

FUJI ELECTRIC REVIEW

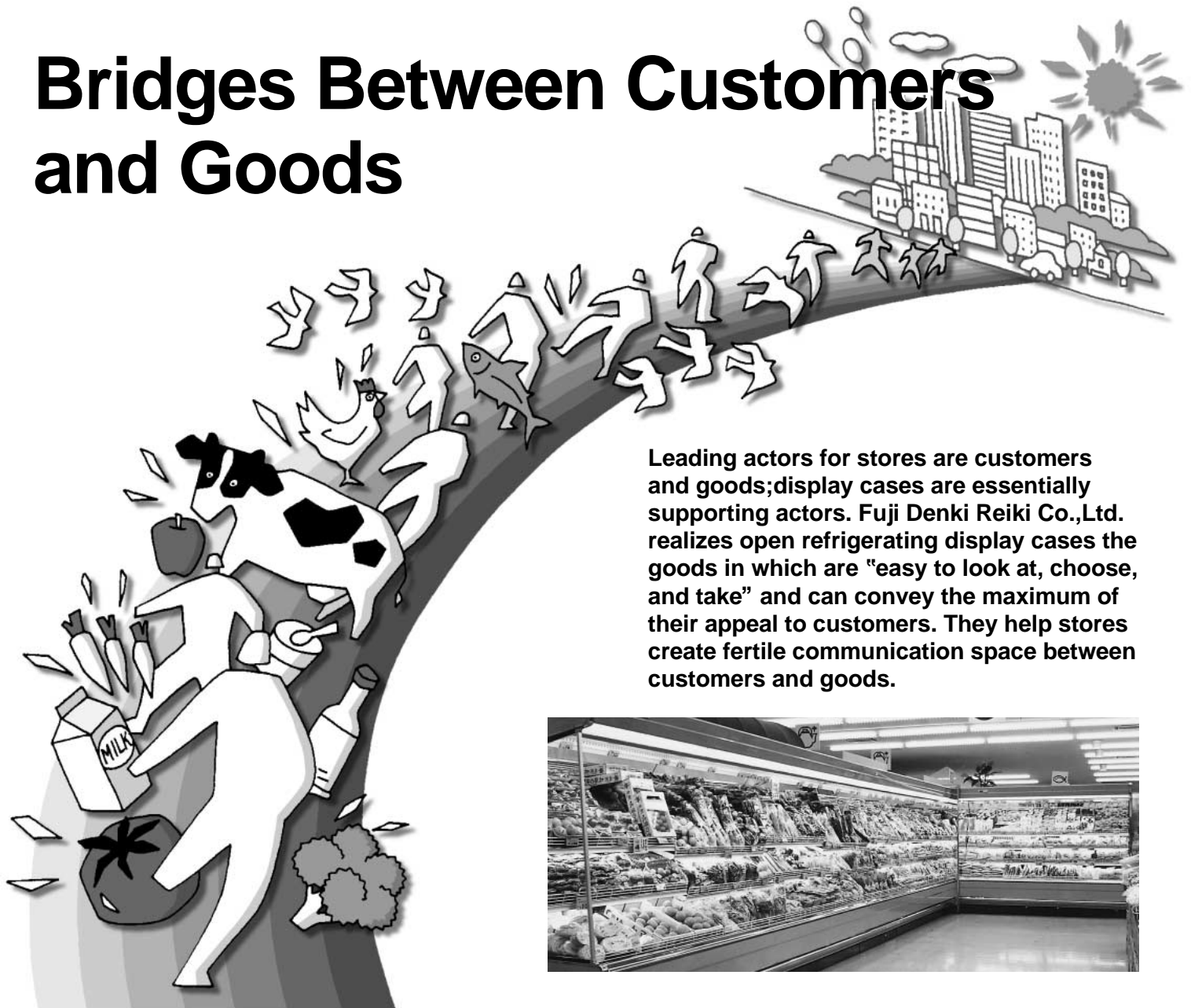


1997 VOL.43

Open Refrigerating Display Case



Bridges Between Customers and Goods



Leading actors for stores are customers and goods; display cases are essentially supporting actors. Fuji Denki Reiki Co., Ltd. realizes open refrigerating display cases the goods in which are "easy to look at, choose, and take" and can convey the maximum of their appeal to customers. They help stores create fertile communication space between customers and goods.



1 Easy to look at and take goods

Standard arrangement of multi-deck and wide golden space convey the maximum of goods appeal.

2 High-freshness control with M microcomputer controller

M microcomputer controllers regularly equipped in each display case strictly perform freshness control according to goods items and changes in the environment.

3 Cleanliness through simple cleaning

Simple, easy-to-handle structure facilitates daily cleaning.

4 Cost reduction by energy-saving operation

Using the M microcomputer controller and new evaporator to raise refrigeration efficiency realizes more energy-saving operation and helps stores reduce cost.

5 Simple installation and maintenance

Simplified, standardized installation work such as simplified wiring circuits facilitates maintenance.



Fresh MAX Series

Open refrigerating display cases for supermarkets

Fuji Electric's Open Refrigerating Display Cases

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Cover Photo:

To meet changes in the life-style and food diversification, supermarkets now desire open refrigerating display cases capable of maintaining freshness and contributing to environmental preservation.

To protect the irreplaceable earth, Fuji Electric has striven to offer energy-saving products useful to environmental preservation. While designing air curtains for open refrigerating display cases, it carried out computer simulation to realize optimum cooling having an energy-saving effect as well as improved food display effectiveness and ease in handling.

The cover photo images the advanced display case technology with a combination of the simulation result and an open refrigerating display case in operation.

Present Status and Future Prospects of Open Refrigerating Display Case

Takakazu Takada

1. Introduction

For food retail stores like supermarkets and convenience stores, store-use large open refrigerating display cases are necessities. These cases have been developed with features including self-service and modernized cold-state distribution for perishable food.

Since their introduction into Japan in the latter half of the 1950s, supermarkets have rapidly grown into large stores. However, to protect small food retail stores, the Large-Scale Retail Store Act from the late 1970s was enacted and their increase was slowed down. This Act was the subject of the U.S.-Japan Structural Conference in the late 1980s, which resulted in deregulation and law amendment. The time for large stores has come again. Now, there is severe competition for survival among stores focusing on systematization of national chains.

2. Changes in Market Needs and Fuji Electric's Technology

Fuji Electric began manufacturing open refrigerating display cases in 1972 and has successively developed products through technical development to meet market needs. The main topics are described below.

2.1 Changes in market needs

The era when any goods on display were sold (the 1960s and 1970s) shifted to the era of quality-orientation (the 1980s). From the latter half of the 1980s to the 1990s, needs tended toward better goods that were lower in price. A new conception developed: the store is not a storage area for goods but a salesroom with displays and a buying room with suggestions.

The diversification of eating habits and the diffusion of prepared and semi-prepared food (daily dishes) due to an increase in the proportion of working women have brought about an increase in the number of different items. This in turn necessitates ease in the purchase and selection of goods, which attaches importance to display efficiency and stage effects of the refrigerating display cases.

Since the regulation of the Large Store Act limiting multiple store development, importance has been attached to a reduction in goods loss and the quality of freshness control in selecting a refrigerating display case to improve the income of food retail stores and secure customers' reliance.

In particular, uniform refrigeration to minimize any difference between cold storage temperatures and minimization of the influence of defrost cycles on the stored goods are major points. Ever since the incidents of food poisoning by the pathogenic colon bacillus O-157 last summer, more careful temperature control has been demanded. As a result, antibacterial treatment for refrigerating display case materials and surfaces to prevent the propagation of bacteria has been introduced.

Due to the rise in crude oil prices in 1980, the impact on supermarkets by the increase in power rates was so serious that energy-saving measures including the use of two-layer air curtains, increasing efficiency of the basic functions with simulation technology, optimizing the basic structure, and raising the power factor of the lighting have been energetically pushed. As a result, required electric charges have been reduced by half or more.

After striving for measures concerning fluorocarbon control in connection with ozone layer protection, Fuji Electric put an end to the use of all "specified fluorocarbons" and has substituted materials with a lower factor of ozone layer destruction at the end of 1995. Separate from ozone layer protection is global warming prevention. Substitutes with a large greenhouse effect were determined at the 7th Treaty Powers' Conference held in December 1995, and Fuji Electric is attempting to replace them. In October 1996, our refrigerating display case plant received recognition of the international environmental standard ISO14001, a first for Fuji Electric's plants.

On the other hand, since the opening of the first store in the mid 1970s, convenience stores have rapidly spread in urban communities. Conveniences such as 24-hour operation match our present society, so they still maintain a very high rate of growth and are spreading throughout the country. Because of the

severe air conditioning in stores, reach-in refrigerating food cases with glass doors were primarily installed. However, to facilitate removal of goods and due to a rapid increase in the sale of pre-packed lunches and sandwiches, small open refrigerating display cases are gaining popularity.

2.2 Technical developments

Many new products and technical developments that meet market needs have been realized. Among them, the following technical developments are highly rated in the market and verified as “Fuji Electric’s technology”, demonstrating our leadership in the industry.

2.2.1 Air defrosting

With the air curtains kept in operation, defrosting is performed by introducing room air around the evaporator and using its energy as the heat source. Therefore, this is an energy-saving, highly reliable defrosting system requiring no electric heaters. It is patented in 11 countries around the world.

2.2.2 High-freshness control technology

The icing temperature high-freshness display case can keep food as it is at an icing temperature range (−2 to −5°C), just before the food freezes. It operates nonstop by reciprocally operating and defrosting the two evaporators.

2.2.3 Total control with microcomputer

By means of optimum control for each individual case, the F/M microcomputer reduces running costs and greatly improves adaptation to the environment. It is also highly reliable and easy to install and maintain. It is standard for all types, a first in the industry, and total control is now possible.

2.2.4 Fuzzy refrigerating display cases

The fuzzy refrigerating display case can judge changes in the ambient environment by itself. It is an industry first, and performs fuzzy control for optimum defrosting, saves energy and attains high-freshness control.

Table 1 shows the changes in market needs and Fuji Electric’s technical developments.

3. Future Market Needs and Fuji Electric’s Attitude

Competition between supermarkets is predicted to increase, and excessive competition has started between local convenience stores, which are continually growing. To realize everyday low prices for goods, store equipment such as display cases requires rationally integrating initial, running, and maintenance costs and improving equipment reliability.

In the food retail industry, the proportion of labor cost is high, and there are growing demands for

Table 1. Changes in market needs and technical developments

Year	Market needs	Technical developments
1974	Large Store Act enforcement	Foreign patents for air defrosting
1976	Increase in local branches	
1980	Oil crisis Energy saving demanded	Two-layer air curtains
1984	Display efficiency and stage effects demanded	Semi-multi-deck series
1985	Freshness control demanded	Icing temp. nondefrost series CVS lunch refrigerating display cases
1990	Environmental problems (ozone layer protection) Energy saving demanded again	Microcomputer controllers
1993		Fuzzy refrigerating display cases
1995		Specified fluorocarbons for foaming agents and refrigerant discontinued
1996		Environmental standard ISO14001 recognition

equipment and devices to reduce manpower and labor. In addition, because labor shortage is still a big problem for installation and maintenance, efforts for simplifying installation and fault prediction technology are required.

In addition to tackling global environmental problems such as ozone layer destruction and global warming prevention, efforts will be made to develop products that minimize environmental degradation and environmental preservation based on life cycle assessment. Such measures include industrial waste reduction and recycling.

China and Southeast Asia are in a state of rapid economic growth and are expected to be profitable markets for the refrigerating display case business. Fuji Electric plans to enter into a joint enterprise with China and begin overseas production in the latter half of 1997.

4. Conclusion

Among the innovations of Japanese industrial structure, the open refrigerating display case area of the food distribution and retail industry has rapidly raised its position and is expected to receive a large amount of equipment investment. To be at harmony with the changing social environment, we will develop new products fulfilling customer needs and would appreciate it very much if the parties concerned would offer us further guidance and help in the future.

Multi-Deck Open Refrigerating Display Case for Chilled Food

Eiji Yamada

1. Introduction

Because of serious competition between stores, open refrigerating display cases now strongly require not only a reduction in initial expenditure and running costs but also high display efficiency and stage effects so that the merchandise excites customer interest.

To meet these requirements with “friendly” as the central theme and with the goal of “easy to see, select, and remove merchandise”, Fuji Electric developed and marketed the “Fresh MAX series open refrigerating display cases”. This series is friendly to customers and fitters alike. An outline of the series is introduced below.

