide products with $\phi 66$ mm)

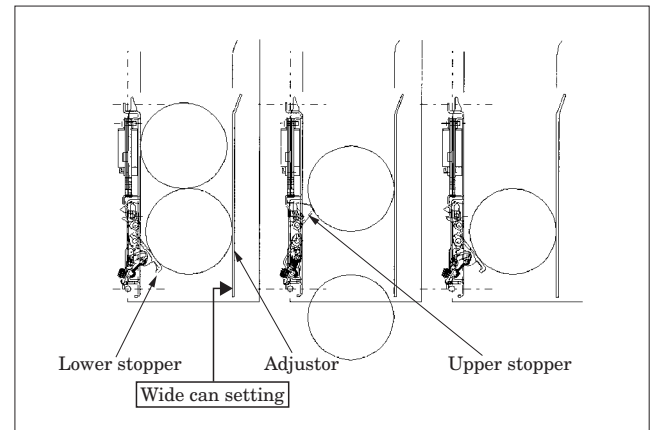


Fig.5 Vending behavior of conventional rack (slim products with $\phi 53$ mm)

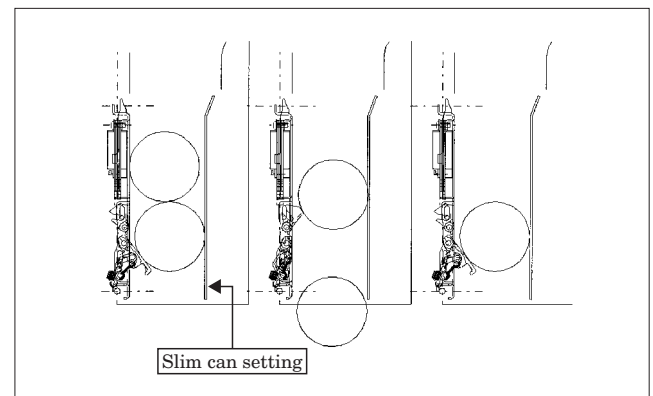
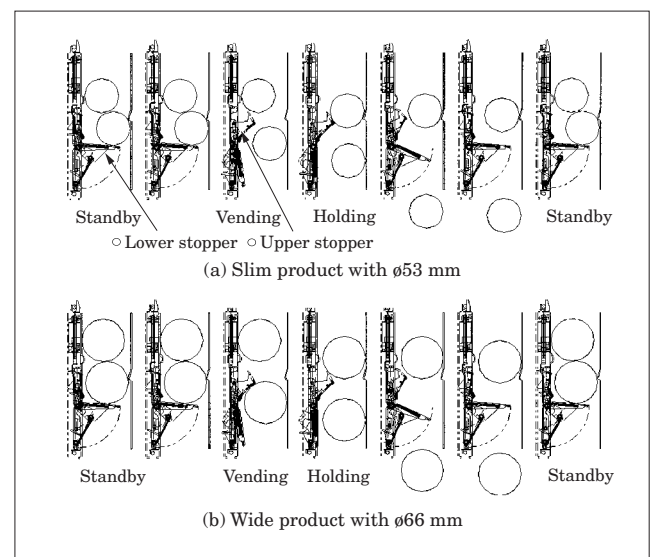


Fig.6 Vending operation of new rack (having no setting change for wide/slim cans)



racks.

(1) Vending operation of a conventional rack

Figure 4 shows the operation of a conventional rack in the case of vending wide cans. In the standby state, all products are supported by a lower stopper that project about 22 mm into the path that is about 70 mm deep. During vending, the solenoid is switched on, the product path is opened by unlocking the lower stopper, a product in the lowest stage is delivered, and the upper stopper is inserted about 14 mm into the product path to hold the products in the second and higher rows. By turning off the solenoid, the lower stopper projects into the product path, the upper stopper opens the product path, and the second and subsequent products move on top of the lower stopper and the rack returns to its standby state. As an upper stopper supports a maximum weight of approximately 8 kg and projects in the direction of the line connecting the rotation axis of the lower stopper with the center of the wide product, that projection is limited to about 14 mm. If slim products ($\phi 53$ mm) are put into the vending machine in this condition, they will slip through the upper stopper. Therefore when vending slim products, paths are set for slim products (about $\phi 56$ mm) by shifting the adjusters in the paths or by installing additional attachments as shown in Fig. 5.

(2) Vending operation of a new rack

Figure 6 shows the vending operation of a new rack. The operating cycle of standby – vending – holding – standby is similar to that of the conventional rack. In the new rack, the projection of the lower stopper was set to be about 54 mm and nearly horizontal, and the projection of the upper stopper was about 25 mm so that slim products could be held, while leaving the path for wide cans unchanged owing to an ingenious link mechanism.

This enabled the vending of slim products along a path configured for wide cans and eliminated the necessity for making setting changes at the rack outlet, thereby simplifying the tasks involved in a product change.

3.1.2 Product insertion

For conventional racks, if wide products are inserted when the racks are set for slim products, the wide products will jam in the narrow path entrance at the outlet and make vending impossible. Also problems would sometimes occur along the main paths of the rack, making vending impossible if slim and short products ($\phi 53$ mm, 200 mL cans, etc.) were vended in a column intended for vending wide products ($\phi 66$ mm, 350 mL cans etc.), as they would turn vertically and become jammed in the product path. Special expert skill was required to solve these problems and resulted in large added cost. For these reasons, when vending slim products, it was necessary to make the main path entrance narrow for the purpose of stacking products horizontally in the rack. These problems were solved through use of a mechanism requiring no outlet setting

and the use of a posture control mechanism at the main path entrance. The posture control mechanism uses a damper to correct the posture of products installed at the entrance of the main path so that they will be aligned horizontally even if they are inserted aslant. The larger the damper moment, the larger the posture control function, but wide and light products jam if the moment is too large. If the damper moment is made too small, products do not jam but the posture control does not function. Therefore the proper damper moment was determined using working models, reliability was verified with video analysis of vending experiments, and a “rack that does not require slim and wide setting at insertion” was installed in a can vending machines for the first time in the market. The construction of the damper installed at the main path entrance is shown in Fig. 7. Figure 8 shows an example of the working models. The left figure shows the 3-D data of the product inserted into the rack, the main path of the rack, and the damper projecting into main path. The graph at right shows data of the change in falling speed and change in product posture after the product begins to fall. The shape and

Fig.7 Product insertion for new rack

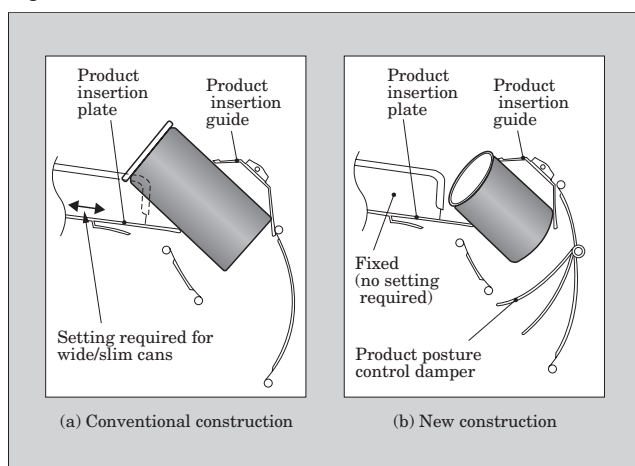
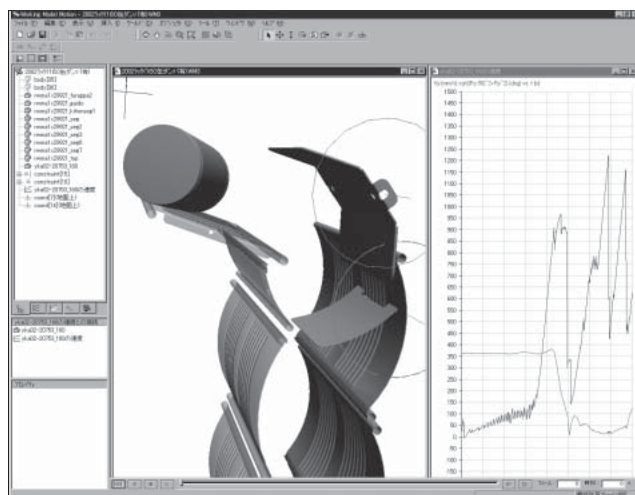


Fig.8 Working model



moment of the damper were determined by simulating the fall of wide and light products intentionally inserted aslant with various damper moments.

