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EXAMINATION OF PATIENT TRAY FOOD SERVICE EQUIPMENT/ AN EVALUATION OF THE ALPHA CART

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

At the request of personnel at the Walter Reed Army Medical Center, the U.S. Army Natick Research and Development Command evaluated the patient food cart (Alpha Cart) to be used in their new hospital facility. The cart was evaluated for operating and functioning characteristics first with a model bentonite, glycerine water system and then with food products representative of those to be served to patients. The results show that the cart heats very erratically, and substantial differences in heating occur from one

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trial to another. Testing with food products shows that the cart, even at its highest heater code settings, will not heat all surfaces of many foods above the minimum required 140°F (60°C). The refrigeration unit generally maintains cold foods in the desirable chill temperature range, even while other products are being reheated.

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SUMMARY

An evaluation of the Alpha Food Cart has been conducted at the U.S. Army Natick Research and Development Command (NARADCOM). The evaluation was conducted in two parts, the first using a model bentonite-glycerine-water system (Part I). In the second part (Part II), food products representative of those served to patients were used.

Results from Part I show that the cart heats erratically, and substantial differences in heating occur from one trial to another. The erratic heating appears to be caused by a combination of factors including uneven heat transfer from the platens to the heating medium and uneven heating of the platens themselves. The refrigeration unit of the cart is quite successful in keeping the medium cold even when heating elements are rethermalizing other filled dishes. After rethermalization, the cart keeps heated items hot and chilled items cold while the cart remains attached to the Floor Environmental Unit (FEU) and when the doors of the cart are left shut or opened only to remove trays. The temperatures of hot items drop and cold items rise much more quickly when the cart is disconnected from the FEU.

Part II of testing the Alpha Cart using a variety of food products showed many areas of difficulties in the rethermalization of food. The principal problem was in rethermalizing food to above 140°F (60°C) as required by Military and Public Health standards. Although redesigning the computer chip to lengthen the rethermalization cycle was a significant help in bringing some foods up to temperature, not all foods reached the prescribed temperatures. While the internal temperatures would usually be higher than necessary, the top and side portions of certain foods would be lower than recommended. The erratic heating of liquids, as found in Part I, was also encountered when working with foods and contributed to a lack of reliability when bringing food to the proper temperatures. A few chilled foods occasionally reached temperatures higher than the recommended 55°F (13°C) for a short time during the rethermalization cycle, but this is not seen as a major problem. Tests were also run rethermalizing foods with the refrigeration turned off during the reheating cycle. Although this was of some help in heating the foods, the temperature rise in the cold foods and the scorching of hot foods was too great to make this a desirable procedure.

Scorching of some foods while in the process of being brought to recommended temperatures was also a problem. Much of the scorching can be overcome byadding water to the food, by spraying the dishes with a vegetable release coating agent, or by reformulation of the product itself.

Much of the food examined suffered from the deleterious effects of condensation forming on the bottom surface of the cover and dripping down onto the food. This resulted in a poor appearance and soggy food.

Testing in the Alpha Cart also showed the necessity of reformulating products especially for use in the cart. With the heat source coming

directly through the bottom of the dish and not through the other surfaces, some foods which rethermalize well in the convection oven have to be adjusted for use in the cart.

Numerous mechanical breakdowns of the Alpha Cart occurred during the course of the Part I and Part II testing. These were corrected by engineers from Anchor Hocking Corporation.

The following problem areas may be anticipated in the initial use of the Alpha Cart:

1. Hot foods not reaching desirable temperatures

2. Scorching of some items

3. Condensation dropping onto heated food products

4. Mechanical difficulties

5. Programming errors

PREFACE

The Food Engineering Laboratory of the U.S. Army Natick Research and Development Command is engaged in giving technical support to the Walter Reed Army Medical Center's new food service system. As part of this support, the patient tray cart (Alpha Cart) was evaluated as to its operating characteristics and functioning and the effect of these parameters on the various foods placed in the cart. The first portion of this report (Part I) is concerned with the characteristics and functioning of the cart using a model system; the second portion (Part II) deals with the effect of these features on the heating and cooling of selected food items.

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 investigations of the Alpha Cart were conducted at NARADCOM at the request of personnel at the Walter Reed Army Medical Center (WRAMC). The Alpha Cart is a component of the Chill-Therm™ system produced by Alpha Food Systems, a division of Anchor Hocking Corporation. The term "Alpha Cart" describes the operation of the Food and Beverage Transporter (FBT) in the Chill-Therm™ patient food system. This cart will be used to transport meals, keep chilled food cold, and to heat precooked frozen foods at the new WRAMC.

Most of the food served in the new hospital will be precooked frozen foods that are tempered before being loaded into the carts. Chilled foods such as salads will be loaded cold into the cart. Beverages will be served separately on the patient floors so will not be of concern in this study of the Alpha Cart. The loaded carts will travel by monorail to the floors where they will be connected to a stationary Floor Environmental Unit (FEU) which will provide refrigeration to the cart. Each FEU has the capacity of providing refrigeration to two carts. However, in this study, a single cart was attached to the FEU. Figure 1 is an illustration of a cart attached to the FEU. A computer programmed transport memory pack (TMP) will be inserted into the FEU and will cause designated foods to rethermalize according to preset times and codes.

Each cart has two vertical rows of ten shelves which will accomodate twenty trays. Running from top to bottom, shelves on the left side of the cart are numbered from 1 to 10 and on the right hand side numbered from 11 to 20. Figure 2 shows the cart with the doors open and the numbering of the shelves. Designed into each shelf are slightly raised (0.08 in. or 2 mm) rectangular shaped platens or heating elements. Figure 3 illustrates the platens on one shelf and the numbers from 1 to 5 that were assigned to each platen to facilitate reference to a specific platen.

The trays are designed with rectangular shaped openings so that when a proper size dish is placed onto the tray opening it will drop through to rest on a platen. Figure 3 which also diagrams one tray shows these openings. The openings are numbered so the position or opening on the tray corresponds with the element under the opening. Those openings numbered 1, 2 and 5 are approximately the same size as the correspondingly numbered platens and are designed to hold soup or vegetable dishes. The larger sized hole, numbered 3 & 4 holds an entree dish that covers platens 3 & 4. From the diagram it can be seen that the entree dish positions have an area in the center that does not directly contact a platen. The two positions labeled A & B were used for testing cold items.

When in use at WRAMC, the TMP will cause the elements to heat according to codes set by computer. In this study, the heating codes were entered manually. The Alpha Cart was designed to operate with 15 heating codes (Figure 4) reflecting platen rethermalization temperatures from 225°F (107°C) to 325°F (163°C) and holding temperatures from 180°F (82°C) to 210°F (99°C). Each rethermalization cycle is 32 minutes. However, certain codes allow a four to twelve minute lag time before heating begins. When the cart is connected to the FEU, a refrigeration unit provides chilled air to the cart. Thus, circulating cold air passes over all foods and keeps chilled those foods not in contact with a heated platen.

This study of the Alpha Cart was divided into two parts. In the first part a mixture of bentonite, glycerine, and water was made and used as a model system in testing. In the second part actual foods were used for testing.