2. Outline of the Fresh MAX Series and Multi-Deck Open Refrigerating Display Cases

To meet the diversity of stores, merchandised items, display methods, and sales systems, the Fresh MAX series open refrigerating display cases consists of four types differing in their basic sectional views: multi-deck, semi-multi-deck, flat, and pair-freezer

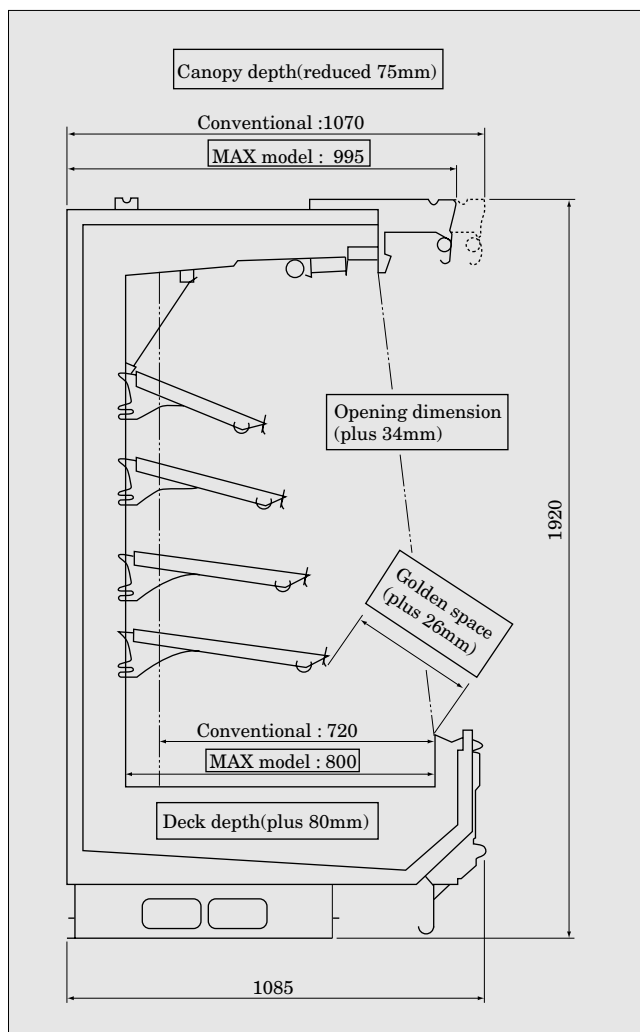
Fig. 1 External view of the Fresh MAX series multi-deck open refrigerating display case



types. Each type can be divided according to different working temperature ranges. A grand total of 423 types compose the series. Included among these is the multi-deck open refrigerating display case which has a separately installed refrigerator. A sectional view of this type is shown in Fig. 2.

In this type of case, a curtain of cooled air is formed in front of the open space by cold air blown

Fig. 2 Sectional view of the Fresh MAX series multi-deck open refrigerating display case



from the upper exhaust outlet and drawn back through the bottom suction inlet. This air curtain isolates the interior from the open air and keeps the air cold for the display of merchandise. This type is subdivided into 98 types, differing in cold storage temperatures of the displayed merchandise, case depth and length dimensions, and the number of air curtain layers.

Among these, the fuzzy series which first applied fuzzy control to open refrigerating cases has attracted attention. Individualized and diversified needs can be met by corner cabinets, special cabinets, and other options.

3. Advantages of the Multi-Deck Open Refrigerating Display Case

3.1 Customer friendly

(1) Structure facilitates display and selection of merchandise

Case dimensions are determined by human engineering so that merchandise can be efficiently exhibited and customers can select and remove merchandise naturally.

(a) Shelf configuration

For customers standing near the open refrigerating display case for selection and removal of merchandise, the standard shelf configuration is such that the shelf depth gradually increases from the top to bottom. Also taking eye height calculated from the average person's standing height as the reference point, shelf angles are determined so that customers standing in front of the display case can glance from top to bottom over the merchandise.

(b) Canopy dimensions

The canopy depth, formerly the same as the lower part, was shortened by 75mm to eliminate a feeling of oppression when approaching the open refrigerating display case. Also, rounding the canopy end psychologically and physically facilitates a closer approach than before to the open display case for the selection of merchandise.

(2) Improvement in display efficiency

Increased the dimensions of the case opening and the golden space (the distance between the lowest shelf and the suction opening) enlarge the angle of view and increases the appeal of the exhibited merchandise.

Two heights of price cards and POP (point of purchase) hangers can be affixed on the upper support for the inclined mirror, which produces the impression of the bulk and continuity of the merchandise. The lower support's construction enables easy change of the mirror inclination in two stages, which greatly improves the stage effect of the merchandise.

3.2 Store friendly

(1) Improvement in display efficiency

To reduce the frequency of merchandise restocking and prevent lost sales due to a sellout, the depth of the

deck was increased. As a result, the display capacity of the merchandise grew by about 10%.

(2) Standard equipment of new microcomputer controllers

The standard equipment of the new microcomputer controllers for all cases realizes high freshness management through efficient operation. The compact indicator with a liquid crystal digital display offers refined design and easy temperature checking.

(3) Reduction in running and initial costs

The improvement of sectional and lengthwise air velocity distributions at the air curtain outlet, improved effects of air curtain rectification by improving the honeycomb, and the increase of evaporator efficiency by improving the pattern all reduce the required refrigeration capacity of the cabinet.

With regard to open refrigerating display cases for vegetables and dairy products, the former two layers of air curtains are reduced to one layer, and the number of parts is greatly reduced, due to a reduction in required refrigeration capacity.

3.3 Fitter friendly

(1) Use of 200V power supply

The former 200V and 100V mixed power supply for the cabinet was changed to a single-phase, 3-wire, 200V power supply for all the fan motors, dew prevention heaters, and lighting circuits. This improvement reduces the number of electrical circuits for installation by half and greatly simplifies electrical work.

(2) Improvement of installation and maintenance

The application of the kit form (optional) to the standard equipment of the new microcomputer controller and the mounting of a solenoid valve and defrost timer cases enable work on the case control functions on the case side. This simplifies installation and greatly improves maintenance.

4. Microcomputer Control

Fuji Electric was the first to introduce microcomputer control to open refrigerating display case operation control. The external view and the input/output block diagram of the M microcomputer controller for this series are shown in Figs. 3 and 4, respectively.

Temperature control, defrost end control, alarm output, and draining (differential time lag) control, which were formerly carried out individually with the mechanical or electronic thermostat, are performed by the M microcomputer controller in the lump. In addition, greatly improved control precision and severe storage temperature control realize high freshness control of the merchandise.

In addition, the case has new functions enabled only with the microcomputer such as adjustment of control temperature by changes in the ambient environment, the self-diagnostic function for indicating

Fig. 3 External view of the M microcomputer controller

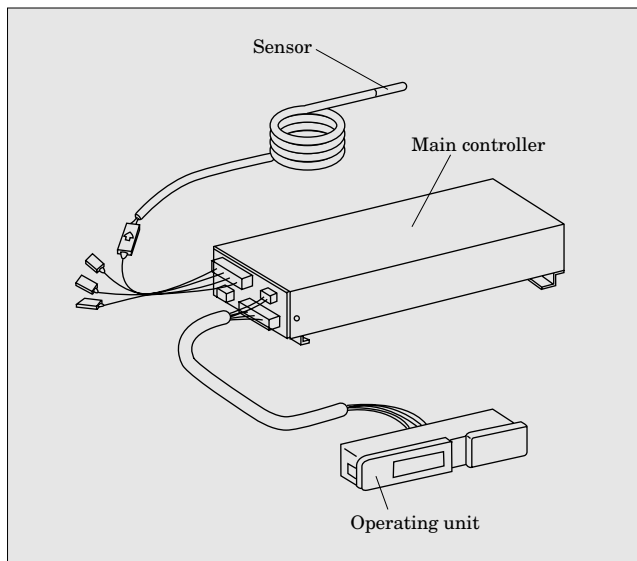
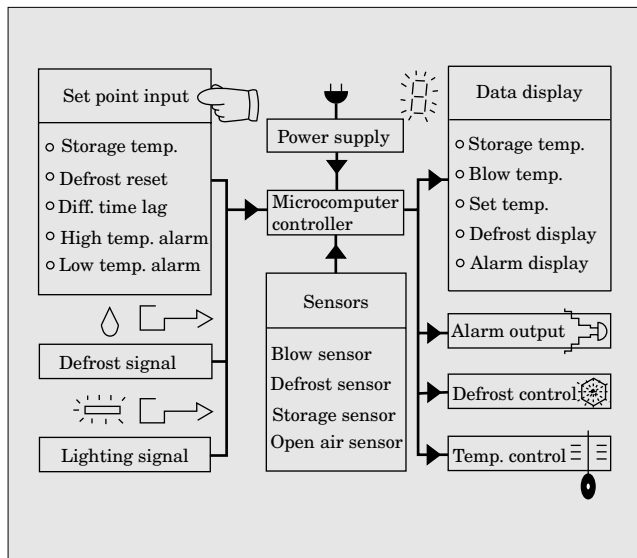


Fig. 4 I/O block diagram for the M microcomputer controller



sensor abnormality, and the temperature monitor function for various parts.

The major functions are described below.

(1) Display function

Storage temperature, set points, alarm contents, sensor temperature, and sensor abnormalities can be checked with the liquid crystal digital display on the operating unit.

(2) Setting function

With the push button of the operating unit, storage temperature, defrost reset temperature, alarm temperature, and draining time can easily be set.

(3) Storage temperature control function

This function adjusts control temperature for storage based on open air temperature sensor signals, temperature adjuster sensor signals, and set temperature. It maintains storage temperature at the proper level to ensure high freshness control of the merchan-

Fig. 5 Air velocity vectors

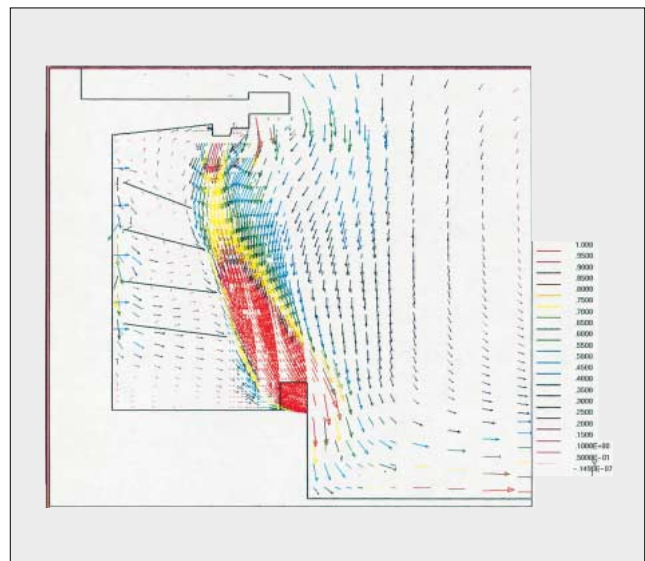
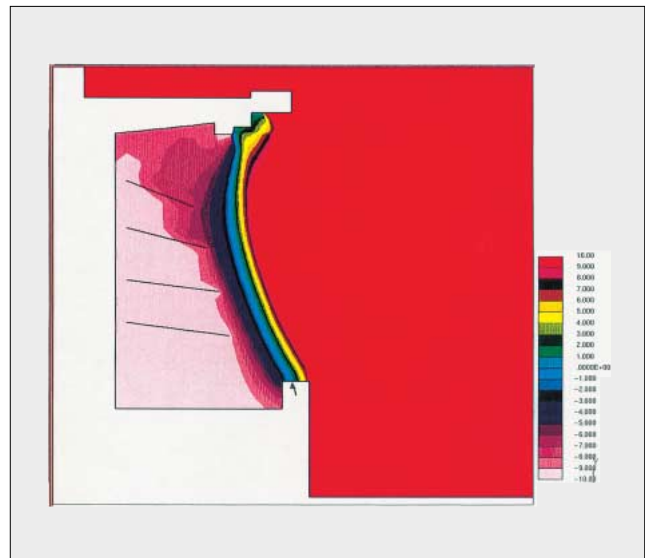


Fig. 6 Temperature distribution



dise as well as reduce energy loss due to excess cooling.

(4) Defrost control function

Based on defrost temperature sensor signals, this function controls defrost reset as well as draining time to securely discharge defrost water and attain reliable defrosting.

(5) Alarm output function

Judging the condition of case operation from temperature at the sensors and sensor input data, this function gives the alarm display when an abnormality occurs and also outputs the alarm to the outside.

5. Simulation Analysis

In developing this series, Fuji Electric maximized thermal fluid analysis, optimized air curtain performance, and made great improvements in the open refrigerating display case characteristics.

An example of an air velocity analysis is shown in Fig. 5, and an example of temperature analysis is shown in Fig. 6.

In this series, particularly the positional relationship between the air curtain exhaust and suction openings and the correlation between the honeycomb rectifier at the exhaust outlet, the blown air velocity, and the back flow from the rear of the case are optimized. Thus, temperature at the farthest parts, i.e. the lowest shelf and the case bottom near the suction opening, has now been improved. In the past, this has posed problems.

Due to these improvements, the storage temperature is more uniform than in the former types, and energy savings and high freshness control are attained.

6. Conclusion

Supermarkets tend toward individualization and diversification when seeking a new sales style. For example, showcases are also breaking tradition from the conventional uniform style. Fuji Electric will further the expansion of this series and the development of related products in a positive manner.



Multi-Deck Open Refrigerating Display Case for Frozen Food

Haruhiko Sudo

1. Introduction

Demand for frozen food has greatly increased in recent years due to an increase in working women, a general lack of cooking skills, trends toward irregular mealtimes, and remarkable improvements in the quality of frozen food. Once categorized as only a labor saving food, today's frozen food has emerged as major food category.