3.2 Door

3.2.1 Easy to understand signs

The vending machines were made still easier to use by customers by doubling the size of display characters in the “In service” display indicating that the machine is in service and the “Accepted amount” display indicating the amount of money inserted by the purchaser. Braille lettering was added at the coin insertion slot and coin return lever, and “Consumer use” indications common to all vending machines were added at the product outlet and money insertion slot. Figure 9 shows the money indicator and Braille lettering at the coin insertion slot and Fig. 10 shows the indications for users.

Fig.9 Money amount display and Braille lettering

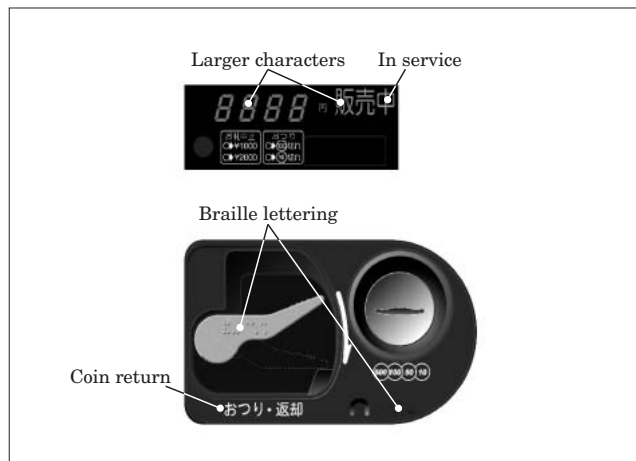


Fig.10 Indications for consumers

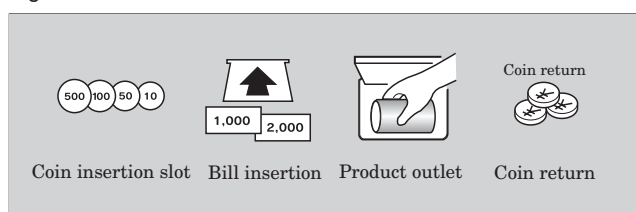
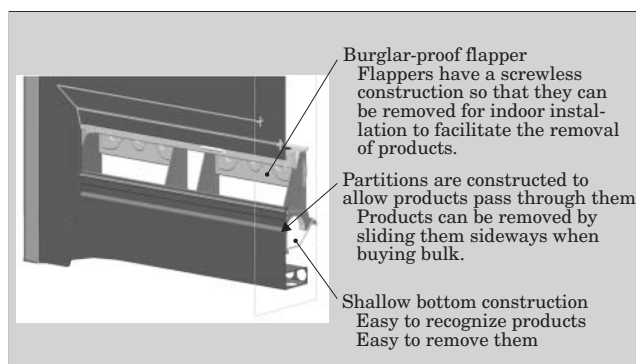


Fig.11 3-D CAD drawing for product outlet



3.2.2 Outlet for easy removal of products

The product outlet from which consumers retrieve products must allow for the easy removal of products even when several items are purchased, and the outlet must be sanitary. The product outlet was developed to have a bottom about 70 mm higher than conventional ones, and was composed of partitions having a passage way, through which the products may be shifted sideways. Raising the standstill height of the products enabled them to become easier to see and to take out. The problem of forming of carbonate drinks was remedied largely by reducing the height that the product falls from the rack outlet. Figure 11 shows a 3-D CAD drawing of the product outlet.

3.2.3 Construction for easy disassembly

The door is disassembled frequently to replace parts damaged by vandalism and the like. Moreover, during an overhaul, the door is disassembled and repainted, and its parts are replaced. Consequently, it is required that the replacement of door parts be performed more easily and with reduced work costs.

Fig.12 Construction of operation mechanism

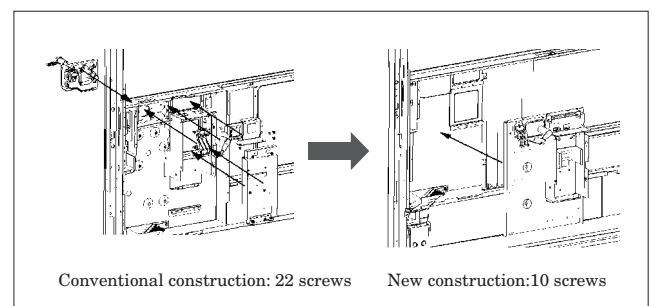


Fig.13 Construction of illuminated sign

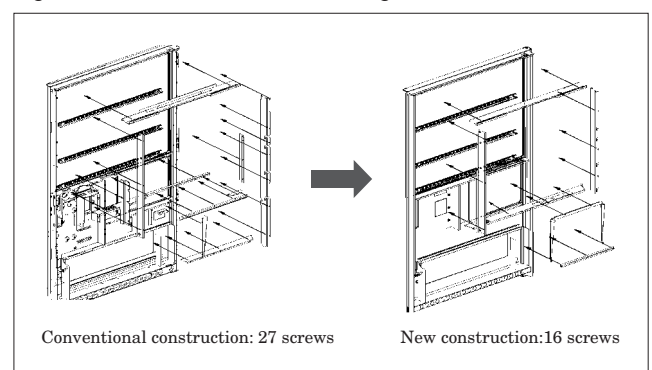
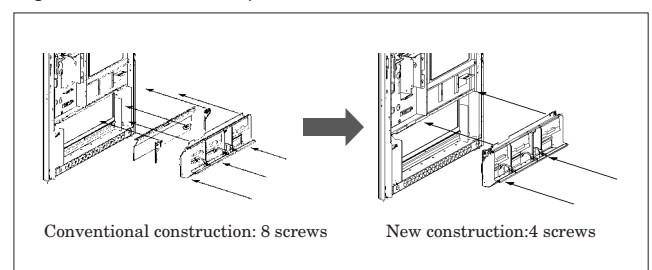


Fig.14 Construction of product outlet



By modularizing the construction of operating components, electric sign components and product outlet components, by enabling replacement to be performed in block module units, and by reducing the number of screws for securing these components as shown in Figs. 12 to 14, the disassembly of a complete door was realized in 7 to 8 minutes.

3.2.4 Optional support of Java* applications

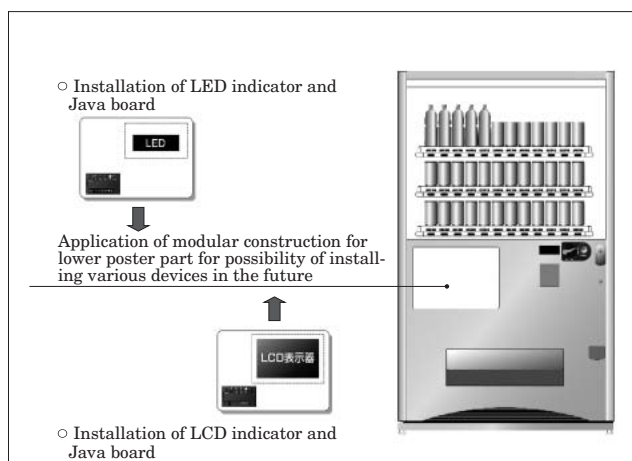
The controller of a can vending machine may be equipped with support for Java, a programming language well suited for Internet use. Display support was made available as an option. Figure 15 shows the options available for the door.

