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NATICK/TR-79/026

EXAMINATION OF PATIENT TRAY FOOD SERVICE EQUIPMENT AN EVALUATION OF THE SWEETHEART FOOD SERVICE CART

by
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and
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The Food Engineering Laboratory (FEL) of the U.S. Army Natick Research & Development Command (NARADCOM) is engaged in giving technical support to the Walter Reed Army Medical Center's cook-freeze food service program. As part of this support, the Sweetheart Food Service Cart was evaluated. The parameters considered dealt with the system's capability of maintaining temperatures of a preheated testing medium as well as of temperatures of chilled items. The testing medium was utilized in order to avoid introducing variations inherent in natural food products. Contained herein are the results of the above

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evaluations.

FOREWORD

At the request of the Office of the Surgeon General (OTSG), the Sweetheart Cart was evaluated by members of the technical staff of the Food Engineering Laboratory of the U.S. Army Natick Research and Development Command (NARADCOM). The assistance of Anne Marie Antico, Lynn Curley, Mary Neri, Melanie Piscia, and Shelley Werner in conducting the studies is gratefully acknowledged. Mr. John Swift and Mr. Grover Haigh rendered invaluable engineering and mechanical help in installing the equipment and ensuring that it operated according to design.

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INTRODUCTION

The Sweetheart Food Cart, a serving cart for hospital use (Fig. 1) is designed to hold precooked, preheated foods at a temperature range of 60°C to 71°C. It is part of the Sweetheart Serving System manufactured by Sweetheart Plastics, Division of Maryland Cup Corporation, Willmington, MA. The system is based on a motorized or non-motorized serving cart, which contains three modular compartments with removable sliding doors. The modules contain twenty removable Temp-Trays™ each consisting of two sealed, solidstate heating devices: one for the entree dish and the other for hot soups, cereal, or dessert (Fig. 2). A 12-volt (dc), 6-cell battery, rechargeable at the end of the day, supplies the power to the trays' heaters and also provides the power to move the cart. The system also includes an automatic air circulation system which directs an air flow, at ambient temperature, over each of the twenty trays. Push buttons labeled Off, Dish, or Bowl, corresponding to the heaters on each tray, are activated to either On or Off positions.

The Sweetheart System uses disposable plastic dinnerware made from thin (0.015-in. (0.4-mm)), high impact polystyrene. The entree dish has three sections, a large section for the entree and smaller sections for the starch and vegetable.

Cold foods are assembled on the trays along with hot foods. However, a new unit, called a Koolatron™*, has been adapted to utilize the energy system of the cart. This is a storage unit similar in size to an ice chest or cooler presently being modified for hospital use.