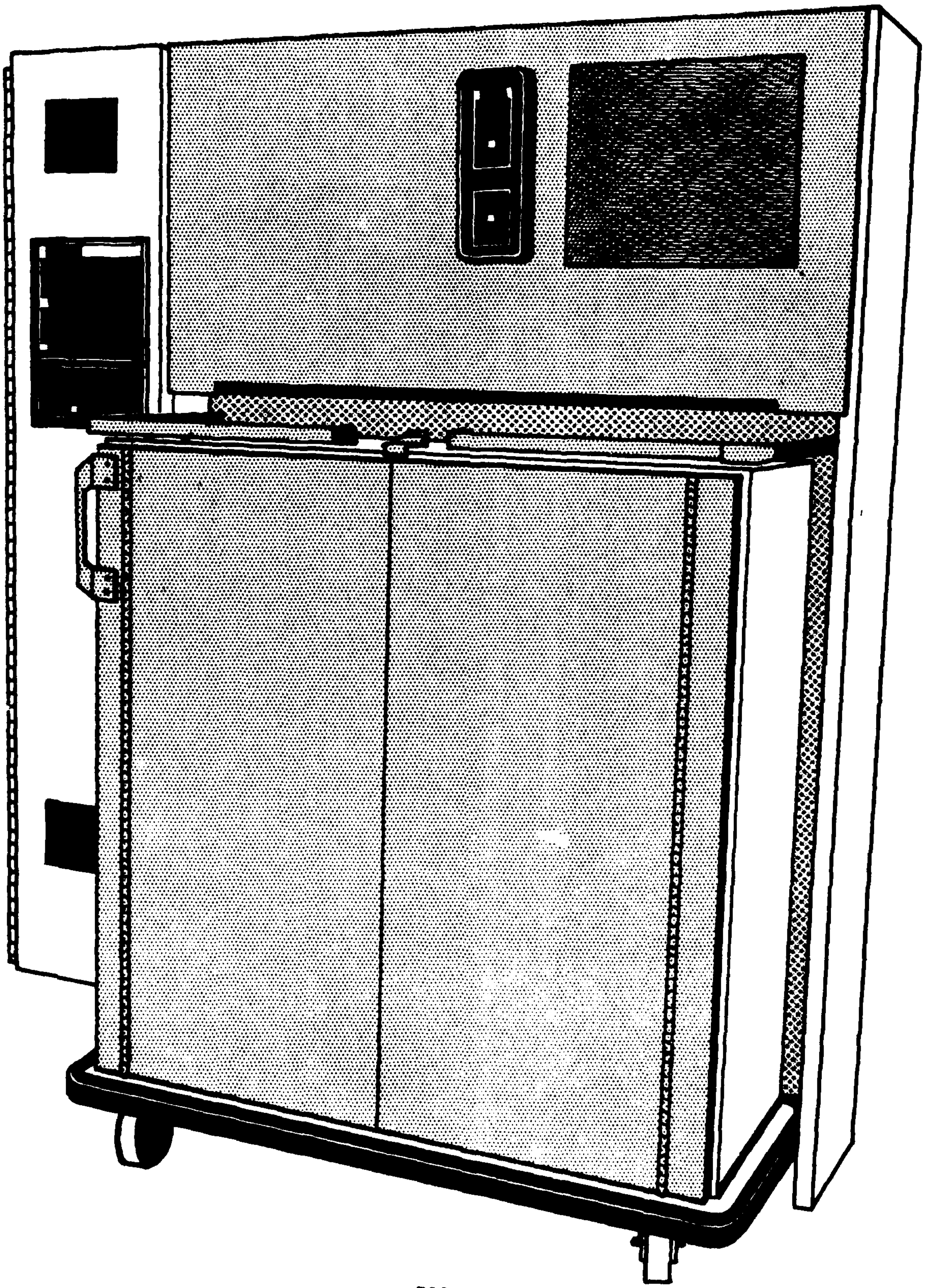


FIGURE 1
ALPHA CART CONNECTED TO THE FLOOR ENVIRONMENTAL UNIT

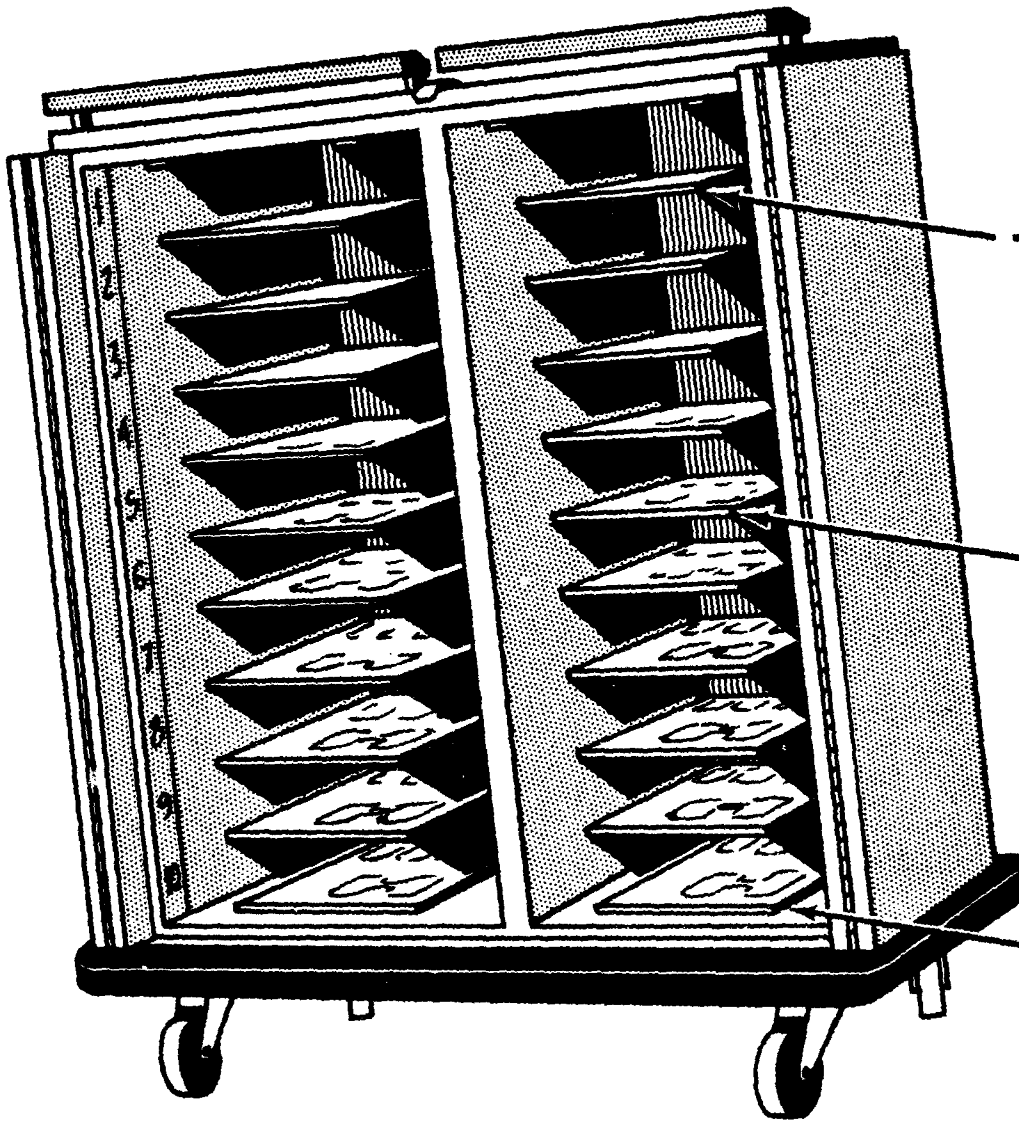


FIGURE 2

ALPHA CART, DOORS OPEN

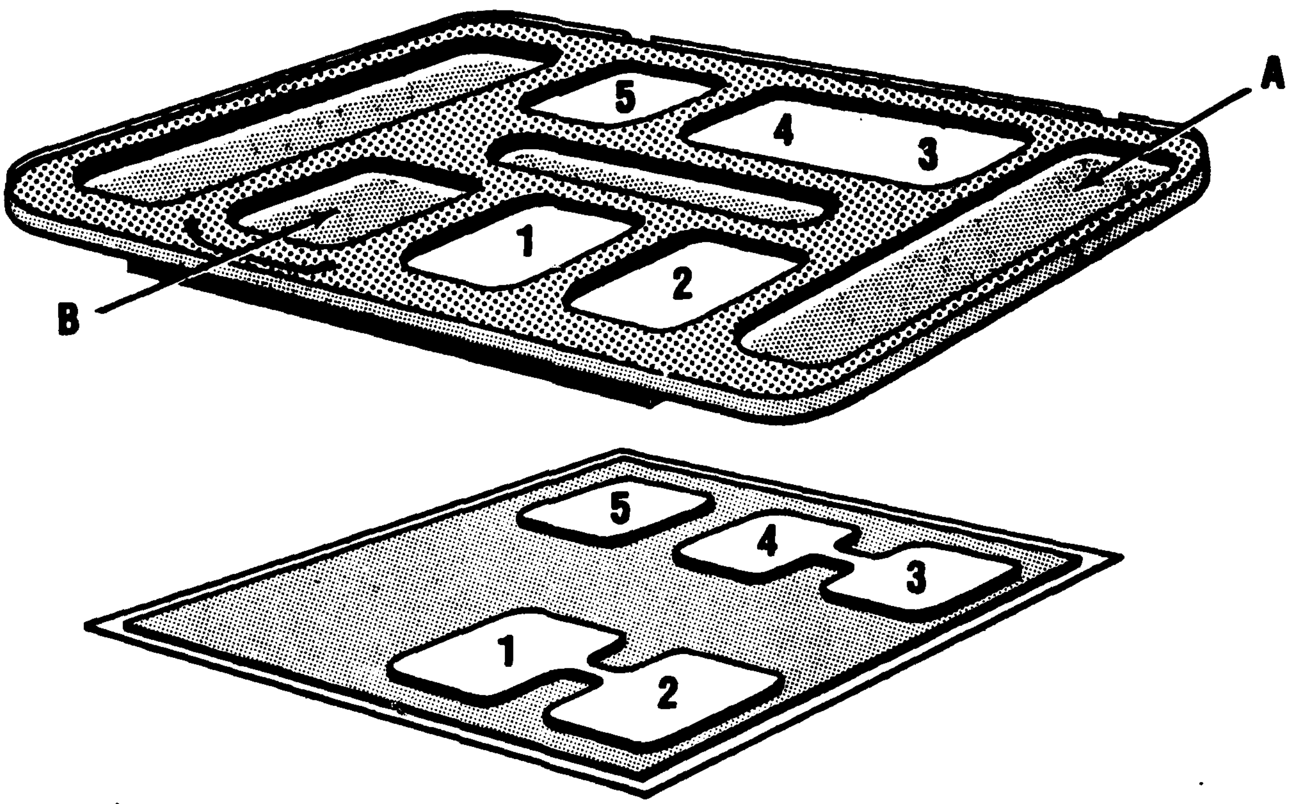
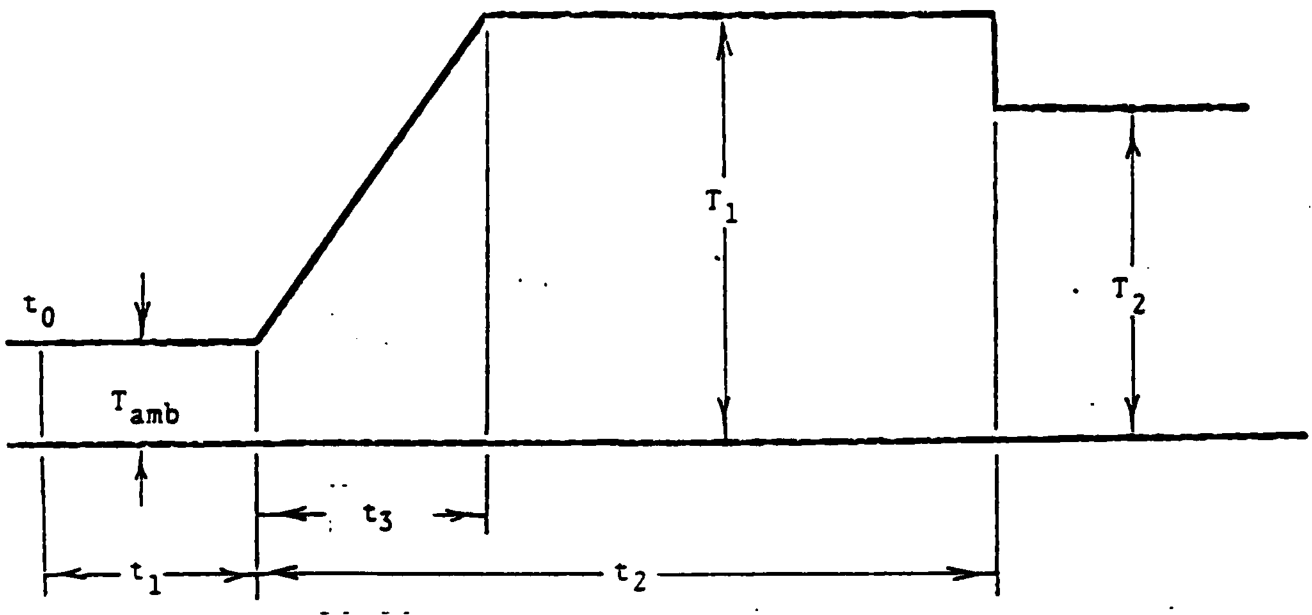


FIGURE 3

ALPHA CART TRAY OVER ALPHA CART SHELF SHOWING NUMBERED OPENINGS ON TRAY AND NUMBERED HEATING ELEMENTS ON SHELF



Profile No.	t_1	t_2	t_3	T_1	T_2
0	0	0	0	0	0
1	0	32	4	225	180
2	4	28	4	225	180
3	8	24	4	225	180
4	12	20	4	225	180
5	0	32	4	255	190
6	5	27	4	255	190
7	10	22	4	255	190
8	0	32	6	275	200
9	5	27	6	275	200
10	10	22	6	275	200
11	0	32	6	300	200
12	5	27	6	300	200
13	0	32	4	325	210
14	3	29	8	325	210
15	8	24	8	325	210

FIGURE 4

STANDARD HEATER PROFILES *

All times (t) are in minutes and all temperatures (T) are in degrees Fahrenheit.

*Courtesy of Anchor Hocking Corporation

Part I: Investigations of Alpha Cart Using a Model Bentonite-Glycerine-Water System

METHODS AND MATERIALS

NARADCOM received an Alpha Cart (FBT) and FEU on loan from WRAMC. Alphaware™ plastic dishes and plastic trays designed to be used in the system were purchased from Alpha Foods Systems. For experimental purposes, a mixture of 5.0% bentonite, 47.5% glycerine and 47.5% water was used in the entree and vegetable dishes to simulate food. A 1.0% bentonite, 49.5% glycerine and 49.5% water mixture was used in the testing to simulate soup. The bentonite mixtures were used in testing to avoid introducing variations inherent in natural food products. Bentonite, glycerine, and water combinations, unlike water alone, have heat retention characteristics similar to many foods.[1]

To measure the temperatures of the bentonite mixtures during heating and cooling in the Alpha Cart, 48 thermocouples were calibrated at 32°F (0°C) in an ice bath and at 212°F (100°C) in boiling water. In the soup and vegetable dishes the thermocouples were attached to a nylon post cemented in the geometric center of the dish. Two thermocouples were placed in each entree dish. One was located over the exact center of element #3 and the other over the exact center of element #4. The thermocouples were held in place in the center of the nylon post by a slit which held the thermocouple in the middle of the depth of the bentonite as well as in the center of the dish. A hole was drilled in the front of each dish to allow passage of the thermocouple wire. To prevent leaking, this hole was packed with rubber cement. The thermocouple wires were passed through the front doors of the cart by the rubber gasket. The magnetic locks on the doors made contact despite the presence of the wires. A loose latch on the door was tightened by inserting a small piece of plastic tubing under the top portion of the latch. The wires were connected to a Honeywell Electronic 112 recorder, calibrated by the U.S. Army Calibration System on 17 March 1978.

Forty dishes were prepared with thermocuples: eight entree dishes, eight soup dishes, and 24 vegetable dishes. Except in Experiment 3, the entree dishes were filled with 8 oz (227 ml) of the 5% bentonite mixture, the soup dishes with 6 oz (170 ml) of the 1% bentonite mixture, and the vegetable dishes with 4 oz (113 ml) of the 5% mixture. The cold positions also held vegetable dishes containing 4 oz (113 ml) of the 5% mixture. In Experiment 3 all positions were filled with vegetable dishes holding 4 oz (113 ml) of the 5% mixture. The height of the nylon posts was exactly level with the volume of bentonite placed in each dish. The dishes were covered with flat plastic snap-on lids designed and made by engineers of the Packaging Division of the Food Engineering Laboratory, NARADCOM.

[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.

After each experiment the thermocouples were checked to ensure they were in the proper location, the nylon posts were checked to ensure they were still cemented in place, the cement over the hole was checked to ensure tight coverage, the lids were examined for tight fit, and the volume of bentonite checked for the proper level. The bentonite mixture was cooled, to a temperature of from 39°F to 46°F (4°C to 8°C) before another trial was made. Before a trial was started, the dishes were pressed down and rocked in the openings within each tray to assure the dishes had properly settled into their holes over the platens.

For Experiment 5c, 15 additional thermocouples were calibrated and one thermocouple was placed in the center of each element of shelves 1, 5, and 10. Thermon™* was placed over the thermocouple and cured by heating at Code 1 for one 32-minute cycle. Where fissures appeared in the Thermon, the procedure was repeated until a thick, smooth mound or mass of Thermon thoroughly covered each thermocouple.

For Experiment 14, the energy study, actual food was used in the cart (see Appendix A for the listing of the foods in each tray).

In Experiment 15, newly designed dishes received from Anchor Hocking were fitted with thermocouples and used in the same way as the dishes used previously. These dishes were designed with a decreased lip so the plates would drop deeper into the holes of the tray and perhaps make better contact with the platen. All of these dishes were also inspected at the point of manufacture for flatness.

EXPERIMENTAL

An experimental plan was designed, a copy of which was sent to WRAMC on 27 June 1978. Because of early inconsistent findings, however, the plan was modified to check further the variability in the functioning of the cart and the causes of this variability. In addition, a few experiments were not done because reliable, applicable data could not be obtained. Following is a copy of the experimental plan with the changes made.

*Thermon™ - a heat transfer cement, manufactured by Thermon Manufacturing Company, San Marcos, Texas

ALPHA CART

INVESTIGATIONS OF ALPHA CART USING A MODEL SYSTEM OF BENTONITE-GLYCERINE-WATER

Experiment Number	Experiment	Change from Original Plan	Purpose
1.	Prepare thermocouples for 40 dishes. Use two thermocouples in each entree dish, one in soup and vegetable dishes. Attach thermocouples so positioning will not change during test. Prepare bentonite, glycerine and water solution.	No Change	For further experiments.
2.	Fill dishes in two trays with bentonite mixture in amounts comparable to portion sizes. (4 oz (113 ml) veg. dishes, 6 oz (170 ml) soup dishes, 8 oz (227 m) entree dishes). Place filled trays (5 dishes over heating platens, 2 dishes not over platens) on center shelves (numbered 5 and 15). With thermocouples, record heating curves at settings 1, 5, 8, 11 and 13. Repeat two times.	Added code 2 to investigate a code setting with a time lag. Repeated code 1 and 2 settings three times to try to obtain more consistent data.	a. Determine if bentonite mixture is a suitable testing medium. b. Compare heating of any given element at one code setting with its replicate. c. Compare heating of any given element at one code setting with a similar element on another shelf. d. Establish a mean temperature and standard deviation of elements 1 through 5 at different heating codes. This will determine normal variation from code to code and shelf to shelf. e. Establish optimum heat settings of various elements using bentonite mixture. f. Compare heating of a code with a time lag with codes without lag.
3.	Repeat using vegetable dishes filled with 4 oz. bentonite mixture in positions 1, 2, 3, 4, and 5. Run at settings 1, 5, 8, 11 and 13.	No Change	Determine differences between heating elements on one shelf.
4.	Using shelf 5, fill all dishes over hot elements and one dish on position B. a. Heat all elements on setting 13. b. Heat no elements.	Not done because data obtained in Experiment 2.	To determine lateral heat transfer.