4. Conclusion

Product automatic vending machines were specified as energy-saving designated products in 2001, and subsequently, a large-scale of savings of energy is required. Pursuant to the Ozone Layer Protection Law, HCFC-141b and HCFC-22 will be totally abolished by 2004 and 2020, respectively, and a non-Freon alternative will be required in the cooling unit and as an insulator of can vending machines. Fuji Electric

* : Java is a registered trademark of Sun Microsystems, Inc.

Fig.15 Options for the door



has already been studying these tasks and is continuing to improve its products. In the future, Fuji will establish even higher goals and continue to make efforts in research and development, taking into consideration the global environment, and will develop can vending machines that enable consumers to easily purchase products and are easy to operate by operators.

Current Status and Future Outlook for Refrigerated Display Cases

Eiji Yamada

1. Introduction

Supermarkets (SMs), having been introduced into Japan in the latter half of the 1950's as an efficient type of European and American style sales format, have grown rapidly in terms of the number of stores and sales, carry an abundant variety of commodities, are enlarging the scale of their stores, and are favored with a wave of high economic growth. Currently, in Japan, there are approximately 23,000 SMs and their annual sales are about 25,000 billion yen (208 billion dollars). The SMs function as a central pillar of Japanese daily life.

On the other hand, convenience stores (CVSs) are essentially agile, small-scaled stores and have also increased their number of stores and sales, targeting the young generation by stocking hot selling (highly marketable) commodities and carrying as many as 3,000 articles. The number of CVSs in Japan is approximately 32,000 and their sales have reached about 5,000 billion yen (41.7 billion dollars).

2. Trends of SM and CVS Equipment

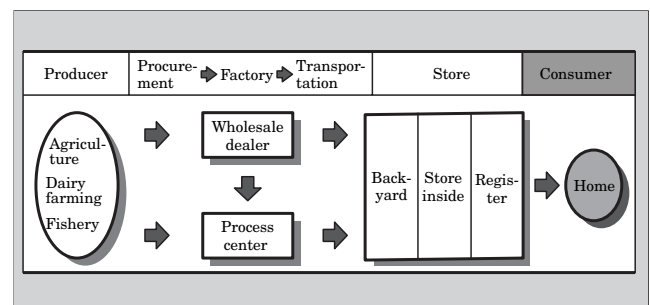
As for marketing in retail stores, merely exhibiting food in a freezer and refrigerated display case does not guarantee that it will sell. Customers demand that the food be of high quality, and in recent years, the retail stores have been offering food that also satisfies customer demand for safety and low price.

Along with changing consumer demands for food, store equipment has greatly advanced in such aspects as higher freshness, greater energy savings and reduced cost. However, over the past several years, the affect of economic stagnation has led to sluggish demand for store equipment.

Representative of SM store equipment, remote condensing type refrigerated display case had steadily increased in number of shipments until reaching a peak in about 1996. Since then, year-over-year shipments have tended to decrease. This severe market recession is expected to continue for the near future.

In such a severe slump, however, sales of refriger-

Fig.1 Mechanism of food distribution



ated single-shelf display case have tended to rise marginally. This fact suggests that people have begun to search for a new style and sales format for the stores. We expect demand for new store equipment to increase in accordance with this trend.

Moreover, it is assumed that the lifestyle changes will incite consumers to more strongly demand benefits and convenience from the retail store market. It is necessary to reexamine the overall mechanism for the distribution of food from producers to consumers. Figure 1 shows the mechanism of the distribution for food.

A review and restructuring of the food distribution mechanism will result in new proposals for foodstuffs, and new shop equipment will be required to support those foodstuffs.

3. Current Status of Fuji Electric Refrigerated Display Cases

3.1 Social needs

The market environment for refrigerated display cases changes at an extremely rapid pace. Particularly remarkable changes in regulations and social needs in recent years are described as follows:

- (1) "Large-scale retail stores location law" (Large stores location law)

This law prescribes the rules to observe when a large-scale retail store such as an SM or department

store is opened or branched out. This law was enacted on June 1, 2000. Before then, the "Large-scale retail stores law" (Large stores law) regulated the opening of a large-scale store or its branch store, and aimed to "securing business opportunities (commercial adjustment)" for local commercial entities. The large stores location law, however, focuses on "lifestyle preservation" around the stores in the local district. In principle, the size of the store's floor space and the setting of non-business days are deregulated. Instead, restrictively regulated are the number of parked cars, the removal of garbage put out by the store, and environmental measures such as those against traffic jams, noise, stink, etc, in the vicinity of the store.

(2) Compliance with HACCP

A recent problem concerning *Escherichia coli* O157 has demanded that the business such as SMs comply with HACCP (Hazard Analysis Critical Control Point) to secure safety in a wide range of processes from the raising or preparation of food to consumption thereof. The concept of HACCP was originally introduced by NASA (National Aeronautics and Space Administration) as part of the space exploration program. HACCP is a technique applied to the quality control of rocket parts in the space exploration program. This method is also applied to the management of "space food."

The HACCP is a hygienic management technique as described below. This technique analyzes hazards, decides the place (process) and the processing method to control the hazard, establishes the corresponding standards, and records documentary evidence concerning "Who did what work? When? Where? And according to which standard?" It is necessary to establish the HACCP technique as a system. Use of this technique for better freshness management has been demanded for the store equipment.

(3) The global environment

At the "Third conference of parties to the U.N. for climate change framework treaty" (Kyoto convention on climate change: COP3) in December 1997, it was resolved to aim to prevent global warming, and to promptly execute measures for that purpose. In Japan, "energy" is the source of about 90 percent of the carbon dioxide emissions that constitute the majority of greenhouse gases. Therefore, Japan has decided to drastically bolster comprehensive measures to control both energy demand and supply, and in addition, to strengthen the emissions control of greenhouse gases other than carbon dioxide. In addition, regulation of fluorocarbon emissions has also been demanded for ozonosphere protection. Thus, measures for environmental conservation such as energy saving, are urgent and unavoidable challenges.

(4) Revision of the "Pharmaceutical affairs law" (Drugs, cosmetics and medical instruments act)

The pharmaceutical affairs law enacted in 1960 prescribed the standards, certification, and handling,

etc., of prescription medicine, over-the-counter medicine (unregulated drugs), cosmetics and medical instruments. A revised version of this law was enacted on March 12, 1999 to reclassify medicine and over-the-counter medicine. This reclassification eased restrictions on the handling and sales of health drinks (ampuled liquid medicine) and similar soft drinks, and the SM and the CVS have been authorized to carry and sell them. As a result, store fixtures to sell the health drinks have been much in demand.

3.2 Current status for development of refrigerated display cases

To boost sales of open refrigerated display cases mainly destined for SMs and CVSs, we have promoted, on the one hand, development as a cooling facility system including the display case unit and the associated refrigerator, and on the other hand, improvement of display performance and handling efficiency, HACCP-based high freshness management, environmental measures to reduce fluorocarbon emissions, energy savings, etc.

As system products, we have developed "ECOMAX V", which provides total control of the operation of the display case and the refrigerator, and was awarded the "Grand Prize for Energy Savings", and an ice thermal-storage system for display cases intended for use in SMs in which cheaper nighttime electric power can be utilized for saving energy.

As store equipment intended for use in an SM, we have developed our top of the line "ECOMAX series" of open refrigerated display cases. The "ECOMAX series" achieves enhanced cooling performance through optimization of a cold air circulation system that uses an air curtain, and is the industry's first series to use microcomputer control.