* Product of Sweetheart Plastics

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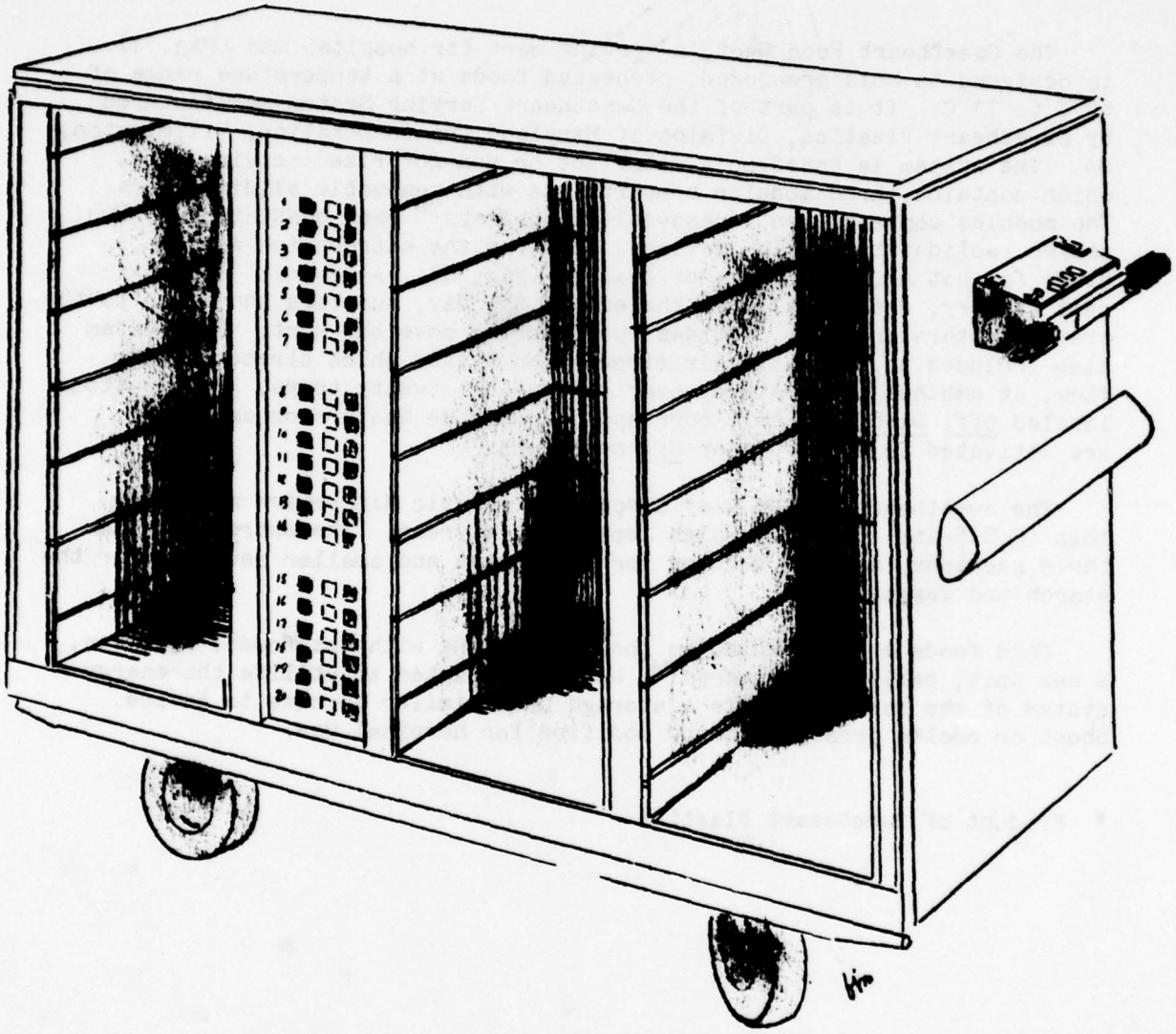