Experiment Number	Experiment	Change from Original Plan	Purpose
5a.	Using bentonite, fill dishes on shelves 1, 5 and 10 with appropriate amounts and set all elements on shelves at temperatures determined optimum from Experiments 1 and 2 above. Record heating curves.	Repeated three times in an attempt to get usable data.	To determine differences between a fully loaded and partially loaded cart.
5b.	Using bentonite as above, completely fill dishes on all shelves in cart and heat at optimum temperatures. Record temperatures of trays 1, 5, and 10.	No change, but data not suitable for comparison purposes.	To determine differences from top, middle and bottom of cart.
5c.	Attach thermocouples to platens 1 to 5 on shelves 1, 5, and 10; cover with Thermon and cure. Record temperatures of the 15 platens on codes 1, 5, 8, 11, and 13. Repeat 3 times.	Added to original plan.	Determine variability of platens.
5d.	1. Heat bentonite mixtures at optimum codes (as in 5a.). Repeat three times using the same dish in the same tray in the same location for each replication.	Added to original plan.	Determine the variability when using constant dishes and trays. Compare results with Experiment 5a.
	2. Same as above but use water as heating medium.	Added to original plan.	Compare variability using bentonite vs. water.
5e.	1. Same as 5d but use dishes ground flat to a tolerance of ± 0.001 in. (0.02 mm).	Added to original plan.	Determine heating pattern with flat dishes and compare variability using bentonite vs. water.
	2. Same as above but use water as heating medium.		
6.	Fill dishes on shelves 1, 5 and 10 and heat at optimum codes (as in 5a). Insert trays on shelves 1 to 10. After rethermalization remove trays (except 1, 5, and 10) every three minutes. Record temperatures curves of filled dishes on shelves 1, 5, and 10 up to 60 minutes.	Run for 30 minutes to simulate opening one side of cart.	Determine effect of opening and closing doors during serving, on heat and chill retention of bentonite mixture.
7.	Same as #6, except leave doors open after rethermalization.	No Change	Determine effect of leaving doors open during serving on heat and chill retention of bentonite mixture.
8.	Same as above, except leave doors shut and record temperatures up to 60 minutes after rethermalization.	No Change	Determine effect of cart detachment from FEU on heat and chill retention of bentonite mixture.
9.	Same as above, except disconnect FBT from FEU after rethermalization.	No Change	Determine heat and chill retention of bentonite mixture.

Experiment Number	Experiment	Change from Original Plan	Purpose
10.	Same as above, but remove trays 1, 5, and 10 after rethermalization. Record heating and cooling curves up to 60 minutes with trays standing at room temperature.	No Change	Determine heat and chill retention of bentonite mixture after removal from cart.
11.	Fill dishes on shelves 1 to 4. Use permanent domes on #1, disposable domes on #2, flat lids on #3, film on #4. Fill, heat, and record as previously. Repeat, interchanging trays as necessary.	Not carried out because data suitable for comparison purposes could not be obtained.	Determine effect of using permanent or disposable domes, lids, and film.
12.	Fill cart with normally full load, except for one cold tray. Record temperature of items on cold tray.	No Change	Determine cart's capability of holding cold foods with normally full load.
13.	Fill shelves 1, 5, and 10. Record temperature of lid or film with temperature code settings of 13.	No Change	Determine maximum temperature of bottom surface of film or lid.
14.	Fill cart with normally full load of actual menu items. Rethermalize and maintain holding temperatures for 30 minutes. Record energy usage before, during, and after rethermalization.	Changed to include usage of cart with no rethermalization period (refrigeration only), with 32-minute rethermalization period with 30-and 60-minute maintenance heating. Also obtained usage when heating was done with no refrigeration.	Determine energy usage of cart.
15.	Repeat experiment 5a using newly designed dishes received from Anchor Hocking.	Added to original plan.	Determine if redesigned dishes would heat less erratically and/or to a higher temperature.

RESULTS

EXPERIMENT 2

Table 1 gives the results of rethermalizing bentonite on each of the five heating elements at Codes 1, 2, 5, 8, 11, and 13. Mean values represent trials on shelves 5 and 15. No major differences were found between the two shelves, but wide variations occurred between replications on the same elements on the same shelf. Additional replications of Code 1 and Code 2 settings were made to ensure the differences were not due to experimental error, but additional replications only gave more inconsistent and erratic heating patterns.

The widest temperature variation from one trial to another on the same element was 50°F (10°C) and differences of 27-49°F (15-27°C) were common. It should also be noted that the temperatures between codes overlap and the higher codes did not always heat the product to the highest temperature. In Table 1, it can be seen that at times Code 1 may heat higher than Code 2 for example, or Code 8 higher than Code 13. One reason for this may be that the elements are using the maximum wattage to heat the bentonite mixture, equilibrium is not reached during the short, 32-minute cycle, and thus low codes are using as much wattage as higher codes. Graphs of the heating curves generally showed that temperatures did not level off during the normal 32-minute rethermalization time.

Code 2 was added to the experimental plan to see if the same differences occur in a code with a time lag. Results generally show greater variation in the codes with a time lag than in the codes with no time lag.

TABLE 1
Experiment 2
Final Temperature, Mean, Range, and Difference for Bentonite Filled Dishes Heated at Six Code Settings[a]

Code Element	Mean °F	Mean °C	Range °F	Range °C	Difference °F	Difference °C
Code 1[b]						
Element 1	170	77	138-187	59-86	49	27
Element 2	162	73	129-187	54-86	58	32
Element 3	154	68	134-167	57-75	33	18
Element 4	156	69	138-176	59-80	38	21
Element 5	147	64	126-156	52-69	30	17
Code 2[b]						
Element 1	163	72	131-180	55-82	49	27
Element 2	156	69	126-174	52-79	48	27
Element 3	137	58	108-156	42-69	48	27
Element 4	140	60	117-160	47-71	43	24
Element 5	131	55	117-142	47-61	25	14
Code 5[c]						
Element 1	201	94	192-208	89-98	16	9
Element 2	194	90	187-201	86-94	14	8
Element 3	172	78	169-178	76-81	9	5
Element 4	167	75	156-171	69-77	8	15
Element 5	154	68	151-162	66-72	11	6
Code 8[c]						
Element 1	210	99	194-221	90-105	27	15
Element 2	203	95	198-216	90-102	18	10
Element 3	178	81	172-181	78-83	9	5
Element 4	167	75	160-178	71-81	18	10
Element 5	154	68	151-156	66-69	5	3
Code 11[c]						
Element 1	199	93	181-219	83-104	38	21
Element 2	194	90	185-208	85-198	23	13
Element 3	180	82	158-189	70-87	31	17
Element 4	174	79	154-189	68-87	35	19
Element 5	154	68	142-160	61-71	18	10
Code 13[c]						
Element 1	208	98	201-216	94-102	15	8
Element 2	203	95	183-216	84-102	33	18
Element 3	189	87	180-201	82-94	21	12
Element 4	189	87	185-192	85-89	7	4
Element 5	169	76	156-176	69-80	20	11

a For all codes elements 1 & 2 held 4-oz veg. dishes filled with 4-oz (113 mL) bentonite; elements 3 & 4 contained an entree dish filled with 8-oz (227 mL) bentonite; element 5 had soup dish filled with 6-oz (170 mL) bentonite.

b Six replications.

c Four replications.

EXPERIMENT 3

Only one replication on two trays was made in Experiment 3 because it was felt that the large variations from trial to trial would overshadow any differences between elements. Results in Table 2 show the final rethermalization temperatures on shelves 5 and 15 at five code settings. From this and other experiments it can be concluded that variation due to element position is insignificant when compared to the variation between runs using the same element. In Table 2, the higher codes did not always heat the product to the highest temperature. Element 1 would sometimes heat higher than Element 5, while at other times Element 5 would heat higher than Element 1. This does not preclude the possibility that certain mixtures on certain shelves could consistently reach higher or lower temperatures.

TABLE 2
Experiment 3*
Final Temperatures of Bentonite Filled Dishes at Various Code Settings (2 replications)

	Mean °F	°C	Range °F	°C	Mean of All Elements °F	°C
Code 1						
Element 1	180	82	180	82		
Element 2	171	77	165-176	74-80		
Element 3	167	75	165-167	74-75	174	79
Element 4	176	80	167-183	75-84		
Element 5	172	78	169-190	76-88		
Code 5						
Element 1	199	93	198-201	92-94		
Element 2	194	90	190-198	88-92		
Element 3	187	86	185-189	85-87	194	90
Element 4	194	90	189-198	87-92		
Element 5	198	92	187-208	86-98		
Code 8						
Element 1	208	98	201-216	94-103		
Element 2	216	102	212-221	100-105		
Element 3	199	93	198-201	92-94	210	99
Element 4	210	99	203-216	95-102		
Element 5	214	101	208-219	98-104		
Code 11						
Element 1	208	98	207-210	97-99		
Element 2	214	101	214-216	101-102		
Element 3	199	93	181-216	83-102	210	99
Element 4	207	97	201-212	94-100		
Element 5	212	100	210-214	99-101		
Code 13						
Element 1	214	101	210-217	99-103		
Element 2	216	102	216-217	102-103		
Element 3	214	101	212-217	100-103	217	103
Element 4	221	105	217-225	103-107		
Element 5	217	103	217	103		

* All elements held vegetable dishes containing 4 oz. bentonite

EXPERIMENT 4

Experiment 4 was not carried out as a separate experiment because the data from Experiment 2 gave the desired data on lateral heat transfer from hot to cold positions. The lateral heat transfer to cold items at most code settings was minimal. The highest temperature increase in the cold items occurred when hot items were heated at the hottest code (Code 13). At Code 13, the maximum temperature increase at a cold position was 7°F (4°C) or from 43°F (6°C) to 50°F (10°C).

EXPERIMENT 5A

Experiment 5A also shows the variation in the cart during three trial runs. Table 3 shows the final rethermalization of each run as well as the mean, range, difference, and standard deviation. The maximum differences at the same element on the same shelf was 60°F (33°C). Differences of 18°F (10°C) on the same element and the same shelf were quite common. The data obtained in Experiment 5A are not considered valid for testing (1) the differences between a fully and partially loaded cart or (2) the differences from the top, middle, or bottom shelves of the cart. Once again, the differences between replications on one element are greater than the other variabilities to be studied.

TABLE 3
Experiment 5A
Final Temperatures of Bentonite Filled Dishes at Optimum Code Settings Using
Randomly Placed Dishes and Trays

	Shelf 1			Shelf 2			Shelf 3						
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Mean	Range	Maximum Difference	Standard Deviation
Element 1													
°F	162	160	149	162	163	167	163	165	149	160	149-167	18	6.5
°C	72	71	65	72	73	75	73	74	65	71	65-75	10	3.7
Element 2													
°F	167	169	149	118	149	178	156	174	158	158	118-178	60	18.1
°C	75	76	65	48	65	81	69	79	70	70	48-81	33	10.0
Element 3													
°F	162	196	178	169	185	180	167	180	174	177	162-196	34	10.3
°C	72	91	81	76	85	82	75	82	79	80	72-91	19	5.7
Element 4													
°F	162	172	167	167	181	176	180	181	189	175	162-189	27	8.7
°C	72	78	75	75	83	80	82	83	87	79	72-87	15	4.8
Element 5													
°F	181	181	176	180	178	176	172	172	149	174	149-181	32	9.9
°C	83	83	80	82	81	80	78	78	65	79	65-83	18	5.5

*Elements 1 & 2 held vegetable dishes filled with 4-oz of bentonite.
Elements 3 & 4 held entree dishes filled with 8-oz bentonite.
Element 5 held soup dishes filled with 6-oz bentonite.
Elements 1 & 2 were programmed at code 1, elements 3 & 4 at code [illegible], and element 5 at code 13.

EXPERIMENT 5B

Because the data in 5A were not considered adequately valid for the comparisons desired from Experiment 5B, the data from this experiment were not compiled.

EXPERIMENT 5C

In an effort to determine the cause of the variability in the individual heating elements of the Alpha Cart, the temperatures of the shelf platens were tested using thermocouples attached directly to the platens. The thermocouples were covered with Thermon, a heat conductive cement, and heated to effect a cure. Thermocouple recordings showed a maximum difference of 13°F (7°C) on one element on one shelf (Table 4) and a maximum difference of 20°F (11°C) between elements at the same code on all 15 elements (Table 5). When bentonite was heated in previous experiments, the heating codes overlapped to a large extent and lower codes would often heat higher than hotter codes. However, in measuring the platen temperature, the higher codes consistently heated to a higher temperature. The differences found in measuring the platen temperature indicate that some of the erratic heating is caused by variations in the control of platen temperatures.

TABLE 4
Experiment 5C
Maximum Temperature Range of One Element on One Shelf*
as Measured by Thermocouples Placed on Element and
Covered with Thermon

Code	Final Thermalization Temperature Range		Difference	
	°F	°C	°F	°C
1	207-216	97-102	9	5
5	230-243	110-117	13	7
8	253-259	123-126	6	3
11	273-280	134-138	7	4
13	288-295	142-146	7	4

*Based on 3 replications.

TABLE 5
Experiment 5C
Maximum Temperature Range of Fifteen Elements*
on Three Shelves as Measured by Thermocouples
Placed on the Element and Covered with Thermon

Code	Mean		Final Rethermalization Range		Difference	
	°F	°C	°F	°C	°F	°C
1	208	98	203-217	95-103	14	8
5	235	113	226-243	108-117	17	9
8	235	123	243-261	117-127	18	10
11	273	134	261-280	127-138	19	11
13	291	144	280-300	138-149	20	11

*Based on 3 replications.

EXPERIMENT 5D

Part 1. In order to determine what portion of the cart's variability was caused by uneven platens, uneven dishes, and/or uneven trays, Experiment 5A was repeated using the same dishes and the same trays, in the same location for each trial run. As can be seen in Table 6, considerably fewer variations in final temperatures were found. The largest variation in temperature from the same element, on the same shelf, the same tray, and the same dish was 16°F (9°C). Maximum differences on the same element over the three shelves was 23°F (13°C). The standard deviations over the three trial runs were generally much lower in this experiment than in 5A. Thus, a significant part of the cart's variability also comes from the variability of the trays and dishes.

Part 2. To ascertain whether the variability could be caused by the use and reuse of the bentonite mixture, the above experiment was repeated using water as the heated medium. As seen in Tables 6 and 7, the differences between water and bentonite on the variability of the final rethermalization temperature were small, although the final rethermalized temperature of the water was lower than bentonite. Therefore, it is concluded that bentonite was not the cause of the heating variation.