In addition, we have developed a showcase suitable for HMR (Home meal replacement), which has been attracting attention recently. This showcase provides a system in which customers place orders over a counter for prepared foods exhibited in the display case, and then take those foods home.

As a manufacturer of store equipment for CVSs, we provide custom display cases for specific commodities such as ice cream and health drinks in accordance with the revised pharmaceutical affairs law. These display cases have been well received in the marketplace.

In response to environmental problems such as global warming, it is increasingly important to bolster measures for the conservation, recycling and renewal of resources as well as measures for reducing waste and saving energy. The discontinuance of fluorocarbon use is also strongly required.

Under such circumstances, we have begun to switch from regulated fluorocarbons to CFC substitutes as well to new fluorocarbons having an ozone-layer depletion coefficient 0.

4. Future Outlook for Refrigerated Display Cases

The present day society is pursuing the key elements of the environment, energy and the establishment of an information network. The standalone display case unit is no longer adequate. Society tends to demand a systematized product that considers both the environment and information. At SMs and CVSs, customers will not be satisfied if the focus is only on the display case unit. It is becoming necessary to also consider trend management and loss management of the commodities, as well as methods to secure a steady clientele base.

Equipment such as systemized products that integrate environment-friendly refrigerated equipment with HACCP must be proposed for SMs.

A proposal is needed for a total system to cover the entire store. Such “store solutions” are expected to become a new business field in the future.

On the other hand, IT (information technology) solutions are advancing at an ever increasing pace, and non-contact type IC cards are expected to be in widespread use.

From now on, all payment at railways, SMs, CVSs, vending machines, amusement facilities, etc. will be card-based transactions, and IT application to financial settlement is continuing to advance.

In the future, the development of proposals that respond flexibly to the changing social environment will be demanded more and more.

5. Conclusion

People depend upon various commodities for food, clothing and housing. These commodities are provided to consumers through the distributive trade industry. In particular, food deeply affects our lifestyle, and is indispensable for our daily life. Fuji Electric has been involved in the distributive trade industry through the refrigerated display cases used at SMs and CVSs. To support our modern lifestyle, the advancement of cold chain stores is especially vital. By developing and supplying showcases for the cold chain stores, Fuji Electric will also play a guiding role in the distributive trade equipment market in the future.

Continued guidance and support from readers and all related people will be highly appreciated.



Open Refrigerated Display Cases “ECOMAX Series” for Supermarkets

Eiji Yamada
Takeshi Watanabe
Norihiko Urakawa

1. Introduction

In the midst of a severe economic circumstance as never before experienced, the supermarket industry has also been experiencing a slowdown in sales caused by slumping consumption, and each supermarket chain in the industry, with few exceptions, is facing very severe business conditions. Under these conditions, display cases are required to contribute to total cost reduction, including the minimization of initial expenditures and running costs, and suppression of installation cost; they must also provide enhanced display efficiency and an appealing presentation of product to motivate customers to make purchases, and in addition, provide high-grade freshness control in order to reduce product loss. On the other hand, as the supermarket industry has become more concerned with environmental conservation through such measures as acquisition of ISO 14000 certification, the supermarket equipment users have increased demands on display case producers, and energy saving, waste reduction and other features are requested more strongly.

In response to these needs and by enhancing the advanced features and high performance of the existing series, Fuji Electric has developed and marketed a new series of open refrigerated display cases for supermarkets. This series, named the “ECOMAX series,” is easy to install and is customer and environmentally friendly. An appearance of the series is shown in Fig. 1 and an overview of the series is introduced below.

2. Overview of the ECOMAX Series

To be compatible with the various types of selling floor configurations, the ECOMAX series consists of four models differing in their basic cross-sectional profiles: multi-deck, semi-multi-deck, flat and pair-freezer types. Each model can be specialized for use in different working temperature ranges, so the series provides for an abundant variety of 500 model types. Furthermore, the series can meet the needs of diversity and individuality of stores with corner cases, special

Fig.1 Appearance of an ECOMAX series open refrigerated display case for supermarket use

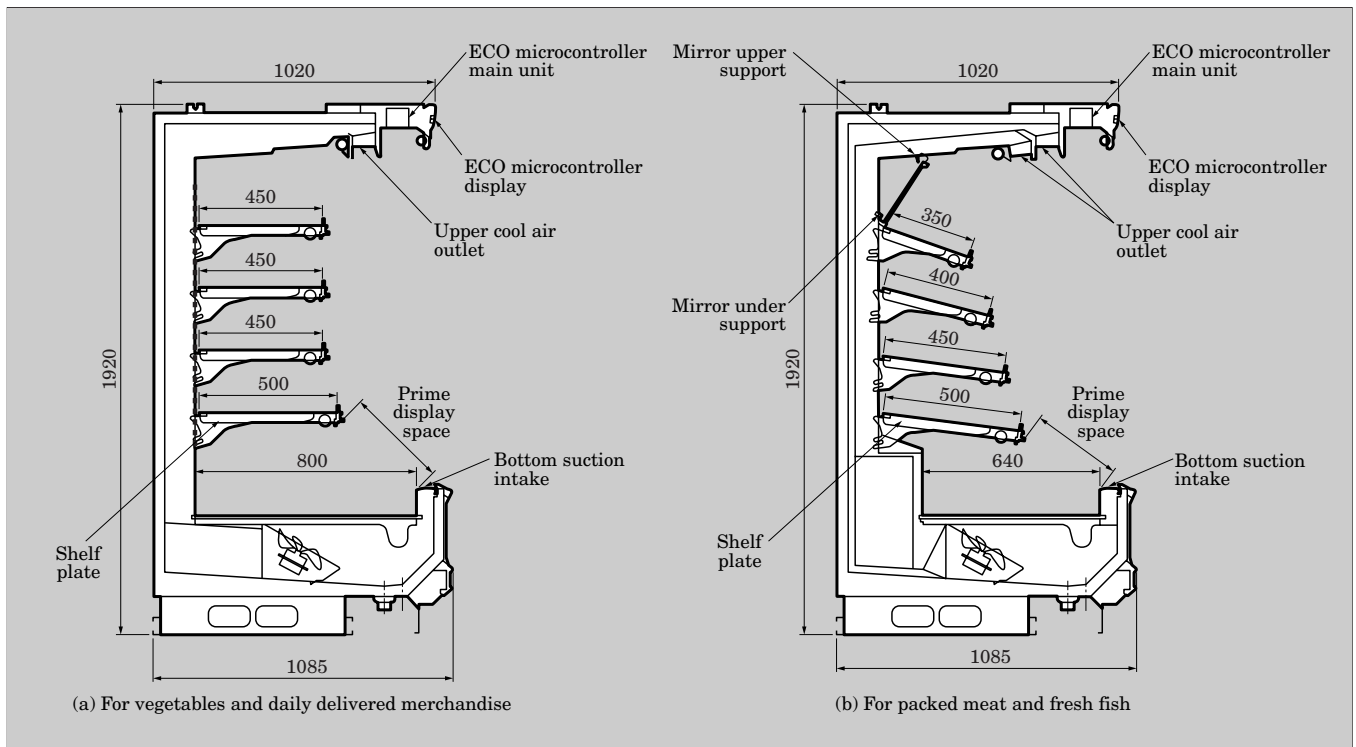


cabinets and optional parts. The core product line in this series is the multi-deck open display cases.

A cross-sectional view of the ECOMAX series, multi-deck open refrigerated display case, is shown in Fig. 2. In this type of case, an airflow cooled in the evaporator is blown through a backside duct, rectified by a honeycomb rectifier and then blasted out from an upper cool air outlet. This blasted cold airflow is blown down along the front edge of the shelves, tracing out an arc shaped projection, and then is drawn back through a bottom suction intake, so that an air curtain is formed in front of the open space of the display case. This air curtain isolates the interior from the open air and keeps the product in the case cold.

