NBSIR 78-1556

Kitchen Range Energy Consumption

J. V. Fechter
L. G. Porter

Consumer Ergonomics and Information
Consumer Sciences Division
Center for Consumer Product Technology
National Bureau of Standards
U.S. Department of Commerce
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Final Report

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Table of Contents

	Page
List of Figures	iii
List of Tables	iii
Acknowledgements	v
Executive Summary	vii
Background	1
Participants, Equipment, Procedures	3
Results	8
Discussion	19
Summary	21
References	23
Appendix A - Research Participant Agreement	24
Appendix B - Recipes of AHAM Meals Involving Cooking on Kitchen Ranges	25
Appendix C - Summary of Range Characteristics	34
Appendix D - Graphic Illustration of Energy Consumption and Variation for Each Range, Cook, and Day	40

List of Figures

Number	Title	Page
1	Floor Plan of NBS Consumer Research Laboratory	7
2	Combined Efficiency of Each Range Plotted Against the Mean kWh used for Actual Cooking	11
3	Mean kWh and EkWh used to Prepare Each Menu Day (Breakfast, Lunch, Dinner) on Gas and Electric Ranges	18

List of Tables

Number	Title	Page
I	The AHAM Menu, as Used by NBS for Range Tests	5
II	Range Energy Efficiency Measured with the Laboratory Test Method	9
III	Mean kWh or Equivalent kWh (EkWh) Used by Ranges to Cook Each Menu-Day (0.293 kWh = 1 cubic foot of Natural Gas)	10
IV	ANOVA Summary Table for Total Energy Used on the Electric Ranges	13
V	Newman-Keuls Test of Differences Between Rank-Ordered Electric Range Means	14
VI	ANOVA Summary Table for Total Energy Used on the Gas Ranges	16
VII	Newman-Keuls Test of Differences Between Rank-Ordered Gas Range Means	17
VIII	Percentage Differences Between the Highest and Lowest Energy Users for Each Kitchen Range	19

Executive Summary

In support of the national appliance energy conservation program, the National Bureau of Standards (NBS) has evaluated and recommended to the Department of Energy (DOE) standard test methods for use by manufacturers in measuring the energy efficiency of their major appliances. In particular, NBS has recommended and DOE has adopted a test method for measuring the relative energy efficiencies of kitchen ranges. The method utilizes established laboratory techniques and instrumentation for measuring the amount of energy required by the range to raise the temperature of a standard aluminum block by a specified temperature difference. In further support of this recommendation, an additional study was undertaken in which non-professional cooks, i.e. homemakers, individually prepared meals on ranges which had been previously used to establish the published test procedure, and for which efficiency ratings had been obtained.

The ten kitchen ranges used (five electric and five gas) had been previously selected to exhibit a variety of the technical range features that may be found in the marketplace, rather than to be statistically representative of that market. The meals cooked on these ranges were prepared by 58 homemakers. Each prepared 21 meals, or a week's menu for an "average American family of four." The menus had been selected from a group of menus generated by the Association of Home Appliance Manufacturers (AHAM). In all cases, the range energy consumption was measured and recorded.

In addition to determining the correlation between "real-life" and laboratory test methods for measuring efficiency, this study also revealed a number of other interesting results. These follow along with certain significant conclusions.

(1) The correlation between laboratory measured range efficiency and that exhibited by the homemakers was high ($p < 0.05$). Consequently no major modification to that laboratory test method would appear to be in order.

(2) The variation in energy used by the different cooks on the same range for the same meals was high (differences between cooks was as high as 50 percent). Whereas some of this variation could be ascribed to random individual behavior; other of the variation could be ascribed to certain generic behavior and would be amenable to control via range design.

(3) Regarding energy consumption, much of range design is independent of human factors, (random and generic) as evidenced by the high correlation between laboratory and home simulated tests. Accordingly, the test procedures should provide effective guidance to manufacturers for improving the energy efficiency of their ranges.

(4) An evaluation of the energy used to cook each of the 21 meals from the AHAM menu indicated that only three to five of the energy intensive meals (usually dinners) would have been sufficient to study relative efficiencies of kitchen ranges.

KITCHEN RANGE ENERGY CONSUMPTION

BACKGROUND

The reality of the energy shortage has affected Americans in many ways. The nation has acknowledged that the problem is real and is trying to do something about it. A part of the national effort to reduce energy consumption and encourage energy conservation is through the production and use of more efficient appliances. The Federal government's program in this regard is administered by the Department of Energy (DOE) and requires (1,2) manufacturers to improve the energy efficiency of:

- refrigerators and refrigerator freezers,
- freezers,
- dishwashers,
- clothes washers and dryers,
- water heaters,
- room and central air conditioners,
- home heating equipment,
- televisions,
- humidifiers and dehumidifiers,
- kitchen ranges and ovens, and
- other products as stipulated by Public Law 94-163.

In addition to improving the energy efficiency of their appliances, manufacturers must attach energy related information to their appliances.* Presented on labels, this information will show consumers the relative efficiency of the labeled appliances and will include an estimate of the annual energy cost for their operation. The goal of the program is to enable consumers to select appliances that will minimize the cost they will have to bear each year to operate their appliances. Consumers who use the label information will be able to select energy efficient appliances which not only meet their needs, but also consume minimum amounts of energy in doing so.

Test Methods

The standard test methods to be used by manufacturers to measure appliance energy efficiency must be accurate, reliable and usable with all design variations. In addition, test results must be both replicable and valid--a kitchen range ranking high in energy efficiency under laboratory conditions should also rank low in energy consumption under ordinary home use. Under the appliance energy

*The Federal Trade Commission's Bureau of Consumer Protection is still considering whether all of these appliances should in fact be labeled.
Federal Register, Vol. 44, No. 34--Friday, February 16, 1979.

conservation program, the Department of Energy (DOE) is required to provide test methods to be used in the program. The Federal Trade Commission (FTC) will specify how these methods are to be used to arrive at labeled values.

In supporting DOE, the National Bureau of Standards (NBS) has evaluated available test procedures and recommended procedures which can be used for the appliance energy conservation program. NBS recommended a test method for each appliance covered by the legislation and provided information about appliance use. That information is being used in developing estimates of the annual cost of energy to operate the appliances.

Kitchen Range Study

This report describes kitchen range tests involving actual meal preparation by non-professional cooks, i.e. homemakers. The study was done to provide realistic energy consumption data (collected under known conditions) to engineers who were evaluating kitchen range, energy-efficiency laboratory test methods.

Energy use data collected during this study served several purposes. The main purpose was to measure energy-use under "simulated" real life conditions, where various types of use data could be easily collected. The staff could then compare the energy use of the ranges in the "real life" setting to the energy efficiency of the same ranges tested under laboratory conditions. Insights into possible discrepancies in test methods could then be resolved later by reference to the great variety of data collected during the real life study.

The secondary purpose of studying actual cooking activities was to obtain specific data on human behavior in the use of the kitchen, as for example, hot water use or knife use. Behavioral data included both written logs of the cooks' activities as well as continuous video tapes of their behavior. These records will serve in the future as a valuable data base of kitchen activity--range use and safety, knife use and safety, water use and temperature preferences, but are not discussed further in this report.

PARTICIPANTS, EQUIPMENT, PROCEDURES

Participants

Fifty-eight cooks (six per range on all but the last gas range) were recruited from the vicinity of NBS in Gaithersburg, Maryland; all were female. Applicant cooks were accepted if they:

- normally cooked for a family of four,
- were between 29-50 years of age, and
- were married, with two children living at home who were between 3-19 years of age.

These selection criteria were based on assumptions built into the test menu used in the study--a menu developed by the Association of Home Appliance Manufacturers (AHAM) and described later in this report.

All cooks were assigned to test conditions in approximately the same order in which their telephone inquiries were received. After reporting for the study, each cook was shown a pre-recorded TV-introduction to the Consumer Research Laboratory (3) and then shown the video console and observation booth. After that introduction and the signing of the informed consent form (Appendix A) each cook became familiar with the kitchen layout, range controls, location of food and utensils, and the individual recipes to be used that day. The cooks were also told that NBS was studying many aspects of kitchen behavior--safety, appliance use, water use, energy use, and other kitchen activity. This explanation, and the inclusion of some meals involving little or no energy use, served to prevent the homemaker from concentrating solely on energy use but instead to act naturally as at home. A full debriefing at the end of her participation informed each cook of the primary reason for undertaking the project.

Having been selected and introduced to the study, each cook reported to the Laboratory for seven consecutive weekdays--either for seven morning sessions (8:30-12:30) or seven afternoon sessions (1:00-5:00). Cooks used the same type of cooking energy (gas or electricity) in the study as they used in their own homes. Each cook used only one of the ten ranges.

Menu

Cooks were allowed to prepare the food to their own family's preference (e.g. doneness and seasoning),

but were not allowed to substitute or omit any major ingredients in the recipe.

The seven-day menu (Table I) had been developed in 1975 by the Subcommittee on Ranges of AHAM's Consumer Education Committee and was meant to represent the typical foods prepared by an average family of four in one week. Very detailed instructions for preparing each food item had been developed by the AHAM committee. These detailed procedures enable professional cooks to prepare all meals under precise laboratory conditions wherein such factors as the starting temperature of the water or the type of cooking utensil are precisely defined. Because such precise procedures are not used in the average home, they were not used here and the AHAM menus/instructions were converted into typical recipe formats having simple preparation instructions (see Appendix B for complete recipes).

The original AHAM menus had been planned with the "typical" working family in mind, with the most energy consuming meals being on Day 1. In the present study, however, the order of the menu days was randomized across all cooks to eliminate a day-sequence effect. In addition, some menu items were placed within the overall menu plan so that the amount of energy consumed per day, and hence, the amount of food preparation required per day, would be irregular--as in real-life. The use of simple preparation instructions and recipes allowed the non-professional cooks to express their own individuality in food preparation, in ways which could affect energy consumption. For example, one cook might choose to prepare two or three dishes simultaneously in the oven whereas another might choose to do it sequentially.

Cooks prepared three meals (i.e., one menu-day) within the four hour period allotted and were allowed also to take breaks between meals. They were also allowed to take natural breaks during preparation of items which did not require constant attention to the range.

The seven-day menu was intended for use with gas or electric kitchens, using the same meal ingredients. Further, it was intended to exercise all parts of the range--surface, oven, and broiler.

Ranges

All ranges had been selected by staff engineers working on the efficiency test method. Ten ranges were

TABLE I

The AHAM Menu, as Used by NBS for Range Tests*

	MENU DAY #1	MENU DAY #2	MENU DAY #3	MENU DAY #4	MENU DAY #5	MENU DAY #6	MENU DAY #7
BREAKFAST	Half Grapefruit Oatmeal with raisins, brown sugar Perked coffee Milk	Cranberry Juice Dry cereal with sliced bananas and milk Toast Butter or margarine Hot water (coffee, tea, chocolate)	Orange Juice Scrambled Eggs with bacon strips Toast - Jam Butter or margarine Hot water (coffee, tea, chocolate) Milk	Tomato Juice Dry Cereal with milk Toasted English Muffins Jam Butter or margarine Hot water (coffee, tea, chocolate)	Orange Juice Soft cooked eggs Toast - Jam Butter or margarine Hot water (coffee, tea, chocolate) Milk	Grapefruit Juice Dry cereal with milk Toast Butter or margarine Hot water (coffee, tea, chocolate)	Sliced bananas in Orange Juice Pancakes with syrup & sausages Butter or margarine Perked coffee Milk
MEAL NO.	#1	#4	#7	#10	#13	#16	#19
LUNCH/ DINNER	Grilled cheese sandwiches Relish tray (carrot sticks, tomato, radishes, pickles) Fresh fruit Hot water (coffee, tea) Milk	Vegetable soup Cold beef sandwiches Pickles Hot water (coffee, tea) Milk	Hot dogs on buns Potato chips Pickles Fresh fruit Hot water (coffee, tea) Milk	Chicken noodle soup Tuna and egg salad sandwiches Cookies Hot water (coffee, tea) Milk	Leftover beef stew Fresh fruit salad Hot water (coffee, tea) Milk	Egg salad sandwich on toast Hot water (coffee, tea) Milk	Peanut butter & jelly sandwiches Carrot strips and celery sticks Leftover desserts or fruits Hot water (coffee, tea) Milk
MEAL NO.	#2	#5	#8	#11	#14	#17	#20
DINNER/ SUPPER	Beef pot roast with potatoes, carrots, onions, and gravy Tossed greens with radish slices French dressing Hot rolls Butter or margarine Apple crisp Coffee or tea Milk	Baked chicken with gravy Mashed potatoes Green beans Fruit-in-gelatin salad Refrigerated biscuits Butter or margarine Coffee or tea Milk	Beef stew (with carrots, peas, and potatoes) Tossed greens with French dressing Brown & Serve rolls Butter or margarine Vanilla pudding with strawberry halves in syrup Coffee or tea Milk	Spaghetti with meat sauce Grated parmesan cheese Lettuce wedge with Italian dressing Garlic bread Whipped gelatin Coffee or tea Milk	Braised pork chops Skillet scalloped potatoes Buttered spinach Red hot applesauce Bread Butter or margarine Lemon meringue pie Coffee or tea Milk	Broiled fish Rice pilaf Peas with pearl onions Broiled tomato Hard rolls Butter or margarine Tapioca pudding with fruit topping Coffee or tea Milk	Steak Baked potatoes Sauteed mushrooms Broccoli Tossed salad Hot French bread Butter or margarine Chocolate cake Coffee or tea Milk
MEAL NO.	#3	#6	#9	#12	#15	#18	#21

*Selected food items (such as ice cream for dessert) were not included in the NBS version of the AHAM menu.

used--five gas and five electric. The ranges were selected to reflect the variety of technical types available, for example, a gas range which used electronic ignition, ones with large ovens, ones with small ovens, and ones with self-cleaning and continuous range cleaning features. At the same time the chosen ranges were not statistically representative of those in the marketplace. The data therefore cannot be generalized to all ranges in the marketplace; however, this does not prevent making valid statistical comparisons among the ranges actually selected.

The overall project objective to which this study contributed was to develop and recommend a standard laboratory test procedure for measuring the energy efficiency of any range in the marketplace, and not to concentrate on "statistically significant," small differences. To reiterate, the main purpose of this study was to compare the energy consumed by ten kitchen ranges used in a simulated, real-life cooking study to the relative energy efficiencies of the same ranges when measured under laboratory conditions.

Only conventional ranges were used. Convection ovens, induction or smooth-top surface units, and microwave ovens were not included. Appendix C presents size, wattage or BTU, and other specifications for each of the ten ranges.

Kitchens

Two separate kitchens were used--one for gas ranges and the other for electric ranges. The work triangles (sink-refrigerator-range) were identical in both kitchens, and the same kinds of refrigerators, dishwashers, cabinets, and sinks were used in both. Aside from the absence of windows in the basement kitchen, differences between kitchens were minor.

A floor plan of the Laboratory (Figure 1) notes the location of television cameras and observation booths for each kitchen.

Data Collection

For the electric ranges, two dial-type, watt-hour meters were used to measure the number of kilowatt hours (kWh) used for each meal. One meter measured total energy used by the countertop (surface units) and the other measured total oven and broiler use. Meters were read

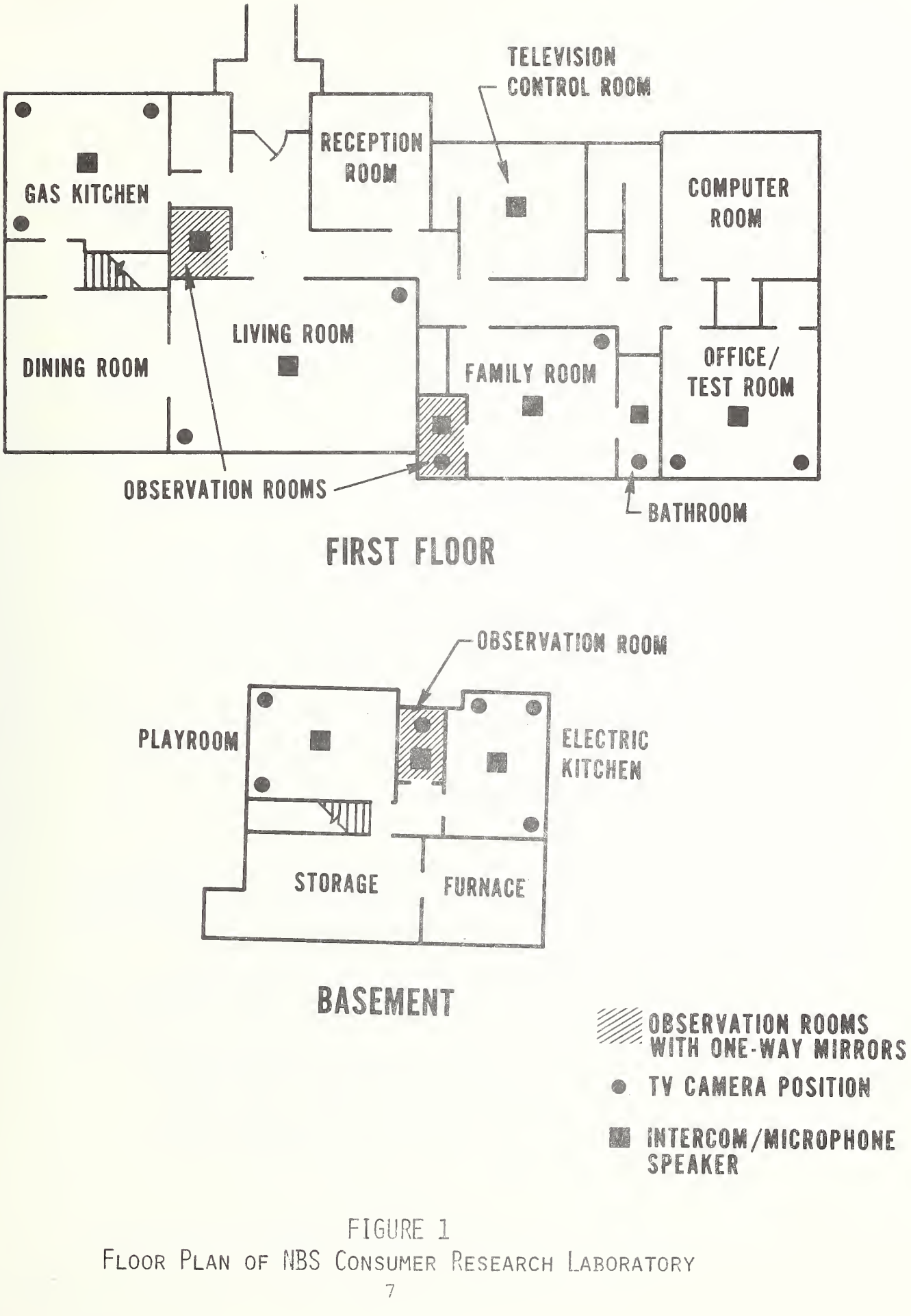


FIGURE 1
FLOOR PLAN OF NBS CONSUMER RESEARCH LABORATORY

before and after each meal. Later in the study digital watt-hour meters were used in place of the dial type meters to simplify data collection.