FIG 1 SWEETHEART FOOD SERVING CART

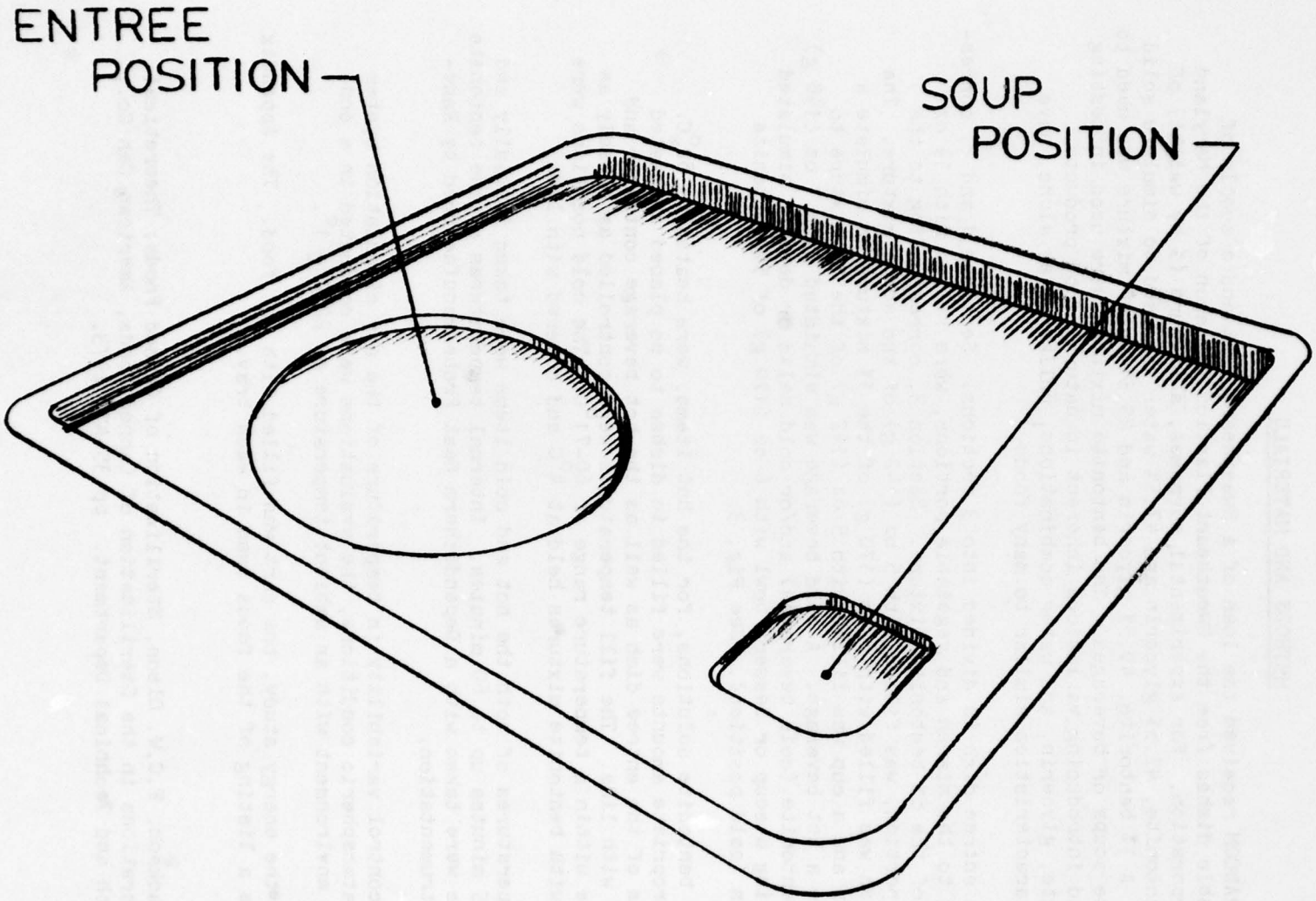

FIG 2 SWEETHEART TEMP-TRAY™

METHODS AND MATERIALS

NARADCOM received the loan of a Sweetheart Cart and a supply of disposable dishes from the Sweetheart Plastics Division of the Maryland Cup Corporation. For experimental purposes, a mixture (% by weight) of 5.0% bentonite, 47.5% glycerin and 47.5% water was used to simulate solid foods. A 1% bentonite, 49.5% glycerin and 49.5% water mixture was used to simulate soups or beverages. The bentonite mixtures were used in testing to avoid introducing variations inherent in natural food products. Bentonite, glycerin, and water combinations, unlike water alone, have heat characteristics similar to many foods.[1]

The entree dish is divided into 3 sections. Sections 1 and 2, corresponding to the starch and vegetable portions, were filled with 1½ oz (42 g) of the 5% bentonite mixture. Section 3, corresponding to the entree portion, was filled with 5 oz (142 g) of the above mixture. The soup dish was filled with 6 oz (170 g) of the 1% mixture to simulate a hot soup and a cup was filled with 5 oz (142 g) of the 1% mixture to simulate a hot beverage. A cold beverage was simulated with 7 oz (198 g) of 1% bentonite (cold beverages) and/or cold salad or dessert simulated by filling a soup or dessert bowl with 6 oz (170 g) of 5% bentonite solution (cold position). See Fig. 3.

The bentonite solutions, for the hot items, were heated to 82°C. The appropriate amounts were filled in dishes to be placed in heated sections of the entree dish as well as the hot beverage container and covered with lids. The fill temperatures were controlled as closely as possible within a temperature range of 60-71°C. The cold positions were filled with bentonite mixtures held at 4°C and covered with lids.

Temperatures of both the hot and cold items were taken initially and every 15 minutes up to 60 minutes. Internal temperatures of the bentonite mixtures were taken with a Dependatherm Heat Probe manufactured by Kane-May Instrumentation.

To control variability in temperature of the air circulation system due to atmospheric conditions, the evaluations were conducted in a controlled environment with an ambient temperature of 22°C ± 1°.

For the energy study, the cart was filled with hot food. The Appendix provides a listing of the foods used in each tray.

[1] J.M. Jackson, F.C.W. Olson, Sterilization of Canned Foods; Theoretical Considerations in the Sterilization of Canned Foods, American Can Co., Research and Technical Department. pp 35-47, 1973.