This ECOMAX series multi-deck open refrigerated display case is subdivided into 90 models, differing in storage temperature zones, dimensions of case depth and length, number of air curtain layers, etc. Among these models, there is also a product line of display cases that feature fuzzy logic-based high-grade freshness control and the capability to sense operational and environmental conditions and determine the cooling and defrosting timing accordingly.

Fig.2 Cross-sectional view of the ECOMAX series multi-deck open refrigerated display case



3. Features of the Multi-deck Open Refrigerated Display Case

3.1 Enhanced display efficiency and presentation of product

Each part of the display case was designed so as to create a non-oppressive selling space where customers are able to easily see, select and buy product.

3.1.1 Shelf plate configuration

Based on the eye height calculated from the average woman's height as a reference point, the shelf angle was positioned so as to provide the maximum visible range of shelf plates. Also, the standard shelf plate depth was determined based upon an average woman's reach from a natural standing position. The shelves were configured according to these dimensions so that customers standing near the display case can easily view the product from top to bottom, and take out articles easily. In addition, the shelves can be raised or lowered with a 25 mm pitch, and a newly designed bracket for the shelves allows adjustment of the shelf angle in 5 steps.

3.1.2 Upper part (canopy) depth

The canopy depth was shortened to eliminate the oppressive feeling sensed by customers near the display case. Also, the rounded design of the canopy end compels customers, both psychologically and physically, to approach the case closer than before when selecting product.

3.1.3 Dimensions of prime display space

As a consequence of achieving a wider prime

display space (the space between the lowest shelf and the suction intake) through clever positioning of the evaporator and the use of a thinner duct for the suction, the viewing angle was enlarged so that the volume of the exhibited product appeared to increase.

3.1.4 Presentation effect of mirror

To stage the product so that is presented with a sense of volume and continuity, 5 types of inclined mirrors are provided, so that a mirror with an appropriate width can be selected according to the exhibited product, the shelf dimension, and so on. Furthermore, the presentation of the product was significantly enhanced by the structure of the upper support of the inclined mirror to which a POP (point of purchase) hanger can be attached and the under support whose structure allows the mirror angle to be changed easily depending on the shelf angle.

3.2 Reduction of total cost

3.2.1 Reduction of initial cost

Standardization of components among the model types was promoted and executed thoroughly based on review of the skeletal structure. Also, use of a riveted structure, component integration and so on, enables the number of screws to be reduced.

Furthermore, through incorporating various individual specifications to meet the diverse needs of customers to the extent possible into the standard specification during the initial phase of the development, the generation of special components was strongly suppressed. Additionally, options were cleverly designed to be easily attachable.

3.2.2 Reduction of running cost

(1) Reduction of the required refrigerating capacity

The development of a newly designed high-efficiency evaporator based on review of the optimum heat transfer area and fin pattern enabled clogging by frost deposits to be reduced drastically. Also, by increasing the number of refrigerant paths, loss of the evaporator was reduced and efficiency was improved. As for the air curtain, by means of simulation analysis, the correlation between the air velocity of the air curtain and the back flow from the interior backside was optimized, and the optimized results were applied to actual products (Fig. 3). Furthermore, the ability to shutout outside air was enhanced extensively through making the velocity of the air curtain uniform in the lengthwise direction of the case and improving the rectifying effect by modifying the shape of the honeycomb rectifier.

Additionally, in display cases for vegetables and daily delivered merchandise with high working temperature zones, a “rear jet air curtain system” was

Fig.3 Example of the simulation analysis

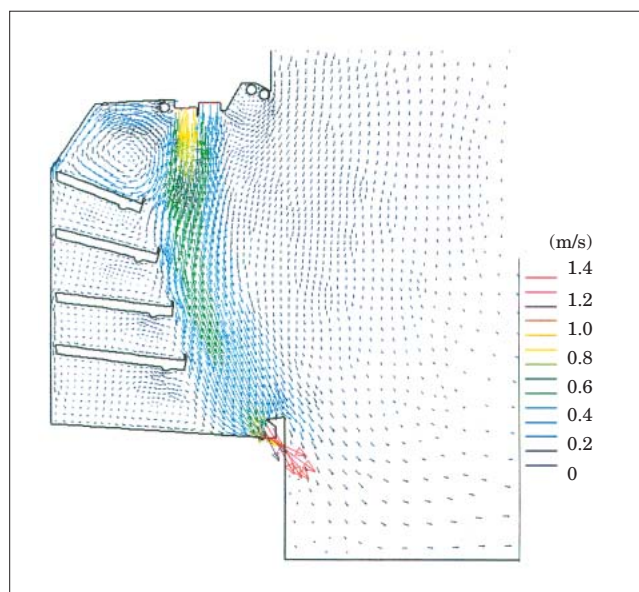
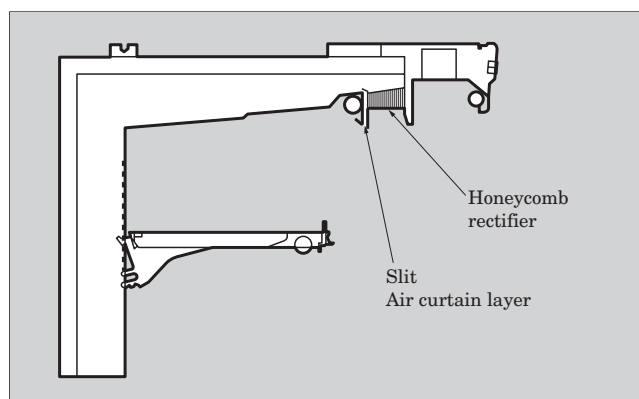


Fig.4 Structure of the air outlet part of the display case for vegetables and daily delivered merchandise



developed from the existing one layer air curtain system. In the new system, to improve the ability to shutout outside air, a slit type air outlet was added inside of the existing air outlet. This new system achieved a dramatic improvement in the rectifying effect of the air curtain. Figure 4 shows the structure of the air outlet of the display case for vegetables and daily delivered product. Through the above-mentioned improvements, the required refrigerator capacity was reduced by approximately 20 % in display cases for packaged meat and fresh fish and by approximately 10 % in display cases for vegetables and daily delivered product, as shown in Fig. 5.

(2) Microcontroller

In the ECOMAX series, a microcontroller (the ECO microcontroller) is equipped as standard equipment in each display case. Figure 6 shows the input-output configuration of the ECO microcontroller. With this ECO microcontroller, all sorts of control for the display case, e.g. temperature control, defrost control, alarm output and so on, is centralized, and also the temperature control in the case interior is executed precisely through significant improvement of the operation control accuracy to realize high freshness control of the merchandise. Furthermore, when applied in combination with the total control system “ECOMAX V,” which provides total control of the display case and the refrigerator, a dramatic energy savings (49 % reduction of the annual electrical power consumption) through the reduction of refrigerator power consumption and a large improvement in freshness control ability (50 % lowering of the temperature fluctuation) were both realized.