Because of high gross profit and easy operation, supermarkets put a great deal of effort into frozen foods.

With regard to the recent sale of frozen food, usage has increased of both flat open refrigerating display cases that provide ease in displaying and removing articles, as well as multi-deck open refrigerating display cases that offer high sales efficiency (effective capacity per installation area) and efficient sales of several types of frozen foods.

Because of its low operating temperature, the temperature difference between the inside and outside of multi-deck open refrigerating display cases exceeds 40K.

Advanced technology is required to maintain the

inside at a uniform constant temperature suitable for frozen food.

On the other hand, improvements in the display are also necessary.

Fuji Electric has developed the Fresh MAX series of multi-deck open refrigerating display cases having the same display features as multi-deck open refrigerating display case for chilled food (shortened canopy depth, etc.) as well as a structure and specifications for refrigeration efficiency. These features are introduced below.

2. Features

- (1) Major external dimensions in accordance with the series standard (canopy depth 995mm)
- (2) Stable refrigeration efficiency with a 3-duct circulation structure (an industry's first)
- (3) High efficiency defrosting system improved by reversing the middle and outer air curtain fans, and by using heaters
- (4) Improved refrigeration prevents from drop in refrigeration efficiency due to frost deposits from the evaporator
- (5) Standard equipment with M microcomputer controller

3. Structure and Specifications

3.1 External shape

As shown in Fig. 2, major external dimensions are in accordance with the standard dimensions of the Fresh MAX series multi-deck open refrigerating display cases.

A short canopy depth prevents customers from sensing overhead oppression, but causes a greater non-alignment between the air curtain nozzle and inlet (dimension A in Fig. 2).

Cooled air with high specific gravity has a marked tendency to flow in the direction of gravity. This tendency is particularly strong in the air curtains of multi-deck open refrigerating display cases used for the lowest temperature range. The non-alignment of the nozzles of exhaust and inlets is a serious disadvan-

Fig. 1 External view of the multi-deck open refrigerating display case for frozen food



Fig. 2 Structure of the multi-deck open refrigerating display case for frozen food

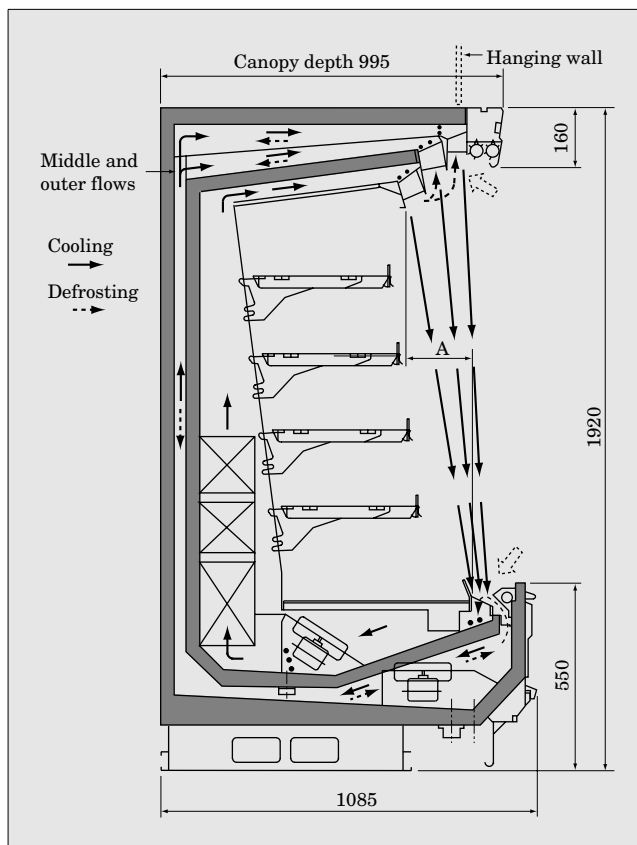
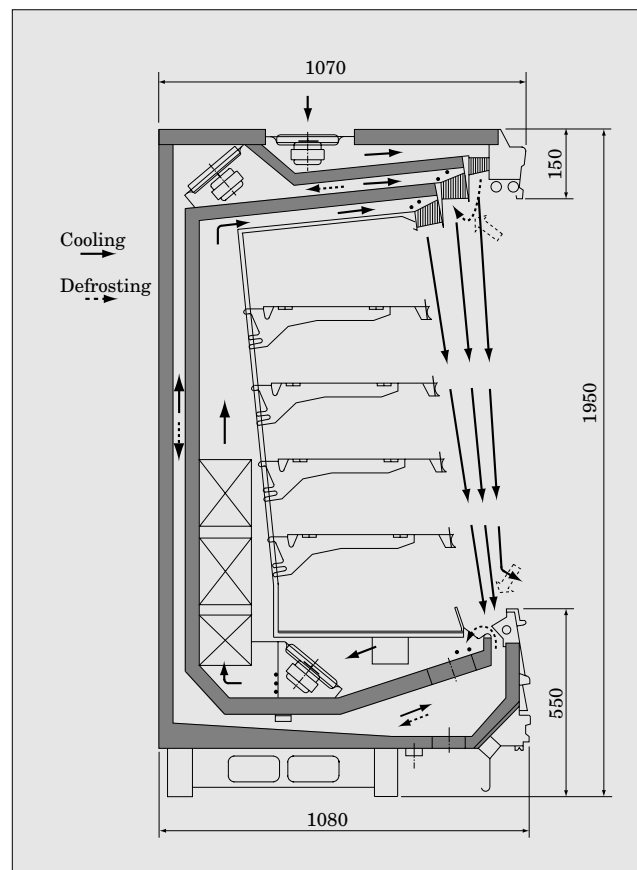


Fig. 3 Structure of the conventional device



tage to refrigeration efficiency.

In spite of this disadvantage inherent in the external shape, the development of the 3-duct air curtain circulation structure has achieved high refrigeration efficiency and has resulted in many other advantages.

3.2 Structure

3.2.1 Duct configuration

Prior systems use 3-duct air curtains consisting of 2-duct circulation and 1-duct downward blowing, but the Fresh MAX series introduced the industry's first 3-duct circulation system.

In the 3-duct circulation system, the outer air curtain duct formerly installed inside the case only for downward blowing is changed because it reduces the display area and effective capacity, and the backside duct is partitioned lengthwise to be shared by outer and inner air curtains. (Patent pending)

At the upper section, the air flow is divided into flows for the outer and inner air curtains. Because the duct is partitioned lengthwise, the divided air flows lack lengthwise uniformity. To make the air flows uniform, static pressure in the duct is raised by tapering the duct from the point of flow division toward the nozzles as shown in Fig. 2. In addition, louvers are provided near the nozzles.

Fans for the middle and outer air curtains, former-

ly mounted at the top, are now located at the bottom. Each air flow for the middle and outer air curtains is adjusted by the number of fans and duct lengths.

The 3-duct circulation system has the following advantages.

- (1) Outer air curtain temperature can be optimized using the inner circulating air flow.
- (2) In the summer, hot air near the ceiling does not flow into the air curtain, preventing a drop in refrigeration efficiency.
- (3) Decorative walls, hung from the ceiling, can be installed.
- (4) Location of fans at the bottom of the unit improves the ability to maintain the fan motors, etc.

3.2.2 Air curtain nozzles

At the air curtain nozzles, an aluminum honeycomb with small cells is used to rectify the blown air. The air velocity distribution over a cross-section of each air curtain is optimized by using slanted trapezoids as the honeycomb cell shape.

Moreover, the air curtain blowing directions intersect each other at optimum angles to form good air curtains.

3.2.3 Air curtain inlets

The air curtain inlets are shaped so as to minimize both the mixing of air curtains from each duct and the deposit of frost on the inlets. The inlets are shaped as shown in Fig. 2. Frost deposited during defrosting does

not drain water drops into the case.

3.3 Evaporator

The evaporator is divided into three sections and the fin pitch of each section is experimentally determined to minimize clogging by frost deposits. Because the evaporation temperature is as low as -40°C , supercooling in the cooling process causes large quantities of frost to be deposited locally, resulting in clogging within a short time.

In this device, the relation between the cooling process and heat transfer area has been selected for strong resistance against frost formation.

3.4 Heater

In addition to the heaters that prevent condensation and frost accumulation on the case surfaces, heaters to prevent frost generation are used in the air passage of the inner air curtain to prevent clogging due to local frost deposits in a short time. The low evaporation temperature sometimes causes what is called air-borne frost in the air flow. Frost production also depends on the duct area, the direction of flow, sudden changes in air velocity, and collision with obstacles. The inner and middle honeycomb heaters shown in Fig. 2 (black spots in the passages) are provided to prevent such frosting. The outer honeycomb heaters are provided mainly to optimize the blow air temperature.

Heaters are equipped also for the inlets and inlet ducts to prevent frost generation and deposits. The inner and middle blow air is nearly saturated. When nearly saturated air at different temperatures is mixed, the water content in the air causes an excess water condition.

Since the air curtain is not static air, it is not considered to be supercooled. However, the fact that mist is generated in the boundary between the inner and middle air curtains in experiments with fuming material suggests the existence of supercooling vapor. The excess water is frozen into ice crystals, i.e. frost, on obstacles such as the inlets and the frost deposits result in clogging.

The heaters for the inlets and ducts are considered very effective.

3.5 Control

3.5.1 Thermostat control

Thermostat control is performed with an M microcomputer controller, standard equipment for all models of the Fresh MAX series. The sensor for this control, installed in the inner air curtain duct, achieves stable thermostat control.

3.5.2 Defrosting control

The defrosting control uses a system which starts at a scheduled time and is reset by temperature.

Table 1 Specifications of the multi-deck open refrigerating display case for frozen food

Use		Frozen food	
Model		MFA55L3-064A	MFA55L3-084A
Operating temperature ($^{\circ}\text{C}$)		-20 to -18	
Dimensions	Height (mm)	1,920	
	Length (mm)	1,830	2,440
	Canopy depth (mm)	995	
	Front depth (mm)	1,085	
	Front height (mm)	550	
Shelf area (m^2)		3.93	5.25
Capacity (L)		1,095	1,460
Mass (kg)		410	550
Drain bore		40A	
Refrigerating capacity	Required capacity (kW)	2.14	2.79
	Evaporation temperature ($^{\circ}\text{C}$)	-40	
	Refrigerant	R-22	
Defrosting system		Reversible outer/middle fans and heaters	
Power consumption	Single-phase 200V, 50/60Hz (): Defrosting	1,746/1,753 (1,845/1,852)	2,313/2,318 (2,368/2,373)
	Three-phase 200V, for defrosting heaters	1,620	2,160
Shelf (ft. \times pos)		3×2	4×2

Control is performed with an M microcomputer controller, similar to temperature control.

The defrosting heater capacity is experimentally determined to optimize defrosting efficiency. Inadequate heater capacity unnecessarily prolongs defrosting time, while excessive capacity causes water to refreeze and may form ice banks during extended operation. The heater capacity is determined giving consideration to these points as well as voltage fluctuation.

During defrosting, the fan for outer and middle air curtains is reversed to agitate air in front of the cabinet and introduce outside air. Thus, by positively utilizing the heat of outside air, the defrosting heater capacity can be reduced and defrosting time can be shortened.

4. Conclusion

The features of the Fresh MAX series multi-deck open refrigerating display case have been summarized above.

Fuji Electric will continue to strive to improve air curtains to reduce energy for refrigeration, develop new defrosting systems, and improve display effectiveness.

Island Type Open Refrigerating Display Case

Takashi Hirano

1. Introduction

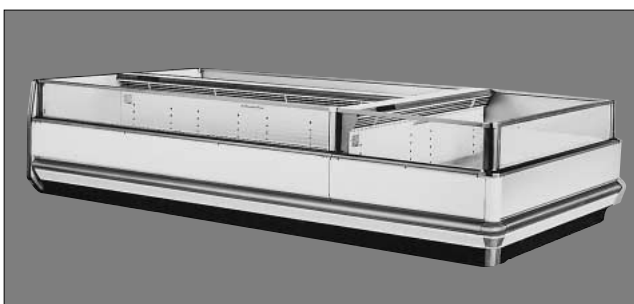
In supermarkets, exhibiting and selling methods of goods have remarkably changed as stores have become larger, resulting from the deregulation of the Large Scale Retail Store Law, thereby strengthening their ability to compete against other stores. Furthermore, there are strong demands to reduce not only display case price but also total price, including limiting store operating and construction expenditures.

Therefore, island type display cases, which have low initial and running costs, are gaining popularity and demand for them is rapidly increasing. Against such a background, Fuji Electric has developed and brought its “Fresh MAX series of island type open refrigerating display case for supermarkets” to the marketplace. A summary is presented below.