EXPERIMENT 5E

In order to determine the heating pattern with dishes known to be flat, dishes were ground to a flatness of 0.001 in (0.02 mm). No significant differences were found from the other dishes when used in a constant position. Tables 8 and 9 give the detailed results when bentonite or water was heated.

TABLE 6

EXPERIMENT 5D - PART 1
Final Temperatures of Bentonite Filled Dishes at Optimum Code Settings Using The Same Dish and Tray on the Same Element for Each Trial*

		Shelf 1			Shelf 2			Shelf 3						
		Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Mean	Range	Maximum Difference	Standard Deviation
Element 1	°F	154	162	156	163	162	165	165	163	162	161	154-165	11	3.7
	°C	68	72	69	73	72	74	74	73	72	72	68-74	6	2.1
Element 2	°F	169	171	167	171	181	171	165	163	163	169	163-181	18	6.0
	°C	76	77	75	77	78	77	74	73	73	76	73-78	5	1.9
Element 3	°F	178	171	172	180	176	181	176	169	165	174	165-181	16	5.3
	°C	81	77	78	82	80	83	80	76	74	79	74-83	9	3.1
Element 4	°F	176	165	160	176	167	171	183	183	178	173	160-183	23	8.1
	°C	80	74	71	80	75	77	84	84	81	78	71-84	13	4.5
Element 5	°F	176	165	162	176	169	162	165	172	162	168	162-176	14	6.0
	°C	80	74	72	80	76	72	74	78	72	75	72-80	8	3.3

*Elements 1 and 2 held vegetable dishes filled with 4-oz of bentonite.
Elements 3 and 4 held entree dishes filled with 8-oz bentonite.
Element 5 held soup dishes filled with 6-oz bentonite.
Elements 1 and 2 were programmed at code 1, elements 3 and 4 at code 8, element 5 at code 13.

TABLE 7

EXPERIMENT 5D - Part 2
Final Temperatures of Water Filled Dishes at Optimum Code Settings Using The Same Dish and Tray on the Same Element for Each Trial*

		Shelf 1			Shelf 2			Shelf 3						
		Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Mean	Range	Maximum Difference	Standard Deviation
Element 1	°F	145	144	147	147	145	145	162	163	163	151	144-163	19	8.6
	°C	63	62	64	64	63	63	72	73	73	66	62-73	11	4.8
Element 2	°F	145	149	167	145	145	160	154	154	151	152	145-167	12	7.5
	°C	63	65	75	63	63	71	68	68	66	67	63-71	12	4.1
Element 3	°F	165	163	172	167	163	169	165	165	165	166	163-172	9	2.9
	°C	74	73	78	75	73	76	74	74	74	74	73-78	5	1.6
Element 4	°F	163	162	171	165	162	167	163	163	163	164	162-171	9	3.0
	°C	73	72	77	74	72	75	73	73	73	74	72-77	5	1.6
Element 5	°F	183	180	181	169	169	172	178	171	178	176	169-183	4	5.4
	°C	84	82	83	76	76	78	81	77	81	80	76-83	7	3.1

*Elements 1 and 2 held vegetable dishes filled with 4-oz of water.
Elements 3 and 4 held entree dishes filled with 8-oz of water.
Element 5 held soup dishes filled with 6-oz of water.
Elements 1 and 2 were programmed at code 1, elements 3 and 4 at code 8, and element 5 at code 13.

TABLE 8

EXPERIMENT 5E - PART 1
Final Temperatures of Bentonite Filled Dishes at Optimum Code Settings Using The Same Dish and Tray on the Same Element for Each Trial (Flat Dishes)*

		Shelf 1			Shelf 2			Shelf 3						
		Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Mean	Range	Maximum Difference	Standard Deviation
Element 1	°F	[illegible]	171	165	175	163	163	169	167	167	166	163-171	8	2.8
	°C	76	77	74	74	73	73	76	75	75	75	73-77	4	1.0
Element 2	°F	167	167	165	176	171	172	165	160	165	168	160-176	16	4.8
	°C	75	75	74	80	77	78	74	71	74	75	71-80	9	2.6
Element 3	°F	190	185	174	167	174	169	167	158	176	173	158-190	32	9.7
	°C	88	85	79	75	79	76	75	70	80	78	70-88	18	5.5
Element 4	°F	181	176	174	176	174	167	180	174	181	176	167-181	4	4.5
	°C	83	80	79	80	79	75	82	79	83	80	75-83	8	2.5
Element 5	°F	178	171	162	180	178	165	180	160	149	169	149-180	31	10.9
	°C	81	77	72	82	81	74	82	71	65	76	65-82	17	6.0

*Elements 1 and 2 held vegetable dishes filled with 4-oz of bentonite.
Elements 3 and 4 held entree dishes filled with 8-oz of bentonite.
Element 5 held soup dishes filled with 6-oz of bentonite.
Elements 1 and 2 were programmed at code 1, elements 3 and 4 at code 8, and element 5 at code 13.

TABLE 9

EXPERIMENT 5E - PART 2
Final Temperatures of Water Filled Dishes at Optimum Code Settings Using The Same Dish and Tray on the Same Element for Each Trial (Flat Dishes)*

		Shelf 1			Shelf 2			Shelf 3						
		Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Mean	Range	Maximum Difference	Standard Deviation
Element 1	°F	145	149	149	145	151	153	153	165	145	150	145-165	20	6.3
	°C	63	65	65	63	66	67	67	74	63	66	63-74	11	3.4
Element 2	°F	147	160	158	145	154	160	151	162	154	154	145-162	17	6.0
	°C	64	71	70	63	68	71	66	72	68	68	63-72	9	3.2
Element 3	°F	165	167	172	162	163	162	162	165	160	164	160-172	12	3.6
	°C	74	75	78	72	73	72	72	74	71	73	71-78	7	2.1
Element 4	°F	162	162	169	158	162	162	160	167	158	162	158-169	11	3.7
	°C	72	72	76	70	72	72	71	75	70	72	70-76	6	2.0
Element 5	°F	174	171	178	176	178	183	169	169	158	173	158-183	25	7.2
	°C	79	77	81	80	81	84	76	76	70	78	70-84	14	4.1

*Elements 1 and 2 held vegetable dishes filled with 4-oz of water.
Elements 3 and 4 held entree dishes filled with 8-oz of water.
Element 5 held soup dishes filled with 6-oz of water.
Elements 1 and 2 were programmed at code 1, elements 3 and 4 at code 8, and element 5 at code 13.

EXPERIMENT 6

In this test one side of the cart was filled with dishes containing bentonite mixtures and heated at codes which should bring the mixtures to approximately 160°F (71°C). As shown in Table 10, at the end of the 30-minute period with the doors opened every three minutes, there was a temperature drop of 12°F (7°C) to 153°F (67°C). The cold items (Table 11) rose an average of 5°F (3°C) to a mean of 48°F (9°C) after the thirty-minute period. Therefore, one can assume a fairly small temperature gain or loss when the cart remains connected to the FEU and doors are closed each time trays are removed.

EXPERIMENT 7

In this test where one side of the cart was filled and rethermalized to approximately 160°F (71°C), the doors of the cart were left open after rethermalization to simulate trays being removed from the cart when the cart is still attached to the FEU. As shown in Table 10, the mean temperatures of bentonite dropped from 163°F (73°C) at the end of rethermalization to 138°F (59°C) after 30 minutes and to 102°F (39°C) after 60 minutes. Thus, leaving the doors open during serving and still having the circulating cold air surround the hot items caused a substantial temperature drop. The cold items (Table 12) that were at 45°F (7°C) at the end of rethermalization rose to 52°F (11°) at the end of thirty minutes and to 59°F (15°C) at the end of 60 minutes. Thus, the cold foods were slightly affected by leaving the doors open.

EXPERIMENT 8

In this test where the cart was left attached to the FEU with the doors shut for 60 minutes the holding or maintenance temperatures kept the hot and cold items quite satisfactorily. As shown in Table 10, from a mean rethermalization temperature of 172°F (78°C) the temperature dropped an average of 18°F (10°C) to 154°F (68°C) after 30 minutes and 24°F (14°C) to 148°F (64°C) after 60 minutes. Thus, if the bentonite solution is rethermalized to 160°F (71°C) a 60-minute holding time is not too detrimental to the heat retention. The cold items (Table 11) also withstood the 60-minute holding period with only a 5°F (3°C) to 50°F (10°C) temperature rise after the 60-minute time interval.

EXPERIMENT 9

In the tests where the cart was removed from the FEU after rethermalization and the doors left shut, the hot and cold items showed considerable change after the 60-minute holding time (Tables 10 & 11). The hot items dropped from a mean of 165°F (74°C) after rethermalization to 133°F (56°C) after 30 minutes, and to 111°F (44°C) after 60 minutes. The cold items reose 16°F (9°C) from 45°F (7°C) to 61°F (16°C) after 60 minutes. Therefore, if the cart is removed from the FEU, the hot and cold items show considerable changes after an hour. It should also be noted that if the hot items do not reach the desired 160°F (71°C) after rethermalization, the temperature loss would be more detrimental to the foods.

EXPERIMENT 10

This experiment was designed to compare products held under various conditions in the Alpha Cart with items standing at room temperature. After a mean rethermalization temperature of 163°F (73°C), the hot items, with covers on at room temperature (75°F (24°C) 54% R.H.), dropped to 127°F (53°C) after 30 minutes standing and to 102°F (39°C) after 60 minutes. This was very close to the results of the product left in the cart with the doors open, and only slightly warmer than the product in the Alpha Cart when disconnected from the FEU. The cold items started at 45°F (7°C) and gained 9°F (5°C) after 30 minutes and 19°F (11°C) after 60 minutes. The cold items stayed colder in the Alpha Cart, expecially when the doors remained shut with the cart still attached to the FEU.

TABLE 10

EXPERIMENTS 6-10
Temperature Changes of Bentonite Solutions Under Different Holding Conditions After Rethermalization
Hot Positions*

Experiment Number		Rethermalization Temperature	Temperature after 30 minutes	Temperature changes after 30 minutes	Temperature after 60 minutes	Temperature change (from rethermalization after 60 minutes)
6 Doors open to remove trays then shut	°F	165	153	-12	-	-
	°C	74	67	-7	-	-
7 Doors of cart left open after rethermalization	°F	163	138	-25	102	-61
	°C	73	59	-14	39	-34
8 Door of cart left shut after rethermalization	°F	172	154	-18	148	-24
	°C	78	68	-10	64	-14
9 Food cart removed from floor environmental unit	°F	165	133	-32	111	-54
	°C	74	56	-8	44	-30
10 Trays removed from food cart & left at room temperature	°F	163	127	-36	102	-61
	°C	73	53	-20	39	-34

*Mean of 15 heating positions

TABLE 11

EXPERIMENTS 6-10
Temperature Changes of Bentonite Solutions Under Different Holding Conditions After Rethermalization
Cold Positions*

Experiment Number		Rethermalization Temperature	Temperature after 30 minutes	Temperature change after 30 minutes	Temperature after 60 minutes	Temperature change (from rethermalization after 60 minutes)
6 Doors open to remove traps then shut	°F	43	48	+5	-	-
	°C	6	9	+3	-	-
7 Doors of cart left open after rethermalization	°F	45	52	+7	59	+14
	°C	7	11	+4	15	+8
8 Door of cart left shut after rethermalization	°F	45	48	+3	50	+5
	°C	7	9	+2	10	+3
9 Food cart removed from floor environmental unit	°F	45	52	+7	61	+16
	°C	7	11	+4	16	+9
10 Trays removed from food cart & left at room temperature	°F	45	54	+9	64	19
	°C	7	12	+5	18	11

*Mean of 6 cold positions

EXPERIMENT 11

Experiment 11 was not carried out because the variability from one trial to another in the Alpha Cart would not have allowed a meaningful test of the permanent domes, disposable domes, flat snap-on lids, and film.

EXPERIMENT 12

In this experiment the Alpha Cart was loaded with a normally full load of dishes filled with bentonite. All of the hot positions except those on shelf 5 were programmed to bring the final temperatures near 160°F (71°C). Shelf 5 contained a tray with cold bentonite filled dishes not programmed in order to determine the possible temperature rise of one cold tray in the cart. The mean initial temperature of the cold tray was 45°F (7°C). After rethermalization, the mean temperature was 48°F (9°C), a rise of just 3°F (2°C). Thus, the cart was able to maintain one cold tray quite well.

EXPERIMENT 13

In this experiment, shelves 1, 5, and 10 contained dishes filled with bentonite rethermalized at Code 13. The thermocouples were bent upward so that they touched the bottom surface of the plastic snap-on lid. The purpose of this experiment was to determine the highest temperature to which a lid or film would be exposed. The mean lid temperature after rethermalization was 178°F (81°C) and the lid temperatures ranged from a low of 151°F (66°C) to a high of 201°F (94°C).

EXPERIMENT 14

In this study, trays were prepared with actual food and heated at codes suggested by Anchor Hocking in their literature. Appendix A shows the foods on each tray. Kilowatt readings were taken for refrigeration only, for refrigeration and rethermalization, for refrigeration and maintenance heating, and for rethermalization and maintenance heating with the refrigeration unit disconnected. Results were as follows:

	Kilowatts
Refrigeration only (60 minutes)	1.2
Rethermalization (with refrigeration) (32 minutes)	1.6
Maintenance Heating (with refrigeration) (60 minutes)	1.6
Rethermalization (with no refrigeration) (32 minutes)	1.1
Maintenance Heating (with no refrigeration) (60 minutes)	0.6

EXPERIMENT 15

One of the suspected sources of variability in heating was the unevenness of the Alphaware dishes. Newly designed dishes were received from Anchor Hocking. To determine if these dishes would give more reliable heating and perhaps heat to higher temperatures than the original dishes, Experiment 5A was repeated using the new dishes.