(3) Electronic ballasts provided as standard equipment

Energy efficiency was improved by providing electronic ballasts as standard equipment and installing

Fig.5 Comparison of refrigerating capacities (with our existing type)

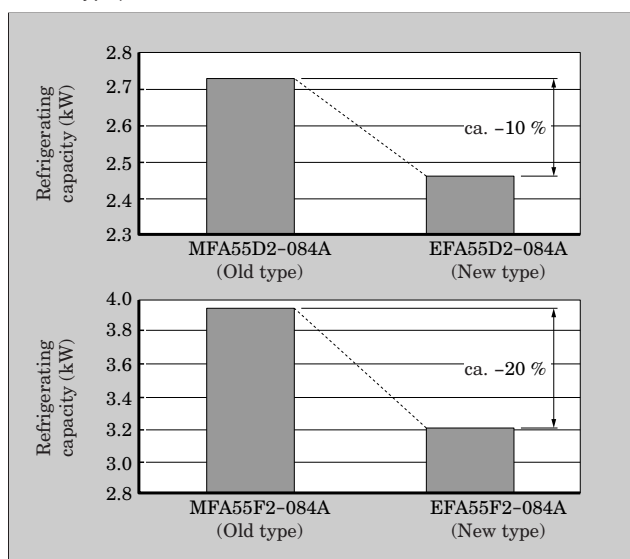
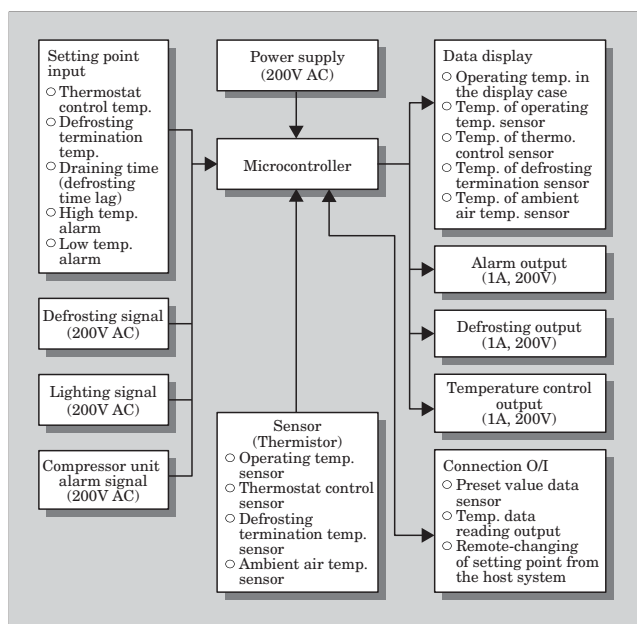


Fig.6 Input and output configuration of the ECO microcontroller



them for the canopy lighting, the interior lighting and the shelf lighting in chilled storage display cases, and electric power consumption was reduced by 26 % compared with the existing ballast. Also, since high-frequency lights were used, the flickering of fluorescent lighting was suppressed, resulting in illumination that is easy on the eye and shows off the merchandise well.

3.2.3 Easier installation

The power supply for the lighting, fan motors, dew prevention heaters and ECO microcontroller was changed to a single-phase, 3-wire, 200 V power supply from the former single-phase, 100 V power supply. As the number of circuits was reduced to less than one half of the former system, a drastic reduction of installation materials and manpower and also shortening of the construction period were realized. Also, by pre-installing the defrosting synchronous wiring of the display case into the main wiring of the case, the onsite wiring work was simplified.

The quality of the installation of the solenoid valves and the defrost timer is improved by preparing kits in advance according to the ordered options and the work standards for onsite installation.

3.2.4 Easier maintenance

(1) Detachable honeycomb rectifier

Since the honeycomb rectifier mounted on the air curtain's air outlet requires periodic cleaning, an easily detachable wire fastening method was newly adopted.

(2) Lighter shelves

The shelf structure has been redesigned with 15 %

less mass than before while maintaining the same strength. This enhancement improves makes it easier to change the position or inclination of the shelf.

(3) Central monitoring of the display cases

The above-mentioned ECO microcontroller is equipped with a communication function that enables central monitoring of the display cases when used in conjunction with Fuji Electric's "ECOMAX-Net" central monitoring system. Central monitoring greatly enhances the efficiency of maintenance management.

3.3 Measures for environmental conservation

3.3.1 Discontinuance of chlorinated vinyl materials and improvement of recycling capability

In the ECOMAX series, as a part of the measures for environmental conservation, the use of chlorinated vinyl materials for resinous components was discontinued with the exception of material for lead wire insulation, because chlorinated vinyl can become a source of dioxin emission and might produce poisonous gas. This measure was pursued aggressively by using highly safe materials, such as ABS (acrylonitrile butadiene styrene), PP (polypropylene), AES (acrylonitrile ethylene styrene) and so on, instead of chlorinated vinyl materials. Also, in order to improve recycling capability, material names were marked on the resinous components.

3.3.2 Lighter mass product

By redesigning components, using resin-based trims and the like, the product was simplified and the amount of on-site waste material was reduced.

3.3.3 Use of new refrigerant

The ECOMAX series uses substitute chlorofluorocarbons (HFC) with low ODP (Ozone Depletion Potential) instead of the designated chlorofluorocarbons (HCFC) with high ODP., R404A, having zero-ODP, may be used.

4. Conclusion

An overview of the open refrigerated display cases "ECOMAX series" for supermarkets has been presented above. As supermarkets trend toward diversification and individualization when seeking a new store style, display cases will increasingly be required to breakaway from undifferentiated designs. Therefore, Fuji Electric will strive to further the expansion of this series and the development of new characteristic products.

In closing, the authors wish to thank the related individuals who offered their assistance and cooperation in the development of this series.

Open Refrigerated Display Cases for Convenience Stores

Kazuyuki Yamaguchi
Katsuhiko Maegawa
Masaya Ueno

1. Introduction

In recent years in the convenience store (CVS) marketplace, competition between different store chains has intensified due to market saturation by the growing number of stores. The percentage of stores that are newly opened has been decreasing, and daily sales have not showed much growth. Accordingly, in order to differentiate itself from the competition, each chain develops new articles for sale and at the same time makes efforts to pursue better freshness control, improved product presentation and higher sales efficiency of existing articles such as prepackaged lunches, prepared foods, beverages, deserts and ice creams.

Moreover, due to the growing awareness of environmental conservation, CVS companies are promoting environmental measures such as the acquisition of ISO 14000 certification, reduction of power consumption in stores, recycling of article containers, and the utilization of new types of refrigerant in air-conditioners and refrigerators.

Under such circumstances, Fuji Electric has developed a new series of remote condensing-type ultra-slim, open refrigerated display cases for CVSs, the “EFT 40” series. This series is environment-friendly and provides excellent presentation and handling performance.

2. Special Features of the New EFT 40 Series

In response to requests and suggestions from CVSs, the EFT 40 series was developed with the goals of providing “excellent presentation of the articles being sold,” “ease of use” and a machine that is “environment-friendly.” Special features of this series are as follows.

2.1 Excellent product presentation

- (1) Product presentation is improved by adoption of a structure having terraced shelves and slanted back face with a shallow canopy.
- (2) Display area is increased by adoption of a low and thin shelf front to increase the effective display height within the display case and to enlarge the

effective display height between shelves.

2.2 Ease of use

- (1) Shelves and deck pans are equipped with a sliding mechanism to improve the ease of the replenishing articles and of cleaning.
- (2) In order to be compatible with various kinds of articles, a sliding steel shelf version and a thin glass shelf version are available as an option for each model.

2.3 Concern for the environment

- (1) High freshness control and energy savings are realized by a microcontroller installed as standard equipment.
- (2) Plans to use the new refrigerant HFC are established by utilizing highly clean tubes and ensuring the required cooling performance.
- (3) Power saving is realized by utilizing a slit air curtain, inverter ballast and DC fan motors.

3. Specifications

Specifications of the EFT 40 series and features of each model are given in Table 1.

4. Structure

The external appearance of the EFT40 series is shown in Fig. 1.