2. Overview of island Type Open Refrigerating Display Cases for Supermarkets

Island type open refrigerating display cases open at the top and forcibly circulate cold air cooled with an evaporator to form an air curtain at the plane of the opening. These cases are classified as follows according to usage and construction. There are three classifications according to usage: for meat and fish (-2 to $+2^{\circ}\text{C}$), frozen food (-18°C or less) and ice cream (-22°C or less). Cabinet construction can be roughly classified into two types: wall-side models and dual-sided models, with variations for each type depending

Fig. 1 External view of Fresh MAX series island type open refrigerating display case for supermarkets



on the widths. There is also a series of standardized cabinets that have inside illumination to light up the goods or an inclined mirror to create the effect of an abundance of goods. As a result, there is a total of 43 case models. In addition, corner type cases, custom cases and other options are available to meet a variety of individual needs.

3. Features of Island Type Open Refrigerating Display Cases

3.1 Construction

(1) Wall-side island type models

The wall-side island type open refrigerating display case has a nozzle at the rear and an inlet at the front of the case as shown in Fig. 2. Therefore, the goods can be arranged on a level plane, with the benefit that customers can see all the displayed goods at a glance when standing at the front of the case.

Further, the case has a large glass plate attached to the front enabling customers to see the goods inside the case even from a distance.

(2) Dual-side island type models

The construction of the typical MFX type dual-

Fig. 2 Cross-section of the wall-side island type open refrigerating display case

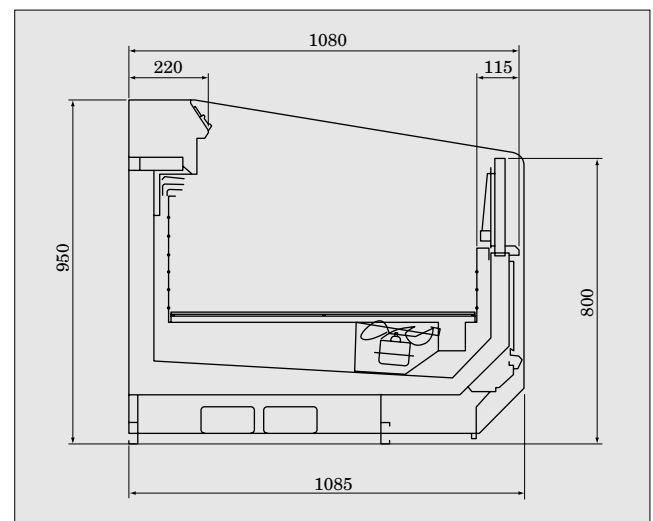
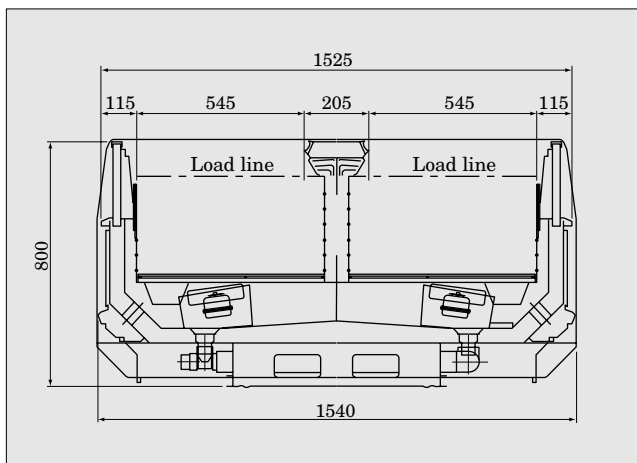


Fig. 3 Cross-section of the dual-sided island type open refrigerating display case



sided island type open refrigerating display case is shown in Fig. 3. This case has nozzles for cold air at its center and inlets are provided at both sides. With this configuration, goods can be arranged on both sides of the cabinets, and therefore, these cases are installed along passageways in the store. The cold air blown out from the center is suctioned into each inlet, and sent by fans to the evaporators. The cold air path is constructed so that cold air from both sides is mixed in a central air duct to prevent temperature inequalities at both sides of the cases and then blown out from the nozzles. The construction utilizes a large glass plate at the front, as in the wall-side model.

3.2 Improvement of exhibition ability

(1) Expansion of effective internal volume

Here, we will describe the dual-sided island type refrigerating display case for exhibiting ice cream, an item of interest in recent years. The case's internal width and depth were determined after investigating the dimensions of many cup-type ice cream goods. As a result, the effective internal volume has been expanded by 35% over previous models, achieving the maximum internal volume in the industry world-wide. Furthermore, the sales capacity is remarkably improved because of the increased display volume per case.

(2) Enrichment of exhibition functions

Options such as internal partitions for the goods, attached illumination and a POP rail at the front table part are available to enrich the exhibition functions.

3.3 Improvement of operating characteristics

(1) New microcomputer controller

All of the cases are equipped with a new standard microcomputer controller to enable high-grade freshness control. In dual-sided island type cases, in order to enable temperature setting and temperature verifi-

cation for either side of the case, two displays are provided at the center to improve operability.

3.4 Reduction of total cost

(1) Reduction of running cost

(a) Reduction of required refrigeration capacity

The required refrigeration capacity was reduced by 30% compared with previous models by equalizing the wind velocity blown out from the nozzle in the long direction, improving the cross-sectional wind velocity balance and developing a high-efficiency evaporator. This has resulted in a remarkable reduction of the running cost.

(b) Reduction of heater capacity for preventing dew condensation

A large glass plate is attached to the front of the case. Dew condensation occurs on the outside surface of the glass plate due to low temperature inside the case and obstructs the display. Conventionally, a transparent heater panel stacked on the surface of the glass to form a "paired glass" is used as a countermeasure. A special pair glass, which has lower heat conductivity than that of the conventional one, was newly developed to reduce this heater capacity. With this new pair glass, the heater capacity for preventing dew condensation was reduced by 15% compared with previous models.

(2) Reduction of initial cost

(a) Review of basic construction

After reviewing the basic construction, the MAX series and other case types (multi-deck cases and semi-multi-deck case) were thoroughly standardized. Furthermore, the assemblies for attaching the glass plate and case duct have been simplified and the number of parts dramatically reduced.

(b) Reduction of installation work cost

The cost to have the case installed is drastically reduced owing to the miniaturization of the refrigerator due to the reduction of the required refrigeration capacity, simplification of the wiring work by the reduction of the heater capacity, and the 200V. AC power supply for the display case.

4. Conclusion

In this paper we have presented a summary of the island type open refrigerating display cases for supermarket. As in the case of multi-deck open cases, many improvements such as lower cost, reduced required refrigeration capacity, and an improved display have been realized. We believe that these improvements meet the need for total cost reduction. At that time, Fuji Electric will strive to promote energy savings and to expand the varieties of the display case in response to widely diversifying needs.

Super-Slimed Multi-Deck Open Refrigerating Display Case for Convenience Store

Hatsuo Kobayashi

1. Introduction

Recently in Japan, sales by convenience stores and the number of newly opened stores continue to grow, due to such conveniences as being open 24 hours.

At the same time, many original brand name goods have been developed in response to diverse eating habits. Display methods, ingredients, and the selling of merchandise has changed remarkably due to competition.

On the other hand, cost reduction is strongly required not only for the refrigerating display cases but also for the total costs, including running and installation, of the store.

To meet these market needs, Fuji Electric has developed a new series comprised of 8 types of super-slimed multi-deck open refrigerating display cases for the convenience store, having such features as elaborated display performance and a temperature control function (Fig. 1).

They have already been marketed and widely accepted.

Fig. 1 External view of super-slimed multi-deck open refrigerating display case



2. Outline of the Super-Slimed Multi-Deck Open Refrigerating Display Cases for Convenience Stores

- (1) All 8 types come in either a basic length of 650mm or 750mm.
- (2) The case is designed so that a single case can handle a variety of goods ranging from lunches (15 to 20°C) to dairy products (3 to 8°C).
- (3) The front sizes (case width) come in 4 basic sizes.
- (4) The front height is 500mm for all types.

3. Features

- (1) Standardized equipment of the new microcomputer controller improves installation and service.
- (2) Application of a double-layered construction in all types saves more energy.
- (3) The application of return grills that are easily attachable/removable and the subdivision of the shelf pitches improve handling and display performance.
- (4) Adoption of a return grill with a radial corner maintains cleanliness.

4. Specifications and Construction

Refer to Table 1 for the specifications and Fig. 2 for construction.

4.1 Improved installation and service

- (1) For achieving elaborated freshness control, all types are equipped with a new standard microcomputer controller, a first in the convenience store field.

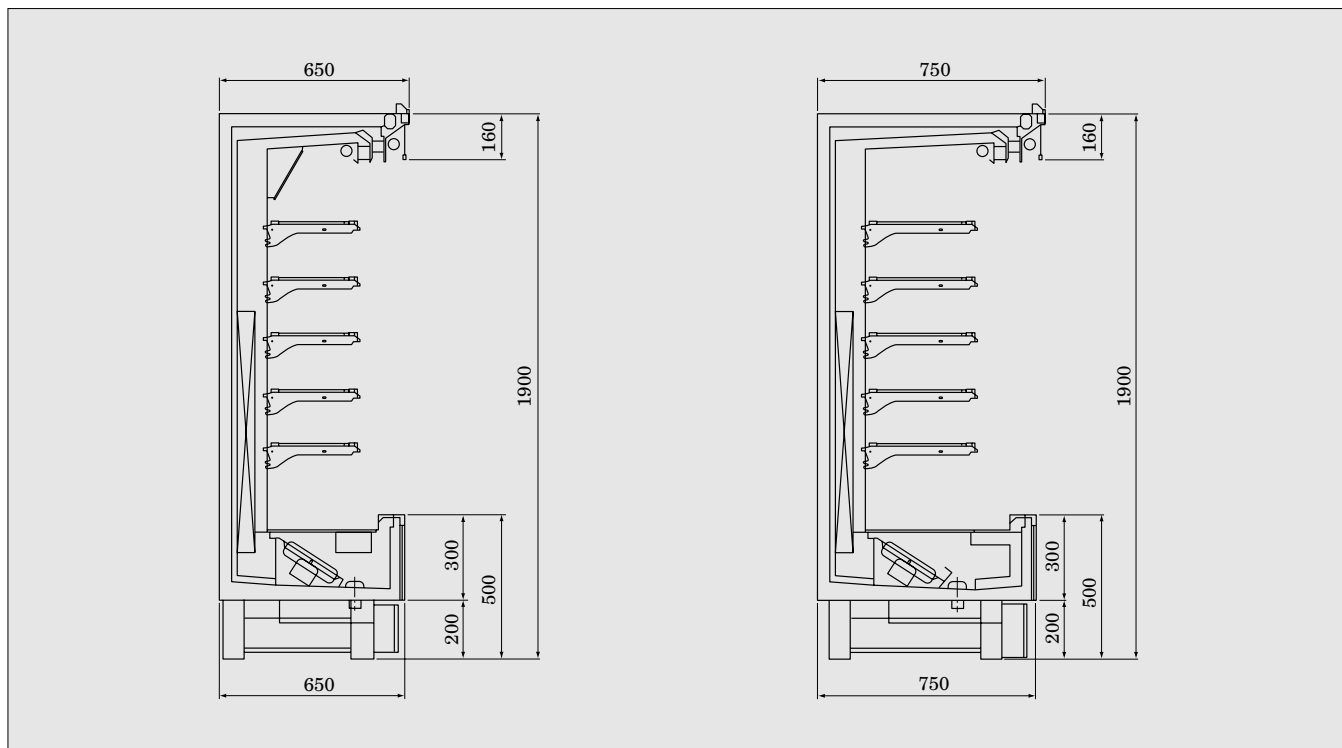
Figure 3 shows the input/output configuration of the new microcomputer controller. Its functions include temperature indication, alarm indication and temperature control, and adaptive control according to its installed environment is possible.

- (2) All types are equipped with standard magnetic valves which drastically simplify installation.
- (3) The newly developed case can control temperature, ranging from the lunch case (15 to 20°C) to

Table 1 Specifications of super-slided multi-deck open refrigerating display case

Item		Type	MFQ50D2 -035BM	MFQ50D2 -045BM	MFQ50D2 -055BM	MFQ50D2 -065BM	FT50D2 -035AFG	FT50D2 -045AFG	FT50D2 -065AFG	FT50D2 -085AFG
Usage			Goods delivered daily/dairy products (lunches)							
Applied temperature		(°C)	3 to 8 (15 to 20)							
Effective capacity		(L)	389	518	611	777	467	623	934	1,245
Shelf area		(m ²)	1.73	2.30	2.72	3.46	2.07	2.76	4.14	5.52
Mass		(kg)	130	170	220	260	150	190	285	380
Drainage diameter			40A							
External size	Overall height	(mm)	1,900							
	Overall width	(mm)	915	1,220	1,440	1,830	915	1,220	1,830	2,440
	Canopy length	(mm)	650				750			
	Front length	(mm)	650				750			
	Front height	(mm)	500							
Freezing capacity	Required freezing capacity	(kW)	0.76	0.85	1.16	1.45	0.82	0.94	1.53	2.00
	Evaporation temperature	(°C)	- 10							
	Coolant		HCFC-22							
Defrosting capacity			Off-cycle (4 times per day)							
Power consumption 50Hz		(W)	121	142	188	256	121	142	256	304
Single phase (100V) 60Hz		(W)	125	146	195	262	125	146	262	310
Shelf composition, types (width×row)			3'×1	4'×1	2.5'×2	3'×2	3'×1	4'×1	3'×2	4'×2
			Glass shelf							

Fig. 2 Cross section of super-slided multi-deck open refrigerating display case



the dairy product case (3 to 8°C) with the temperature setting function of the new microcomputer controller.