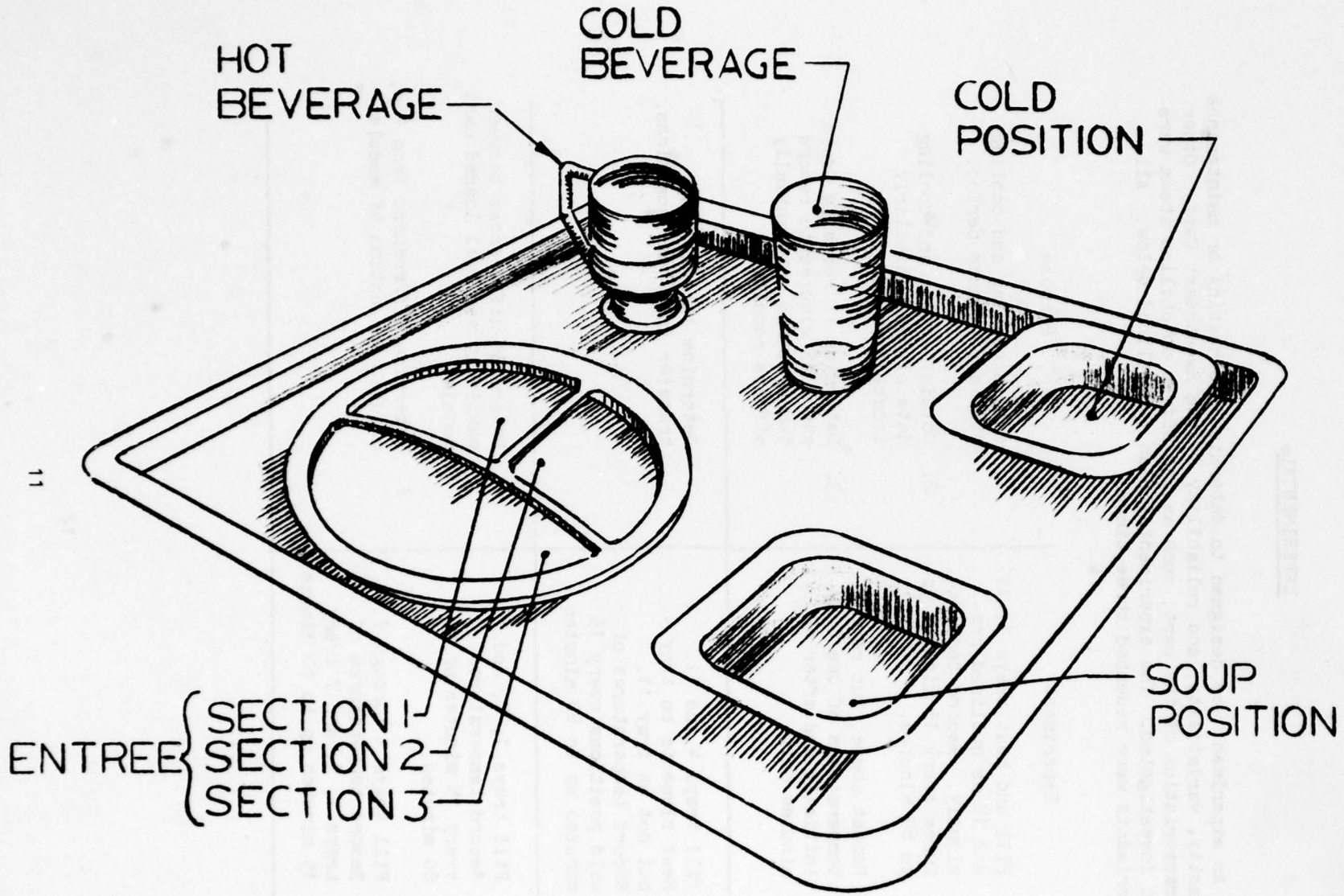

FIG 3 TEMP-TRAY™ WITH DINNERWARE

EXPERIMENTAL

An experiment was designed to determine the heating or maintenance capacity, variability, and reliability of the Sweetheart Cart. Other characteristics of the cart, such as its effect on chilled items were also investigated. The experimental plan is outlined below. All experiments were repeated three times.