4.1 Enhanced product presentation

4.1.1 Terraced shelves

In order to enhance product presentation, this series is equipped with terraced shelves having a slanted back face and a shallow canopy that is 50 mm smaller than the former types, resulting in better fenestration and improved product presentation and visibility. If cool air blows down from the ceiling of the canopy as in the former machines, formation of an air curtain becomes impossible in the new machines because the position of the cool air outlet is shifted back due to adoption of the shallow canopy. Moreover, adoption of slanted back face makes it impossible to

secure the required quantity of air flow and degrades the cooling performance due to increased draft resistance of the circulating cool air flowing in the duct. Accordingly, the EFT40 series adopts both a wide backflow system that blows cool air out from the slanted back face and a slit air curtain to achieve uniform cooling performance and enhance product presentation.

4.1.2 Low rail height

In a CVS having limited floor area, increasing the number of stages of the display shelves is one way to enlarge the area of product display. Accordingly, the effective inside height of the newly developed display case was extended through lowering the front rail

height by 100 mm below that of the former machine. In addition to lowering the rail height, by reducing the shelf thickness, an additional shelf stage could be realized, thereby increasing the display area by about 15 % compared to the former machine. A cross section of the display case structure is shown in Fig. 2.

4.2 Ease of use

4.2.1 Sliding steel shelf

Unlike supermarkets and department stores, the selling point of CVSs is that they supply convenience all day long, 365 days a year. For this reason, it is important that CVSs replenish and restock articles for first-in first-out turnover effectively during business

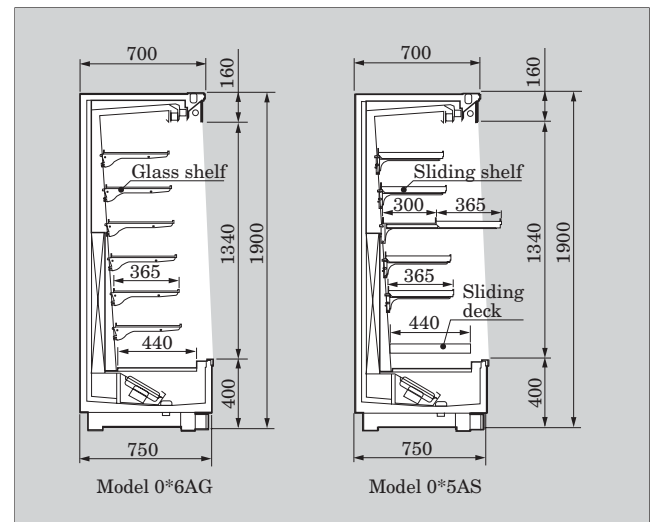
Table 1 Constitution of models of EFT40 series

| Machine model number Item | | EFT40D2 (HFC) | | | | | | EFT40D2 (HCFC) | | | | | |
|----------------------------------|---------------------|---|---------------|------------|------------|---------------|-------------------------|-------------------------------|---------------|-----------|-----------|---------------|-------------------------|
| | | 036 AG4 | 035 AS4 | 046 AG4 | 066 AG4 | 065 AS4 | 065 AC4 | 036 AG | 035 AS | 046 AG | 066 AG | 065 AS | 065 AC |
| Application | | Beverages, prepared foods, deserts, prepackaged lunches, etc. | | | | | | | | | | | |
| Working temperature (°C) | | 3 to 20 | | | | | | | | | | | |
| Effective internal volume (L) | | 531 | | 707 | 1,061 | | | 531 | | 707 | 1,061 | | |
| Display area (m ²) | | 2.38 | 2.07 | 3.17 | 4.76 | 4.14 | 4.45 | 2.38 | 2.07 | 3.17 | 4.76 | 4.14 | 4.45 |
| External dimensions | Overall height (mm) | 1,900 | | | | | | | | | | | |
| | Overall length (mm) | 915 | | 1,220 | 1,830 | | | 915 | | 1,220 | 1,830 | | |
| | Canopy depth (mm) | 700 | | | | | | | | | | | |
| | Front depth (mm) | 750 | | | | | | | | | | | |
| | Rail height (mm) | 400 | | | | | | | | | | | |
| Refrigerant | | R404A | | | | | | R22 | | | | | |
| Type of ballast | | Inverter ballast | | | | | | Magnetic circuit type ballast | | | | | |
| Type of internal fan | | DC fan motor | | | | | | AC fan motor | | | | | |
| Method of defrosting | | Off-cycle defrosting | | | | | | | | | | | |
| Shelf structure | Number of rows | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 |
| | Number of stages | 6 | 5 | 6 | 6 | 6 | 5 | 6 | 5 | 6 | 6 | 6 | 5 |
| | Type of shelf | Glass | Sliding-steel | Glass | Glass | Sliding-steel | Glass and sliding-steel | Glass | Sliding-steel | Glass | Glass | Sliding-steel | Glass and sliding-steel |

Fig.1 Appearance of EFT40 series



Fig.2 Cross-sectional structure of EFT40 series display case



hours in order to avoid losing sales opportunity. Accordingly, a sliding steel shelf was developed to facilitate the repositioning of articles and the replenishment of articles at the rear of the shelf. For the slide rail, stainless steel having excellent durability and strength was used to realize smooth handling performance and high reliability. The structure of this sliding shelf is shown in Fig. 3.

4.2.2 Flexible construction of shelves

The sliding shelf is effective for articles that are relatively tall and are easy to group together such as beverages, spirits and health drinks. However, for low-profile articles such as prepackaged lunches, prepared foods and deserts, the product presentation must include a sense of cleanliness and drama. Accordingly, a low-profile glass shelf with good fenestration and sense of cleanliness was developed, adopting a full-face glass and transparent front tag rail.

Either a sliding shelf or glass shelf can be chosen freely as an option by each store chain according to the kinds of articles they will vend; the structural body of the display case will remain the same.

4.3 Concern for the environment

4.3.1 Control using a microcontroller

Fig.3 Structure of sliding shelf

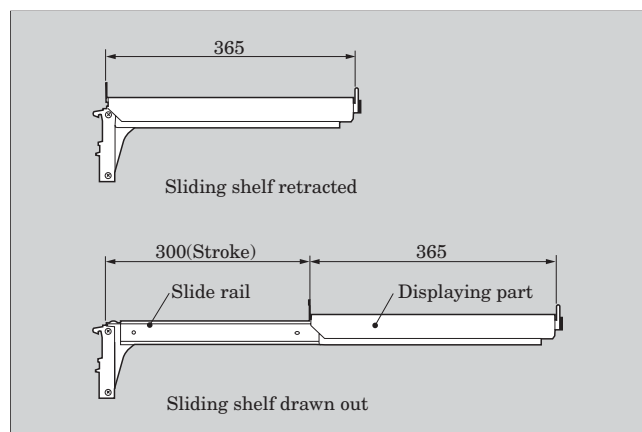
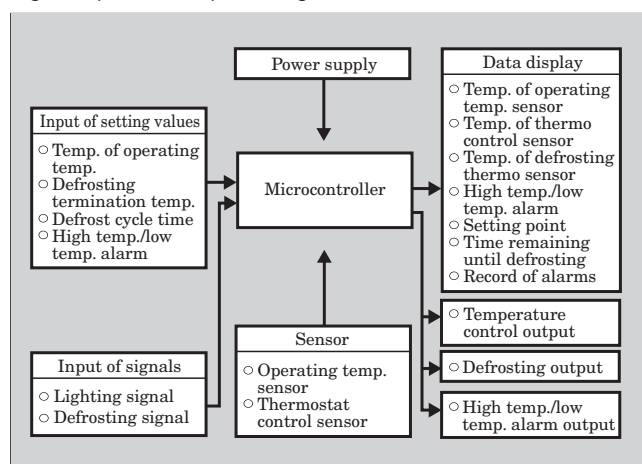


Fig.4 Input and output configuration of microcontroller



All models in the EFT40 series are equipped with a microcontroller to perform centralized control of temperatures in the display case and of alarm functions. Temperature fluctuation within the display case can be controlled more precisely than when using a mechanical thermostat. Moreover, it is also possible to externally output temperature data indicated by sensors at various positions as well as to confirm operating conditions and change settings from an external location through a phone line. This enables operation and acquisition of operating conditions from a backyard location. Temperature settings for prepackaged lunches, beverages, deserts, etc., can be changed over a wide temperature range in intervals of 1°C by changing settings on the microcontroller without having to implement changes on the display case. Figure 4 shows the input and output configuration of the microcontroller.