For the gas ranges, a single flow-meter was connected in the line supplying bottled, industrial-quality, natural gas to the range. Accordingly, separate records for top and oven/broiler were not available from this range type. Gas consumption was measured in cubic feet, but for this report all cubic feet have been converted to equivalent-kWh (EkWh, where 0.293 kWh = 1 cubic foot of natural gas. This conversion is based on a nominal heating value of 1000 BTU per cubic foot of natural gas (4)).

RESULTS

Range Energy Consumption versus Range Efficiency

As discussed in the Background section of this report, manufacturers must all use a standard test method when measuring the energy efficiency of kitchen ranges. The laboratory test method under consideration at the time this study was done consisted of raising the temperature of an aluminum block a specified temperature differences and measuring the amount of energy required to do so. The exact procedures eventually recommended to DOE by NBS and specifications for the aluminum test block--including size, weight, location of sensor devices, tolerance for flatness, etc., are all listed in the test method published in the Federal Register, May 10, 1978. Also listed are all definitions and formulae needed to perform these measurements accurately and reliably.

The ten ranges used in this study were first tested according to those procedures; resultant energy efficiency figures for the countertop (all surface units) and oven of each range are listed in Table II. Also listed is the combined energy efficiency of each range. As is obvious from the data, gas ranges are not as efficient as electric ranges. Table III contains the mean energy consumption of each range on each menu day.

Linear correlations were high between the combined computed efficiency of each range and the overall mean amount of energy used per menu day by cooks. Plotted data are presented in Figure 2. For the electric ranges the correlation was 0.89 ($p < 0.02$), and for the gas ranges it was 0.83 ($p < 0.05$).

Table II

Range Energy Efficiency
Measured with the Laboratory Test Method

Electric Ranges	Oven Efficiency	Countertop (Surface Unit) Efficiency	Combined Efficiency*
E1	0.143	0.71	0.45
E2	0.115	0.76	0.42
E3	0.104	0.68	0.38
E4	0.140	0.77	0.47
E5	0.133	0.79	0.46
Gas Ranges**			
G1	0.058	0.40	0.22
G2	0.058	0.40	0.22
G3	0.075	0.40	0.25
G4	0.059	0.40	0.22
G5	0.060	0.40	0.23

*As noted in section 4.3.2 of the Federal Register notice,

$$\text{Combined Efficiency} = \frac{1}{\frac{0.145}{\text{oven efficiency}} + \frac{0.855}{\text{countertop efficiency}}}$$

**Gas ranges require a constant supply of oxygen to burn fuel, resulting in a considerable amount of heat being lost to the surrounding air. For both electric and gas ranges, surface units are more efficient than ovens.

Table III

Mean kWh or Equivalent kWh (EkWh) Used
by Ranges to Cook Each Menu Day (0.293 kWh = 1 cubic foot of natural gas)

	Electric Ranges						Gas Ranges						
Menu Day	E1 kWh	E2 kWh	E3 kWh	E4 kWh	E5 kWh	Mean kWh	G1 E-kWh	G2 E-kWh	G3 E-kWh	G4 E-kWh	G5 E-kWh	Mean E-kWh	Menu Day
1	3.97	4.24	4.44	3.91	3.32	3.97	8.25	8.26	6.55	8.21	6.69	7.59	1
2	2.39	2.61	2.82	2.31	2.06	2.43	5.12	4.81	3.87	4.81	3.99	4.52	2
3	2.76	2.75	3.01	2.44	2.55	2.69	5.32	4.37	3.76	4.67	4.37	4.49	3
4	3.34	3.68	3.73	3.05	3.10	3.38	8.00	6.50	5.38	6.51	5.60	6.39	4
5	3.02	3.37	3.54	2.89	2.67	3.09	6.97	6.26	5.03	6.40	5.60	6.05	5
6	3.55	3.62	3.64	2.79	2.99	3.31	7.65	5.84	5.23	6.24	5.73	6.13	6
7	4.04	4.22	4.24	3.45	3.17	3.82	7.86	7.31	5.87	6.64	6.03	6.74	7
Mean of the Means	3.29	3.49	3.63	2.97*	2.83*	3.24	7.02	6.19	5.09	6.21*	5.43*	5.98	Mean of the Means

* Data for ranges E4, E5, G4, and G5 were collected after the 1976 NBS Open House. Some cooks who later participated in the study became aware of the energy use aspect of the project during the Open House when they or their friends or family toured the Consumer Research Laboratory. The range tests were halted just before the Open House and resumed immediately after. Such awareness by future participants may have affected their energy consumption in this study.

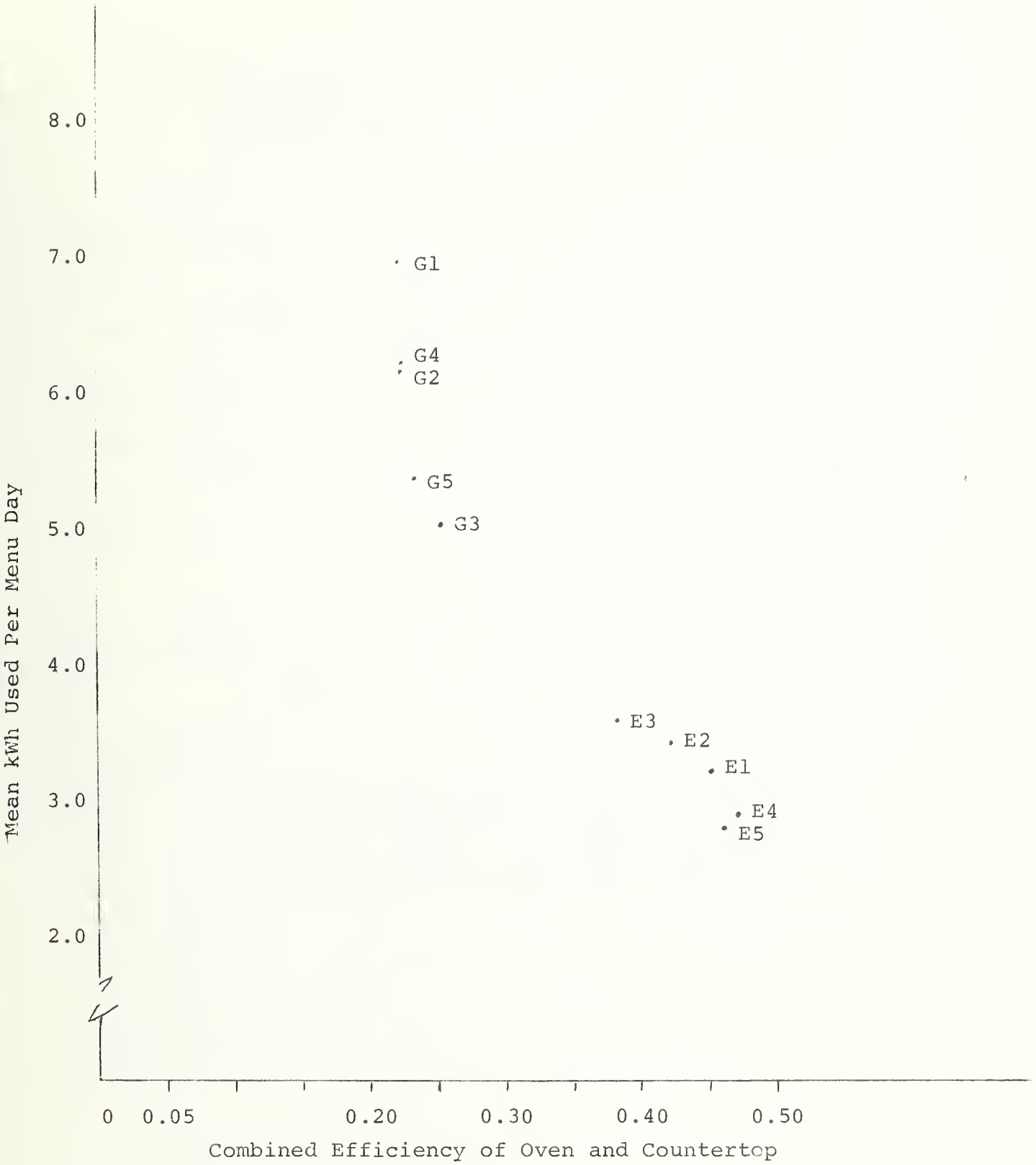


FIGURE 2

Combined Efficiency of Each Range Plotted Against the Mean kWh Used for Actual Cooking

In other words, for electric ranges, 79 percent of the variance in measured efficiency can be predicted from the variance in energy used during actual cooking. For gas ranges, 69 percent of the variance in one could be predicted from a knowledge of the variance in the other.

The higher the measured efficiency, the lower the total energy used by cooks. Because the correlation between measured efficiency and actual energy use was high, NBS engineers considered it unnecessary to modify the test method being proposed at that time. Instead, they concluded that the proposed test method would be adequate for measuring range efficiency for the appliance energy conservation program.

Other data which had been collected during the study were therefore not needed to identify test method changes for the time being, but an analysis of these other data may serve to assist manufacturers and others who are involved in range improvement work.

Range Energy Consumption

Data for each of the two range types, gas and electric, were analyzed separately because they consume significantly different amounts of energy. Further, because the same criteria were not used when selecting the gas ranges as when selecting the electric ranges, a comparative analysis would be inappropriate.

Electric range energy consumption data were analyzed by a repeated measures, two-factor analysis of variance test (ANOVA). The two factors were ranges (five) and menu-days (seven) wherein the seven different days of meal preparation constituted repeated measures on the same range. The results of the ANOVA for electric ranges are summarized in Table IV.

TABLE IV

ANOVA Summary Table for Total
Energy Used on the Electric Ranges

Source of Variation	SS	df	MS	F
Between Subjects				
Ranges	19.0	4	4.75	8.18**
Subj. within group	14.7	25	0.58	
Within Subjects				
Menu days	55.0	6	9.16	101.78**
Ranges X menu days	3.0	24	0.12	1.33
Menu days X subj. within group	13.2	150	0.09	

** = $p < 0.01$

Examination of Table IV clearly reveals a significant difference in the energy consumption of the electric ranges [$F(4, 25) = 8.18$, $p < 0.01$], and further indicates that the differences between ranges were much greater than the differences between the groups of subjects who used each range. This is a most interesting result since the study was carried out over a long period of time, with breaks of several days between range changeovers, and this could have led to the possibility that the later cooks might tend to conserve energy purposefully because they had attended the NBS Open House* or talked to others who had already participated in the study. This might have influenced the main effect (ranges) with differences between groups. Under such conditions, it would not have been possible to determine whether energy efficiency was due to range design or to the cooks' attempts to be energy efficient. Thus, the present results indicate

*As noted on Table II.

that range differences in energy consumption are sufficiently large that even statistically insensitive tests will detect the differences.

Since the main effect (ranges) was significant, it was desirable to test mean differences between all possible pairs of electric ranges. A Newman-Keuls procedure was used to compare mean differences. Table V presents the results of these procedures.

TABLE V

Newman-Keuls Test of Differences
Between Rank-Ordered Electric Range Means

Range	E5	E4	E1	E2	E3	Required Ratio
E5	--	5.8	18.3**	27.7**	33.3**	17.99
E4		--	12.5	21.9**	27.5**	17.08
E1			--	9.4	15.0	15.79
E2				--	5.6	13.78
E3					--	

** $p < 0.01$

The resulting differences can be illustrated as:

Range E5 Range E4 Range E1 Range E2 Range E3

where the "bars" indicate the overlap due to variance.

In words, Ranges E5 and E4 do not differ from one another, but do differ from Ranges E2 and E3. Other examples of differences are displayed by the above illustration.

The results of the Newman-Keuls test demonstrate that the use of non-professional cooks in a simulated real-life study can detect relatively modest differences in the amount of energy consumed by different electric ranges. In terms of actual kWh differences, one may question whether small, statistically significant differences are practically meaningful. Such a question, however, requires more information than was available and, hence, is not considered further in this report.

The second part of Table IV evaluates the second main effect (menu-days) by considering the variability between subjects within each group; menu-days were significantly different in terms of energy consumption [$F(6, 150) = 101.78$, $p < .01$]. Since the food preparation instructions and recipes were designed to be different, this result is to be expected. The interaction between range and menu variations was also evaluated but was insignificant. This result is also not surprising since it merely means that electric ranges are not selectively better for preparing one menu than another. What is surprising is that menu-days accounted for so much of the total variance in energy consumption. Examination of mean kWh consumption shown in Table III provides some insight into these results. The variability of the energy required to prepare the various sets of menu-day meals was very much larger than the variability between the cooks in preparing a given menu-day. For example, the difference in energy required to prepare a Day 1 menu versus a Day 2 menu was very much greater than the difference in energy used by the five cooks in preparing a Day 2 menu. From other evidence, it is known that the variability between cooks was very small on low energy requirement menu-days. As energy requirements per menu-day increased, so did the variability between cooks in the amount of energy actually used. This means that low energy requirement days do not contribute much to subject variability and, hence, could easily be omitted from any future study.

In a sense, the evaluation of the menu-day effect is superfluous in that it merely proves the obvious. But the sheer magnitude of the menu-day effect indicates that making the energy requirements different for each menu-day is not the approach most sensitive for comparing the relative efficiency of ranges by using non-professional

cooks in a simulated real-life environment. A more effective methodology would be to use just a few high energy-requirement menus (with repeated measures) or better yet to use the same menu prepared a number of times by the same cooks (replication). The approach used in the present study is appropriate, however, if the problem is concerned with how people use ranges in a wide variety of home conditions.

For gas ranges, six different sets of cooks had used each of the first four ranges, but only four cooks used the last (fifth) gas range. An ANOVA was again performed, but using an unweighted means analysis because the number of cooks per condition was unequal. The ANOVA summarized in Table VI produced results much like those for electric range data.

TABLE VI

ANOVA Summary Table for Total Energy Used on the Gas Ranges

Source of Variation	SS	df	MS	F
Between Subjects				
Ranges	89.03	4	22.25	12.93**
Subj. within group	39.68	23	1.72	
Within Subjects				
Menu days	218.73	6	36.45	107.20**
Ranges x menu days	11.78	24	0.49	1.44
Menu days X subj. within group	47.73	138	0.34	

** = $p < 0.01$

In the gas range ANOVA, range differences $F(4, 23) = 12.93$, $p < 0.01$, and menu day differences, $F(6, 138) = 107.20$, $p < 0.01$, were statistically significant; the range by menu day interaction was not. As with the electric range data, the Newman-Keuls procedure was used to isolate the source of main effect differences. The results of those additional tests are presented in Table VII.

TABLE VII

Newman-Keuls Test of Differences
Between Rank-Ordered Gas Range Means

Range	G3	G5	G2	G4	G1	Required Ratio
G3	--	2.24**	7.65**	7.75**	13.44**	1.24
G5		--	5.41**	5.51**	11.20**	1.17
G2			--	0.10	5.79**	1.08
G4				--	5.69**	0.95
G1					--	

** $p < 0.01$

Range differences (from Table VII) can be illustrated as:

Range G3	Range G5	Range G2	Range G4	Range G1
———	———	———————		———

In words, Ranges G2 and G4 did not significantly differ, but all other ranges did.

Figure 3 illustrates the amount of energy used to prepare each menu day. This figure also shows the relative difference in kWh between gas and electric ranges used to prepare the same menus.

For each range, data from the cook who used the most overall energy and the cook who used the least, were summarized. Absolute percentage differences between high- and low-consuming cooks on each range varied from a low of 4 percent on one gas range to a high of 33 percent on two of the electric ranges (see Table VIII).