Table 12 shows the final temperature, mean, range, maximum differences, and standard deviation for these three trials with the new dishes compared with the data from the old dishes. The results show that Element 2, which had such a large deviation with the old dishes, had less with the new dishes. The other readings indicate slightly less variation with the new dishes except for one side of the entree dish. The standard deviation with the new dishes was relatively low on the low Codes on Elements 1 and 2, but became greater on the entree dish, Positions 3 and 4 and the soup dish on Element 5. When these results are compared to the results of Experiment 5D, which compared dishes not randomly placed, only the new entree dish had a substantially higher variation. This indicates that the new soup and vegetable dishes may be of some help in heating less erratically, but the entree dish is still a problem. The new dishes were not of significant value in heating the product to a higher temperature. Tests in Part II with food showed no substantial differences in heating food when using either the old or new dishes.

TABLE 12

EXPERIMENT 15
FINAL TEMPERATURES OF BENTONITE FILLED NEW AND OLD ALPHAWARE DISHES AT OPTIMUM CODE SETTINGS USING RANDOMLY PLACED DISHES AND TRAYS

	Mean		Range		Maximum Difference		Standard Deviation	
	°F	°C	°F	°C	°F	°C	°F	°C
Element 1								
New dishes	164	74	160-169	71-76	9	5	3.7	2.1
Old dishes	160	71	149-167	65-75	18	10	6.5	3.7
Element 2								
New dishes	167	75	163-172	73-78	9	5	3.0	1.6
Old dishes	158	70	118-178	48-81	60	33	18.1	10.0
Element 3								
New dishes	169	77	145-181	63-83	36	20	10.5	6.4
Old dishes	177	80	162-196	72-91	34	19	10.3	5.7
Element 4								
New dishes	173	78	156-181	69-83	25	14	8.1	4.5
Old dishes	175	79	162-189	72-87	27	15	8.7	4.8
Element 5								
New dishes	158	70	147-169	64-76	22	12	7.7	4.3
Old dishes	174	79	149-181	65-83	32	18	9.9	5.5

CONCLUSIONS

The variability of heating bentonite-glycerin-water mixtures in the Alpha Cart is substantial. The variation from one trial to another using the same shelf and element is so great that it overshadows other possible variations in the cart such as variation between elements and variation between shelves. Because of this variation, it is impossible to ascertain an optimum heating code for each food product. The variability and erratic heating should be corrected before the Alpha Cart is used in any hospital feeding operation.

The findings of the tests also show that:

1. There is a significant amount of variation in platen temperature.

2. The heating variation is greatly reduced when the same dishes and the same trays are used on the same platen in each trial.

The refrigeration unit on the cart is quite successful in keeping chilled items cool, even when products are heated next to cold foods and when the rest of the cart has a normal load of heated products.

The maintenance and holding cycle of the cart retains the heat in hot proudcts when the cart remains connected to the FEU or when the doors are opened only to remove trays. The refrigeration under those conditions will also keep the cold food chilled. However, when the cart is removed from the FEU or when the doors to the cart are left open, considerable heat is lost from the hot products and the chilled foods become warmer.

Part II: Investigations of Alpha Cart Using Selected Food Items

METHODS AND MATERIALS

Entrees from the regular and modified diet menus of WRAMC were prepared and frozen for the initial testing of food in the Alpha Cart. The products included a range of meat, poultry, fish, and egg items from the regular menu as well as modified meat entrees, pureed bland and dental liquid entrees from the special diet menu.

Further testing was done with a standardized group of food products, which were transferred into Alphaware dishes and put into the cart for each test. The foods were selected to represent a range of entree, starch, vegetable, and dessert items, as well as to simulate a normal cart load. Appendix B lists the foods used, the portion size, the heater position and type of cover.

Additional testing was done on hard-to-heat items such as bone-in chicken, spareribs, and pork chops, and also on easily scorched items such as egg products and items with a cream or cheese sauce.

Final temperatures of all food items were recorded by a heat probe placed on the top and side edges as well as internally.

Initial experiments were undertaken using the computer chip originally developed for programming the codes used in the Alpha Cart by Anchor Hocking Corp. (Figure 4 on page 20 of Part 1 of this report). Three additional computer chips that allowed further changes in heating times and temperatures were requested and received from Anchor Hocking (Figures 5, 6, and 7). An on-off switch on the refrigeration unit of the cart allowed rethermalization with or without refrigeration.

EXPERIMENTAL

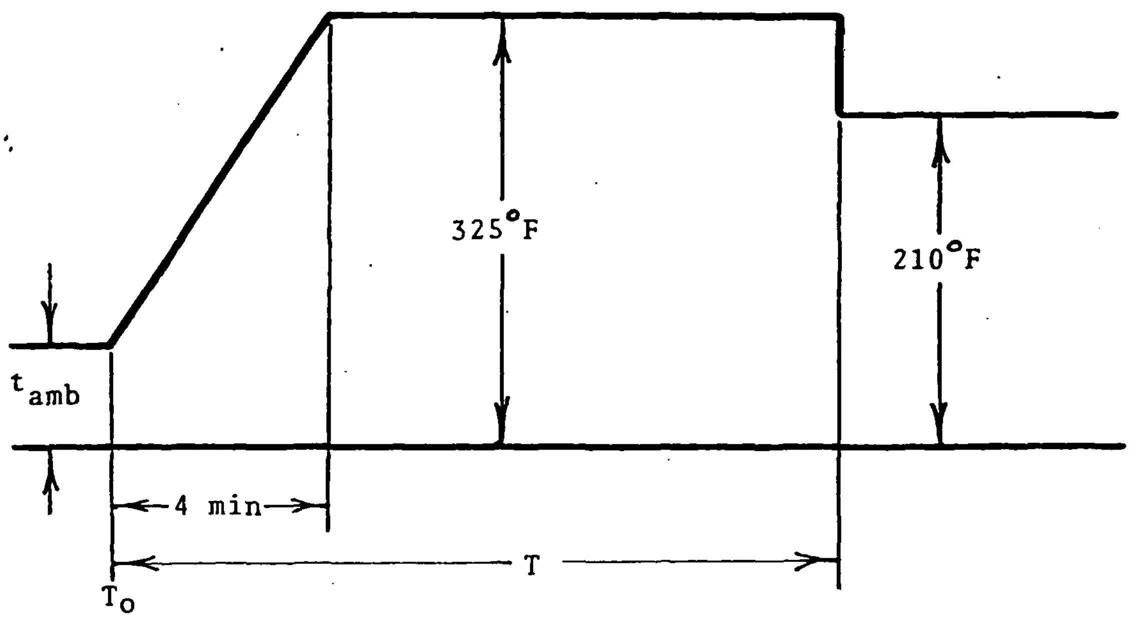
In the first rethermalizations of food using the original computer chip supplied with the Alpha Cart by Anchor Hocking, nine items, including one pureed bland product, two dental liquids, one creamed item (Eggs a la Goldenrod), a loaf item (veal loaf), a patty (veal patty), two meats with sauces (veal steak with mushroom gravy and roast turkey with brown gravy), and a solid muscle meat (baked pork chops) were tempered and tested in the Alpha Cart. These products were heated at three different code settings: 32 minutes at 275°F (135°C), 32 minutes at 300°F (149°C), and 32 minutes at 325°F (163°C). Further testing at 325°F (163°C) for 32 minutes was done on a larger variety of foods to corroborate initial testing and to determine the reaction of these foods to the conduction type heating of the Alpha Cart. Modifications and variations in heating and plating using the highest code of 32 minutes at 325°F (163°C) were also tried.

Because the results of the testing with the original times and temperatures governed by the original computer chip were largely unsuccessful, a new computer chip (Figure 5) received from Anchor Hocking allowed the programming of rethermalization times from 26 to 54 minutes with two-minute increments, while the temperature remained standard at 325°F (163°C). At the same time, a switch was installed to permit the refrigeration to be turned on and off as desired.

A series of experiments was designed to test the effects of various rethermalization times and also to test the effects of rethermalization without refrigeration. The tests were carried out using the standardized groups of foods listed in Appendix B. The rethermalization times tested were 32, 40, 44 and 54 minutes at 325°F (163°C). Rethermalization without refrigeration was tried at 32 and 40 minutes at 325°F (163°C). All tests were run in duplicate.

A third computer chip (Figure 6) was requested to determine if a longer time cycle with a lower temperature might prevent scorching of such items as those with a cheese sauce or white sauce or the egg products. This chip allowed for time cycles from 22 to 54 minutes with temperatures ranging from 250°F (121°C) to 325°F (163°C).

The fourth chip (Figure 7) requested and received, incorporated the maximum time of 44 minutes and maximum temperature of 325°F (163°C) and also lower times and temperatures. It allowed testing of hard-to-heat items, those which would heat in a 32-minute cycle, and those which only need a gentle warming cycle.



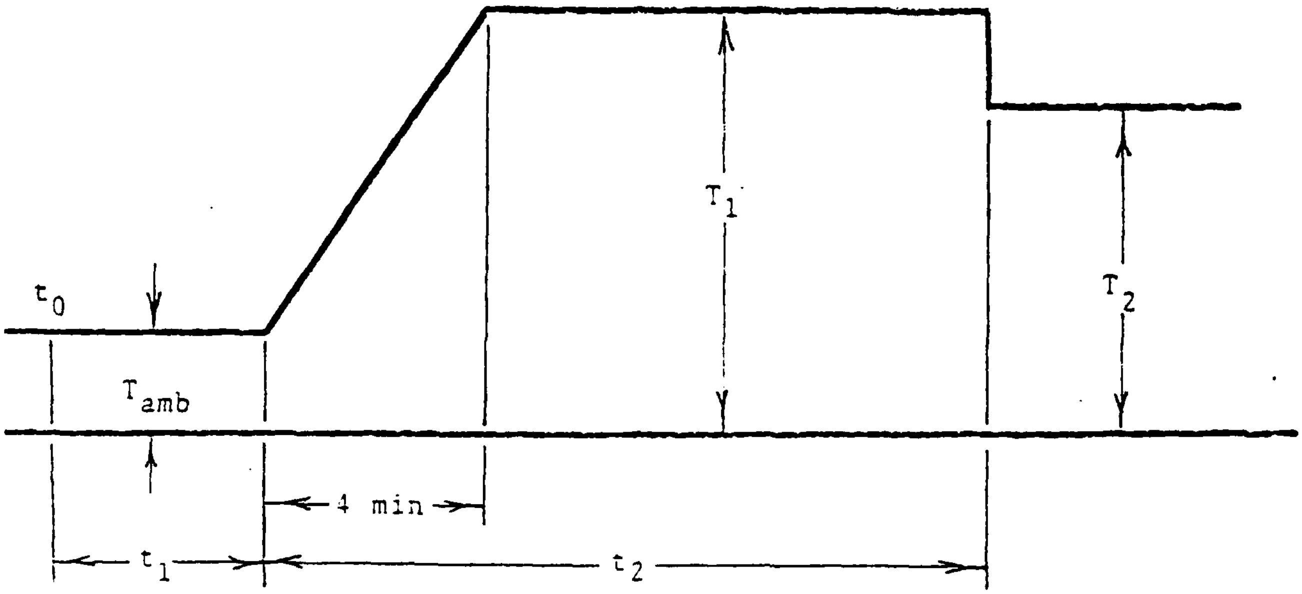
Profile No.	T (min.)
1	26
2	28
3	30
4*	32
5	34
6	36
7	38
8	40
9	42
10	44
11	46
12	48
13	50
14	52
15	54

FIGURE 5

HEATER PROFILES PROGRAMMED FOR NATICK LABS
PROM 800 (10-2-78) NAT

All times (t) are in minutes and all temperatures (T) are in degrees Farenheit.

* Courtesy of Anchor Hocking Corporation

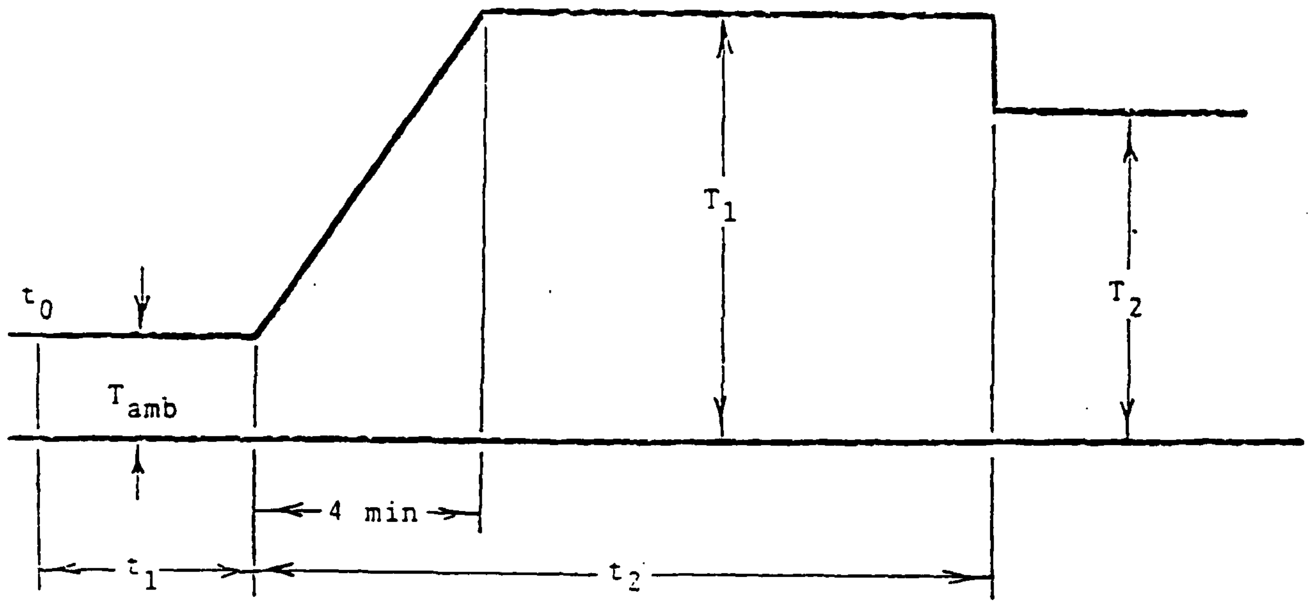


Profile No.	t_1(NAT1)	t_1(NAT2)	t_2	T_1	T_2
1	32	0	22	250	190
2	22	0	32	250	190
3	10	0	44	250	190
4	0	0	54	250	190
5	32	0	22	275	200
6	22	0	32	275	200
7	10	0	44	275	200
8	32	0	22	300	210
9	22	0	32	300	210
10	10	0	44	300	210
11	0	0	54	300	210
12	32	0	22	325	210
13	22	0	32	325	210
14	10	0	44	325	210
15	0	0	54	325	210

FIGURE 6
HEATER PROFILES PROGRAMMED FOR NATICK LABS
PROM'S 800(10-30-78) NAT1 & NAT 2

All times (t) are in minutes and all temperatures (T) are in degrees Farenheit.