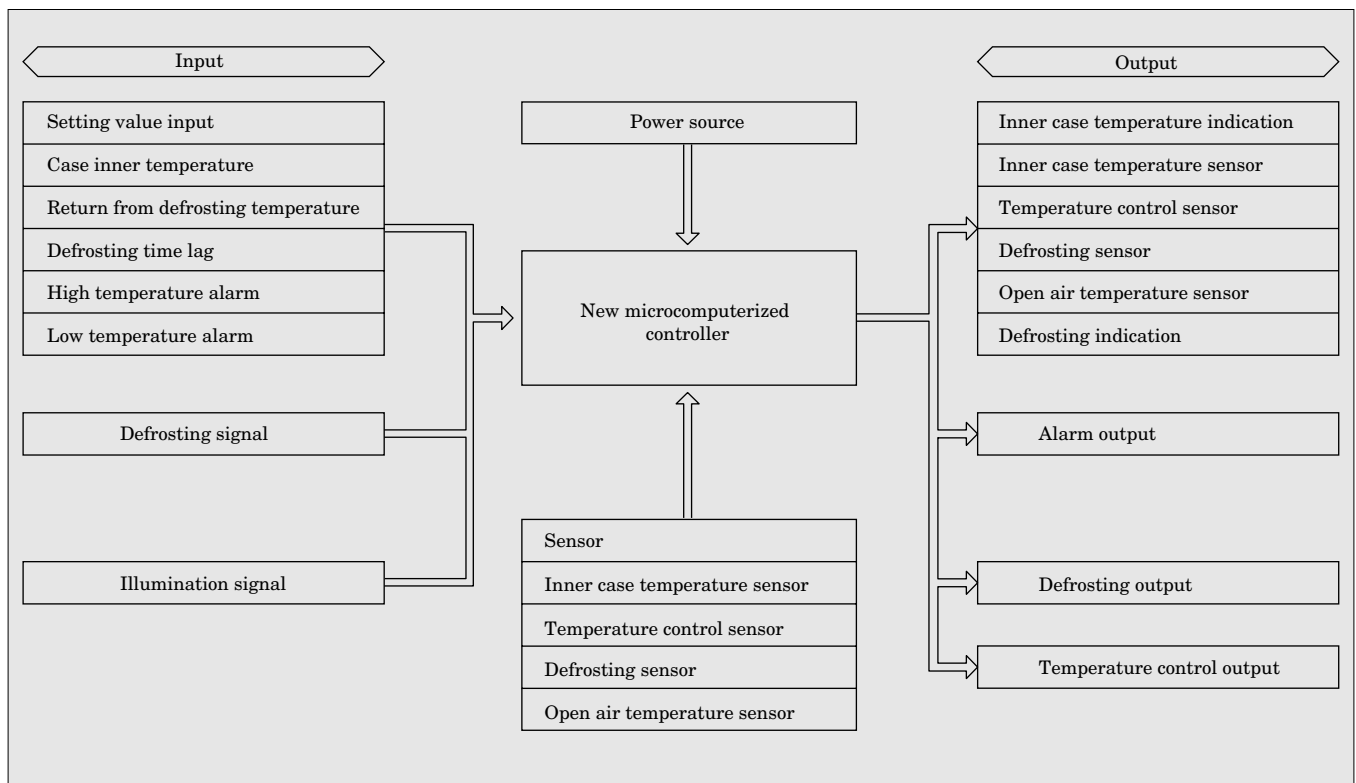
- (4) Most convenience stores are open 24 hours a day, 365 days a year and require minimized maintenance time. Thus, the control devices and fan

motor are located at the bottom for easier regular maintenance.

4.2 Energy saving

- (1) By applying a double-layered construction and high density honeycombs for all types, energy

Fig. 3 Input/output configuration of the new microcomputer controller



savings of about 30% (compared with our conventional cases) are achieved.

- (2) The adoption of a wide backflow (cold air blown directly out of the back wall of the case) dissolves the temperature variance among the merchandise in the case.
- (3) The application of full-face glass shelves eliminates lighting on every shelf, attaining 15 to 20% in energy savings.

4.3 Improved handling and display performance

- (1) The subdivided variable shelf pitches (25mm to 15mm) allow a variety of merchandise to be displayed in the convenience store, corresponding to the diverse number of items.
- (2) The unification of the shelf plate with the bracket improves handling by facilitating change of the shelf position.
- (3) For easier search and removal of the merchandise, the front height (decreased from 550mm to 500mm), shelf size and shelf position are determined based on human engineering.
- (4) Application of the acrylic illumination plate for the canopy enhances advertisement of the merchandise.
- (5) By unifying the external appearance of all 8 types

with a single design, the store's interior is improved.

4.4 Improved cleaning

- (1) All parts to be cleaned including the honeycombs, glass shelves, price tag rails on the shelves, drain filters, and return grills are attachable/removable with a single touch. This construction facilitates frequent cleaning in the store.
- (2) Application of a larger, specially formed return grill and a radius at the rear part of the deck pan improves safety and cleaning.
- (3) Application of the straight back wall and stainless steel bottom pan improves cleaning.

5. Conclusion

The decrease in consumption caused by the recession and the need for distinguished sales against competitors drive convenience stores to select more diversified specifications for individual chain stores.

This makes it necessary for the supplier to offer not only cases but a complete proposal, including additional equipment, utensils and refrigerators.

In the future, we at Fuji Electric intend to develop products with originality.

Reach-In Refrigerating Food Case for Convenience Store

Daisuke Sugimoto

1. Introduction

If walking in a city or driving through the suburbs, one will soon encounter convenience stores. In fact, the total number of convenience stores in Japan has remarkably increased over the last several years and even today high growth continues owing to the convenience of these 24 hour stores and the diverse line of goods they carry to meet the needs of present-day society.

Such high growth has led to serious competition among stores, not only with regard to the display of goods, product line and sales methods, but also to reduce total costs including equipment and installation costs.

Responding to such market needs, Fuji Electric has developed and introduced to the market a new series with 10 models of reach-in refrigerating food case for convenience stores that are being accepted popularly.

A summary is presented in the following paragraphs. (See Fig. 1)

Fig. 1 External view of a FG-series reach-in refrigerating food case



2. Overview of the Reach-In Refrigerating Food Case

The FG-series of reach-in refrigerating food case were developed with the goal of providing “reliable technology that is easy to use”.

Consideration was given to the appropriate size, function and design to effectively utilize the small spaces in convenience stores, with emphasis on easy installation and maintenance to cope with the 24 hour operation of these stores.

2.1 Classification of the reach-in refrigerating food case

The FG-series of the reach-in refrigerating food case are classified according to their usage and model type as follows.

2.1.1 Usage

- (1) Freezing :
frozen foods, ice cream; -18°C or lower
- (2) Refrigeration :
raw meat, raw fish; -2 to $+2^{\circ}\text{C}$
daily delivered goods, dairy goods; 0 to 10°C

2.1.2 Model types

- (a) Thick freezer case with 2 or 3 doors
- (b) Thin freezer case with 2 or 3 doors
- (c) Thick refrigerator case with 2 or 3 doors
- (d) Thin refrigerator case with 2 or 3 doors
- (e) Sliding backdoor refrigerator case with 2 or 3 doors

There are a total of 10 model types.

2.1.3 Specifications and construction

The main specifications are shown in Table 1 and schematic diagrams are shown in Fig. 2.

3. Features of the Reach-In Refrigerating Food Case

3.1 Standard features for the entire FG-series

- (1) A substitute for chloro-fluorocarbon is used in all 10 models.
- (2) A large sized glass heater is used on the wide opening doors so that the goods inside the case are clearly visible and attractively displayed through the unblurred doors.

Table 1 Specifications of the FG-series reach-in refrigerating food case

<div><div>Type</div><div>Usage</div></div>		FG75AN -2CRC	FG75AN -3CRC	FG60AN -2CRC	FG60AN -3CRC	FG75MN -2CRC	FG75MN -3CRC	FG60MN -2CRC	FG60MN -3CRC	FG75MS -2CRC	FG75MS -3CRC
		Frozen foods/ice cream		Frozen foods/ice cream		Meat/fish		Meat/fish		Dairy products	
Operating temperature (°C)		- 18 or less		- 18 or less		- 2 to 2		- 2 to 2		0 to 10	
Effective capacity (L)		1,074	1,610	763	1,143	1,093	1,638	773	1,158	1,093	1,638
Displaying area (5 shelves) (m ²)		4.4	6.6	3.1	4.6	4.4	6.6	3.1	4.6	4.4	6.6
Load (kg)		285	420	230	345	265	400	230	345	290	430
Drainage diameter		30A		30A		30A		30A		30A	
External size	Overall height (mm)	1,900		1,900		1,900		1,900		1,900	
	Overall width (mm)	1,430	2,145	1,430	2,145	1,430	2,145	1,430	2,145	1,430	2,145
	Length (mm)	755		605		755		605		807	
	Number of doors	2	3	2	3	2	3	2	3	2	3
	Door size (mm)	700×1,600		700×1,600		700×1,600		700×1,600		700×1,600	
Electrical system	Lighting (W) (A)	60×3 2.0	60×4 2.7	60×3 2.0	60×4 2.7	65×3 3.9	65×4 5.2	65×3 3.9	65×4 5.2	65×3 3.9	65×4 5.2
	Fan motor (W) (A)	68 0.7	102 1.0	68 0.7	102 1.0	68 0.7	68 0.7	68 0.7	68 0.7	68 0.7	102 1.0
	Dew protection heater (W) (A)	727 7.3	1,091 10.9	722 7.3	1,088 10.8	448 4.5	672 6.7	448 4.5	672 6.7	514 5.1	772 7.7
	Drain-pan heater (W) (A)	150 1.5	225 2.3	150 1.5	225 2.3	—	—	—	—	—	—
	1φ 100V total (W) (A)	1,125 11.9	1,658 16.9	1,120 11.5	1,655 16.8	711 9.1	1,000 12.6	711 9.1	1,000 12.6	777 10.1	1,134 13.9
	3φ 200V defrost heater (W) (A)	300×3 2.5	450×3 3.9	300×3 2.5	450×3 3.9	—	—	—	—	—	—
Freezing capacity	Required freezing capacity (kcal/h)	900	1,200	900	1,200	450	650	450	650	650	970
	Evaporation temperature (°C)	- 40		- 40		- 10		- 10		- 10	
	Coolant	R-22		R-22		R-22		R-22		R-22	
	PipingLiquid pipe	φ9.53		φ9.53		φ9.53		φ9.53		φ9.53	
	Suction pipe	φ15.88		φ15.88		φ12.7		φ12.7		φ12.7	
	Defrosting methods	Electric heater		Electric heater		Off-cycle		Off-cycle		Off-cycle	

- (3) The large inner capacity and variable pitches of the shelves make it possible to display many kinds of goods in various ways.
- (4) Utilizing a long-size fluorescent light with a special stabilizer, the inner space is illuminated brightly and evenly.
- (5) Because the case is closed it is influenced little from the external air and is economical owing to the high cooling efficiency.
- (6) All 10 models share a refined design and can form a unified lineup to satisfy the various arrangements in each store. Further, the construction having 2 separate and adjustable kickplates eliminates the space between the cases and the floor, integrating the showcases into the store's interior design.
- (7) The cold air inlet is constructed with a detachable return grill which allows easy cleaning.
- (8) The reversible construction of the glass doors makes changing the door hinges to either the left

or right side easy, as possibly required by changes in the store lay out. The horizontal door line can also be adjusted easily by means of the attached door height adjuster.