Experiment	Purpose
1a. Fill and heat trays 4, 11 and 18 as outlined previously. Record temperatures every 15 minutes up to 60 minutes. b. Repeat above, but record temperatures of one tray initially and after 60 minutes only.	1. Obtain heating and cooling over a 60-minute period. 2. Obtain heating and cooling data of three similarly located trays. 3. Determine if removing trays every 15 minutes to record temperatures substantially affects results.
2. Fill trays 4 and 11. Heat elements on tray 4, but not on tray 11. Record temperatures of cold positions every 15 minutes up to 60 minutes.	Determine lateral heat transfer into cold positions.
3a. Fill trays 1, 4, and 7. Record temperatures every 15 minutes up to 60 minutes. b. Fill trays 1 through 7. Record temperatures of trays 1, 4, and 7 every 15 minutes up to 60 minutes	1. Determine differences between partially and full loaded cart module. 2. Determine differences from top, middle, and bottom of module.

4. Fill trays 1, 4, and 7 and remove from cart after 30 minutes. Record temperatures initially upon removal from cart, and every 15 minutes up to 60 minutes at room temperature.	Determine rate of cooling upon removal from cart.
5a. Fill trays 1 through 7, but leave tray 4 cold. Record temperatures of tray 4 every 15 minutes up to 60 minutes. 5b. Same as above, but do not load trays 1-3 or 5-7.	Determine heat transfer of fully loaded module into one cold tray, in comparison with a cold tray in empty module
6 Attach Koolatron™ to cart. a. Record internal temperatures of Koolatron™ over a 3-hour time period by suspending a thermocouple in the geometric center of the unit. b. Fill 3 cold beverage containers and 3 soup or salad bowls with 4°C bentonite. Record temperatures initially and after 60 minutes.	Determine cooling capabilities of the Koolatron™.
7. Load cart with typical selection of hot food items and program. Hold for 1 hour.	Determine energy consumption of Sweetheart Cart.

RESULTS

Experiment 1a.

As shown in Table 1, the bentonite in the hot entree sections not only maintained heat, but in one instance increased in temperature up to 20°C to bring the temperatures with a range of 69°C to 77°C. Thus, even when the dishes were filled at temperatures slightly less than optimum, the cart's heating system would bring the bentonite in the entree dishes up to a desired holding temperature. The bentonite mixture in the soup dishes dropped slightly in temperature, but was still within the desired 60°C to 71°C range. The hot beverage mixture, not in contact with a heating element, dropped considerably to a mean of 32°C after 60 minutes. The cold positions showed a gradual increase in temperature to a mean of 16°C to 18°C after 60 minutes. Thus, the cart maintained the heat very well in dishes that were in contact with the heating elements. However, the hot beverages, not in contact with a heating position, cooled markedly. The cold mixtures warmed to temperatures above that recommended by Public Health and Military (Army Regulation 40-5) Standards (13°C).

Table 2 shows the data obtained from Experiment 1 when trays 4, 11, and 18 are compared. This shows a fairly close range of heating temperatures among the three trays. Tray 18 appears to have gained the most heat, but because it was the last tray filled, it started at slightly lower temperatures than trays 4 and 11 resulting in a larger temperature range.

TABLE 1

Mean Temperatures of Bentonite Filled Dishes
on Activated Trays
Initially and at 15 Minute Intervals*

	Temperature °C					
	Initial	15 Min	30 Min	45 Min	60 Min	Change
Entree Section #1	55	65	67	69	69	+14
Entree Section #2	57	66	70	70	71	+14
Entree Section #3	57	72	76	77	77	+20
Soup Positions	69	64	63	62	62	-7
Hot Beverage	69	53	43	37	32	-37
Cold Beverage	6	9	13	16	18	+12
Cold Position	6	9	12	14	16	+10

*Mean of three trials on trays 4, 11, and 18.

TABLE 2

Mean Temperatures of Bentonite Filled Dishes

on Activated Trays 4, 11 and 18*

	Temperature °C					
	Initial	15 Min	30 Min	45 Min	60 Min	Change
Entree Section #1						
Tray 4	57	62	68	68	69	+12
Tray 11	54	67	64	68	67	+13
Tray 18	54	67	69	72	72	+19
Entree Section #2						
Tray 4	60	64	70	70	72	+12
Tray 11	57	66	68	68	65	+8
Tray 18	56	67	71	72	72	+16
Entree Section #3						
Tray 4	59	72	78	77	78	+19
Tray 11	57	73	76	76	75	+18
Tray 18	55	72	75	77	77	+22
Soup Position						
Tray 4	71	64	64	61	62	-9
Tray 11	70	65	63	62	62	-8
Tray 18	65	64	62	62	61	-4
Hot Beverage						
Tray 4	72	54	44	37	33	-39
Tray 11	65	51	42	37	32	-33
Tray 18	65	51	42	37	32	-33
Cold Beverage						
Tray 4	5	8	13	16	18	+13
Tray 11	6	9	13	16	18	+12
Tray 18	7	10	13	15	16	+9
Cold Position						
Tray 4	5	8	11	14	16	+11
Tray 11	7	10	13	15	16	+9
Tray 18	6	8	11	13	15	+9

*Mean of three trials

Experiment 1b.