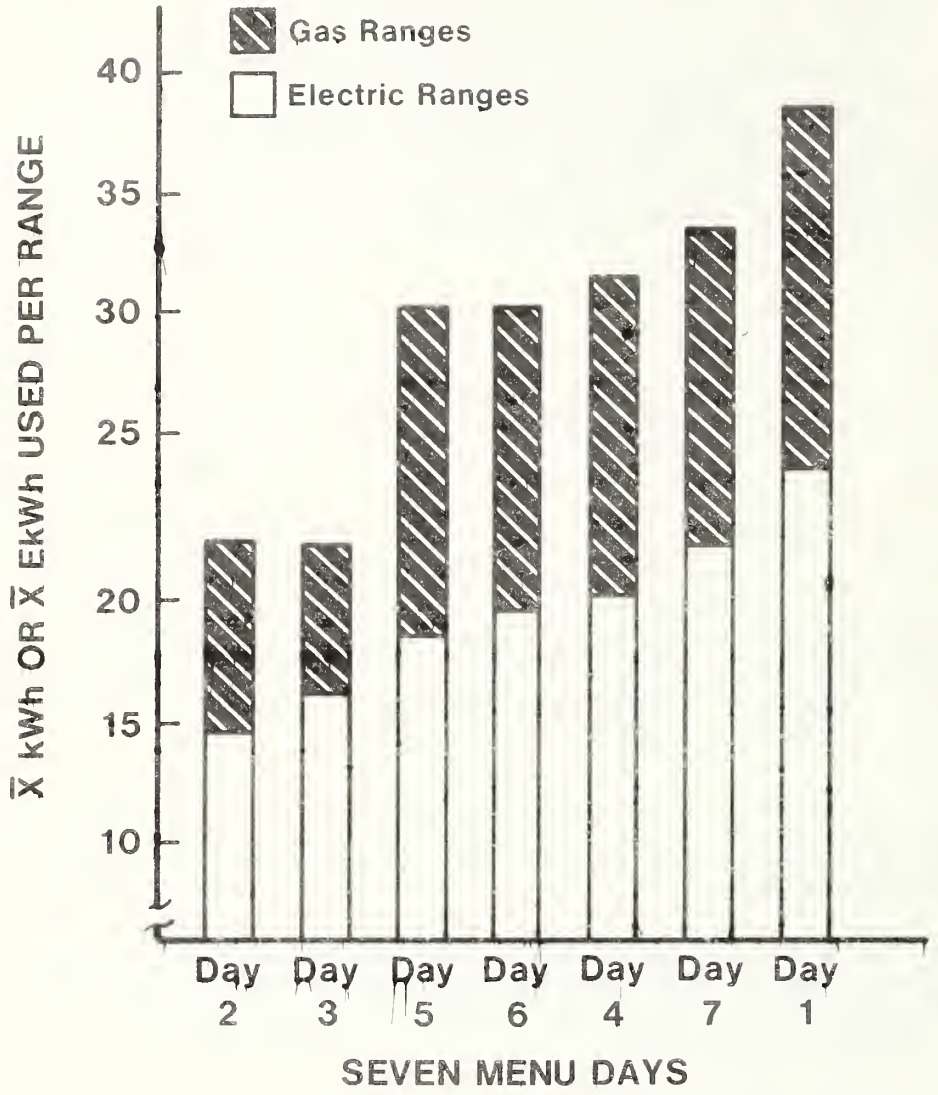


FIGURE 3

Mean kWh and EkWh Used to Prepare Each Menu Day (Breakfast, Lunch, Dinner) on Gas and Electric Ranges

TABLE VIII

Percentage Differences Between the Highest and Lowest Energy Users for Each Kitchen Range

Range	Percentage Difference	Range	Percentage Difference
Electric		Gas	
E1	25.3%	G1	4.3%
E2	14.4%	G2*	30.8%
E3	33.6%	G3**	30.1%
E4	14.8%	G4	16.0%
E5	33.1%	G5	10.7%

*On the electronic ignition gas range one cook was frightened by the ignition spark and asked the research staff to turn the burners/oven on; she left them on during most meal preparation.

**The range controls became so hot that some cooks simply turned them on and didn't turn them off until they had completed the meal.

DISCUSSION

The results of this study have immediate and long range utility. First, the high correlation between measured efficiency and energy used by cooks indicates that the efficiency test method is reasonable in that it relates well to real-life cooking. In other words, high efficiency ranges will consume less energy overall than low efficiency ranges when cooks use them for real cooking. However, the cooking habits of an individual cook may result in energy use much higher than the test method utilizes.

Second, because energy used by cooks declines as measured efficiency improves, it is likely that after all reasonable efficiency improvements have been made, other improvements might also be appropriate to affect the way cooks utilize a mechanically efficient range. For example, after cooking 21 meals over a seven-day period, the most efficient cook differed from the least efficient cook on the same range by as much as 33 percent. A change in the mechanical efficiency of that range will probably not affect the 33 percent figure, unless the change also addresses some human factors involved in

using the range. It is also true that the most efficiently designed appliance will not operate efficiently if it is used improperly. Proper use might be enhanced through improved consumer education, through appliance designs which effectively preclude inefficient procedures, or both.

The importance of separately addressing user considerations in appliance efficiency improvement programs (i.e. product design, consumer attitude, and consumer education programs) depends on the relative and absolute number of appliance users who are inefficient. If most users are efficient the user-caused waste is probably minor and not sufficient to warrant further research. On the other hand, if most users are not efficient, their energy waste is probably substantial and should be further studied. The small sample size used in this study is not adequate to settle the issue.

Regarding range differences, special note should be made of the differences between gas and electric range efficiency. As shown in Figure 2, gas ranges use more EkWh than electric ranges for the same tasks. However, the efficiency with which electric ranges use energy does not reflect the energy lost in its distribution and other factors. Gas ranges burn fuel at the point of use, where all of the heat could conceivably be used in cooking; electric ranges use electricity generated elsewhere, where heat lost during generation is not available for subsequent use. Readers should again be cautioned not to compare the electric and gas ranges used in this study against one another, because the same criteria for selection were not used for both types of ranges.

In addition, while most differences between ranges were significant, the range selection process was not random and the sample was not statistically representative. For those reasons, conclusions about the ten ranges tested apply only to those ranges. Readers interested in the performance of a specific range should refer to the summary of range characteristics in Appendix C, graphic illustrations in Appendix D, and the mean energy consumption summaries in Table III.

The AHAM menu used for all range testing was originally intended to represent the amount of food prepared by a family of four in one week. If so, the energy consumption for a full year could then be predicted by multiplying the AHAM menu energy use by 52. Unfortunately, based on comments made by cooks during post-test interviews,

the menu represents more than one week of cooking to many cooks, making the projection of annual consumption uncertain.

On the positive side, menu day differences are real, even though the 21 meals do not represent 1/52nd of a family's eating and energy use in one year. This study did find that the rank order of meals, from least to most energy consuming, was virtually the same for gas and electric ranges. That conclusion, and the finding that almost all meals required significantly different amounts of energy to prepare them means that future researchers working on range efficiency improvements can choose which meals to use if a full seven-day test is not possible. Post-test interviews also indicated that the cooks rapidly adjusted to the experimental study and felt "at home" in the kitchens. In fact, video tape recordings reveal numerous instances of a spontaneity of behavior that would occur naturally in their own homes. Such naturalness in the experimental environment of the Consumer Research Laboratory strongly suggests that food preparation behavior and energy use should closely approximate normal in-the-home energy consumption.

SUMMARY

Fifty-eight cooks each prepared a seven-day test menu using real food in real kitchens. Five gas and five electric ranges were used.

Results indicate that:

(1) The correlation between laboratory measured range efficiency and that exhibited by the homemakers was high ($p < 0.05$). Consequently no major modification to that laboratory test method would appear to be in order.

(2) The variation in energy used by the different cooks on the same range for the same meals was high (differences between cooks was as high as 50 percent). Whereas some of this variation could be ascribed to random individual behavior; other of the variation could be ascribed to certain generic behavior and would be amenable to control via range design.

(3) Regarding energy consumption, much of range design is independent of human factors, (random and generic) as evidenced by the high correlation between laboratory and home simulated tests. Accordingly, the test procedures should provide effective guidance to manufacturers for improving the energy efficiency of their ranges.

(4) An evaluation of the energy used to cook each of the 21 meals from the AHAM menu indicated that only three to five of the energy intensive meals (usually dinners) would have been sufficient to study relative efficiencies of kitchen ranges.

References

1. Public Law 94-163, Energy Policy and Conservation Act, December 22, 1975.

2. Public Law 94-385, Energy Conservation and Production Act, August 14, 1976.

3. Fechter, J.V. and Van Cott, H.P., The House that NBS Built, Journal of Consumer Studies and Home Economics, 1977, 1, 101-108.

4. Andrews, L.A., National Bureau of Standards, Product Performance Engineering Division, Personal Communication, June 9, 1978.

APPENDIX A

NBS-783
(2-75)

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

3. Cost Center No.
4410121

RESEARCH PARTICIPANT AGREEMENT

1. Principal Investigator
Robert Cunitz, Ph.D.

2. Division/Section
441.02

4. Location
[X] Gaithersburg
[ ] Other *(specify)*

5. Experiment Name Code
Kitchen Utilization Study Program

6. Description of Experiment
This study program is designed to collect data about kitchen use by American homemakers preparing meals for a family of four. Two general types of data will be collected: (a) engineering data on actual appliance use and (b) behavioral data, recorded on video and audio tapes, showing how a homemaker prepares her meals.

7. Risks to Participant
In the worst case, risks to the participant are those normally found in an average middle class home; i.e., electrical shock, contact burns from hot surfaces, scalding injuries from spilled hot liquids, cuts from sharp edges, bruises and contusions from falls and dropped articles, and digestive illnesses from spoiled foods. To reduce these risks, a rigorous safety program will be followed. In no case will participants use unfamiliar or highly specialized tools/instruments. All kitchen equipment will be standard, commercially available items.

8. Responsibilities of Participant
Each participant will: (a) prepare three meals (i.e., breakfast, lunch, dinner) within four hours on seven different days, (b) prepare all meals as she would in her own home, using the menus/recipes provided, (c) dress appropriately, e.g., no high heels, (d) attend orientation and debriefing sessions, and (e) permit video/audio tape recording of her activities.

Although all participants are free to terminate their participation at any time, a bonus of $1.00 per hour will be given to those participants who complete the seven-day test.

9. Responsibilities of Investigator(s)
The investigators will: (a) protect the participants from an unreasonable degree of physical danger, (b) respect the dignity of the participants and protect them from psychological distress, (c) provide prompt medical attention for treatment of injuries which may occur despite safeguards, and (d) ensure the participant's personal privacy as well as maintain confidentiality of information regarding participants. Since the behavioral data will consist of videotapes of the participants' behavior, the investigators will ensure that the participants pictures cannot be identified or otherwise associated with their name.

10. IT IS UNDERSTOOD THAT EITHER THE PRINCIPAL INVESTIGATOR, THE PARTICIPANT, OR THE PARTICIPANT'S PARENT OR GUARDIAN MAY TERMINATE THE PARTICIPANT'S INVOLVEMENT IN THE RESEARCH AT ANY TIME WITHOUT INCURRING LEGAL LIABILITY FOR SUCH TERMINATION.

11. I hereby certify that my participation is voluntary and that I have read and accept the terms of this agreement.

Participant, or Parent or Guardian *(Signature)*	Date
12. Principal Investigator *(Signature)*	Date
13. Early Termination by *(Signature)*	Date

USCOMM-NBS-DC

Appendix B

Recipes of AHAM Meals Involving Cooking on Kitchen Ranges

NU DAY 1
Breakfast

MEAL #1

OATMEAL

3 cups water
1 tsp salt
1-1/3 cups Quaker Quick Oats
Raisins
Brown Sugar

1. Place water and salt in a sauce pan and bring to boil.
2. Stir in oats, boil uncovered for 1 — stirring occasionally.
3. Remove from heat (add Raisins and Brown Sugar if desired).
4. Cover and let stand a few minutes before serving.

MENU DAY 1
Lunch

MEAL #2

GRILLED-CHEESE SANDWICHES

12 slices of bread
6 slices of American cheese
1/2 cup of margarine

1. Prepare six grilled cheese sandwiches (butter both sides of bread if desired).
2. Grill until golden brown on each side (approximately 12 minutes).

MENU DAY 1
Dinner

MEAL #3

ARM POT ROAST

Beef arm roast (4 lbs)
4 medium potatoes
4 small onions
4 carrots
1/4 cup flour
2 Tbls. shortening
1 Tbls. + 2 teaspoons salt
1-1/4 teaspoon pepper
1/4 cup water

Trim excess fat from meat. Mix flour, 1 tablespoon plus 2 teaspoons salt and 1-1/4 teaspoon pepper. Rub flour mixture into meat, shake off excess. Melt shortening in a Dutch oven on range top. Then add meat and brown on both sides. Add water, cover and place in oven set at 350°.

Add peeled quartered potatoes, onions, quartered carrots, and 1/2 teaspoon salt 1-1/2 hours later.

Cook until done, about one hour longer.

Gravy:

1 cup meat broth from pot roast
1/4 cup water
2 Tbls. flour
2 Tbls. gravy coloring

When pot roast is done, remove meat and vegetables from Dutch oven. Pour liquid into large measuring cup, skim off excess fat. Return 1 cup liquid to Dutch oven. Place flour and water in covered jar, shake to blend. Add flour mixture and gravy coloring into hot meat broth, bring to boil, stirring continuously, let cook for 1 minute.

MEAL #3

PEPPERIDGE FARM, PARKERHOUSE ROLLS

1. Follow instructions on package.
2. Warm rolls in a 350° oven for 3-5 minutes.

MEAL #3

APPLE CRISP

2 - 20 oz. cans apples (sliced)
2/3 cup light brown sugar
1/2 cup flour
1/2 cup Oats, Quick Quaker
1/2 cup margarine (soft Chiffon)
3/4 teaspoon cinnamon
3/4 teaspoon nutmeg

1. Drain apples, retain juice.
2. Spread apples evenly over 8" x 8" x 2" greased pyrex dish.
3. Sprinkle 2 Tbls. apple juice over apples.
4. Mix dry ingredent together.
5. Blend in margarine with fork until mixture is crumbly.
6. Spread evenly over apples.
7. Bake in 350° oven until liquid bubbles and topping is golden

MENU DAY 2
Lunch

MEAL #5

VEGETABLE SOUP

1. Place soup in a covered sauce pan.
2. Heat until steam is noted around lid of sauce pan and then turn off.

MEAL #6

BAKED CHICKEN W/GRAVY

8 chicken thighs
1 envelope Shake-n-Bake

Wash chicken thighs under cold water. Then, coat chicken according to instructions on Shake-n-Bake package. Place chicken pieces in single layers in jelly roll pan and bake for 40-50 minutes in 400°F oven. Save drippings for gravy.

GRAVY

1 can Campbell cream of mushroom soup
1/2 cup milk

In a sauce pan combine chicken drippings with soup. Add 1/2 cup of milk gradually. Bring to a boil and serve.

MEAL #6

MASHED POTATOES

2 cups Instant Potato Buds
2 cups Water
3 Tbls. margarine
3/4 teaspoon salt
1/3 cup milk

Place water, milk, margarine and salt in a sauce pan, bring to boil. Remove from heat, stir in potatoes with a table fork until desired consistency.

MENU DAY 2
Dinner

MEAL #6

BIRDSEYE GREEN CUT BEANS

Follow package instructions using a sauce pan w/lid or

1. Place frozen beans in sauce pan and add:

   1/2 teaspoon salt
   1 tablespoon margarine
   1/2 cup water

2. Bring to boil and then simmer for 10 minutes.

MEAL #6

FRUIT-IN-GELATIN SALAD

1 - 3 oz. package strawberry jello
1 - 10 oz. package Birdseye Quick-thaw mixed fruit

1. Bring water to boil in a sauce pan.
2. Add gelatin, stir in until dissolved.
3. Add frozen fruit and stir.
4. Divide mixture evenly into four custard cups.
5. Chill until gelatin sets.

MEAL #6

REFRIGERATED BISCUITS

1. Follow instructions on package.
2. Place biscuits on cookie sheets and place in 400° oven.
3. Remove biscuits when light, golden brown or about 9-11 minutes.

MENU DAY 3
Breakfast

MEAL #7

SCRAMBLED EGGS WITH BACON STRIPS

7 eggs
1/4 cup milk
2 Tbls. butter or margarine
1/2 lbs. bacon (8 strips)

Eggs:

1. Break eggs in bowl.
2. Add milk and beat with fork.
3. Melt butter or margarine in a skillet.
4. Add egg mixture and cook slowly stirring occasionally to allow uncooked portion to flow to bottom.
5. Eggs are done when mixture is set, but still moist.

MENU DAY 3
Lunch

MEAL #8

HOT DOGS

1. Place 1 cup water and 2 hot dogs in sauce pan.
2. Cover and cook over high heat until done (approximately 5 minutes).
3. Serve on a bun.

MENU DAY 3
Dinner

MEAL #9

BEEF STEW

1/3 cup flour
1-1/2 teaspoons salt
1/8 teaspoon pepper
1-1/2 lbs. boneless stew beef, cut in cubes (one inch)
2 tablespoons Wesson oil
3 cups water
3 medium-size onions sliced
4 medium-size potatoes, cut in 1 inch cubes
5 medium-size carrots, quartered
1-1/2 cups frozen peas
1/4 cup water

Combine flour, salt and pepper (save remaining flour). Coat meat with seasoned flour. Brown meat in hot oil in a Dutch oven. Add water and cover tightly, simmer until meat is tender (1½ hours).

Add onions, potatoes, and carrots. Cover and simmer 15 minutes. Add peas cover and simmer until all vegetables are tender. Blend 1/4 cup water with remaining flour. Add to stew, stirring gently; cook until thickened.

MEAL #9

PEPPERIDGE FARM BROWN AND SERVE GOLDEN TWIST ROLLS

According to package instructions or

1. Place on ungreased cookie sheet.
2. Bake in 375° pre-heated oven until golden brown.

MENU DAY 4
Lunch

MEAL #11

CHICKEN NOODLE SOUP

1. Place soup in a covered sauce pan.
2. Heat until steam is noted around lid of sauce pan and then turn off.

MEAL #11

TUNA AND EGG SALAD

2 hard boil eggs
1 (3 oz.) can tuna fish
1/2 cup mayonnaise
salt and pepper

To cook eggs:

Place eggs in a sauce pan, cover with water 1" above eggs bring rapidly to a boil, cover. Remove from heat, let stand 10 minutes. When eggs have cooled, peel and chop. Mix with tuna and toss lightly.

MEAL #11

CHOCOLATE CHIP COOKIES

1/3 cup shortening
1/3 cup margarine (softened)
¼ cup granulated sugar
¼ cup brown sugar (packed)
1 egg
1 teaspoon vanilla
1½ cups all purpose flour
½ teaspoon soda
½ teaspoon salt
½ cup chopped nuts
1 package (6 oz. each) chocolate chip pieces

1. Heat oven to 375°.
2. Mix thoroughly shortening, margarine, sugar, eggs, and vanilla.
3. Stir in remaining ingredients.
4. Drop dough by rounded teaspoonfuls, 2" apart onto ungreased cookie sheet.
5. Bake 8 to 10 minutes or until golden brown.
6. Cool slightly before removing from cookie sheet.

MENU DAY 4
Dinner

MEAL #12

ITALIAN SPAGHETTI

1 lb. ground beef
1/2 cup onion (finely chopped)
1 green pepper (finely chopped)
1 can tomato sauce
1 can tomato paste
1 Bay leaf (crumbled)
1 teaspoon oregano
1 envelope Italian style spaghetti sauce mix w/mushrooms
1-1/2 cups water
1 Tbls. sugar
1 clove of garlic (crushed)
1 - 8 Oz. package Italian spaghetti
grated parmesan cheese

1. Place ground beef, onions, and green pepper in a skillet, cook and stir until meat is brown and onions are tenders.
2. Stir in remaining ingredients except spaghetti and cheese.
3. Cover, simmer 1 hour stirring sauce occasionally.
4. Using a covered sauce pan, cook spaghetti as directed on package.
5. Serve meat sauce over spaghetti and pass the cheese.