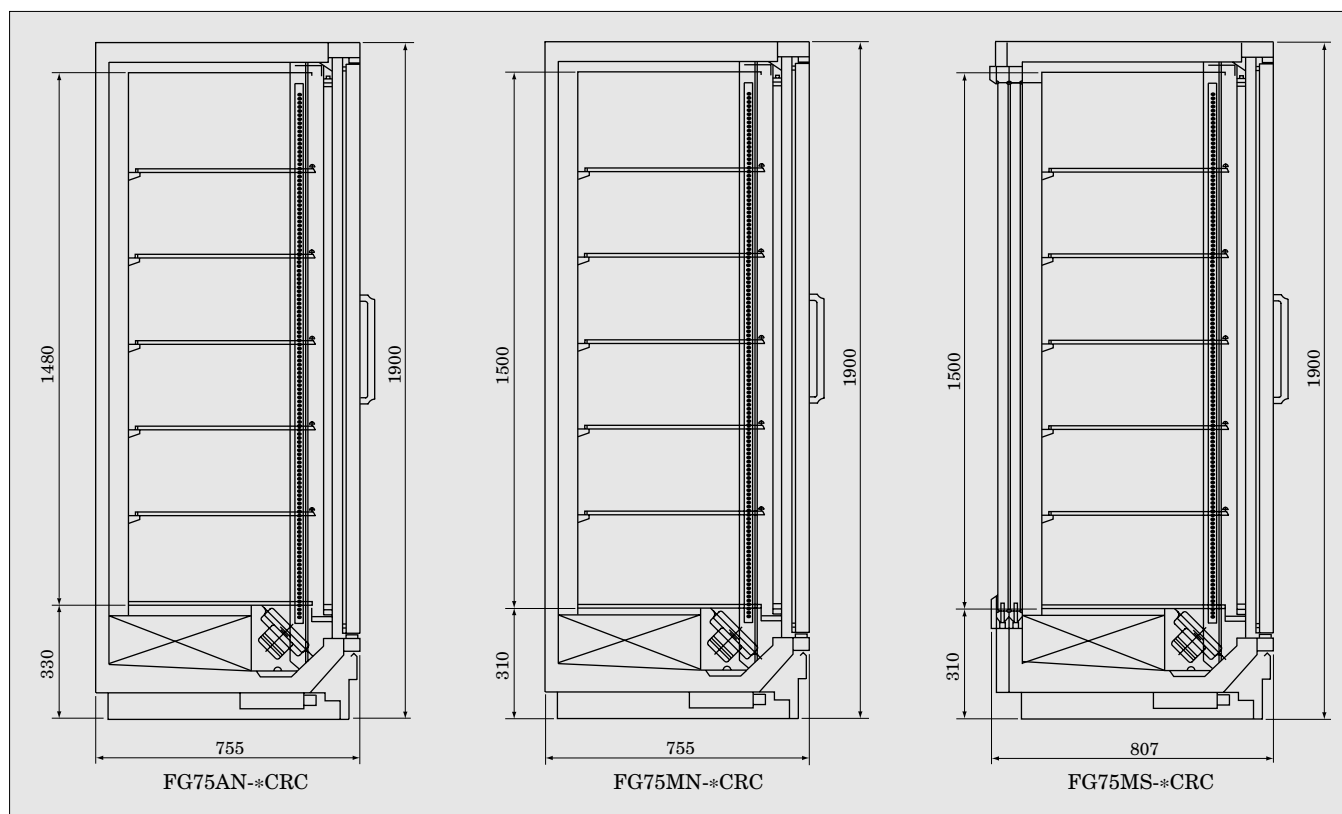
- (9) The concentration of electrical equipment at the front on the case bottom keeps the case top flat and makes installation easier. Also, this makes part replacement of the electrical equipment easier from the front side and improves the serviceability.

3.1.1 Features of the freezing case

(1) Freezing performance

Environmental conditions in the convenience stores are severe because the entrance and exit doors are opened and closed very often, and in addition food processors are installed in the stores where fast-foods are also sold. Even under such conditions the cooling performance of the refrigerating food cases is secured by means of a high efficiency evaporator and a reinforced air curtain with doubled louvers at the cold

Fig. 2 Schematic diagrams of the FG-series reach-in refrigerating food case



air nozzle outlet.

(2) Defrosting performance

Temperature rise of the goods during defrosting must be kept small to prevent softening of the high grade ice cream. These refrigerating food cases prevent softening of the high grade ice cream by means of a drastically shortened defrosting time which reduces the pull-down time after defrosting.

(3) Prevention of frosting in the case

Air that enters during opening and closing of the doors and steam generated during defrosting cause frost to form on the goods, on the inside ceiling and on the back wall. Frost that is repeatedly formed, melted and then frozen not only interferes with the display of goods, but also possibly damages the goods. In these cases the causes of frost formation are suppressed as much as possible by means of a high efficiency evaporator and a shortened defrosting time as mentioned above. Additionally, these refrigerating food cases are equipped with a function for removing already formed frost.

3.1.2 Features of the cases with a sliding back door

(1) Single backdoor construction

Cases with a sliding back door through which goods can be refilled from the store's backyard conventionally had double doors that served as thermal insulation and also as a cold air duct. The back doors were therefore heavy and difficult to open and close.

In the new showcases, cold air ducts are formed by stack-shaped pillars located at the center, and left and right corners of the back wall. This arrangement has a single back door construction. The door can be opened and closed smoothly and also the inner capacity is enlarged.

(2) Refrigeration performance

Cold air nozzles are arranged at the top and bottom ducts on the back wall to secure refrigeration performance by preventing cold air from escaping and external air from entering even during frequent opening and closing of the back door.

4. Conclusion

We have presented an overview of the FG-series of reach-in refrigerating food case for convenience stores. Although these refrigerating food cases exactly correspond with the needs of the rapidly growing convenience store market and are accepted popularly, the requirements are becoming severer for total-cost reduction as a result of decreasing profit margins and the cost destruction and calls for diversification to distinguishing one store from its competitors.

Fuji Electric will continue to meet these requirements of the convenience stores and to develop unique products.

All-in-One Self-Standing Open Refrigerating Display Case

Osamu Ishiyama

1. Introduction

Recently, there have been strong demands from food retail stores such as supermarkets to reduce total costs, which include running, initial and maintenance costs.

The number of goods has increased as a result of diversified eating habits. It is also required that these goods be easy to select and purchase.

In response to these requirements Fuji Electric has developed all-in-one self-standing open refrigerating display cases. These all-in-one self-standing open refrigerating display cases have been favorably received since their introduction to the marketplace. A summary of these cases is presented below.

2. Overview of All-in-One Self-Standing Open Refrigerating Display Cases

The all-in-one self-standing open refrigerating display cases are open cases that have been developed to provide “new friendly standards”. These all-in-one self-standing open refrigerating display cases can be classified into two types, multi-deck and island types. The series of island type open cases, which have excellent display efficiency and low initial and running costs, was enlarged. Furthermore, in combination with custom cases and various options, these cases will correspond to the individuality and diversity of each store.

2.1 Classification according to usage and construction

2.1.1 Classification according to usage

- (1) Daily deliveries and milk products
: +2 to +8°C
- (2) Meat and fish : -2 to +2°C
- (3) Frozen foods : -18°C or less
- (4) Ice cream : -20°C or less
- (5) Refrigerating/freezing (2 temperatures)
: -2 to +7°C / -18°C or less

2.1.2 Classification according to construction

- (1) Multi-deck type
- (2) Wall-side island type
- (3) Dual-sided island type

By combining these types, a total of 30 models of cases have been developed in the series of all-in-one self-standing open refrigerating display cases.

3. Specifications and Construction

A summary of the specifications and cross-sectional views of typical cases are shown in Tables 1 and 2 and in Figs. 1 and 2 respectively.

4. Features of All-in-One Self-Standing Open Refrigerating Display Cases

The features of the newly developed all-in-one self-standing open refrigerating display cases will be described below.

4.1 Global environment friendly

To protect the ozone layer, a worldwide problem, HCFC-141b is used in the heat insulation foam material. Also, HCFC-22 is used as a refrigerant, eliminating the use of specific fluorocarbons.

4.2 Human friendly

The dimensions of each part of the case have been determined based on human engineering so that customers can easily view and retrieve goods without assuming an unnatural posture.

4.3 Product friendly

4.3.1 High-grade freshness control

With a microcomputer as standard equipment, the cabinets operate efficiently according to the operating state and changes in the environment.

4.3.2 Enhanced alarm functions

To rapidly respond to abnormalities, the following alarm functions have been enhanced: temperature abnormality inside the case, temperature sensor abnormality, a filter clogged with dust in the refrigerator, etc.

4.3.3 Environmental resistance

The cases can operate even when the condition of the air in the store is unsatisfactory (case ambient temperature 35°C and humidity 55% RH).

Table 1 Specifications of multi-deck series cases

Model			UFN5502-44A	UFN5502-64A	UFN5502-84A	
Main body	Usage		Daily deliveries and milk products			
	Operating temperature		(°C) 2 to 8			
	Ambient conditions		Ambient temperature 27°C or less, humidity 60% or less, wind 0.2 m/s or less			
	Effective internal volume		(L) 679	1,018	1,357	
	Display area		(m ²) 2.62	3.93	5.25	
	Mass		(kg) 290	320	390	
	Main body length		(mm) 1,220	1,830	2,440	
	Total height		(mm) 1,920	1,920	1,920	
	Main body width		(mm) 995	995	995	
	Front height		(mm) 550	550	550	
	External and internal coating		Galvanized sheet coated with baked acrylic resin			
	Heat insulating material		Urethane foam			
	Diameter of drain outlet		30A	30A	30A	
	Shelf dimensions		(mm) 375×1,216 ④	375×911 ⑧	375×1,216 ⑧	
	Permissible load of shelf		(kg/sheet) 70	50	70	
	Deck dimensions		(mm) 609×543 ②	456×543 ④	609×543 ④	
	Permissible load of deck		(kg/sheet) 55	40	55	
	Refrigeration cycle	Evaporator		Forced air-cooled fin tube type		
		Condenser		Forced air-cooled fin tube type		
Cooling system		Forced circulation cooling				
Control system		Constant pressure expansion valve				
		Type	CFX-3403BH	CFX-3405BH	CFX-3410BH	
Refrigerant		R-22				
Overload protection		Automatic reset type				
Temperature adjustment		Automatic temperature regulator				
Defrost system		Off-cycle defrost				
Compressor type		Totally sealed rotary type				
Compressor nominal output		(W) 750	1,100	1,500		
Refrigerant seal amount		(kg) 2.0	2.3	3.0		
Electrical rating (50/60Hz)	Single-phase 100V	Canopy illumination	Power (W)	48×1	38×2	48×2
			Current (A)	0.9	1.3	1.8
		Shelf illumination	Power (W)	48×5	38×10	48×10
			Current (A)	4.5	6.5	9.0
		Fan motor inside case (inner)	Power (W)	58/66	58/66	58/66
			Current (A)	0.62/0.68	0.62/0.68	0.62/0.68
		Fan motor inside case (outer)	Power (W)	23/21	23/21	23/21
			Current (A)	0.26/0.23	0.26/0.23	0.26/0.23
		Anti-dew heater	Power (W)	2.1	2.2	2.9
			Current (A)	0.21	0.22	0.29
		Sum	Power (W)	390/396	559/565	686/692
			Current (A)	6.49/6.52	8.90/8.93	11.97/12.00
	Three-phase 200V	Refrigerator	Power (W)	750/900	1,400/1,550	1,550/1,600
			Current (A)	3.2/3.4	6.5/6.0	7.1/6.3
Standard attachments			Microcomputer controller, filter for condenser, power supply plug and shelves			

Note: Numbers inscribed within a circle indicate the number of pieces.

4.4 Store friendly

4.4.1 Ease of cleaning

Since the all parts necessary to be cleaned can be detached and attached at a touch, frequent cleaning is facilitated.

4.4.2 Ease of moving

Since the cases are easily moved, time and labor are saved when changing the layout of the sales floor during remodeling or expansion.

4.4.3 Reduction of total cost

Since refrigerant piping and electrical wiring to

Table 2 Specifications of island series cases

Model			UFZ75M7-060A	UFZ75M7-080A	UFY75M7-060A	UFYZ75M7-080A	
Main body	Usage		Meat and fish				
	Operating temperature		(°C) - 2 to +2				
	Ambient conditions		Ambient temperature 27°C or less, humidity 60% or less, wind 0.2 m/s or less				
	Effective internal volume		(L) 270	360	220	290	
	Display area		(m ²) 1.5	2.0	1.2	1.6	
	Mass		(kg) 200	250	180	225	
	Main body length		(mm) 1,830	2,440	1,830	2,440	
	Total height		(mm) 950	950			
	Main body width		(mm) 1,080	910			
	Front height		(mm) 750	750			
	External and internal coating		Galvanized sheet coated with baked acrylic resin				
	Heat insulating material		Urethane foam				
	Diameter of drain outlet		30A		30A		
	Deck dimensions		(mm) 456×818	④	456×648 ④		
	Permissible load of deck		(kg/sheet) 55	40			
Refrigeration cycle	Evaporator		Forced air-cooled fin tube type				
	Condenser		Forced air-cooled fin tube type				
	Cooling system		Forced circulation cooling				
	Control system		Constant pressure expansion valve				
	Type		VPX-3403BHS	VPX-3403BHS	VPX-3403BHS	VPX-3403BHS	
	Refrigerant		R-22				
	Overload protection		Automatic reset type				
	Temperature adjustment		Automatic temperature regulator				
	Defrost system		Heater defrost				
	Compressor type		Totally sealed rotary type				
	Compressor nominal output		(W) 600×1	750×1	600×1	750×1	
Refrigerant seal amount		(kg) 1.7	1.9	1.7	1.9		
Electrical rating (50/60Hz)	Single-phase 100V	Fan motor inside case (inner)	Power (W)	34/35		34/35	
			Current (A)	0.53/0.6		0.53/0.6	
		Anti-dew heater	Power (W)	85/85	112/112	85/85	112/112
			Current (A)	0.85/0.85	1.12/1.12	0.85/0.85	1.12/1.12
		Sum	Power (W)	119/120	146/147	119/120	146/147
			Current (A)	1.38/1.45	1.65/1.72	1.38/1.45	1.65/1.72
	Three-phase 200V	Refrigerator	Power (W)	600/680	810/940	600/680	810/940
			Current (A)	2.5/2.7	3.2/3.3	2.5/2.7	3.2/3.3
	200V	Defrost heater	Power (W)	600/600	800/800	600/600	800/800
			Current (A)	3.0/3.0	4.0/4.0	3.0/3.0	4.0/4.0
Standard attachments			Microcomputer controller ×1 Drain tank (12L)×1 Ceiling price tag plate rail (28 and 32mm sizes are used)×1 Power supply plug ×2				

Note: Numbers inscribed within a circle indicate the number of pieces.

the case are not necessary, installation is simple, resulting in low initial cost and a reduced construction period.