Experiment 1b. was carried out by not removing the trays until 60 minutes had elapsed to determine if removing the trays every 15 minutes as in Experiment 1a. markedly affected the temperature readings. For the various positions in Table 3, the initial temperatures of bentonite mixtures in 1b. were higher initially and rose only a few degrees during the 60-minute time period, whereas the initial temperatures in 1a. were lower, but the cart raised the temperatures of the bentonite mixtures more than those in 1b. Results indicate no substantial difference due to the tray removal, but rather show differences due to initial filling temperatures.

It should also be noted that the greatest temperature rise for those items filled at temperatures slightly lower than optimum, occurred in the first 15-minute time interval, illustrating rapid equilibration.

TABLE 3

Experiment 1b.

Initial and Final (60-Minutes) Temperatures of Bentonite Filled Dishes With and Without Removal at 15-Minute Intervals to Record Temperatures*

	Initial Reading (°C)		60 Minute Reading (°C)	
	Removal Every 15 Minutes	Not Removed Until 60 Minutes	Removal Every 15 Minutes	Not Removed Until 60 Minutes
Entree Section #1	55	71	69	74
Entree Section #2	57	72	71	75
Entree Section #3	57	73	77	81
Soup Position	69	72	62	62
Hot Beverage	69	80	32	37
Cold Beverage	6	6	18	18
Cold Position	6	6	16	16

*Mean of three trials

Experiment 2

In Experiment 2, tray 4 had all hot positions filled and heated and two cold positions filled, while tray 11 had only cold positions filled. Results in Table 4 show that there was little, if any, lateral heat transfer from the hot positions to the cold.

TABLE 4

MEAN TEMPERATURES OF COLD POSITIONS: HEATED VS. UNHEATED TRAYS*

		TEMPERATURE °C		
	TRAY NO.	INITIAL	60 MINUTES	CHANGE
COLD BEVERAGE	4	7	19	+12
COLD POSITION	4	7	17	+10
COLD BEVERAGE	11	7	18	+11
COLD POSITION	11	7	17	+10

*Mean of three trials

EXPERIMENT 3

In experiment 3, trials were run with both a fully loaded and a partially loaded module. The results show very close final temperature indicating no substantial heat build-up in a fully loaded module. Initial and final temperatures may be found in Table 5.

Table 6 shows the trials of experiment 3 when identical positions of the fully loaded module are compared. Results show very close final temperatures and again show that the cart allows those products filled at lower temperatures to approach, and in some instances, surpass the final (60-minute) temperatures of those intially filled at higher temperatures.

TABLE 5

Comparison of a Fully Loaded Module vs. a Partially Loaded Module

(all elements heated)*

	Temperature °C			
	Initial		60 Minutes	
	Partially Loaded Module	Fully Loaded Module	Partially Loaded Module	Fully Loaded Module
Entree Section #1	62	65	72	73
Entree Section #2	64	66	73	74
Entree Section #3	66	67	78	79
Soup Position	73	72	61	63
Hot Beverage	73	73	33	34
Cold Beverage	5	5	19	20
Cold Position	4	4	16	17

*Mean of three trials

TABLE 6

Mean Temperatures of Bentonite Filled Dishes

on Activated Trays 1, 4 and 7 *

(Fully Loaded Module)

	Temperature °C					
	Initial	15 Min	30 Min	45 Min	60 Min	Change
Entree Section #1						
Tray 1	68	69	72	72	74	+6
Tray 4	64	72	72	73	74	+8
Tray 7	63	69	72	74	73	+10
Entree Section #2						
Tray 1	68	68	71	73	74	+6
Tray 4	66	71	74	76	76	+10
Tray 7	62	70	73	74	74	+12
Entree Section #3						
Tray 1	69	75	74	77	78	+9
Tray 4	67	78	78	78	81	+13
Tray 7	64	77	79	79	80	+16
Soup Dish						
Tray 1	73	67	64	64	64	-11
Tray 4	72	65	64	63	63	-11
Tray 7	70	63	61	60	61	-11
Hot Beverage						
Tray 1	76	55	44	39	35	-41
Tray 4	73	56	45	38	35	-38
Tray 7	70	52	43	37	33	-37
Cold Beverage						
Tray 1	4	9	14	18	21	+17
Tray 4	5	10	15	19	21	+17
Tray 7	6	10	14	18	20	+14
Cold Position						
Tray 1	4	7	15	19	21	+17
Tray 4	4	8	11	15	18	+14
Tray 7	4	8	12	14	17	+13