MEAL #12

GARLIC BREAD

1. Cut 2 French bread loaves in half (the long way)
2. Mix 1/2 cup soft margarine and 3/4 teaspoon of garlic powder or 1 finely minced medium sized, garlic clove.
3. Spread thickly on bread and place on ungreased cookie sheet.
4. Place in oven, close to broiler unit.
5. Leave door open and toast to a golden brown.

MEAL #12

WHIPPED GELATIN

1 package gelatin
1 cup boiling water
1 cup cold water

1. Mix gelatin in a bowl, with boiling water.
2. Stir until gelatin dissolved.
3. Add cold water and stir.
4. Chill in refrigerator until set (about 30 minutes).
5. Whip with electric portable mixer 3 minutes at medium speed.
6. Return to refrigerator and chill for 45 minutes.

MENU DAY 5
Breakfast

MEAL #13

SOFT-COOKED EGGS

4 eggs

1. Place eggs in a sauce pan, cover completely with cold water, leave lid off.
2. Place sauce pan on surface unit, turn control to highest setting, and bring to full boil.
3. Remove sauce pan from heat, cover. Let stand for 3 minutes.

MENU DAY 5
Lunch

MEAL #14

LEFTOVER BEEF STEW

1. Use Dinty Moore canned beef stew.
2. Place 2 cups of stew in a covered sauce pan and heat until vegetables and meat are heated throughout.

MENU DAY 5
Dinner

MEAL #15

BRAISED PORK CHOPS

6 pork loin chops, 1/2" thick
3 Tbls. vegetable oil
salt and pepper
1/2 cup water

1. Heat oil in uncovered skillet.
2. Brown chops on each side.
3. Season with salt and pepper to taste.
4. Add a small amount of water, cover tightly and cook until done. (No pink shows in meat.)

MEAL #15

SCALLOPED POTATOES

1. Follow package instructions or
2. Remove potatoes in the container, place in 400°F pre-heated oven.
3. Bake for 45-55 minutes or until top is golden brown.

MEAL #15

BUTTERED SPINACH (GREEN GIANT)

1. Follow package instructions or
2. Place 1 cup of water in sauce pan, bring to full boil at high setting.
3. Put unopened pouch into boiling water and bring to second boil.
4. Turn down to medium and cook for 15 minutes with cover on.
5. Remove and season for table use.

MEAL #15

RED HOT APPLESAUCE

1. Place applesauce in a sauce pan.
2. Add 1/2 package of "red hot" cinnamon candy hearts.
3. Heat at low-medium heat, stir occasionally, for 5-6 minutes.
4. Taste for cinnamon flavor, add more red hots if desired.

MEAL #15

LEMON MERINGUE PIE

9" pie shell (Pet Ritz)
1 - 4-3/4 oz. package jello lemon pie filling (Regular)
3 egg whites
6 Tbls. sugar (confectionery), 1/2 cup plain sugar
3 cups water

1. Pie Shell: Bake for 10 minutes in 400°F pre-heated oven.
2. Pie Filling: According to package instructions.

   Mix package contents with sugar, ½ cup of water, and slightly beaten egg yolks. Stir in 2½ cups of water and place sauce pan (without cover) on surface unit. Turn to medium heat, stir until mixture boils, and remove pie fillin filling. Let cool for 5 minutes and then pour into pie shell.

3. Pie Meringue:

   Place egg whites in bowl and beat until foamy (portable electric mixer). Add 6 Tbls. of confectionary sugar and beat until stiff peaks form.

   Spread meringue over pie.

   Set oven to 325°F and place pie in center of oven.

   Bake until meringue is golden brown (5 minutes) and remove from oven to cool.

MENU DAY 6
Lunch

MEAL #17

EGG SALAD

2 eggs
mayonnaise
salt and pepper

To hard cook eggs:

Place eggs in sauce pan cover with water 1" above eggs.
Rapidly bring water to a boil, cover, remove from heat and let stand covered about 15 minutes.
When eggs have cooled, peel and chop.
Add mayonnaise, salt and pepper to taste.

Make 2 sandwiches.

MEAL #18

BROILED FISH & BROILED TOMATO

2 packages (12 oz. each) frozen halibut steaks
3 Tbls. butter
salt, pepper and paprika
2 medium-size tomatoes

1. Adjust oven shelf for broiling.
2. Set oven control to "BROIL" and preheat for 5 minutes.
3. Melt butter in small pan.
4. Cut tomatoes in half (crosswise) and place on broiler pan grid, brush with melted butter.
5. Place frozen fish in colander and rinse under cold running water.
6. Dry thoroughly with paper towel, place on broiler pan grid, brush fish with melted butter.
7. Place broiler pan in oven and broil for 10 minutes with oven door ajar.
8. Turn fish, brush with butter, sprinkle with salt, pepper, and paprika.
9. Broil an additional 10 minutes or until done.
10. Remove fish and tomatoes.

MENU DAY 6
Dinner

MEAL #18

RICE PILAF

1 cup butter
1 onion, chopped
1 can beef consomme
1 cup rice
1 can water

1. Melt butter; saute onion until yellow.
2. Add consomme, rice and water.
3. Bake in covered casserole at 350°, for 1 hour.

MEAL #18

PEAS WITH PEARL ONIONS

1. Follow package instructions using a sauce pan with cover or
2. Place frozen peas in sauce pan and add

   1/2 teaspoon salt
   1 tablespoon margarine
   1/2 cup water

3. Bring to boil and then simmer for 2-5 minutes.

MEAL #18

TAPICOA PUDDING W/FRUIT TOPPING

1 package (3-1/4 oz.) jello tapicoa pudding - vanilla
2 cups milk
1 package frozen fruit

1. Place mix in sauce pan.
2. Slowly add milk, stirring with spatula for 2 minutes.
3. Cook pudding, stirring constantly, until done (approximately 5-7 minutes).
4. Top with fruit just before serving.

MENU DAY 7
Breakfast

MEAL #19

PANCAKES

1 cup Pillsbury Hungry-Jack Pancake Mix
1 cup whole milk (water can be used for thinner mix)
1 Tbls. plus 1/2 teaspoon cooking oil
1 large egg

1. Preheat griddle at medium setting.
2. In large bowl mix together pancake mix, milk, egg, and 1 Tbls. cooking oil.
3. Grease griddle with 1/2 teaspoon cooking oil.
4. Using 1/4 cup measure, dip batter onto griddle, cooking 4 pancakes at a time. Cook pancakes (1-1/2 minutes) on each side or until bubbles first appear on first side, or pancakes a light golden brown.
5. Repeat cooking for remaining batches make 12-15 pancakes.

MEAL #19

SAUSAGES

10 sausages links
2 Tbls. water

1. Place sausage links in cold skillet, add water and cover.
2. Cook on medium setting for 4 minutes.
3. Remove cover and cook until links are light golden brown, turning frequently (total cooking time — 11-13 minutes).

MEAL #21

RIB STEAKS

4 - 1" thick - 1 lb. rib steaks

1. Wipe meat lightly with paper towel.
2. Score fat by cutting vertical slashes in fat about 1 or 2 inches apart. Do not cut into lean.
3. Piece steaks on broiler rack in broiler pan.
4. Set oven to broil, place broiler pan in broiler unit so that about 3-1/2" clearance is left between heating unit and top of food. Leave oven door ajar.
5. Broil on first side 8 minutes.
6. Turn and broil on second side. About 6-8 minutes for medium done.

MEAL #21

BAKED POTATOES

4 - 6 oz. size Idaho baking potatoes

1. Scrub skins, pierce each one once with cooking fork.
2. Place on oven shelf in position closest to bottom of oven.
3. Bake at 400°F (do not preheat) 45-55 minutes or until potatoes are done.

MENU DAY 7
Dinner

MEAL #21

SAUTEED MUSHROOMS

1/2 lb. fresh mushrooms
3 Tbls. butter

1. Melt butter in a skillet.
2. Swirl butter in pan. Add mushrooms cook 3-5 minutes stirring frequently until mushrooms are just golden brown (dark color indicates overcooked).

MEAL #21

BROCCOLI SPEARS

1 package (10 oz.) frozen broccoli spears
1/2 teaspoon salt
1/2 cup water

1. Place water, salt, and broccoli in a sauce pan. w/cover. Turn burner to "Hi" setting and bring rapidly to a full boil, about 5-1/2 to 6-1/2 minutes.
2. Separate broccoli with fork. Cover and simmer at low setting for 5 minutes or until tender. Test for tenderness by piercing vegetables in both stem and flower with fork.

MEAL #21

HOT FRENCH BREAD

1 lb. loaf sliced Rainbow French style bread (approximately 14" long)

1. Place bread on cookie sheet.
2. Place cookie sheet in oven, set at 400°.
3. Bake 10 to 12 minutes or until crust is browned.

MEAL #21

DEVIL'S FOOD CAKE

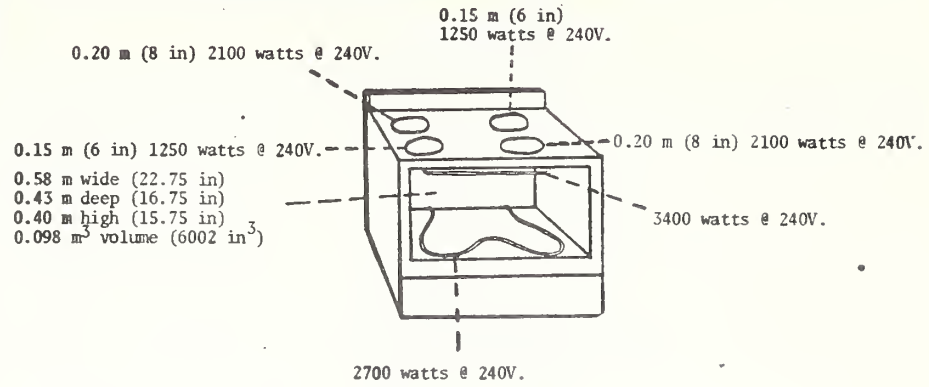
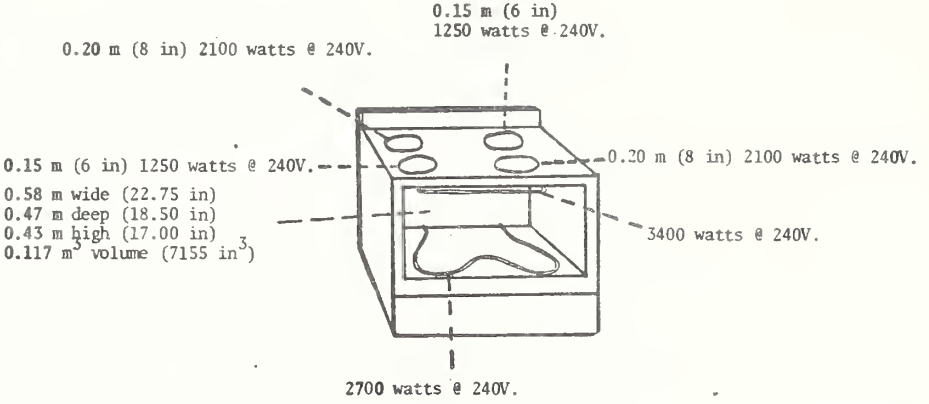
1 - 9 oz. package Jiffy cake mix
1 large egg
1/2 cup water
2 teaspoons Crisco
2 teaspoons flour
to flour and grease casserole

1. Blend cake mix, 1/4 cup water and 1 egg in mixer at No. 1 speed (lowest) for 15 seconds.
2. Beat for 2 minutes at medium speed, scrape bowl often.
3. Add 1/4 cup water and beat 2 minutes longer at medium speed.
4. Pour batter in 8" x 8" x 2" square casserole.

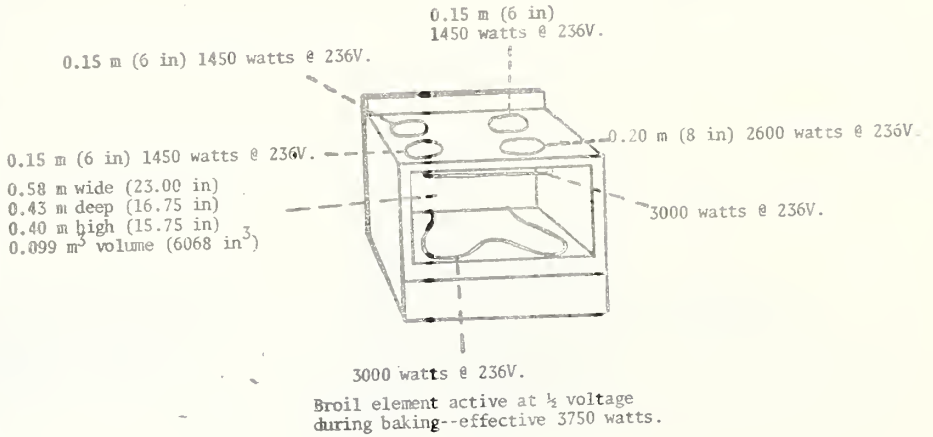
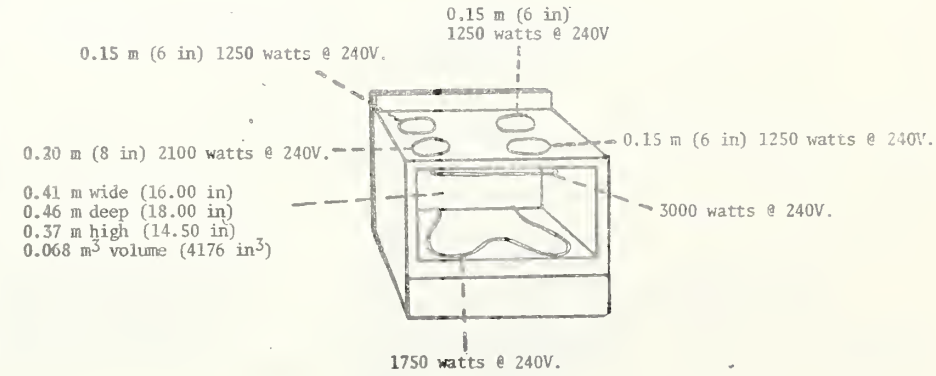
Appendix C

Summary of Range Characteristics

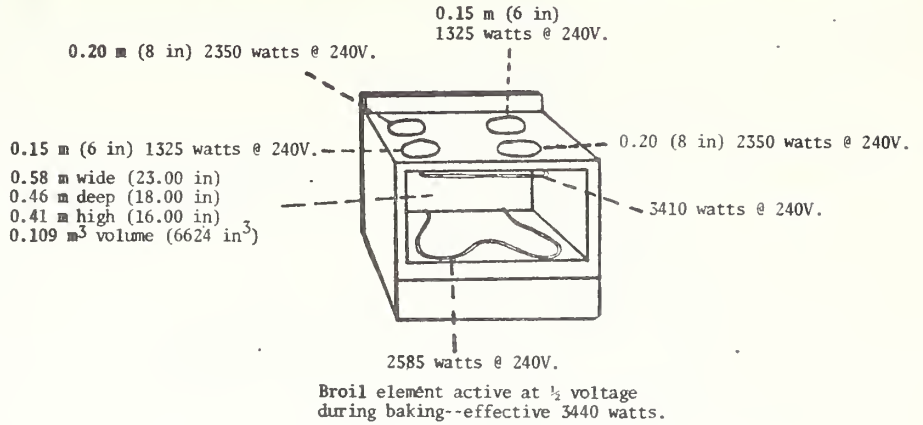
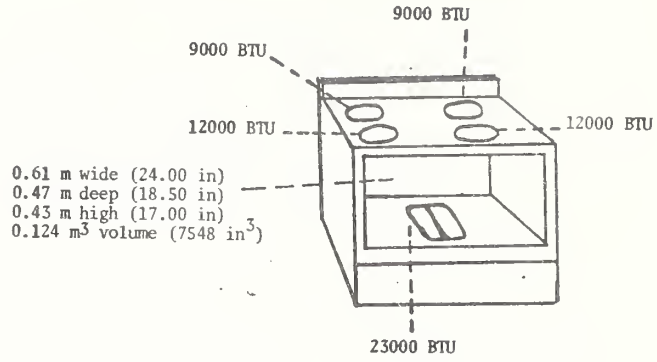
Summary of Range Characteristics

Range	Oven Features	Type of Surface Units	Size and Rating Information
Electric Range 1 0.76 m (30 in) wide	-Self cleaning oven -Oven window -Oven light	Tubular 0.63 cm (¼ in) wide	
Electric Range 2 0.76 m (30 in) wide	-Catalytic cleaning oven -Oven window -Oven light	Tubular 0.63 cm (¼ in) wide	

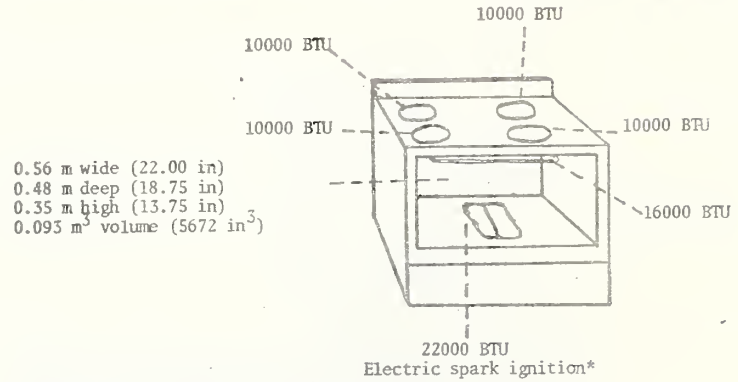
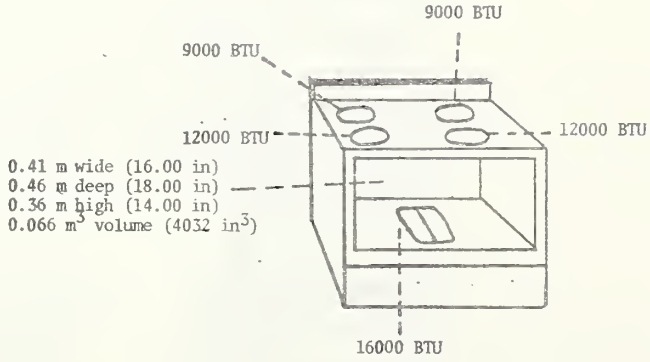
(continued)