4.4.4 Enlargement of floor space

Since the space of refrigerator (machine room) is not necessary, floor space in the store can be effectively utilized.

4.4.5 Operation adjustments are unnecessary

Since the refrigerator, controller, etc. are all-in-one

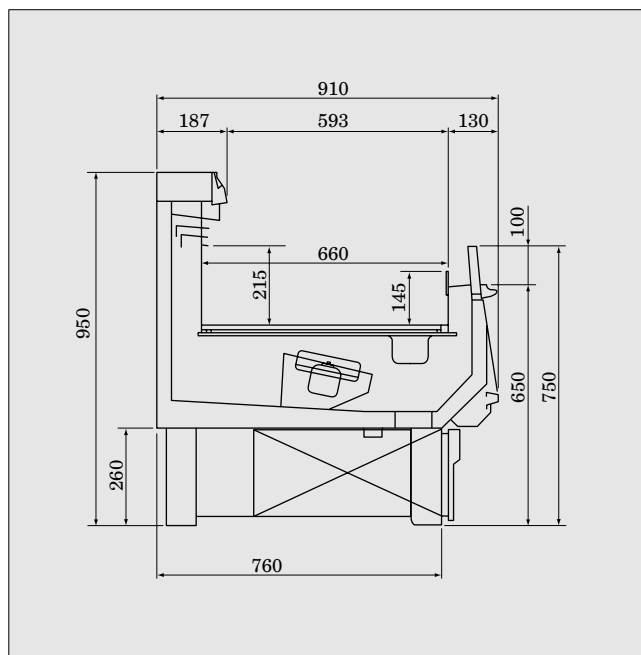
self-standing in the case, the case can operate immediately after installation as soon as the power supply plug is connected to an outlet.

5. Conclusion

A summary of the all-in-one self-standing open refrigerating display cases has been presented.

Since food retail stores are seeking originality by

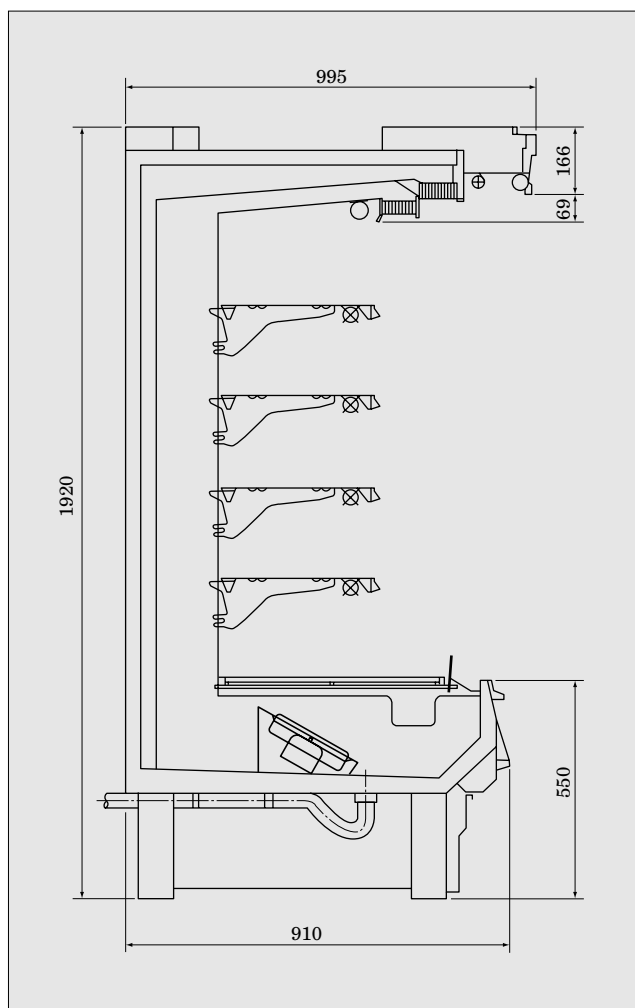
Fig. 1 Cross-section of the multi-deck series case



individualizing and diversifying, all-in-one self-standing open refrigerating display cases should be high-quality and low cost store equipment that fit in with the store's concept of originality.

Fuji Electric will continue to expand this series of case models and will endeavor to develop new all-in-one self-standing open refrigerating display cases.

Fig. 2 Cross-section of the island type series case



Application of Fuzzy Control to Open Refrigerating Display Case

Haruhiko Sudo

1. Introduction

Open refrigerating display cases are cooled appliances for the purpose of displaying and selling meat, fish and vegetables. These refrigerating display cases exhibiting goods are classified as the following types: multi-deck, semi-multi-deck, and single-deck models. The multi-deck models, as shown in Fig. 1 and Fig. 2, are the most from this group.

The first requirement for an open refrigerating display case is to maintain freshness of the goods it contains (freshness control). The second requirement is to effectively display those goods (exhibition method).

Performance of the freshness control directly affects loss of goods and is closely linked to the profit or loss of a supermarket. Improvement of the freshness control is one of the most significant requirements in this business.

Performance of the freshness control in open refrigerating display cases consists of two functions: refrigeration to maintain the inside of the refrigerating display case at an adequate homogeneous and constant low temperature, and defrosting to effectively melt

frost deposited on the evaporator without rising temperature inside the refrigerating display case.

Improving the defrosting performance results in reduced temperature rise and consequently less heat shock to goods. Fuji Electric has been investigating various control systems for defrosting as a key technology for freshness control.

Fig. 2 Cross-section of the open refrigerating display case (multi-deck type)

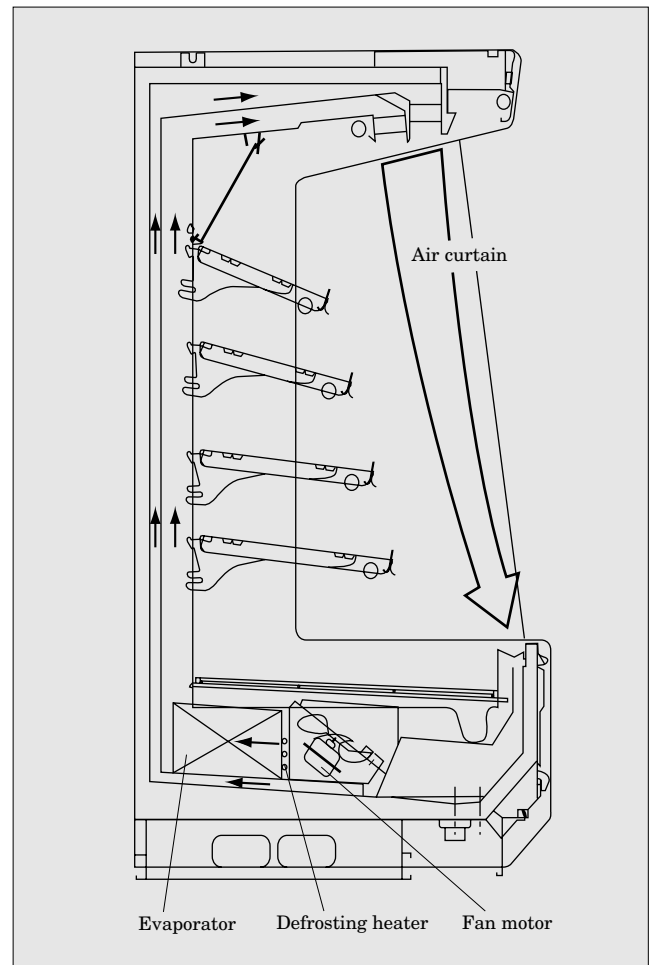


Fig. 1 External view of the open refrigerating display case (multi-deck type)



2. Current Control Systems for Defrosting

Control systems for defrosting are classified according to their methods and timing for defrosting. Current systems and their problems are described below.

(1) Methods for defrosting

It is common to heat the evaporator with a heater. However, after a variety of technical trials, the performance of this method has already reached its limitations. To overcome this problem, one solution is to provide the system with a pair of evaporators that are alternately defrosted. Another solution is to use the heat of condensation, generated by the mixed gas and liquid refrigerant supplied from the refrigerator into the evaporator. However, because these two methods make the refrigerating display case unit and its on-site installation so costly, they are only suitable for a few specific customers.

(2) Timing for defrosting

Refrigerating display cases are generally operated as a group of several units. The start and end times for defrosting are set by a timer for each group. At the start time, the control system outputs a start signal to a refrigerating display case controller. Defrosting of each refrigerating display case is completed independently by a timed thermostat in each refrigerating display case controller. However, to avoid excessive temperature rises inside the refrigerating display case caused by defrosting for a long duration time due to equipment failure or other accidents, the control

system also outputs an end signal to the refrigerating display case controller at the end time. Problems concerning the timing control for defrosting are related to the time interval to start defrosting. Conventionally, this interval is set independent of the deposited frost, that is, without any consideration of adverse ambient conditions such as high temperature and high humidity. For favorable ambient conditions (low temperature and low humidity), defrosting is inevitably performed more than necessary.

3. Application of Fuzzy Control

To limit the number of defrosting operations to the absolute minimum required, a controller that utilizes fuzzy logic has been developed to optimize the start time for defrosting based on the given ambient conditions and the amount of deposited frost.

This control system is called the “fuzzy-non-defrost” system, and its controller is the “fuzzy-non-defrost” controller. Fuji Electric’s use of this system in refrigerating display cases is an industry first.

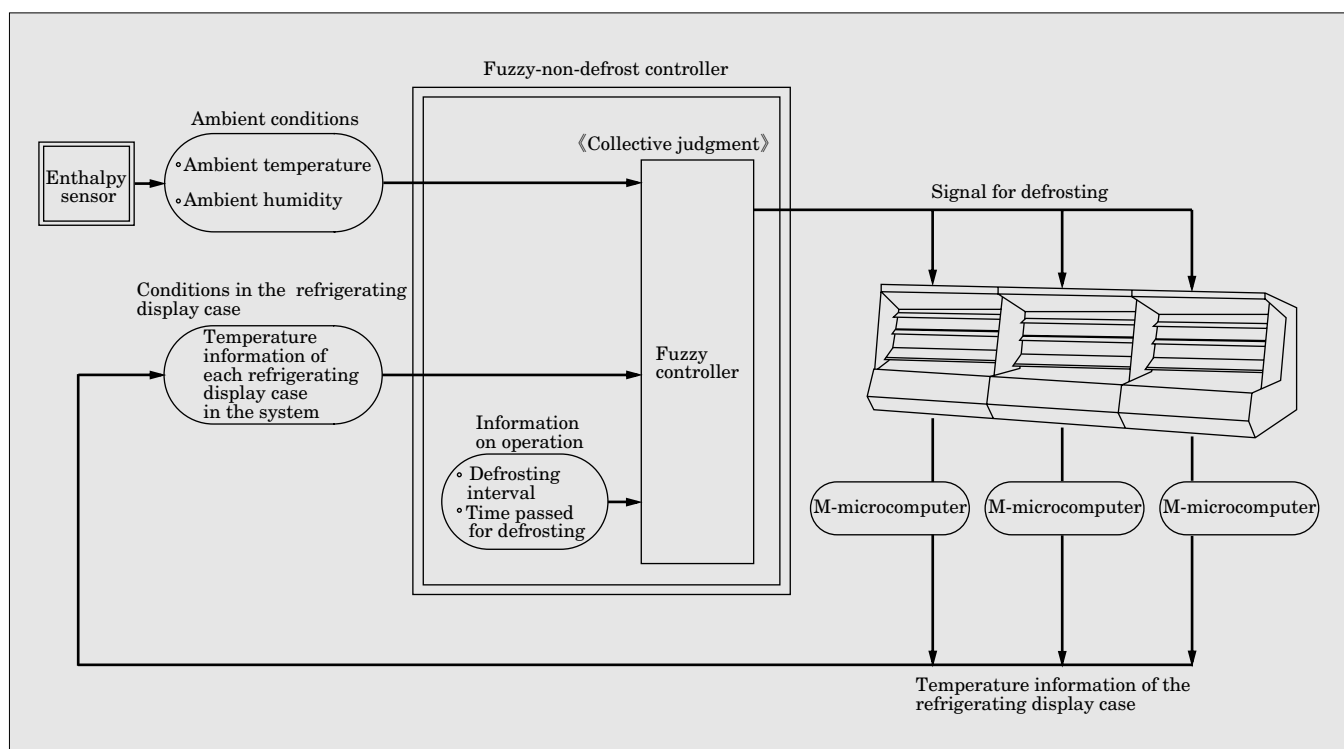
3.1 System configuration and features of the controller

3.1.1 System configuration

The system configuration shown in Fig. 3 consists of a fuzzy-non-defrost controller, an enthalpy sensor with built-in temperature sensor and a humidity sensor and an M-microcomputer controller.