* Courtesy of Anchor Hocking Corporation



Profile No.	t_1	t_2	T_1	T_2
0	0	0	0	0
1	22	22	250	190
2	12	32	250	190
3	0	44	250	190
4	22	22	300	200
5	12	32	300	200
6	0	44	300	200
7	22	22	325	210
8	12	32	325	210
9	0	44	325	210
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0

FIGURE 7
HEATER PROFILES PROGRAMMED FOR NATICK LABS*
PROM'S 800 (12-8-78) NAT3

All times (t) are in minutes and all temperatures (T) are in degrees Fahrenheit

* Courtesy of Anchor Hocking Corporation

RESULTS:

When the first nine entree items were rethermalized in the Alpha Cart, resultant temperatures ranged from 92°F (33°C) to 155°F (68°C) on the top surfaces, from 82°F (28°C) to 159°F (70°C) on the side surfaces, and from 74°F (23°C) to 199°F (93°C) internally. Only one product, the pureed bland item, tested at 325°F (163°C) for 32 minutes heated to the recommended 140°F (60°C) on all surfaces. Three of the nine products did not reach 140°F (60°C) internally and two of the products were above 140°F (60°C) internally at lower code settings but not at the highest code setting. Therefore, it quickly became obvious that there would be problems with the Alpha Cart, not only because of its erratic heating pattern, but also because of its inability to heat all surfaces of the foods consistently and reliably to a desirable temperature.

Another observation made in the early testing of food and confirmed on later tests, was that condensation would form on the bottom surface of the lid and would drop down onto the food when the cover was removed. Some condensation also dripped onto the food during the rethermalization cycle. This was objectionable from a visual aspect and caused poor texture in items tending to get soggy, such as french fried potatoes, toast, pancakes, and waffles.

It was also noted that the sauces and thickened casserole dishes that rethermalized well in the convection oven, reacted quite differently to rethermalizing in the Alpha Cart. While they had a smooth, unseparated appearance after reheating in the convection oven, separation occurred in the Alpha Cart leaving a gelatinous portion on the top and a thin watery portion on the bottom of the dish. Laboratory work was done to determine if this problem could be corrected. It was found that by reformulating the product, adjustments could be made that would enable sauces and casseroles to be reheated without separation in the Alpha Cart.

Further testing was done on the prepared items to corroborate the testing of the initial nine products and to determine which items needed reformulation. Tables 13 through 15 show the results of reheating a selection of regular entrees, modified meat entrees, and meat substitute entrees when reheated on the highest code, Code 13 (32 minutes at 325°F/163°C). The tables indicate those products in which all portions were above 140°F (60°C), those that had some portion below 140°F (60°C), and those that, in repeat testing, sometimes reheated above or below 140°F (60°C). They also indicate if the product scorched during rethermalization. From these tables it can be seen that very few items reheated to above 140°F (60°C) on all surfaces.

Testing of pureed bland entrees in a soup dish showed that these sometimes were above but also at times were below the desired temperatures. When 8-oz (227 g) portions of dental liquid entrees were placed in entree dishes, the product usually heated to above 140°F (60°C).

Those foods that were particularly difficult to heat included those with a large portion size. For example, casseroles containing an 8-oz (227 g) portion would not usually heat as well as a 6-oz (170 g) portion. Products that were thick or deep, such as fried chicken, and nochetos were hard to heat through to the top surface. Meats with sauces were at times a problem because the meat insulated the sauce and prevented enough heat from reaching the top.

TABLE 13
RETHERMALIZATION OF REGULAR ENTREES

Product	Heated above $140^{\circ}F$ ($60^{\circ}C$)	Heated below $140^{\circ}F$ ($60^{\circ}C$)	Heated above* and/or below $140^{\circ}F$ ($60^{\circ}C$)	Scorched
Baked Fish 3 oz (85 g) with Cheese Sauce 3 oz (85 g)	X			
Baked Pork Chops 4 oz (113 g)		X		
Barbecued Chicken 5 oz (142 g) meat, 3 oz (85 g) sauce		X		
Barbecued Pork Loin 3 oz (85 g) meat, 3 oz (85 g) sauce	X			
Barbecued Spareribs 7 oz (198 g)		X		X
Beef Stew 8 oz (227 g)		X		
Beef Stroganoff 8 oz (227 g)		X		X
Chicken Pot Pie 8 oz (227 g)		X		
Country Style Steak 3 oz (85 g) meat, 3 oz (85 g) sauce		X		
Creamed Ground Beef 8 oz (227 g)		X		
Neapolitan Spaghetti 8 oz (227 g)			X	
Oven Fried Chicken 5 oz (142 g) with Chicken Gravy 3 oz (85 g)		X		
Roast Beef 3 oz (85 g) with Natural Gravy 3 oz (85 g)			X	
Roast Turkey 3 oz (85 g) with Brown Gravy 3 oz (85 g)	X			
Salisbury Steak 3 oz (85 g) with Mushroom Sauce 3 oz (85 g)	X			
Savory Chicken 3 oz (85 g) meat, 3 oz (85 g) sauce		X		
Shrimp Creole 6 oz (170 g)		X		
Southern Fried Chicken 5 oz (142 g)		X		
Sweet and Sour Pork 8 oz (227 g)	X			
Veal Cutlet Breaded 3 oz (85 g)		X		
Veal Parmesan 3 oz (85 g) meat, 3 oz (85 g) sauce		X		

* in some tests heated to above $140^{\circ}F$ ($60^{\circ}C$); in others heated below $140^{\circ}F$ ($60^{\circ}C$).

TABLE 14
RETHERMALIZATION OF MODIFIED MEAT ENTREES

Product	Heated above 140°F (60°C)	Heated below 140°F (60°C)	Heated above* and/or below 140°F (60°C)	Scorched
Baked Ham 3 oz (85 g) with Cherry Sauce 3 oz (85 g)	X			
Baked Mackeral 3 oz (85 g)	X			
Beef Stew 8 oz (227 g)		X		
Chicken Cacciatore 6 oz (170 g)			X	
Grilled Chopped Beef 3 oz (85 g)			X	
Grilled Loin Steak 3 oz (85 g)		X		
Halibut 3 oz (85 g) with Creole Sauce 3 oz (85 g)			X	
Italian Meatballs 3 oz (85 g) with Tomato Sauce 3 oz (85 g)		X		
Roast Chicken 5 oz (142 g) chicken, 2 oz (57 g) sauce			X	
Roast Lamb 3 oz (85 g) with Mint Sauce 3 oz (85 g)		X		
Roast Pork 3 oz (85 g)		X		
Roast Turkey 3 oz (85 g) meat, 2 oz (57 g) gravy			X	
Roast Veal 3 oz (85 g) with Currant Sauce 3 oz (85 g)		X		
Roast Veal 3 oz (85 g) with Vegetable Sauce 3 oz (85 g)		X		
Salmon Patties 3.5 oz (99 g) with Lemon Sauce 3 oz (85 g)		X		
Veal Loaf 3.5 oz (99 g)		X		
Veal Patties 3 oz (85 g)		X		
Yankee Pot Roast 3 oz (85 g) meat, 3 oz (85 g) sauce	X			

* in some tests heated above 140°F (60°C); in other tests heated below 140°F (60°C)

TABLE 15
RETHERMALIZATION OF MEAT SUBSTITUTES

Product	Heated above 140°F (60°C)	Heated below 140°F (60°C)	Heated above* and/or below 140°F (60°C)	Scorched
Bows Supreme 8 oz (227 g)	X			
Cheese Strata 5 oz (142 g)		X		
Corn and Cheese Casserole 8 oz (227 g)	X			X
Mushroom Cheese Fondue 6 oz (170 g)		X		
Nochetos 8 oz (227 g)		X		
Spanish Omelet 6 oz (170 g) with Creole Sauce 3 oz (85 g)		X		
Vegetable Cheese Fondue 5 oz (142 g)		X		
Western Omelet 6 oz (170 g)			X	X

* in some tests heated above 140°F (60°C); in other tests heated below 140°F (60°C)

The following conclusions were made as a result of the initial food testing:

1. The Alpha Cart with its original desing, even at the highest code settings would not heat most foods to a desirable temperature.

2. The code settings recommended by Anchor Hocking are not suitable for heating most foods.

3. The lower code settings are unnecessary except as a gentle warming cycle.

4. Erratic heating causes foods to heat to different temperatures on different trials.

5. Condensation occurs on the inside top of the Alphaware cover resulting from the warm air meeting the colder top surface. This results in dripping of water onto the surface of the food product. This problem is relatively minor in liquid items such as soups except from a visual observation of condensing water falling into the liquid. However, in many products such as toast, pancakes, French toast, and deep fat fried products, a definite soggy surface results.

6. A limited amount of food should be placed in each dish to improve the heating of the food. Thick products should be avoided as the top surfaces will not heat to acceptable temperatures.

Both the Army sanitary regulations[1] and the Public Health regulations[2] require that all potentially hazardous precooked, frozen foods shall be reheated to 140°F (60°C) or above. Other published materials recommend reheating to internal temperatures of 165°F (73°C) to 176°F (80°C).[3,4] The Alpha Cart does not consistently heat food to even the minimum temperature regulations; thus it could be implicated in any outbreak of foodborne disease.

Modifications and variations in rethermalization and plating using the highest code (32 minutes at 325°F/163°C) were tested. It was found that adding water or sauce under a meat portion did not markedly improve the heating of the meat. However, the addition of water to vegetables did improve their final rethermalization temperatures. Allowing the food to set at room temperature after removal from the cart did not result in a temperature improvement due to heat equilibrating throughout the food. Leaving the food on the maintenance cycle of the Alpha Cart gave a slight lowering of rethermalization temperatuers. Removal of the cart from its Floor Environmental Unit caused a further lowering of the food temperature. Using aluminum foil as a heat transfer medium under the dishes and on top of the

[1] Army Regulations 40-5, Food Service 6-2, Food, Sanitary Quality. 25 Sep 75.

[2] U.S. Department of Health, Education and Welfare, Public Health Services, Food and Drug Administration. "Food Service Sanitation Manual". 1962.

[3] D.B. Rowley, J.M. Tuomy, and D.E. Westcott, Fort Lewis Experiment. Application of Food Technology and Engineering to Central Preparation. Feb 1972. Natick Technical Report 72-46-FL.

[4] G. Glew, Cook/Freeze Catering. Western Printing Services Ltd. Bristol, Great Britain 1973.

Modifications and variations in rethermalization and plating using the highest code (32 minutes at 325°F/(163°C) were tested. It was found that adding water or sauce under a meat portion did not markedly improve the heating of the meat. However, the addition of water to vegetables did improve their final rethermalization temperatures. Allowing the food to set at room temperature after removal from the cart did not result in a temperature improvement due to heat equilibrating throughout the food. Leaving the food on the maintenance cycle of the Alpha Cart gave a slight lowering of rethermalization temperatures. Removal of the cart from its Floor Environmental Unit caused a further lowering of the food temperature. Using aluminum foil as a heat transfer medium under the dishes and on top of the heating element was not beneficial. Using a cover of aluminum foil directly over the food increased the temperatures somewhat but was not considered beneficial enough to explore in depth. A foam type insulating material formed into an outside cover as a barrier from cold air did not give markedly improved rethermalization temperatures.

Because of the lack of success in improving the heating capabilities of the Alpha Cart by changes in manufacturer's codes originally available, by variations in plating, and by mechanical means, attention was focused on increasing the rethermalization times and by shutting off the refrigeration during the rethermalization.

In the first trials, the cart was filled with the items listed in Appendix B and run at a 32-minute cycle at 325°F (163°C), both with the refrigeration turned on and with the refrigeration turned off. This was repeated at 40 minutes with and without refrigeration. Table 16 gives the mean temperatures for the top, side and internal portions of the foods tested. Starred items are those that had some degree of scorching.

It can be seen from Table 16 that many products did not reach 140°F (60°C) on the top surfaces with the standard 32-minute cycle with refrigeration. Turning the refrigeration off helped substantially in raising the temperatures of several food products. However, the temperatures of the chilled items were largely above the 55°F (13°C) recommended for cold foods. Extending the cycle to 40 minutes and keeping the refrigeration on helped the hot items to about the same or slightly greater extent than shutting off the refrigeration during the 32-minute cycle. When the refrigeration was turned off during a 40-minute cycle, many items were severely scorched. This scorching coupled with the increased temperatures of the chilled items, led to the decision that extending the rethermalization cycle was more advantageous than restricting refrigeration. Figure 8 illustrates the percentage of hot food items that had one or more surfaces below 160°F (71°C), below 140°F (60°C) or, in regard to the cold items, above 55°F (13°C) and reinforces the conclusion that extending the rethermalization time is of more overall benefit than shutting off refrigeration.

Tests were then run using the same cart load of standardized items at various rethermalization times. To observe the effect of extended rethermalization times on final temperatures of various food products, cycles of 32, 40, 44 and 54 minutes were run. Table 17 shows the mean temperature of the top, side and internal portions of the food. It can be seen that increasing the time up to 40 and 44 minutes had a marked improvement over the 32-minute cycle. Figure 9 illustrates the percentage of hot foods under 160°F (71°C), under 140°F (60°C) and chilled items over 55°F (13°C).