Range	Oven Features	Type of Surface Units	Size and Rating Information
Electric Range 3 0.76 m (30 in) wide	-Catalytic cleaning oven -Oven window -Oven light	Tubular 1.59 cm (5/8 in) wide	
Electric Range 4 0.51 m (20 in) wide	-Oven window -Oven light	Tubular 0.63 cm (¼ in) wide	

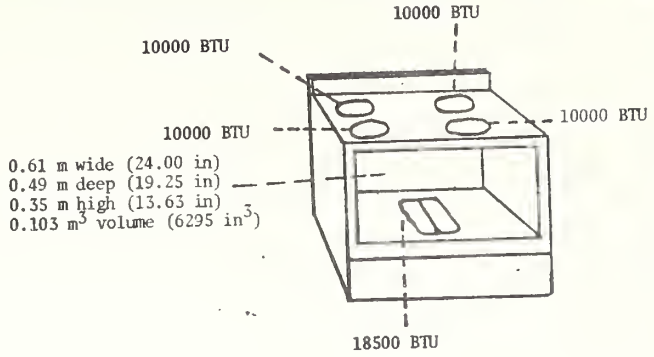
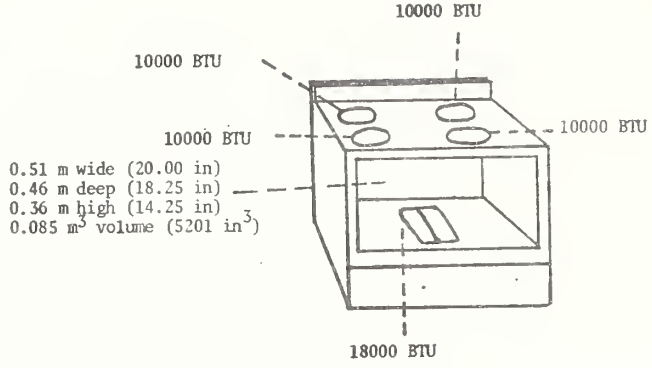
(continued)

Range	Oven Features	Type of Surface Units	Size and Rating Information
Electric Range 5 0.76 m (30 in) wide	-Self cleaning oven -Oven window -Oven light	Tubular 0.63 cm (¼ in) wide	 Broil element active at ½ voltage during baking--effective 3440 watts.
Gas Range 1 0.76 m (30 in) wide Pilot light consumption is 0.0078 ft3/min.	-Catalytic cleaning oven -Oven window -Oven light -Pilot light	Pilot light	

(continued)

Range	Oven Features	Type of Surface Units	Size and Rating Information
Gas Range 2 0.76 m (30 in) wide	-Self cleaning oven separate broiler element in oven. -Glo-bar for oven burner ignition	Electric spark ignition	 * Subject 111 expressed fear of the spark ignition system and left burner on between cooking so she wouldn't have to use the spark. This practice is reflected in her high energy consumption.
GSR-108 0.51 m (20 in) wide Pilot light consumption is 0.0062 ft^3/min.	-Pilot light	Pilot light	

(continued)

Range	Oven Features	Type of Surface Units	Size and Rating Information
Gas Range 4 0.76 (30 in) wide Pilot light consumption is 0.0066 ft^3/min.	-Pilot light	Pilot light	
Gas Range 5 0.91 m (36 in) wide Pilot light consumption is 0.0068 ft^3/min.	-Pilot light	Pilot light	

Appendix D

Graphic Illustration of Energy Consumption and Variation for Each Range, Cook, and Day

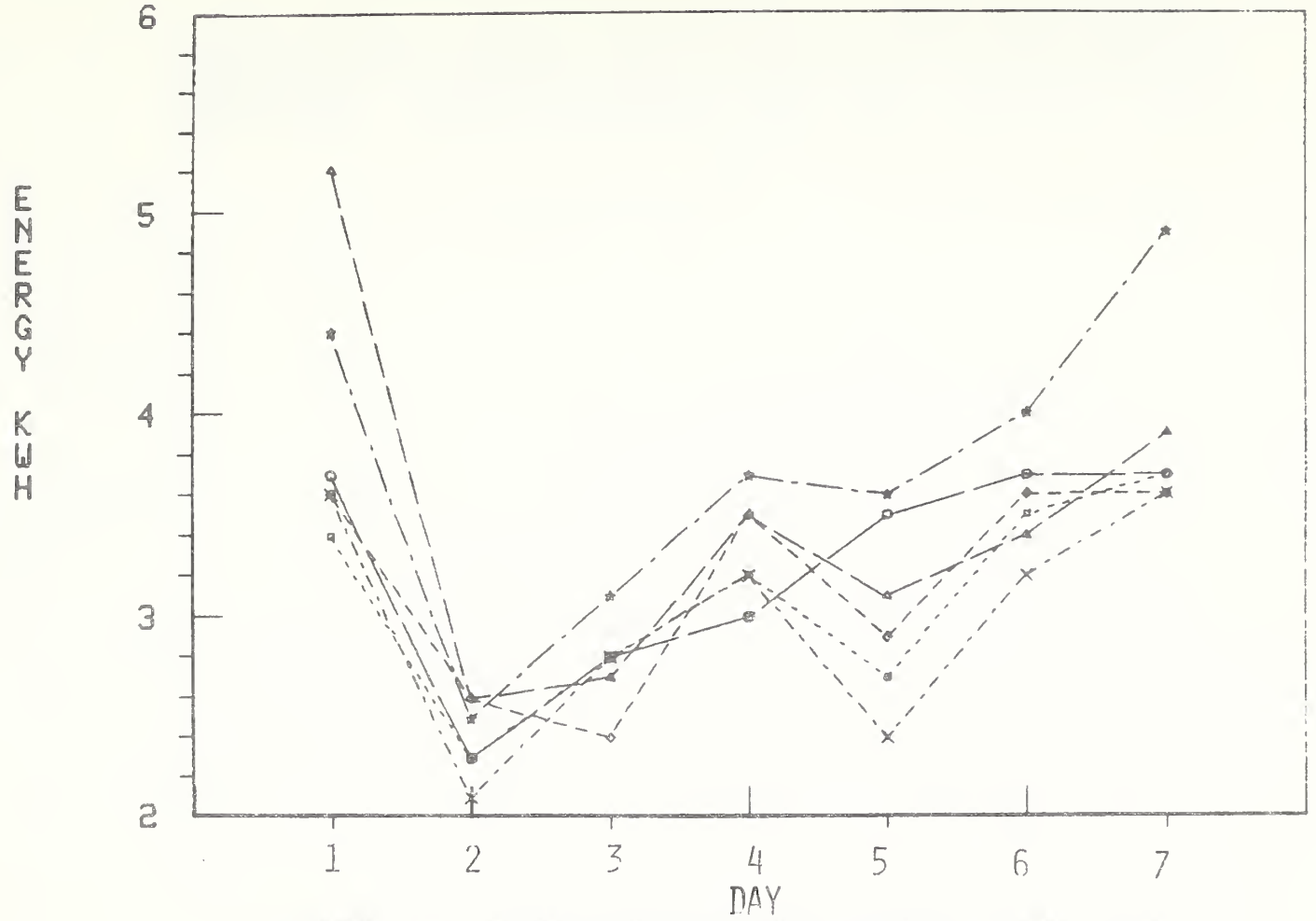


FIGURE D1. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR ELECTRIC RANGE 1.

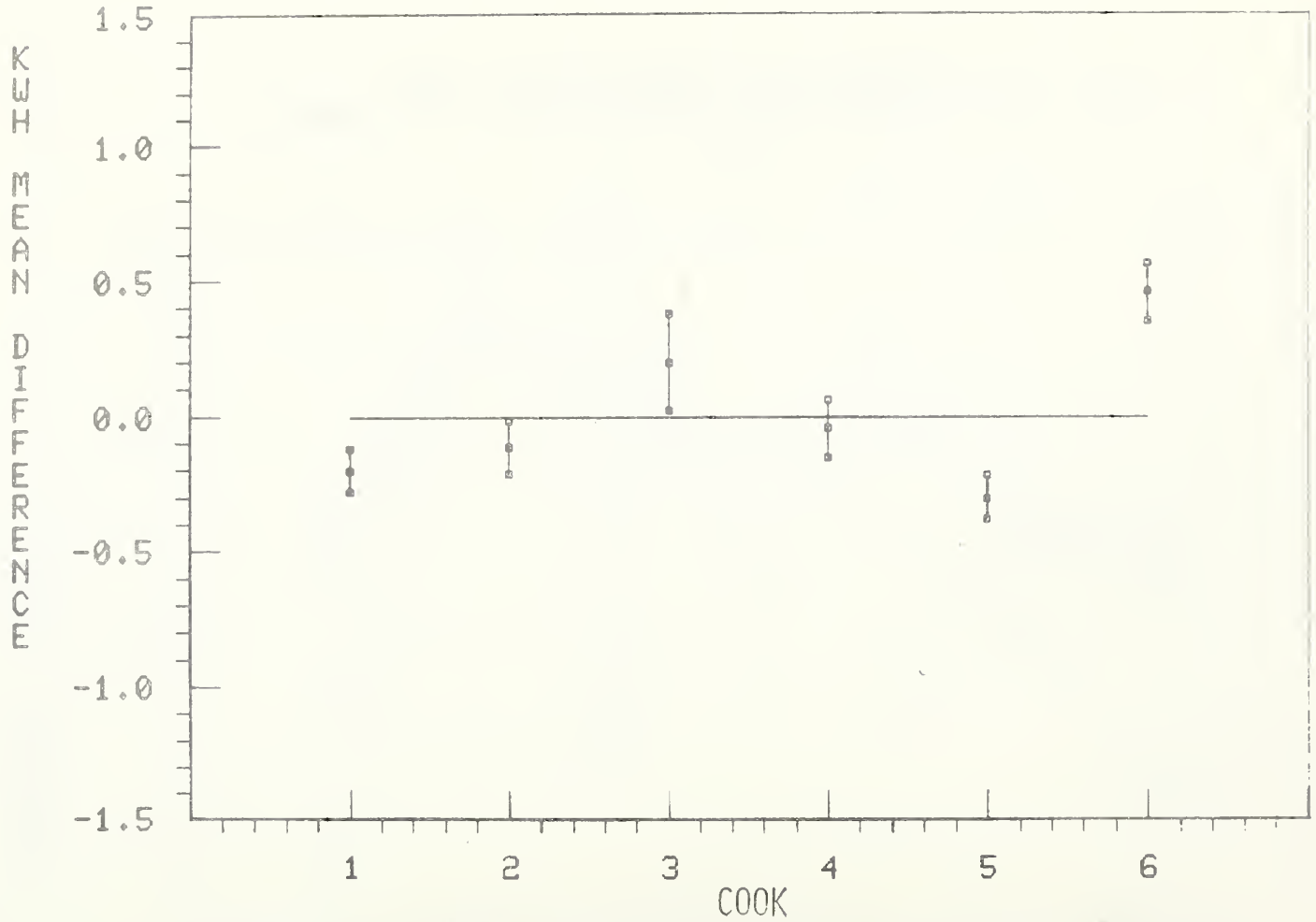


FIGURE D2. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING ELECTRIC RANGE 1 AND THE STD. DEVIATION OF EACH DIFFERENCE.

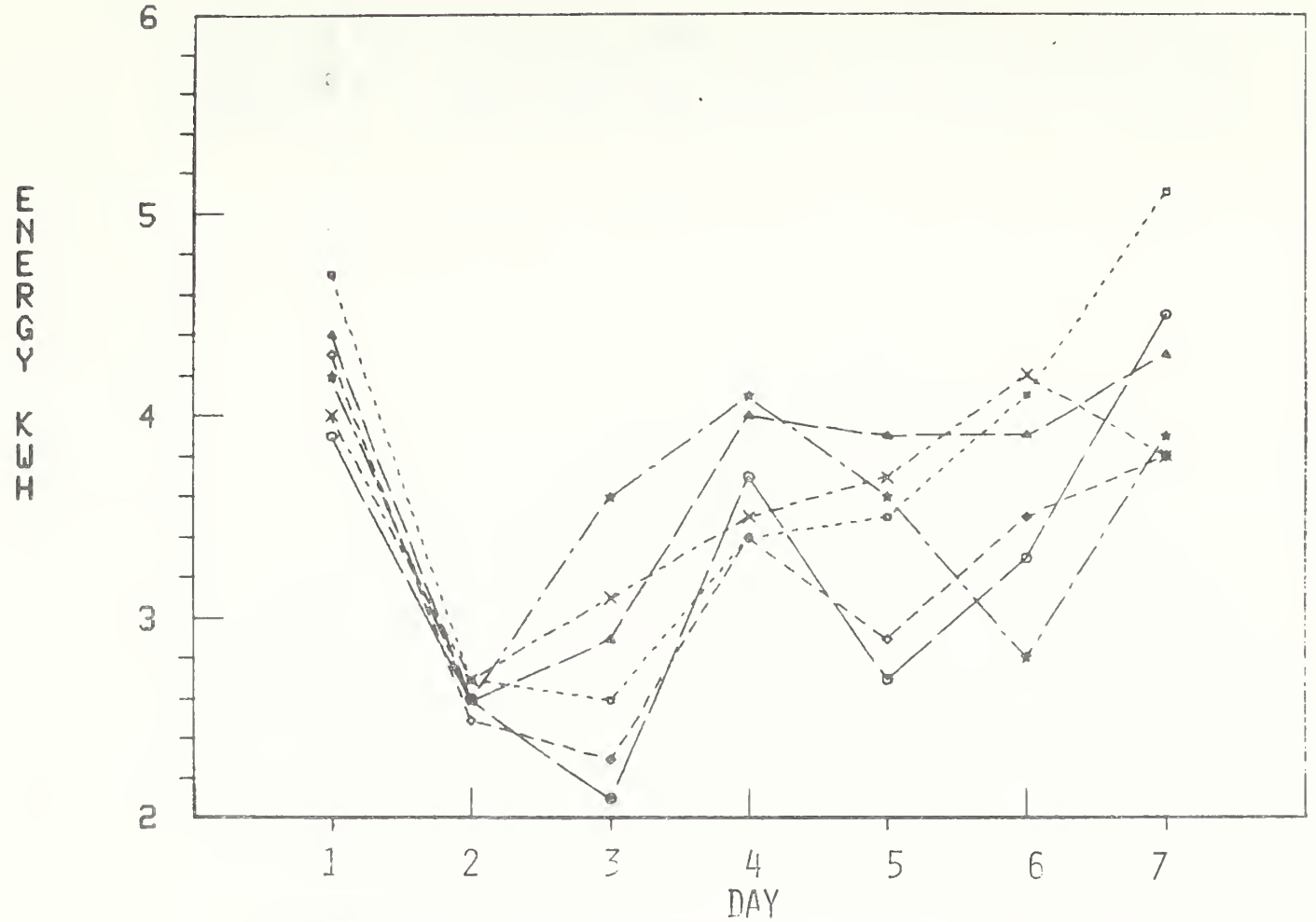


FIGURE D3. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR ELECTRIC RANGE 2.

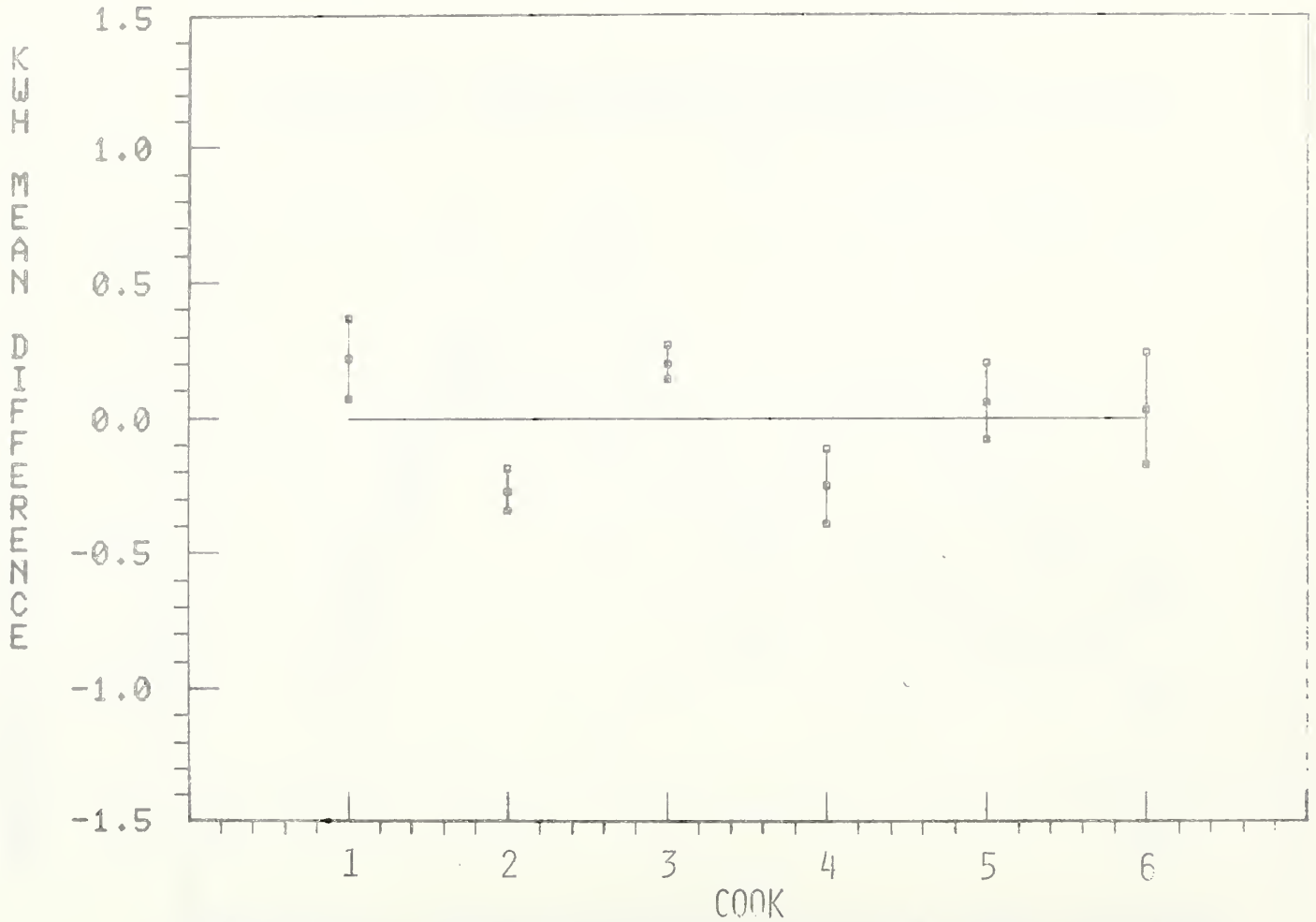


FIGURE D4, MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING ELECTRIC RANGE 2 AND THE STD. DEVIATION OF EACH DIFFERENCE.