* Mean of three trials

EXPERIMENT 4

Table 7 shows the rate of cooling or warming of the bentonite solutions throughout a 60-minute period after removal from the cart. Results were anticipated, with the soup dish losing temperature less quickly due to its greater volume. Also as expected, the cold items continued to increase in temperature.

TABLE 7

Mean Temperatures of Similar Positions on Trays 1, 4 and 7 After Removal From Cart*

	Temperature °C					
	Initial	15 Min	30 Min	45 Min	60 Min	Change
Entree Section #1	71	49	39	34	30	-41
Entree Section #2	71	50	39	34	30	-41
Entree Section #3	76	51	40	34	30	-46
Soup Dish	65	53	46	41	38	-27
Hot Beverage	47	39	34	30	28	-19
Cold Beverage	13	16	18	19	19	+6
Cold Position	11	14	15	17	18	+7

* Mean of 3 Trials

EXPERIMENT 5

Results of Experiment 5, as shown in Tables 8 and 9 indicate that heat generated in a module filled with heated trays causes the cold items on the one cold tray to gain heat to a greater extent, than if the cold tray were in a module by itself. Thus, the circulating airflow in the Sweetheart Cart does not completely protect the cold items from other heated trays in the cart.

TABLE 8

Mean Temperatures of One Cold Bentonite

Filled Tray in a Fully Loaded Module *

	Temperature °C					
	Initial	15 Min	30 Min	45 Min	60 Min	Change
Entree Section #1	7	14	20	23	26	+19
Entree Section #2	7	15	20	23	26	+19
Entree Section #3	7	14	20	23	26	+19
Soup Dish	5	11	16	19	22	+17
Hot Beverage	4	7	10	14	16	+12
Cold Beverage	4	8	8	15	17	+13
Cold Position	4	7	7	13	15	+11

*Mean of three trials

TABLE 9

Mean Temperature of One Cold Bentonite Filled Tray in an Empty Module *

	Temperature °C					
	Initial	15 Min	30 Min	45 Min	60 Min	Change
Entree Section #1	6	13	16	18	19	+13
Entree Section #2	7	13	16	18	19	+12
Entree Section #3	7	13	16	18	19	+12
Soup Dish	5	10	13	16	17	+12
Hot Beverage	4	7	10	12	14	+10
Cold Beverage	4	8	11	13	16	+12
Cold Position	4	7	9	11	14	+10

* Mean of 3 trials.

EXPERIMENT 6

Table 10 shows the internal temperature of the Koolatron™ unit over a three hour period. The three trials are shown separately to indicate that in each instance, the unit went below the freezing point after 60 minutes. Thus, if the Koolatron™ is used for any prolonged period, the products might be subject to sub-freezing temperatures.

Table 11 shows the result of cold bentonite filled dishes stored in the Koolatron™ for 60 minutes. Although the bentonite solutions in the cold beverage and salad containers show a slight rise in temperature, the internal temperature of the Koolatron™ dropped substantially after 60 minutes. It shows that the Koolatron™ should be prechilled, but also that adjustments should be made to keep the Koolatron™ above freezing temperatures.

TABLE 10

Internal Temperature of Koolatron™ Over a Three-Hour Period *

Time (Min.)	Temperature °C			
	Run 1	Run 2	Run 3	Mean
0	26	24	25	25
30	10	10	9	10
60	2	1	0	1
90	-4	-4	-4	-4
120	-6	-6	-7	-6
150	-8	-8	-9	-8
180	-9	-10	-10	-10

*Mean of three trials

TABLE 11

Initial and Final Temperatures of

Cold Bentonite Filled Dishes Stored in the Koolatron™ *

	Temperature °C	
	Initial	60 Minutes
Koolatron™ Temperature	23	2
Cold Beverage	4	6
Cold Salad	4	5

* Mean of 3 trials.