Although the 54-minute cycle at 325°F (163°C) was not found desirable because of the high degree of scorching, it was theorized that a longer time cycle with a lower temperature might bring the foods to the prescribed temperatures without scorching. Therefore, the third computer chip (Figure 6) was installed. Various foods with a tendency to scorch (egg products, products with white sauces, products with cheese sauces) were rethermalized at 250°F (121°C) and 300°F (149°C) for 54 minutes. It was found that those foods heated at 250°F (121°C) were substantially below 140°F (60°C), and those heated at 300°F (149°C) were still severely scorched. The hard-to-heat items (such as bone-in chicken, spareribs, and porkchops) rethermalized at 325°F (163°C) still did not reach 140°F (60°C) on all surfaces. Therefore, the increase in rethermalization time to 54 minutes did not have any significant advantage over the 44-minute rethermalization.

It was decided that a maximum cycle of 44 minutes at 325°F (163°C) was optimum for most foods. This provided a significant temperature increase for most foods, while scorching was not substantially increased compared to the 32-minute cycle.

Application of a spray vegetable shortening to eliminate scorching in those foods that were troublesome was evaluated. When the individual containers were sprayed lightly with vegetable shortening before filling and freezing, the reheated foods had noticeably less scorching than those which received no treatment. An improvement in appearance as well as an ease of release was also noted in the sprayed dishes.

TABLE 16

MEAN TEMPERATURES OF MENU ITEMS RETHERMALIZED AT 325°F (163°C) WITH AND WITHOUT REFRIGERATION

Hot Entrees	Portion Size oz	Portion Size g	Quantity Tested	32-Minute Rethermalization With Refrigeration Top °F	Side °F	Internal °F	32-Minute Without Refrigeration Top °F	Side °F	Internal °F	40-Minute Rethermalization With Refrigeration Top °F	Side °F	Internal °F	40-Minute Without Refrigeration Top °F	Side °F	Internal °F
Chicken (bone-in)	7	(198)	4	108	113	136	124	120	142	124	155	159	134	152	160[a]
Meat with Gravy	3 3	(85) meat (85) gravy	4	140	132	175	154	148	186	164	161	191	167	159	185[a(1)]
Casseroles	8	(227)	3	108	150	169	147	154	170[a(1)]	145	160	160[a(1)]	150	166	166[a(1)]
Omelets	6	(170)	2	132	122	158[a]	136	132	180[a]	144	160	186[a]	156	170	193[a]
Baked Pork Chops	4.5	(128)	1	115	106	155	119	119	153	128	134	160	127	155	153
BBQ Spareribs	7	(198)	1	111	111	136	128	123	151[a]	127	127	147	131	130	164[a]
Veal Loaf	3.5	(99)	1	119	126	154	125	127	154	140	140	160	140	145	163[a]
Dental Liquid	8	(227)	1	160	197	200	157	125	199	160	140	212	175	142	195
Pureed Bland	6	(170)	1	139	134	182	154	136	194	143	115	188	152	158	196
Vegetables[c]															
Corn	3.5	(99)	5	155	154	186	161	157	193[a(1)]	160	173	197[a(1)]	170	167	194[a]
Mixed Vegetables	3.5	(99)	5	139	145	184	153	162	193	160	172	194	155	163	188[a]
Potatoes															
Hashed Brown	4	(113)	4	132	125	169[a]	140	134	178[a]	149	141	181[a]	151	147	181[a]
Mashed Potatoes	4	(113)	4	139	137	176[a]	155	149	176[a]	154	156	185[a]	147	144	182[a]
Potato logs	4	(113)	4	112	111	149[a]	128	132	160[a]	126	134	158[a]	138	145	161[a]
Soups															
Chicken Broth	6	(170)	4	155	159	160	166	171	172	166	160	170	165	172	173
Cream of Mushroom	6	(170)	3	155	137	174	153	143	192	174	148	196	162	158	192
Cold															
Jello	4	(113)	5	54	52	49	60	59	58[b]	51	50	49	61	64	55[b]
Pineapple Pie Filling	4	(113)	4	47	44	44	61	57	55	48	46	45	57	55	60
Applesauce	4	(113)	3	52	53	49	63	63	61	49	49	49	61	66	55
Mashed Bananas	4	(113)	2	53	52	48	72	66	71	61	54	59	74	70	73

a - scorching - if number 1 or 2 follows a letter it indicates only 1 or 2 items scorched
b - sl. melting
c - two tablespoons of water added

TABLE 17

MEAN TEMPERATURES OF MENU ITEMS RETHERMALIZED AT 325°F (163°C) AT VARIOUS RETHERMALIZATION TIMES

Hot Entrees	Portion Size oz	Portion Size g	Quantity Tested	32 minutes Top °F	32 minutes Side °F	32 minutes Internal °F	40 minutes Top °F	40 minutes Side °F	40 minutes Internal °F	44 minutes Top °F	44 minutes Side °F	44 minutes Internal °F	54 minutes Top °F	54 minutes Side °F	54 minutes Internal °F
Chicken (bone-in)	7	(198)	4	108	113	136	124	155	159	127	127	152	133	148	163[a(1)]
Meat with Gravy	3 3	(85) meat (85) gravy	4	140	132	175	164	161	191	158	158	190	169	170	198[a(1)]
Casseroles	8	(227)	3	108	150	169[a]	145	160	160[a(1)]	164	162	169[a(1)]	168	163	185[a]
Omelets	6	(170)	2	132	122	158[a]	144	160	186[a]	160	168	190[a]	166	175	196[a]
Baked Pork Chops	4.5	(128)	1	115	106	155	128	134	160	141	128	169	125	140	178
BBQ Spareribs	7	(198)	1	111	111	136	127	127	147	140	131	176[a]	130	132	156[a]
Veal Loaf	3.5	(99)	1	119	126	154	140	140	160	124	134	160	131	127	161
Dental Liquid	8	(227)	1	160	197	200	160	140	212	189	146	211	168	158	210
Pureed Bland	6	(170)	1	139	134	182	143	115	188	154	112	184	169	135	202
Vegetables [b]															
Corn	3.5	(99)	5	155	154	186	160	173	197[a(1)]	168	166	194	163	170	192[a(3)]
Mixed Vegetables	3.5	(99)	5	139	145	184	160	172	194	159	174	195	170	182	201[a]
Potatoes															
Hashed Browns	4	(113)	4	132	125	169[a]	149	141	181[a]	145	148	179[a]	157	152	185[a]
Mashed Potatoes	4	(113)	4	139	137	176[a]	154	156	185[a]	154	150	183[a]	166	157	197[a]
Potato logs	4	(113)	4	112	111	149[a]	126	134	158[a]	150	142	167[a]	140	137	161[a]
Soups															
Chicken broth	6	(170)	4	155	159	160	166	160	170	166	168	169	170	169	177
Cream of Mushroom	6	(170)	3	155	137	174	174	148	196	178	159	179	168	147	195
Cold															
Jello	4	(113)	5	54	52	49	51	50	49	51	53	50	48	48	46
Pineapple Pie Filling	4	(113)	4	47	44	44	48	46	45	49	49	48	54	51	52
Applesauce	4	(113)	3	52	53	49	49	49	49	52	50	50	54	51	52
Mashed Bananas	4	(113)	2	53	52	48	61	54	59	62	60	61	52	50	50

a - scorching - if number 1 or 2 follows a letter it indicates only 1 or 2 items scorched
b - two tablespoons of water added

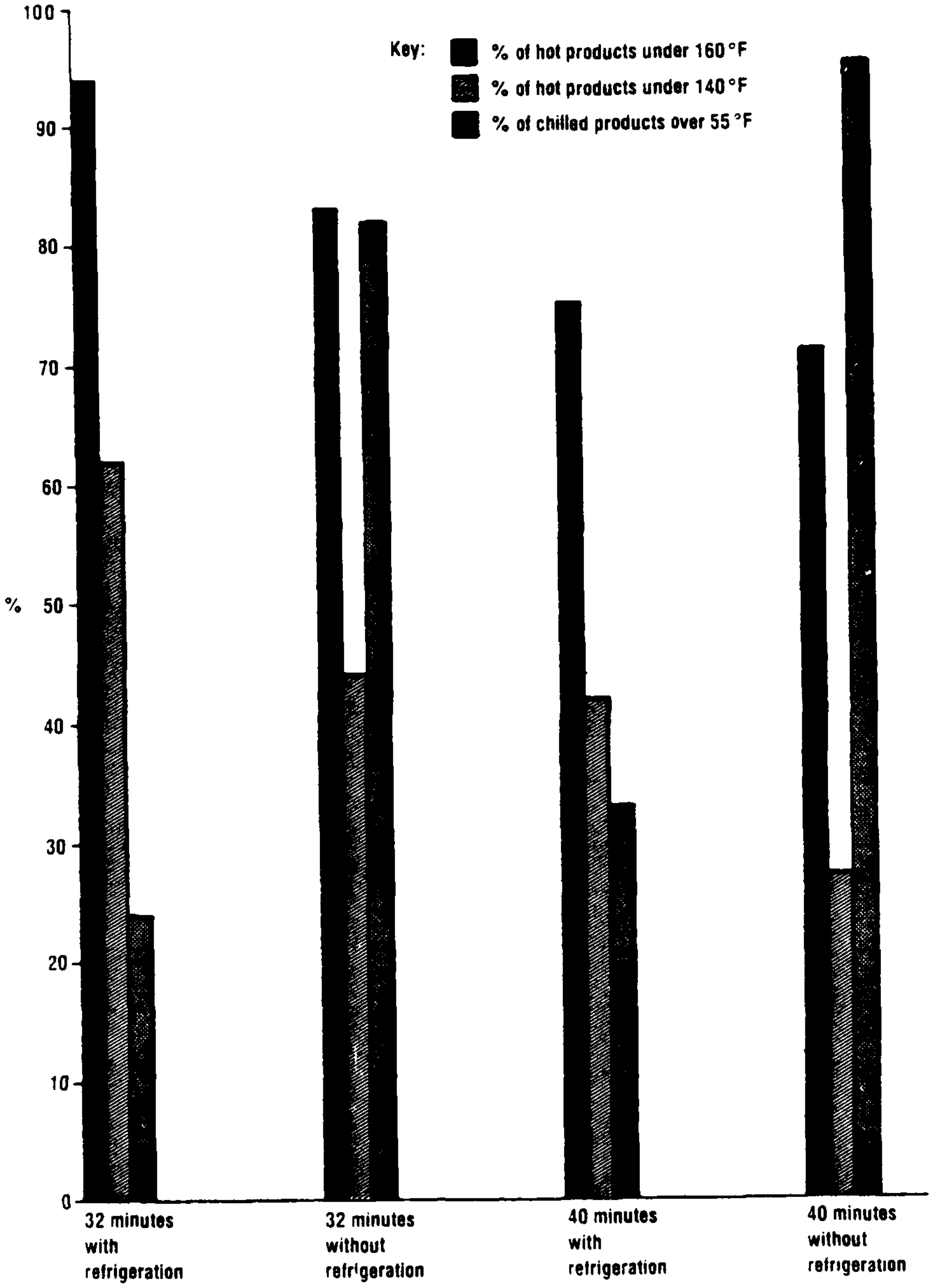


Figure 8
RETHERMALIZATION IN ALPHA CART WITH AND WITHOUT REFRIGERATION

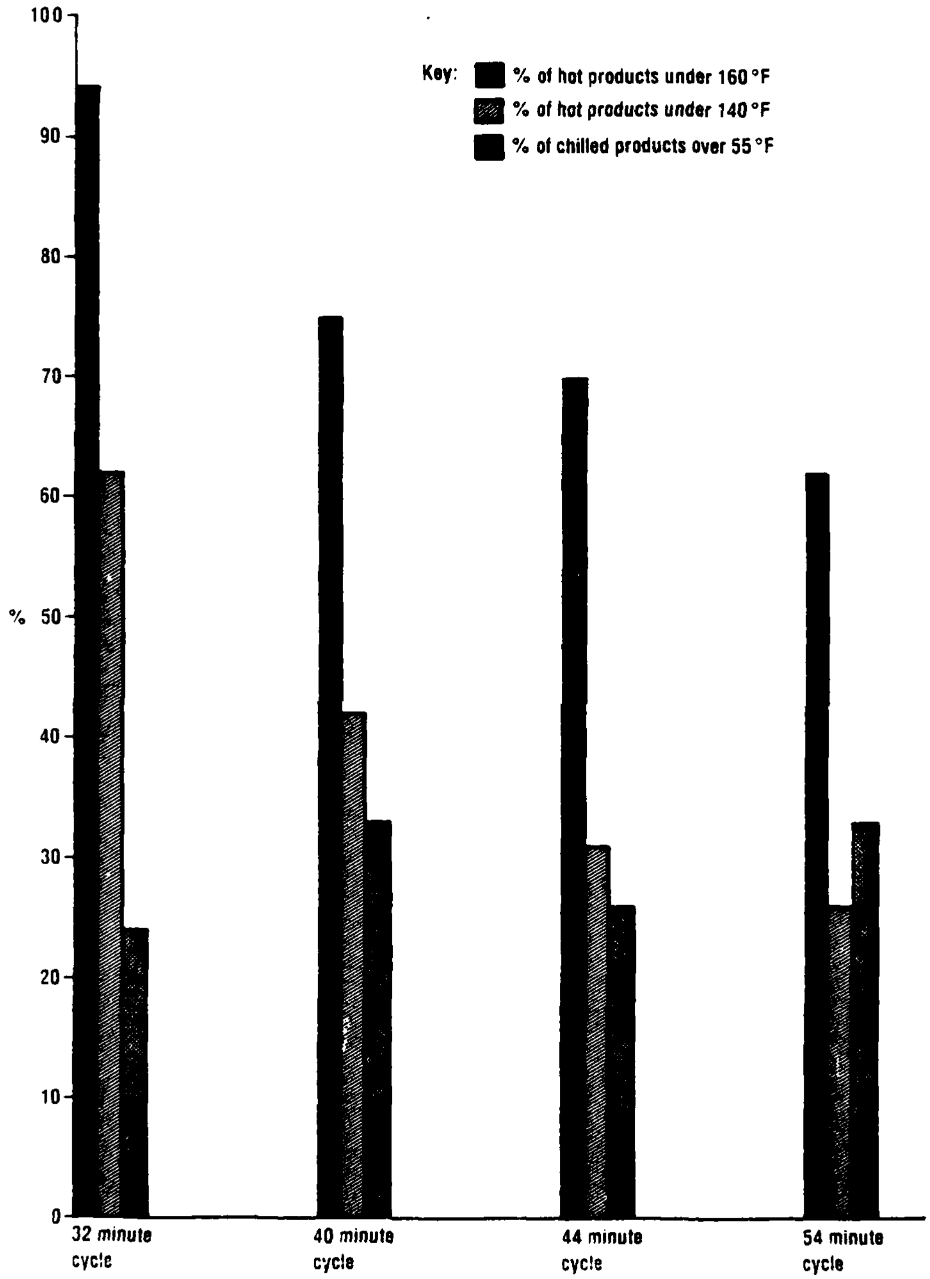


Figure 9
RETHERMALIZATION IN ALPHA CART AT DIFFERENT TIME INTERVALS

CONCLUSIONS

The Alpha Cart does not meet Military and Public Health Standards of heating all surfaces of foods to 140°F (60°C). Erratic heating will cause further difficulties. The cart is capable of keeping most cold items chilled below the required 55°F (13°C). Some scorching is encountered in reheating foods, as might be expected in a conduction type of heating without any agitation of the food. A large percentage of this scorching may be overcome by the use of a vegetable shortening release agent; other foods may have to be reformulated to make thinner sauces less susceptible to scorching. Condensation dripping from the lid of the dish not only detracts visually when the lid is removed, but also makes many foods soggy on the top surface. Many production guides that produced very acceptable products when reheated in a convection oven will have to be reformulated to be acceptable when reheated in the Alpha Cart.