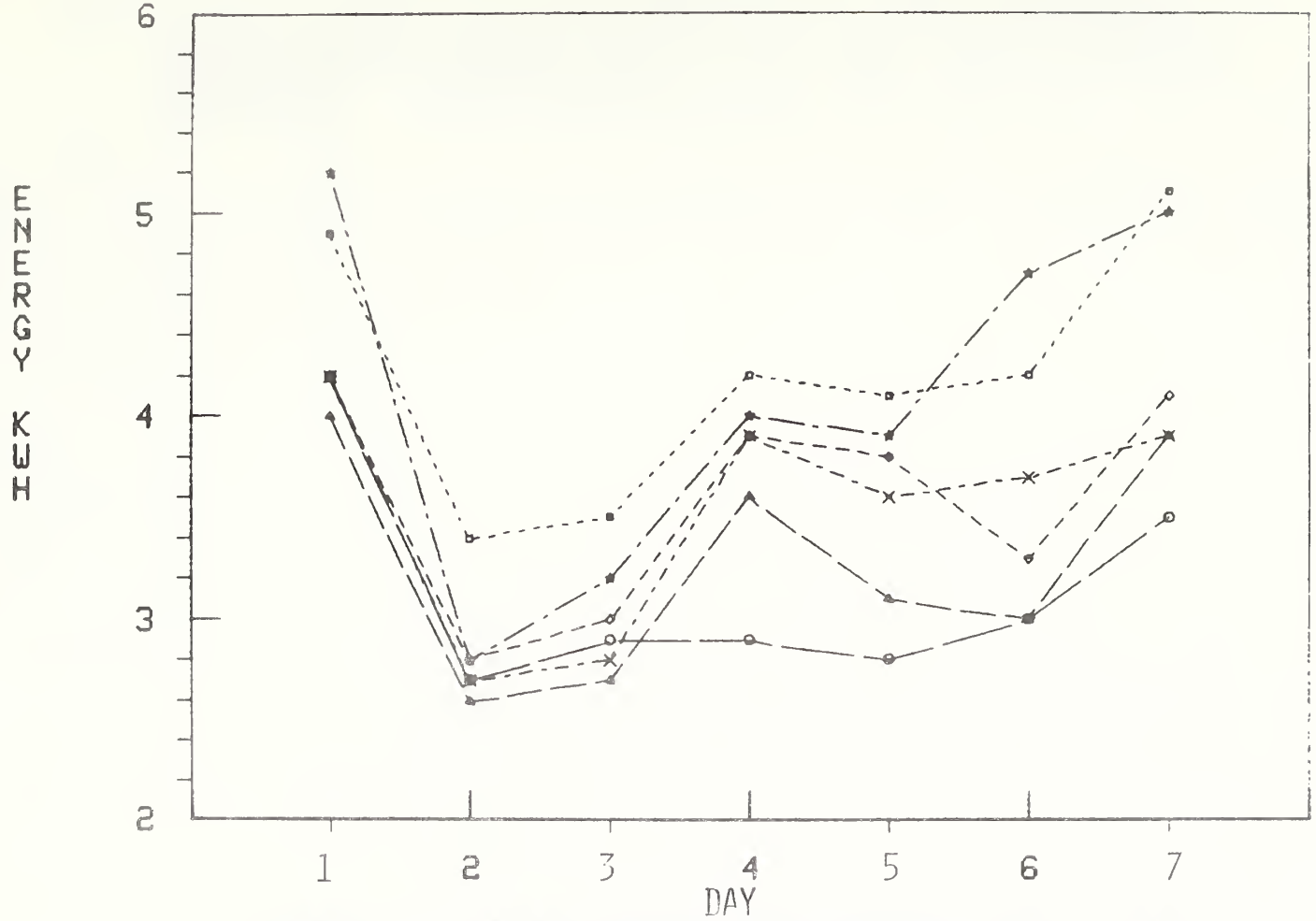


FIGURE D5. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR ELECTRIC RANGE 3.

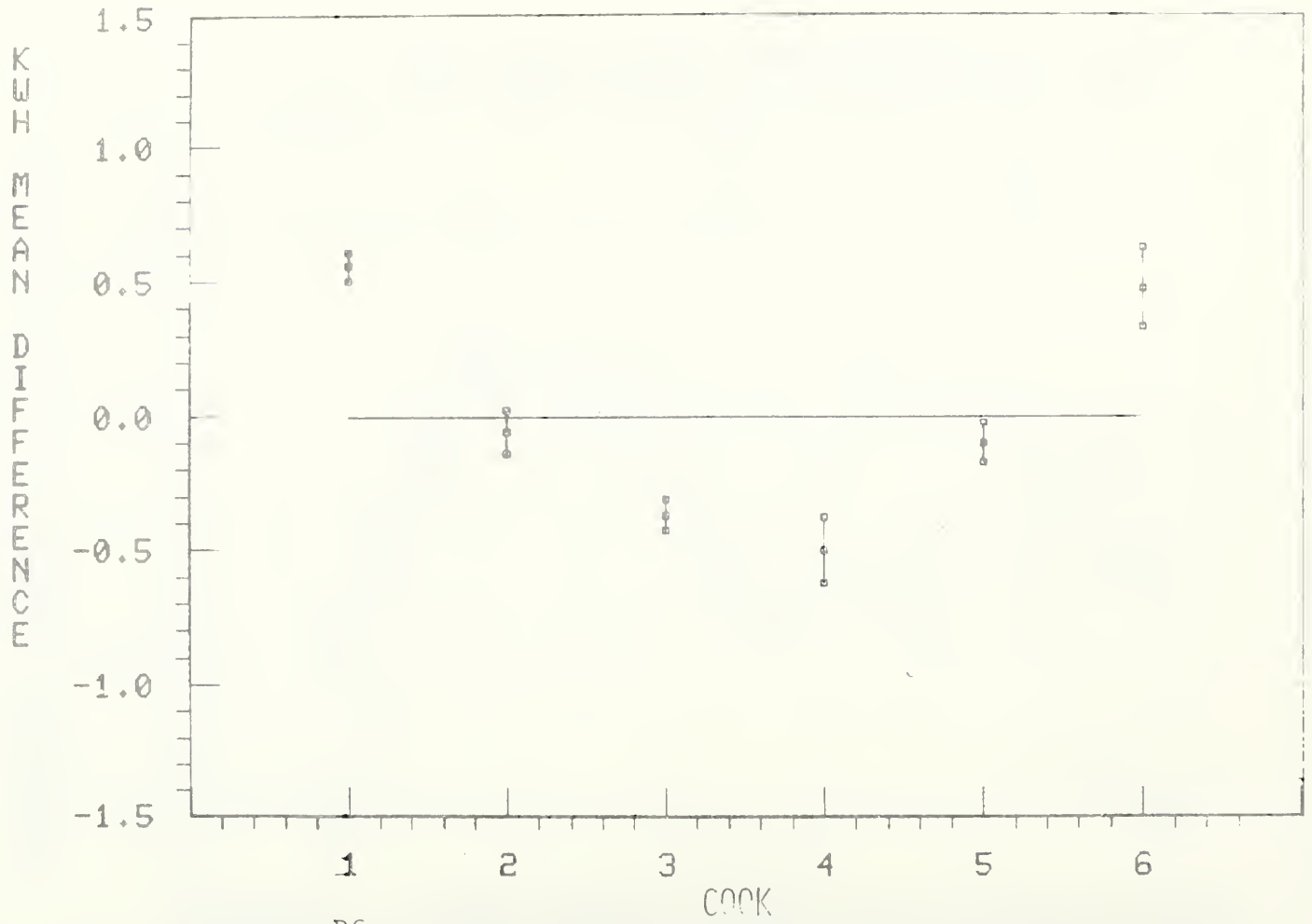


FIGURE D6. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING ELECTRIC RANGE 3 AND THE STD. DEVIATION OF EACH DIFFERENCE.

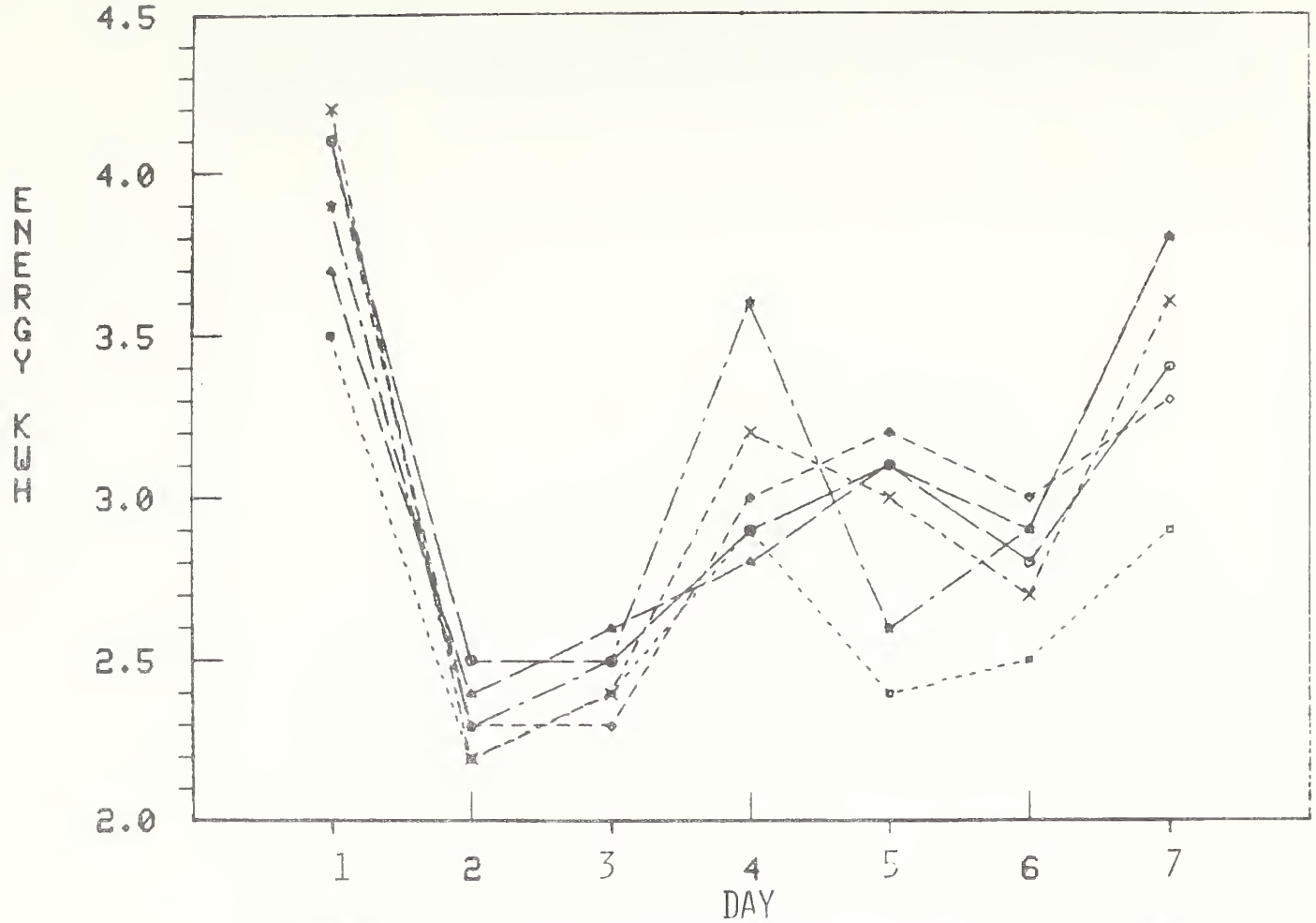


FIGURE D7. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR ELECTRIC RANGE 4.

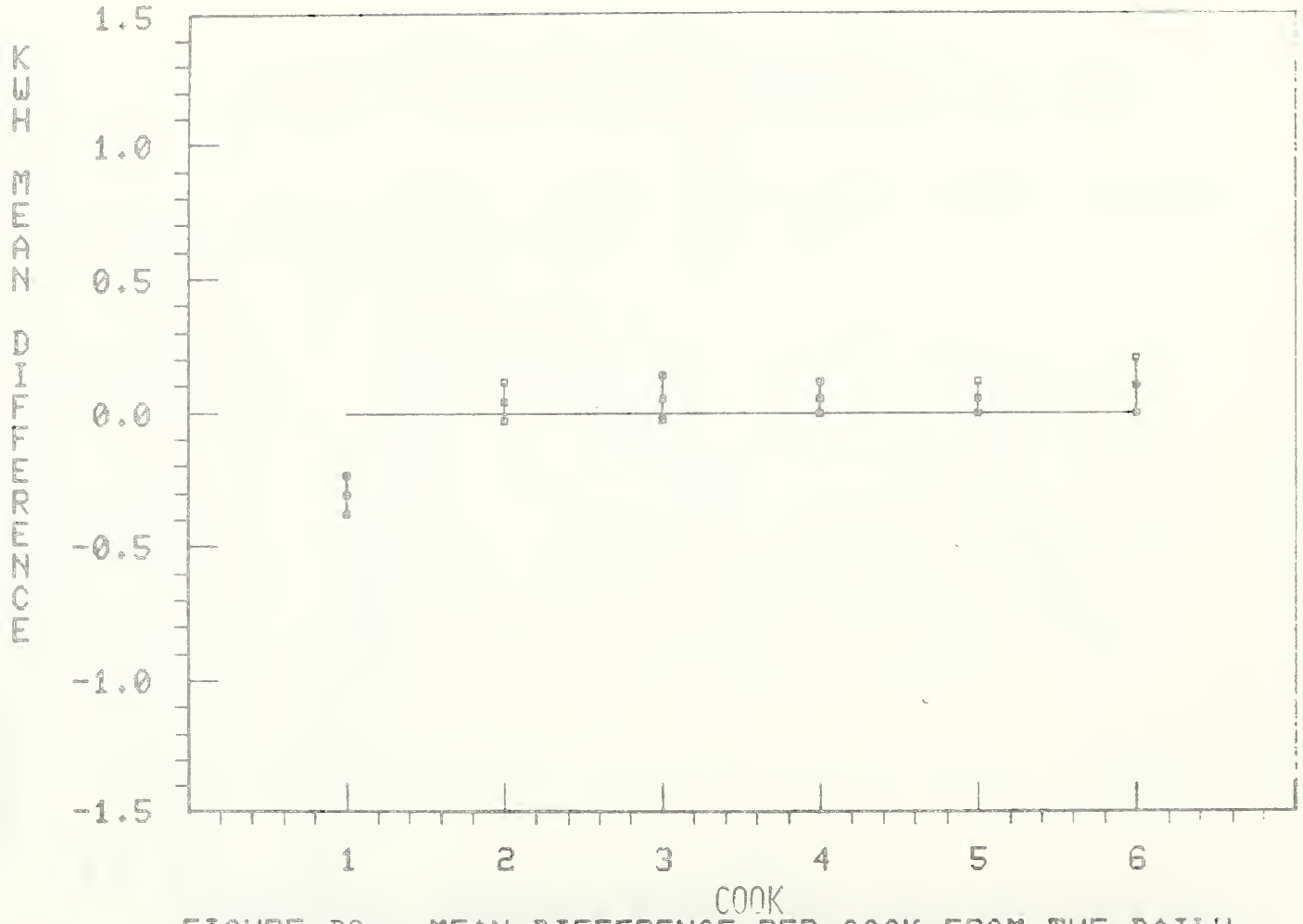


FIGURE D8. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING ELECTRIC RANGE 4 AND THE STD. DEVIATION OF EACH DIFFERENCE.

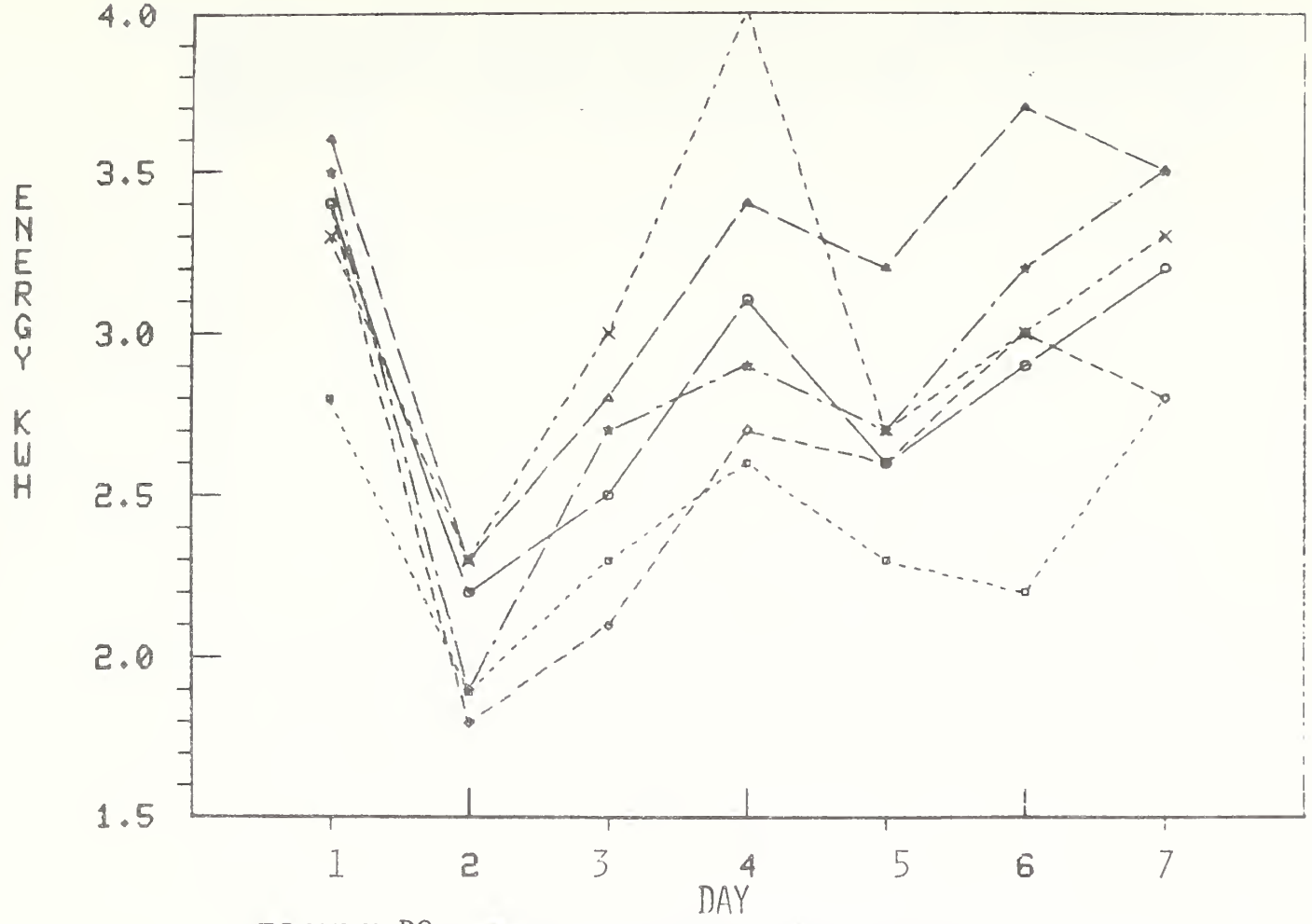


FIGURE D9. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR ELECTRIC RANGE 5.