In the case of a failure or during a regular inspection, the time required to diagnose the operating conditions and estimate the cause of failure can be reduced because a record of the past three alarms is recorded by an alarm log function. The reduction in work time required for inspection and repair thus realized is significant for CVSs that operate 24 hours per day.

4.3.2 Adoption of HFC

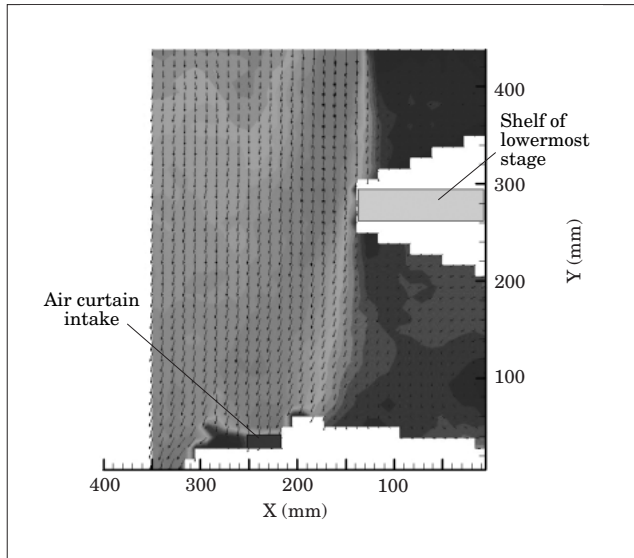
An HCFC reduction plan was enacted according to the Montreal Protocol, and Fuji Electric is working to accelerate the conversion from HCFC to HFC. In recent years, Fuji Electric has promoted the adoption of HFC for self-contained type open refrigerating display cases, and 80 % of those types of cases have already converted. Separate type ultra-slim multi-deck open display cases for CVSs also have adopted HFC for the first time in Fuji's open display case after two-years of field experiments.

In the EFT40 series, use of easy-to-handle azeotropic refrigerant is effective because charging of the refrigerant is sometimes carried out when replacing parts in the refrigeration system and adjusting the cooling performance. Accordingly, R404A refrigerant was adopted. This refrigerant is easy to maintain and has a relatively low value of high pressure. Regarding the tubing materials, clean tubes that have high inside cleanliness were used because oil used for the conventional tubes during manufacturing and assembling processes might cause sludge in the R404A system and water might cause an insulation fault with the compressor.

4.3.3 Reduction of power consumption

Power consumption of the display cases accounts for 60 % of the total power consumption of a CVS and is the most important factor for reducing the power consumption of a CVS. In the EFT40 series, consideration was given to the three major factors influencing power consumption of the display case, that is, refrigeration capacity, power for illumination and power for

Fig.5 Distribution of air curtain velocity vectors



internal fans, and measures were taken to reduce the power consumption of each of these factors.

- (1) Use of a new slit air curtain to reduce the required refrigeration capacity

Fuji Electric's usual types of open display cases utilize Fuji's own proprietary slit air curtains. However, in the EFT40 series, if the usual type slit air curtain is applied, a larger refrigeration capacity would be required due to the low rail height structure with terraced shelves. Accordingly, behavior of the air curtain was visualized to determine a suitable airflow balance between the innermost slit jet, inner jet and outer jet and an appropriate refrigeration capacity, and as a result, a new innermost jet was developed. This realized a low rail height construction without increasing the required refrigeration capacity and reduced the required capacity by 25 % when converted to a rail height identical to that of the former machine. Figure 5 shows the distribution of air curtain velocity vectors flowing near the shelf of the lowermost stage.

- (2) Application of inverter ballast

Due to the adoption of a terraced shelf construction, fenestration of in-store illumination and canopy illumination was improved and the ceiling illumination of the former machine was eliminated. Moreover, inverter ballast was adopted for the canopy illumination to achieve brightness with power savings. Due to the elimination of ceiling illumination and use of an inverter, power consumption was reduced by 63 %.

- (3) Use of DC fan motors

The cooling temperature of the remote condensing type multi-deck open display case is relatively high

Table 2 Power savings of EFT40 series (as compared to former type)

| Machine model number | | | Former type MFT50D2 -065AG | EFT series EFT40D2 -066AG | Ratio of saved energy/(%) |
|---|------------------------------|-------|----------------------------------|---------------------------------|---------------------------------|
| Item | | | | | |
| External dimen- sions | Overall height (mm) | | 1,900 | | — |
| | Overall length (mm) | | 1,830 | | — |
| | Canopy depth (mm) | | 750 | 700 | — |
| | Front depth (mm) | | 750 | | — |
| | Rail height (mm) | | 500 | 400 | — |
| Area of front opening (m ²) | | | 2.3 | 2.5 | — |
| Refrige- ration capacity | Required capacity (kW) | | 1.63 | 1.54 | 6 |
| | Evaporating temperature (°C) | | -10 | | — |
| | Refrigerant | | R22 | | — |
| Illumi- nation | Number of lamps | | 4 | 2 | 50 |
| | Power consumption (W) | 50 Hz | 152 | 56 | 63 |
| | | 60 Hz | 152 | 56 | 63 |
| Internal fan | Number of fans | | 3 | | 0 |
| | Power consumption (W) | 50 Hz | 87 | 48 | 45 |
| | | 60 Hz | 99 | 51 | 48 |

and ranges from 3 to 20°C. Therefore, Fuji Electric adopted an off-cycle defrosting system utilizing heat from the ambient air, and this system had a lower running cost than the electric heater based defrosting system used for low temperature display cases. With the off-cycle defrosting system, fans in the display case are operated all day long and the power consumption by the fans accounts for a large fraction of the total power consumption. Accordingly, DC fans were adopted and power savings of 45 % was achieved.

The power savings achieved by the newly developed type 066 machine is shown in Table 2.

5. Conclusion

In the above, the EFT40 series of remote condensing-type ultra-slim multi-deck open refrigerated display cases for CVSs was introduced. Performance of this newly developed series is highly appreciated by customers. However, CVS market demands are ever-changing and the speed of change will increase more and more. Fuji Electric intends to continue to supply products that can keep pace with market demands and to promote environmental issues such as reuse and renewal.

Lastly, we would like to thank our customers and persons concerned for their continuing guidance and help in this development.

Business Outline of the Each Internal Company

| Company | Business Areas | Major Products |
|--|---|---|
| Energy & Electric Systems Company | Providing optimal solutions from information control systems to substations to meet the individual needs and demands of each customer | Water treatments systems; information, telecommunications and control systems; measuring and instrumentation systems; power systems; environmental equipment and systems; industrial power supplies; electrical equipment for rolling stock; substation systems; thermal, hydraulic and nuclear power plant equipment; and others |
| ED & C · Drive Systems Company | Delivering broad FA system components, individually or as integrated small-scale systems | Small-scale systems combined with PLCs, inverters and actuators; FA control equipment; low-voltage circuit breakers; molded transformers; drive control and power electronics; and others |
| Electronics Company | Providing distinctive electronic devices, based on our world-leading technologies | Power semiconductors; ICs; magnetic disks; photoconductive drums and peripherals; and others |
| Retail Support Equipment & Systems Company | Promoting consumer convenience and comfort, through machinery and systems focused on vending machines | Vending machines; beverage dispensers; food machines; freezing and refrigerated showcases; coin mechanisms and bill validators; leisure-related systems; and others |

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