MECHANICAL PROBLEMS

In carrying out the evaluation of the Alpha Cart, several mechanical problems were encountered of which two were most significant. The first dealt with the refrigeration unit of the Chill-Therm™ system. The evaporation coils frosted over completely causing the internal temperature of the cart to rise to 60°F (16°C). Engineers at Anchor Hocking were notified and a replacement unit was sent containing a clock-timer for defrosting. The new unit was than installed. However, after installation of the new unit, an overflow problem developed in the condensate heater pan. The condensate from the coils did not evaporate quickly enough to prevent an overflow onto the FBT. The unit was shutdown for two days on request from Anchor Hocking and then re-activated. The cart temperature now dropped to 15°F (-9°C) after three hours of use. Examination of the refrigeration system determined that the evaporation coils were completely frosted over. Engineers at Anchor Hocking suggested the voltage be checked at the defrost solenoid valves to determine if sufficient current was available to activate the valve. The voltage was adequate, indicating a malfunction with the defrost solenoid. The original refrigeration unit was reinstalled after modifications were made on the defrost system as well as the replacement of the FBT, with adjustment being made on the spring-loaded air return slots on the new cart. The refrigerator unit then maintained proper temperature levels, although the condensate heater pan had to be emptied regularly when the environmental temperature and humidity were high. It should be noted that the Alpha Cart was kept in the Food Engineering Laboratory at NARADCOM which does not have a controlled temperature and humidity environment. The experimental work was undertaken in the summer when high temperatures and humidity were common.

The second problem dealt with the heating system; in particular, platen No. 3 on shelf 12. Any rethermalization at any code on this element resulted in a scorched and cracked dish. At the request of Anchor Hocking, the system was monitored for continuity of circuits, and each of the five platens evaluated for their resistance factor. It was determined that the values obtained were accurate. Therefore, according to engineers at Anchor Hocking as well as those at NARADCOM, the malfunction occurred at elevated temperatures while the platen was in use. The entire shelf was replaced.

A slight defect on the cart received at NARADCOM, was a very loose fitting latch that held the door closed. This was tightened by placing a piece of nylon tubing between the latch and the door. Leakage of cold air was also noticed through the gaskets of the cart's door.

RECOMMENDATIONS

The Alpha Cart is a unique and innovative food delivery system that has not yet been successfully tested in actual hospital conditions. Although the functioning characteristics of the cart are, in princople, very advantageous, many problems can be anticipated. From the testing described previously, two of the major problems are erratic heating and not heating all foods to a desired temperature. Mechanical problems and programming errors can also be anticipated. NARADCOM has serious reservations about the use of the Chill-Therm^{TM} system at WRAMC without further design modifications; if the system is to be used, the following precautions should be taken:

1. Eliminate from the menu hard-to-heat items such as bone-in chicken, spareribs, and pork chops, or heat by microwave after rethermalization in the Alpha Cart. Keep portion sizes small comparable to dish size to improve heating.

2. Remove food from the Alpha Cart immediately after rethermalization and do not allow food to remain on the maintenance cycle.

3. If possible, allow the cart to remain attached to the Floor Environmental Unit and not be detached for the serving of the meals.

4. Use extreme caution in handling of food during preparation and freezing because of the inability of the system to consistently heat foods to optimum rethermalization temperatures.

5. Set the rethermalization cycle of the Alpha Cart for 44 minutes with optional time lags of 12 and 22 minutes. Temperature available for reheating should be 250^{o}F (121^{o}C), 300^{o}F (149^{o}C) and 325^{o}F (163^{o}C).

6. Apply a spray vegetable shortening on Alphaware^{TM} dishes to reduce scorching.

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APPENDIX A

EXPERIMENT 14

Foods Used in Energy Study

Shelf	Food	Portion Size	Heater Code
1	Cream of Wheat	3 oz (85g)	8
	Toast	2 slices	10
	Sliced Peaches	3 oz (85 g)	-
	Scrambled eggs	4 oz (113 g)	4
	Sausage	3 oz (85 g)	2
2	Cream of Wheat	3 oz (85 g)	8
	Poached eggs	4 oz (113 g)	5
	Sliced Peaches	3 oz (85 g)	-
	Toast	2 slices	10
	Sausage	3 oz (85 g)	8
3	Cold cereal	3 oz (85 g)	-
	Sliced Peaches	3 oz (85 g)	-
	French Toast	6 oz (170 g)	9
4	Cold cereal	3 oz (85 g)	-
	Scrambled eggs	6 oz (170 g)	7
5	Beets, canned	3 oz (85 g)	9
	Pineapple Pie Filling	3 oz (85 g)	12
	Bread	2 slices	-
	Creamed Beef	6 oz (170 g)	9
6	Pineapple Pie Filling	3 oz (85 g)	-
	Corn, canned	3 oz (85 g)	9
	Bread	2 slices	-
	Salad	3 oz (85 g)	-
	Creamed Beef	6 oz (170 g)	9
7	Jello	3 oz (85 g)	-
	Bread	2 slices	-
	Salad	3 oz (85 g)	-
	Creamed Beef	6 oz (170 g)	9
8	Pineapple Pie Filling	3 oz (85 g)	-
	Corn, canned	3 oz (85 g)	9
	Bread	2 slices	-
	Salad	3 oz (85 g)	-
	Salmon, canned	3 oz (85 g)	-
9	Jello	3 oz (85 g)	-
	Beets, canned	3 oz (85 g)	9
	Salad	3 oz (85 g)	-
	Whipped potato	3 oz (85 g)	8
	Salmon, canned	3 oz (85 g)	-

Shelf	Food	Portion Size	Heater Code
10	Baked potato	6 oz (170 g)	13
	Bread, warmed	2 slices	10
	Salad	3 ox (85 g)	-
	Beef Ravioli	6 oz (170 g)	11
11	Pineapple Pie Filling	3 oz (85 g)	-
	Beets, canned	3 oz (85 g)	9
	Bread, warmed	2 slices	10
	Beef Ravioli	6 oz (170 g)	11
12	Corn, canned	3 oz (85 g)	9
	Salad	3 oz (85 g)	-
	Grilled Cheese Sandwich	1	10
	Bean & Bacon Soup	3 oz (85 g)	13
13	Salad	3 ox (85 g)	-
	Grilled Cheese Sandwich	1	10
	Chicken Broth	3 oz (85 g)	13
14	Jello	3 oz (85 g)	-
	Salmon, canned	3 oz (85 g)	-
	Rice	3 oz (85 g)	8
	Cream of Mushroom Soup	3 oz (85 g)	13
15	Cream of Wheat	3 oz (85 g)	8
	Western Omelet	6 oz (170 g)	3
	Sausage	3 oz (85 g)	2
16	Jello	3 oz (85 g)	-
	Salmon Salad Sandwich	1	-
	Bean & Bacon Soup	3 oz (85 g)	13
17	Jello	3 oz (85 g)	-
	Applesauce	3 oz (85 g)	-
	Salad	3 oz (85 g)	-
	Sausage	3 oz (85 g)	8
	Whipped potato	3 oz (85 g)	8
18	Salad	3 oz (85 g)	-
	Beef Ravioli	6 oz (170 g)	11
	Chicken Broth	3 oz (85 g)	13
19	Applesauce	3 oz (85 g)	-
	Chicken and Gravy	6 oz (170 g)	11
	Baked Potato	6 oz (170 g)	13
20	Lamb, pureed	3 oz (85 g)	11
	Ham and Pineapple, pureed	6 oz (170 g)	11
	Whipped Potato	3 oz (85 g)	8

APPENDIX B

Food Item	Portion Size	Tray No.	Home Heater Pos.	Cover
Corn	3.5 oz (99 g)	1	2	Plastic Lid
Oven Fried Chicken	7 oz (198 g)	1	3	Dome
Hashed Browned Potatoes	4 oz (113 g)	1	4	Dome
Applesauce	4 oz (113 g)	1	A	Lid
Mixed Vegetables	3.5 oz (99 g)	2	2	Lid
Spanish Omelet with Creole Sauce	6 oz (170 g) 2 oz (57 g)	2	3	Dome
Hashed Browned Potatoes	4 oz (113 g)	2	4	Dome
Jello	4 oz (113 g)	2	A	Lid
Mixed Vegetables	3.5 oz (99 g)	3	2	Lid
Veal with Vegetable Sauce	3 oz (85 g) meat 2 oz (57 g) sauce	3	3	Lid
Mashed Potatoes	4 oz (113 g)	3	4	Lid
Pineapple Pie Filling	4 oz (113 g)	3	A	Lid
Corn	3.5 oz (99 g)	4	2	Lid
Western Omelet	6 oz (170 g)	4	3	Lid
Hashed Browned Potatoes	4 oz (113 g)	4	4	Lid
Jello	4 oz (113 g)	4	B	Lid
Chicken and Gravy dental liquid	8 oz (227 g)	6	1	Lid

Food Item	Portion Size	Tray No.	Home Heater Pos.	Cover
Chicken broth	6 oz (170 g)	6	2	Lid
Jello	4 oz (113 g)	6	B	Lid
Mixed Vegetables	3.5 oz (99 g)	7	2	Lid
Creamed Ground Beef	8 oz (227 g)	7	3 & 4	Lid
Cream of Mushroom Soup	6 oz (170 g)	7	5	Lid
Pineapple Pie Filling	4 oz (113 g)	7	B	Lid
Chicken Cacciatore pureed bland	6 oz (170 g)	8	1	Lid
Potato Logs	3.5 oz (99 g)	8	2	Lid
Chicken broth	6 oz (170 g)	8	5	Lid
Applesauce	4 oz (113 g)	8	A	Lid
Pineapple Pie Filling	4 oz (113 g)	8	B	Lid
Mixed Vegetables	3.5 oz (99 g)	9	1	Lid
Baked Pork Chops	4.5 oz (126 g)	9	3	Dome
Mashed Potatoes	4.5 oz (126 g)	9	4	Dome
Applesauce	4 oz (113 g)	9	B	Lid
Corn	3.5 oz (99 g)	10	1	Lid
Roast Turkey with Brown Gravy	3 oz (85 g) meat 3 oz (85 g) gravy	10	3	Lid
Mashed Potatoes	3.5 oz (99 g)	10	4	Lid

Food Item	Portion Size	Tray No.	Home Heater Pos.	Cover
Jello	4 oz (113 g)	10	B	Lid
Mixed Vegetables	3.5 oz (99 g)	11	2	Lid
BBQ Spareribs	7 oz (198 g)	11	3	Dome
Potato Logs	3.5 oz (99 g)	11	4	Dome
Applesauce	4 oz (113 g)	11	A	Lid
Veal Loaf	3.5 oz (99 g)	12	3	Dome
Potato Logs	3.5 oz (99 g)	12	4	Dome
Cream of Mushroom Soup	6 oz (170 g)	12	5	Lid
Applesauce	4 oz (113 g)	12	A	Lid
Roast Chicken	7 oz (198 g)	13	3	Dome
Hashed Browned Potatoes	4 oz (113 g)	13	4	Dome
Corn	3.5 oz (99 g)	13	1	Lid
Mashed Bananas	4 oz (113 g)	13	B	Lid
Nochetos	8 oz (227 g)	14	3 & 4	Dome
Mixed Vegetables	3.5 oz (99 g)	14	2	Lid
Chicken broth	6 oz (170 g)	14	5	Lid
Jello	4 oz (113 g)	14	A	Lid
Tuna Noodle Casserole	8 oz (227 g)	16	3 & 4	Dome
Corn	3.5 oz (99 g)	16	2	Lid

Food Item	Portion Size	Tray No.	Home Heater Pos.	Cover
Cream of Mushroom Soup	6 oz (170 g)	16	5	Lid
Mashed Bananas	4 oz (113 g)	16	B	Lid
Roast Beef and Natural Gravy	3 oz (85 g) meat 3 oz (85 g) gravy	17	3	Lid
Mashed Potatoes	4 oz (113 g)	17	4	Lid
Pineapple Pie Filling	4 oz (113 g)	17	A	Lid
BBQ Chicken	7 oz (198 g)	18	3	Dome
Potato Logs	4 oz (113 g)	18	4	Dome
Chicken Broth	6 oz (170 g)	18	5	Lid
Salisbury Steak	8 oz (227 g)	19	3	Dome
Potato Logs	4 oz (113 g)	19	4	Dome