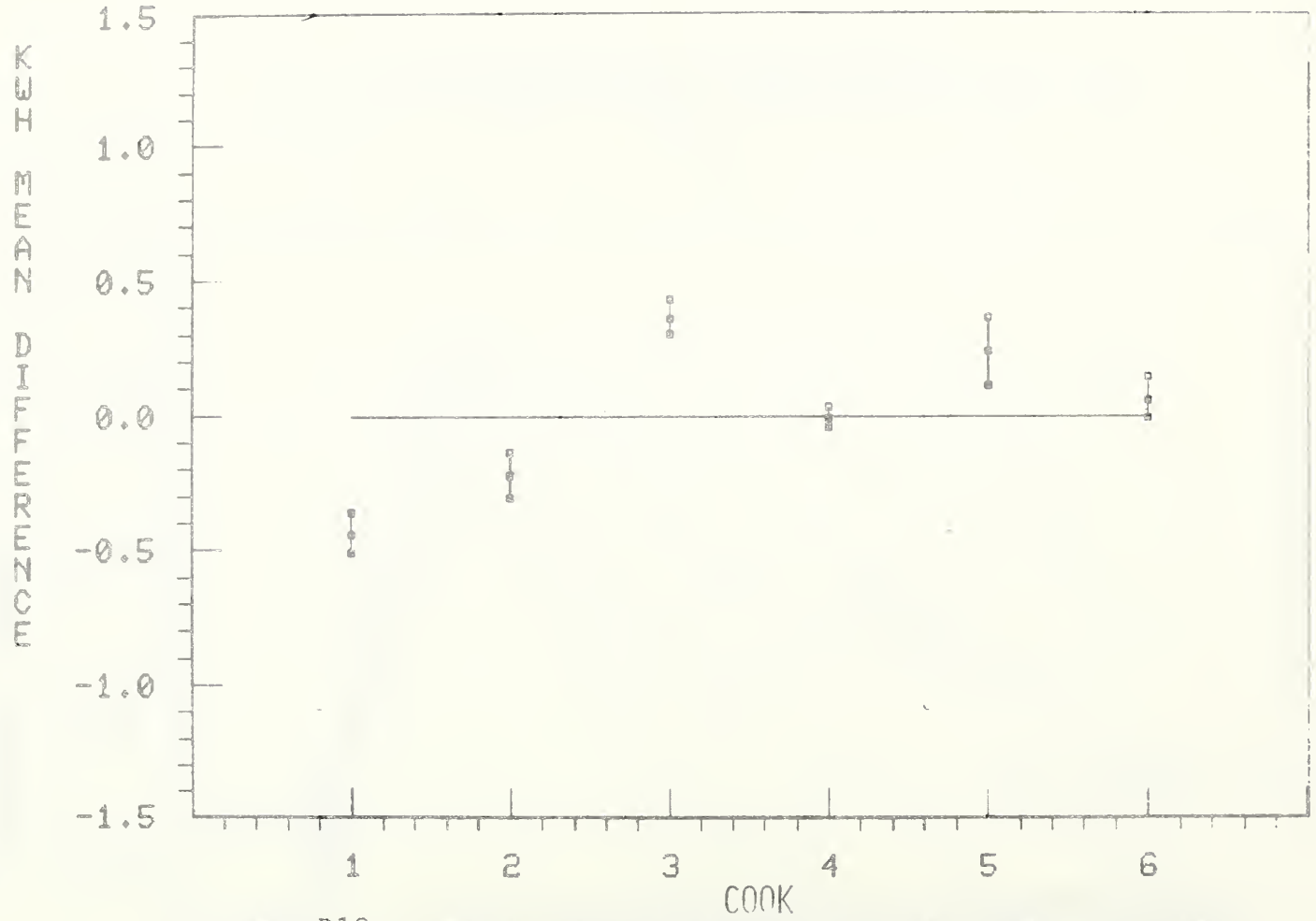


FIGURE D10. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING ELECTRIC RANGE 5 AND THE STD. DEVIATION OF EACH DIFFERENCE.

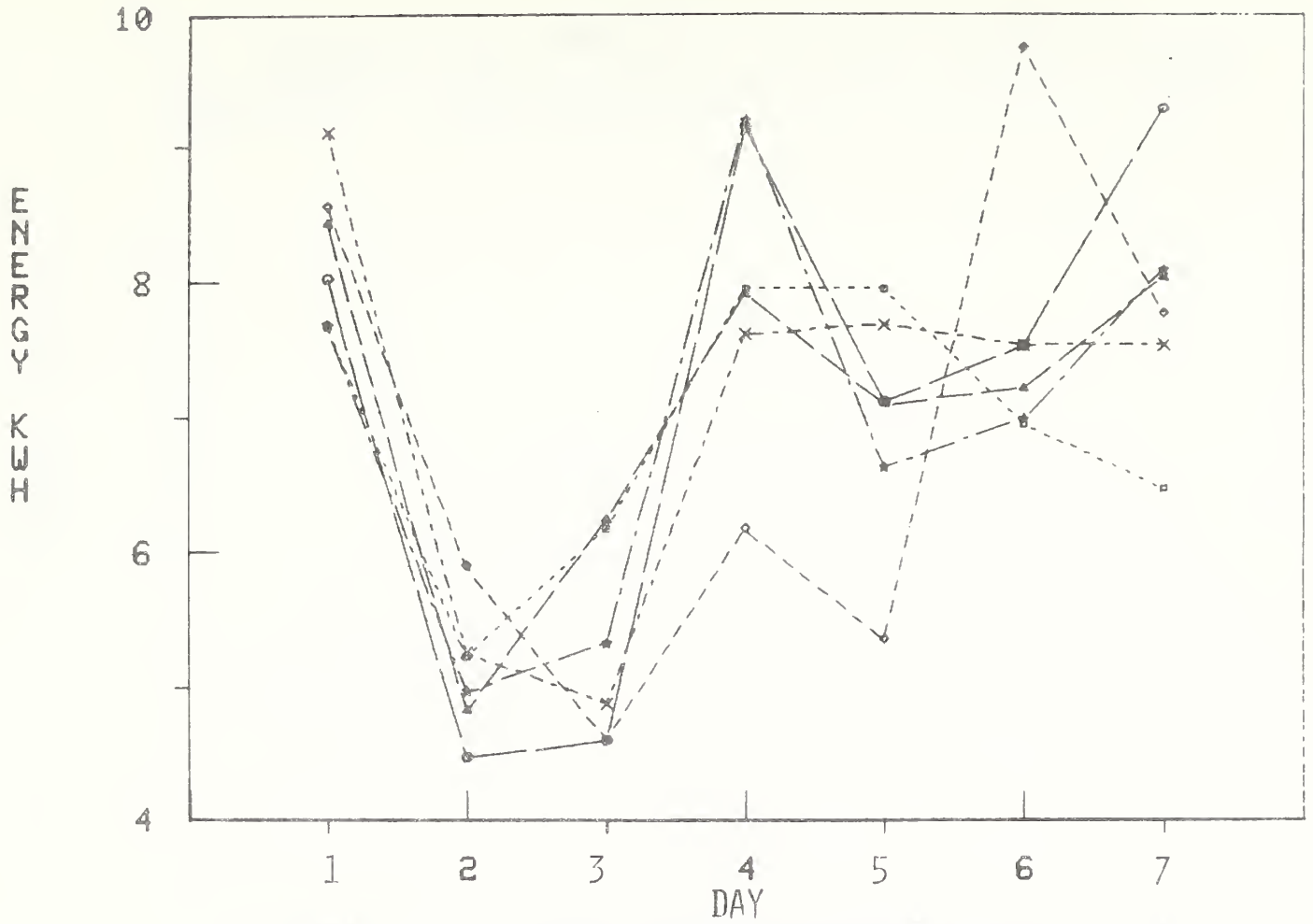


FIGURE D11. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR GAS RANGE 1.

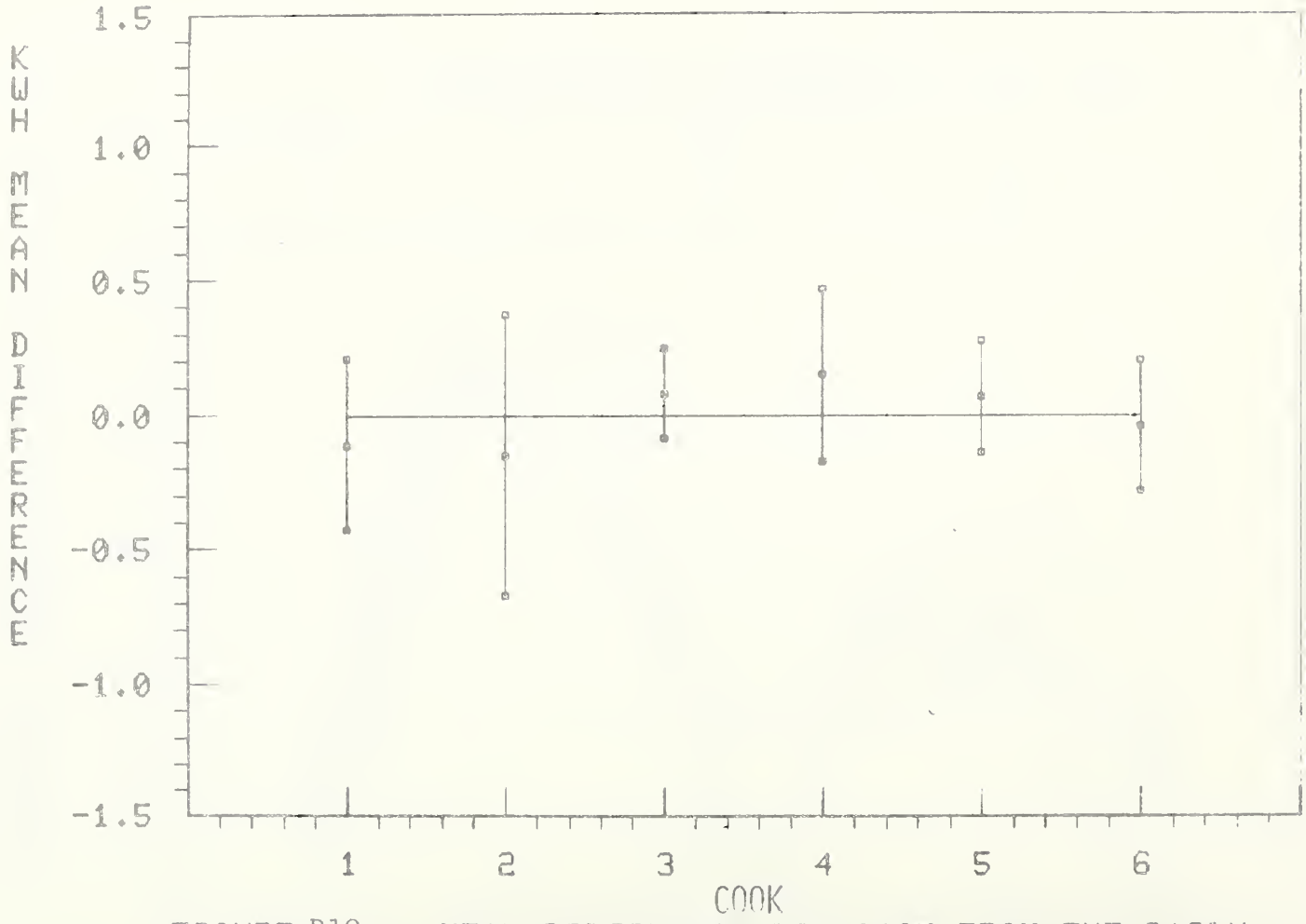


FIGURE D12. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING GAS RANGE 1 AND THE STD. DEVIATION OF EACH DIFFERENCE.

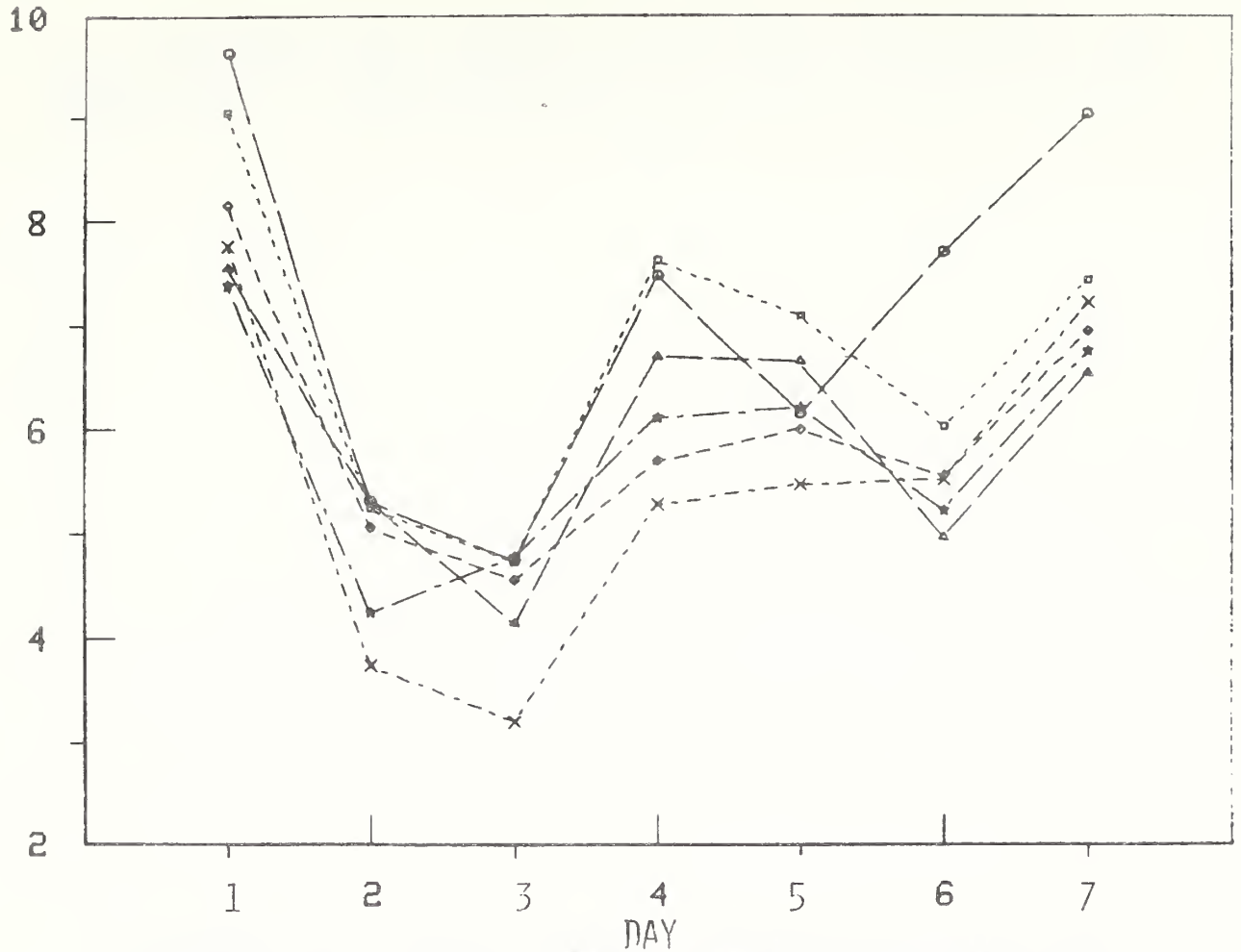


FIGURE D13. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR GAS RANGE 2.