EXPERIMENT 7

In this study, trays were prepared with actual hot food items typical of various breakfast and dinner entrees. The Appendix shows the foods on each tray. The cart was charged to full capacity, the prepared trays were loaded with preheated and precooled items, programed and held for one hour. Kilowatt readings were taken initially and after one hour of use. The resulting energy consumption was 2.4 kilowatts per hour.

PROBLEMS ENCOUNTERED

In carrying out the various phases of the experimental plan, two significant problems were encountered. The first deals with the placement of the Temp-Trays™ into the slots provided in the Sweetheart Cart. Although the trays appeared to be properly placed in the slot as indicated by the illumination of the OFF light, they were in fact, slightly ajar, resulting in poor contact between the tray and module energizing terminals. This poor contact prevented the heating elements on the tray from being activated when programmed. This problem was overcome by insuring the trays were pushed firmly into the slots.

The second problem dealt with the charging of the cart after use. As the cart is recharging, lights indicating the percent charge e.g. 80% and 100% light respectively. When the charging is complete (up to 12 hours) the charger shuts off automatically. However, if the unit is disconnected and then inadvertently reconnected, the cycle will begin again, overcharging the battery. This procedure, if repeated, will reduce the life of the batteries. Therefore, a charging schedule is recommended.

CONCLUSIONS

The Sweetheart Food Service System was capable of maintaining the bentonite-glycerine & water testing medium within the temperature range of 60-71°C for one hour. In instances where the medium was filled in the entree dish at temperatures below 60°C, e.g. 54°C, the system was able to bring the medium up to the desired temperature range of 60-71°C. It was unable to prevent a substantial rise in temperature in the chilled items placed on the tray. After a one hour period, the temperatures of the chilled items were well above the Public Health Standard of 12.7°C.

APPENDIX

Experiment 7

Heated Foods Used in Energy Study

Tray	Food	Portion Size	Position
1	Cream of Wheat	3 oz.	Soup
	Toast	2 sl.	Entree 3
	Scrambled Eggs	4 oz.	Entree 3
	Sausage	3 oz.	Entree 1
2	Cream of Wheat	3 oz.	Soup
	Poached Eggs	4 oz.	Entree 3
	Toast	2 sl.	Entree 3
	Sausage	3 oz.	Entree 2
3	French Toast	6 oz.	Entree 3
4	Scrambled Eggs	6 oz.	Entree 3
5	Beets	3 oz.	Entree 2
	Pineapple Pie	3 oz.	Soup
	Creamed Beef	6 oz.	Entree 3
6	Corn	3 oz.	Entree 2
	Creamed Beef	6 oz.	Entree 3
7	Creamed Beef	6 oz.	Entree 3
8	Corn	3 oz.	Entree 2
	Chicken Broth	6 oz.	Soup
	Baked Potato	6 oz.	Entree 1
9	Beets	3 oz.	Entree 2
	Mashed Potato	3 oz.	Entree 1
10	Hot Bread	2 rolls	Soup
	Beef Ravioli	6 oz.	Entree 3
	Baked Potato	6 oz.	Entree 1
11	Beets	3 oz.	Entree 2
	Bread	2 sl.	Soup
	Ravioli	6 oz.	Entree 3
12	Corn	3 oz.	Entree 2
	Grilled Cheese	2 sand.	Entree 3
	Bean and Bacon Soup	6 oz.	Soup

APPENDIX (Cont'd)

Tray	Food	Portion Size	Position
13	Chicken Broth	6 oz.	Soup
	Grilled Cheese	2 sand.	Entree 3
14	Rice	3 oz.	Entree 1
	Beans and Bacon Soup	6 oz.	Soup
15	Cream of Wheat	3 oz.	Soup
	Western Omelet	6 oz.	Entree 3
	Sausage	3 oz.	Entree 1
16	Cream of Mushroom Soup	6 oz.	Soup
17	Apple Pie	3 oz.	Soup
	Sausage	6 oz.	Entree 3
	Mashed Potato	3 oz.	Entree 1
18	Chicken Broth	6 oz.	Soup
	Beef Ravioli	6 oz.	Entree 3
19	Apple Pie	3 oz.	Soup
	(Pureed) Baked Potato	6 oz.	Entree 1
	Chicken and Gravy	6 oz.	Entree 3
20	Lamb, pureed	3 oz.	Entree 2
	Ham and Pineapple, pureed	6 oz.	Entree 3
	Mashed Potato	3 oz.	Entree 1