The fuzzy-non-defrost controller and the enthalpy sensor are installed in the main refrigerating display case (master) of chain-connected display cases.

Fig. 3 Overall configuration



3.1.2 Features of the controller

The fuzzy-non-defrost controller collects through the above sensors and then stores this data. The controller uses fuzzy logic to determine the defrost timing.

When defrosting is necessary, the controller outputs a start signal to perform the defrosting process. Defrosting is not performed if there is not a thick layer of frost. The controller operates to avoid defrosting during business hours of the supermarket.

These features have resulted in improved freshness control and improved energy efficiency (reduced heater use during defrosting).

3.2 Concept of fuzzy control

It is very difficult for the microcomputer to determine the thickness of the frost layer from the temperature sensor data at a given time during operation of the refrigerating display case.

The temperature is detected at different locations of the refrigerating display case. Frost deposits are revealed as temperature rises or falls at these locations. However, these temperature characteristics are only suitable for ideal ambient conditions in which the frost is homogeneously deposited.

It is more difficult and complex to analyze characteristics of the temperature information in the real-world situation of the supermarket where the frost in the refrigerating display cases is not homogeneously deposited and customers adversely disturb the ambient conditions.

This is the reason why the fuzzy control has been introduced. Using the ambient temperature and

humidity of the refrigerating display case, the time that has passed since defrosting, and weighting the input values with the membership function makes it possible to evaluate the entire situation and determine the exact amount of deposited frost in the variety of cases described above.

Moreover, if varying temperature information indicates a need for emergency defrosting, the fuzzy controller starts defrosting based upon the judgment of its fuzzy logic to prevent an abnormal layer of frost from accumulating on the evaporator (to prevent ice banking).

A basic control function sets a standard daily time, before opening of the supermarket, to start the defrosting process. Defrosting during business hours is avoided as much as possible.

In this manner, the defrosting start process is controlled such that defrosting is only performed as needed, resulting in improved freshness control and energy savings.

4. Results of the Fuzzy Control

4.1 Results of fuzzy control

As shown in Fig. 4, the fuzzy-non-defrost controller annually reduces the number of defrosting operations to 40% of those of the conventional controller. Table 1 shows the number of daily defrosting operations of the fuzzy-non-defrost controller.

Increased quality and freshness of goods due to the decrease in defrosting operations produce a significant improvement in the loss factor of goods. The loss factor of goods refers to financial losses caused by a fall in prices due to deterioration in the freshness of goods. Decreasing the number of daily defrosting operations by one time reduces the economic loss factor of goods by 12.5%.

One fuzzy-non-defrost controller is capable of controlling one system having an average of five refrigerating display cases. Therefore, the economical effect of

Fig. 4 Comparison of the number of defrosting operations during four seasons

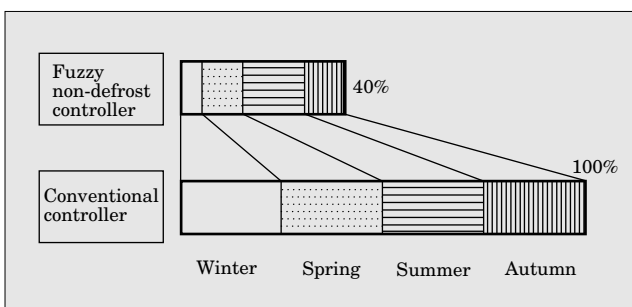


Table 1 Number of defrosting operations of the fuzzy-non-defrost controller

Season	Number of defrosting operations per day	
	Fuzzy-non-defrost controller	Conventional controller
Winter	1 to 2 times	4 or 6 times with fixed intervals
Spring	2 times	
Summer	3 times	
Autumn	2 times	

Note : The number of defrosting operations per day varies depending upon location.

Fig. 5 Economical effect due to improved freshness performance

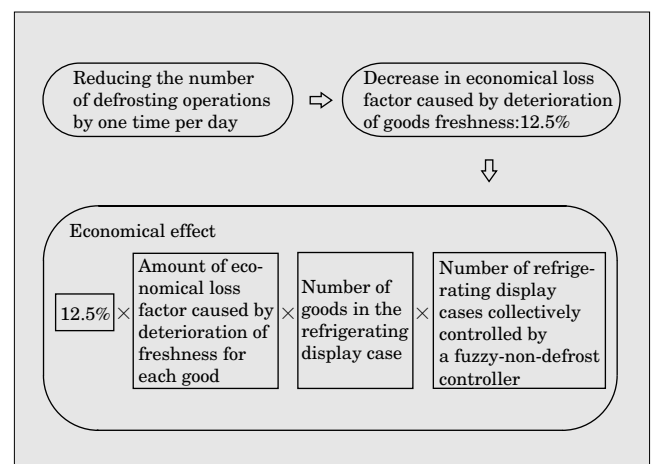
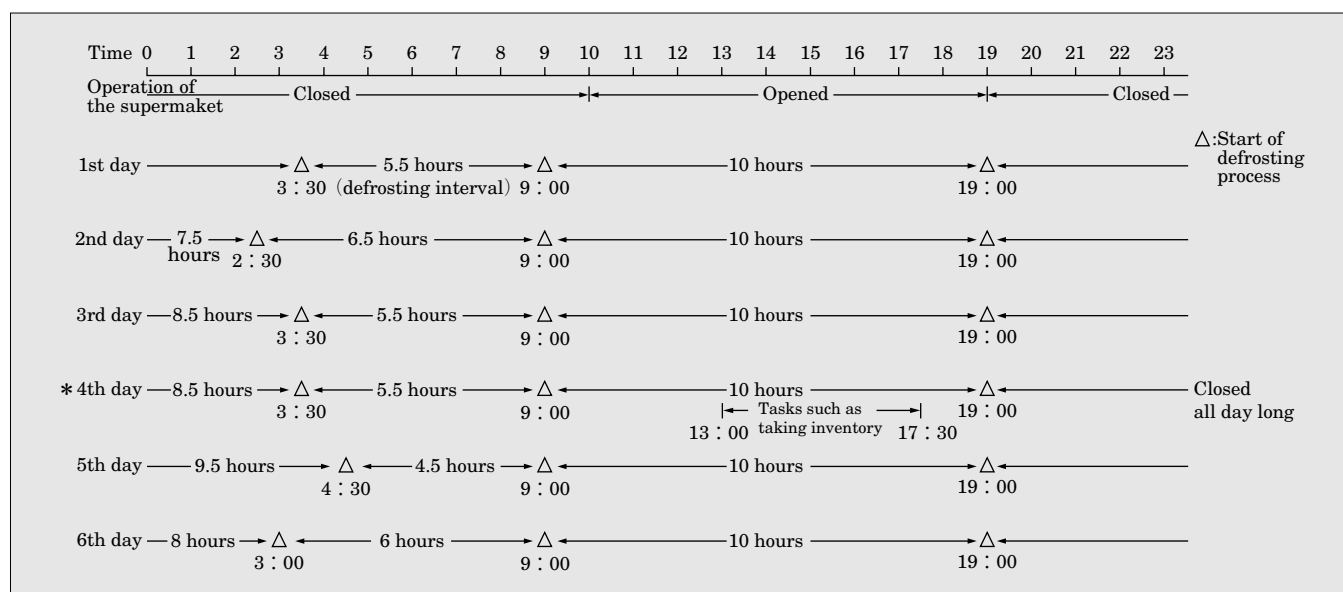


Fig. 6 Conditions of defrosting start process in the field test



goods whose loss factor can be reduced is multiplied as shown in Fig. 5, with the non-defrost-controller producing a greater economical effect than the conventional defrosting timer.

The fewer defrosting operations will reduce electric power consumption (save energy) in refrigerating display cases that use a heater for defrosting.

4.2 Field tests

At first, the fuzzy controller was tested for its performance. During test runs, fuzzy reasoning of the controller was successfully verified by adjusting fuzzy rules and membership functions. The reduction of defrosting operations and avoidance of defrosting operations during the daytime and prevention of ice banking have also been successfully checked.

Next, the fuzzy controller and a real refrigerating display case system were put to work in an operating supermarket for field tests. The field tests have been performed under all possible ambient conditions including summer, winter and the in-between seasons (covering the lowest and the highest temperature and humidity).

4.3 Test results

Figure 6 shows the start times of defrosting which were observed during a field test in the summer, when frost is thicker. This figure shows that defrosting is

steadily performed 3 times a day. This number corresponds to the number of defrosting operations given in Table 1.

On the 4th day (marked*), the supermarket was closed and inventory was taken during the daytime. In such an unstable situation of the refrigerating display case, the controller operation was stable.

The fuzzy-non-defrost controller has proven its ability to provide proper control for various situations of the refrigerating display case.

Thus, overall results of the field tests have verified the stable control characteristics that the design intended to realize.

5. Conclusion

After successful field test results, the fuzzy system was installed in products of the former refrigerating display case series, and has won a reputation for excellent performance from customer supermarkets.

To further improve the control performance, Fuji Electric will introduce new fuzzy control and neuro-computational technology to the control, not merely for the defrosting start process but also for the defrosting reset process and temperature adjustment, and will develop more economical refrigerating display cases that realize quality and freshness control.

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● : Overseas Representative Offices ◆ : Overseas Manufacturing Bases

AMERICA

■ FUJI ELECTRIC CORP. OF AMERICA

● Head Office

Park 80 West Plaza II, Saddle Brook, NJ07663, U.S.A.
TEL : (201) 712-0555 FAX : (201) 368-8258

■ FUJI ELECTRIC DO BRASIL INDUSTRIA E COMERCIO LTDA.

Rua Guajajaras, 1707, Barro Preto,
CEP 30180-101 Belo Horizonte, M. G., BRASIL
TEL : (031) 291-5161 FAX : (031) 291-8185

EU

■ FUJI ELECTRIC CO., LTD.

Erlangen Representative Office, Sieboldstr. 3, D-91052
Erlangen, F.R. GERMANY
TEL : (09131) 729613, 729630 FAX : (09131) 28831

■ FUJI ELECTRIC GmbH

Lyoner Str. 26,
D-60528 Frankfurt am Main, F.R. GERMANY
TEL : (069) 6690290 FAX : (069) 6661020

■ FUJI ELECTRIC CO., LTD.

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London W1H 5RE, U.K.
TEL : (0171) 935-0544 FAX : (0171) 935-6893

■ FUJI ELECTRIC (U.K.) LTD.

40 George Street, London W1H 5RE, U.K.
TEL : (0171) 935-0544 FAX : (0171) 935-6893

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Beijing Representative Office, Suite 3603, China World Tower,
China World Trade Center No. 1, Jian Guo Men Wai Avenue,
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TEL : (010) 6505-1263, 1264 FAX : (010) 6505-1851

■ FUJI ELECTRIC CO., LTD.

Hangzhou Representative Office, #402 Heng He Bldg.,
23-2 Huan Cheng Dong Lu Hangzhou City, Zhejiang Province,
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■ FUJI ELECTRIC CO., LTD.

Taipei Representative Office, 5th Fl.,
Taiwan Fertilizer Bldg., No. 90, Nanking E Rd.,
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TEL : (02)780-5011 FAX : (02)783-1707

■ FUJI ELECTRIC CO., LTD.

Bangkok Representative Office, Room No.1202, 12th Fl.
Two Pacific Place
142 Sukhumvit Rd. Bangkok 10110, THAILAND
TEL : (02) 653-2020, 2021 FAX : (02) 653-2022

■ P. T. BUKAKA FUJI ELECTRIC

Plaza Bapindo, Menara I, 24th Fl. Jl. Jendral Sudirman Kav,
54-55 Jakarta 12190, INDONESIA
TEL : (021) 5266716~7 FAX : (021) 5266718

■ FUJI ELECTRIC CO., LTD.

Singapore Representative Office, 401 Commonwealth Drive,
#04-05 Hawpar Technocentre, Singapore 749598, SINGAPORE
TEL : 479-5531 FAX : 479-5210

■ FUJI ELECTRIC SINGAPORE PRIVATE LTD.

401 Commonwealth Drive, #04-05 Hawpar Technocentre,
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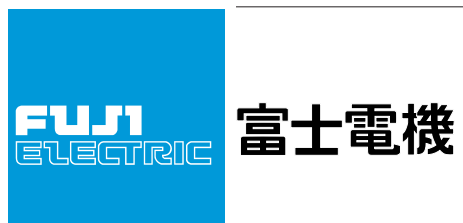
■ HOEI ELECTRONICS (S) PRIVATE LTD.

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TEL : 251-8751 FAX : 251-0827

■ GE/FUJI ELECTRIC CO., LTD.

Nicolaou Pentadromos Centre, Office 908,
Block A, P. O. Box 123, Limassol 205, CYPRUS
TEL : 5-362580 FAX : 5-365174

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