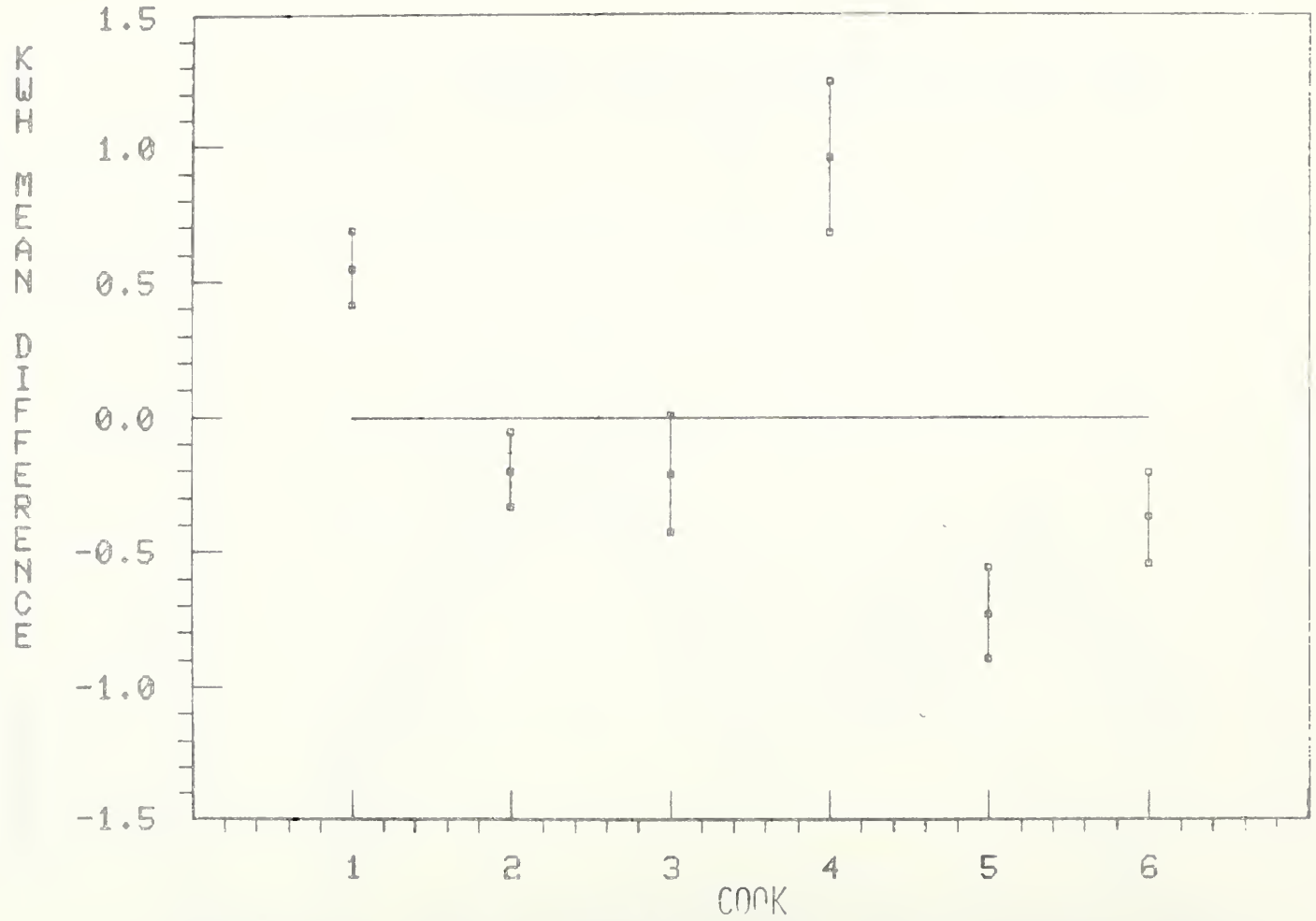


FIGURE D14. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING GAS RANGE 2 AND THE STD. DEVIATION OF EACH DIFFERENCE.

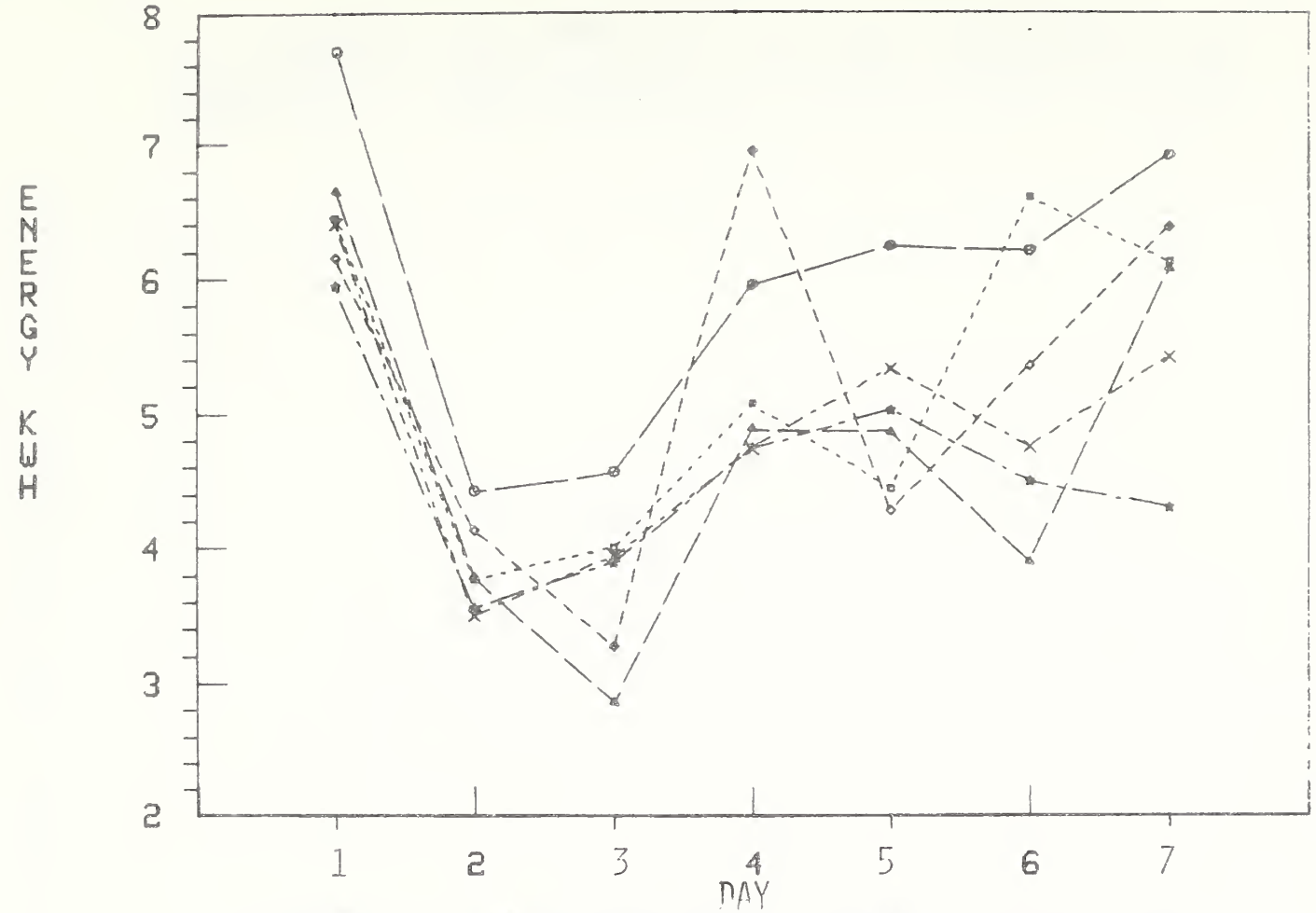


FIGURE D15. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR GAS RANGE 3.

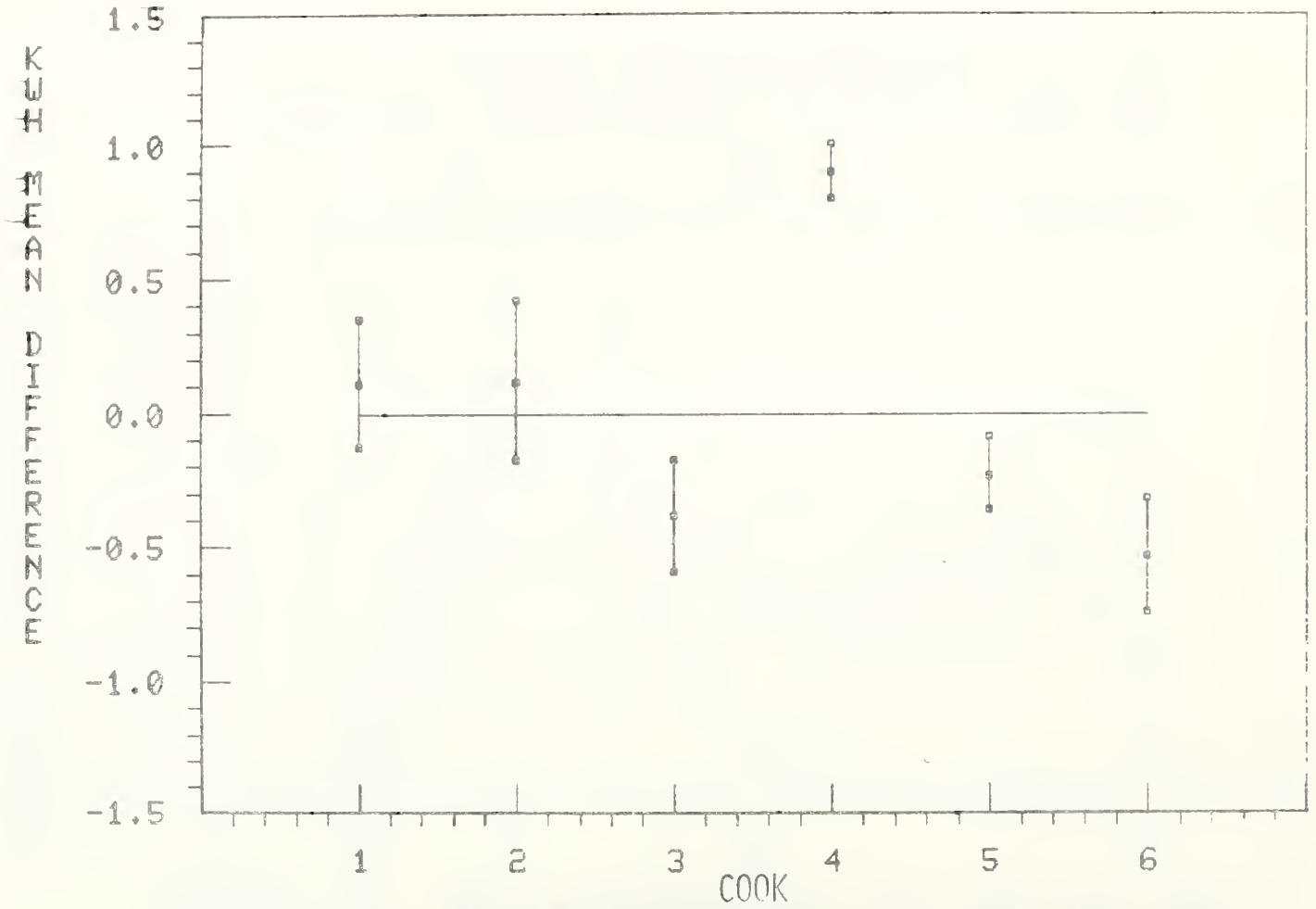


FIGURE D16. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING GAS RANGE 3 AND THE STD. DEVIATION OF EACH DIFFERENCE.

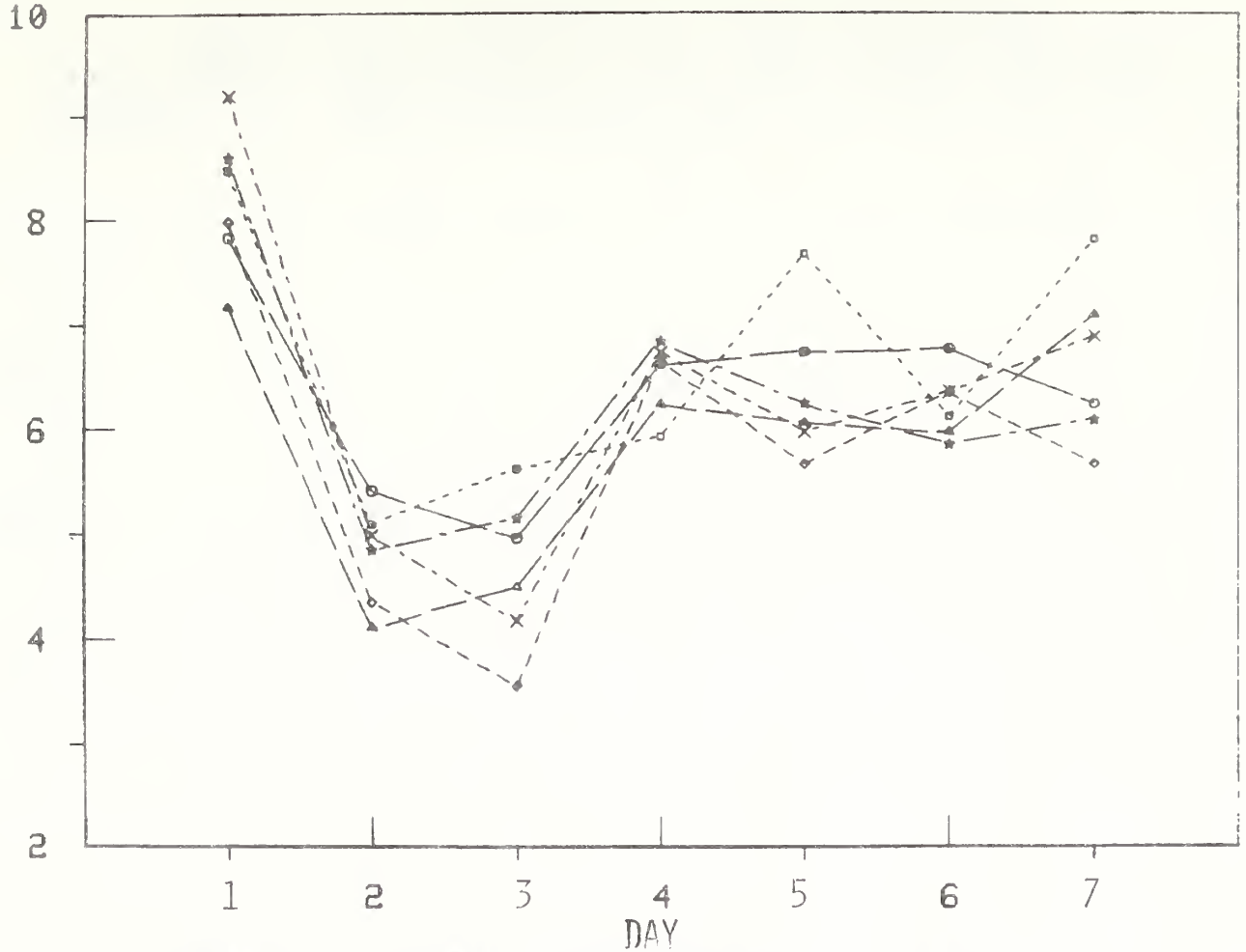


FIGURE D17. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR GAS RANGE 4.

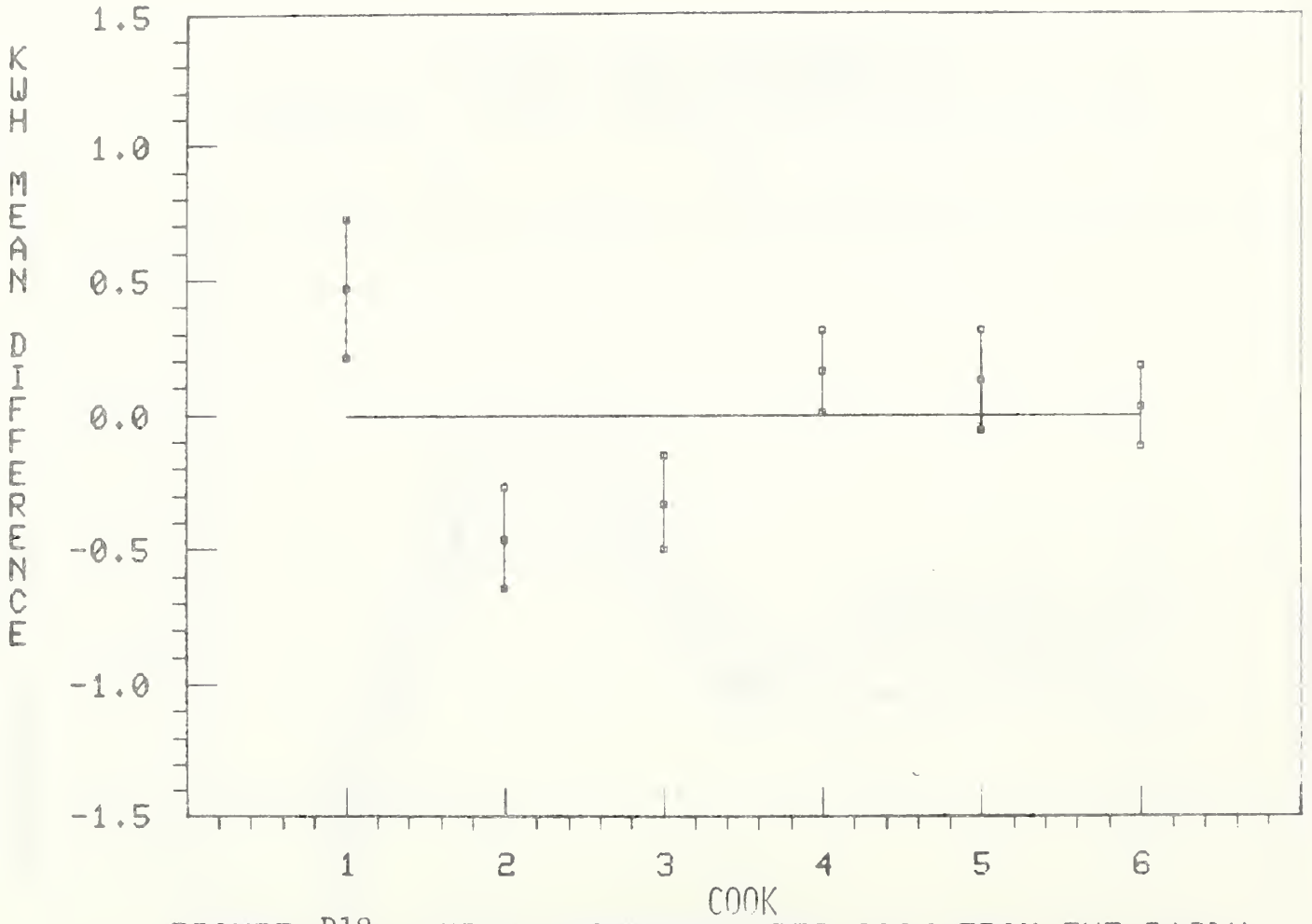


FIGURE D13. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING GAS RANGE 4 AND THE STD. DEVIATION OF EACH DIFFERENCE.

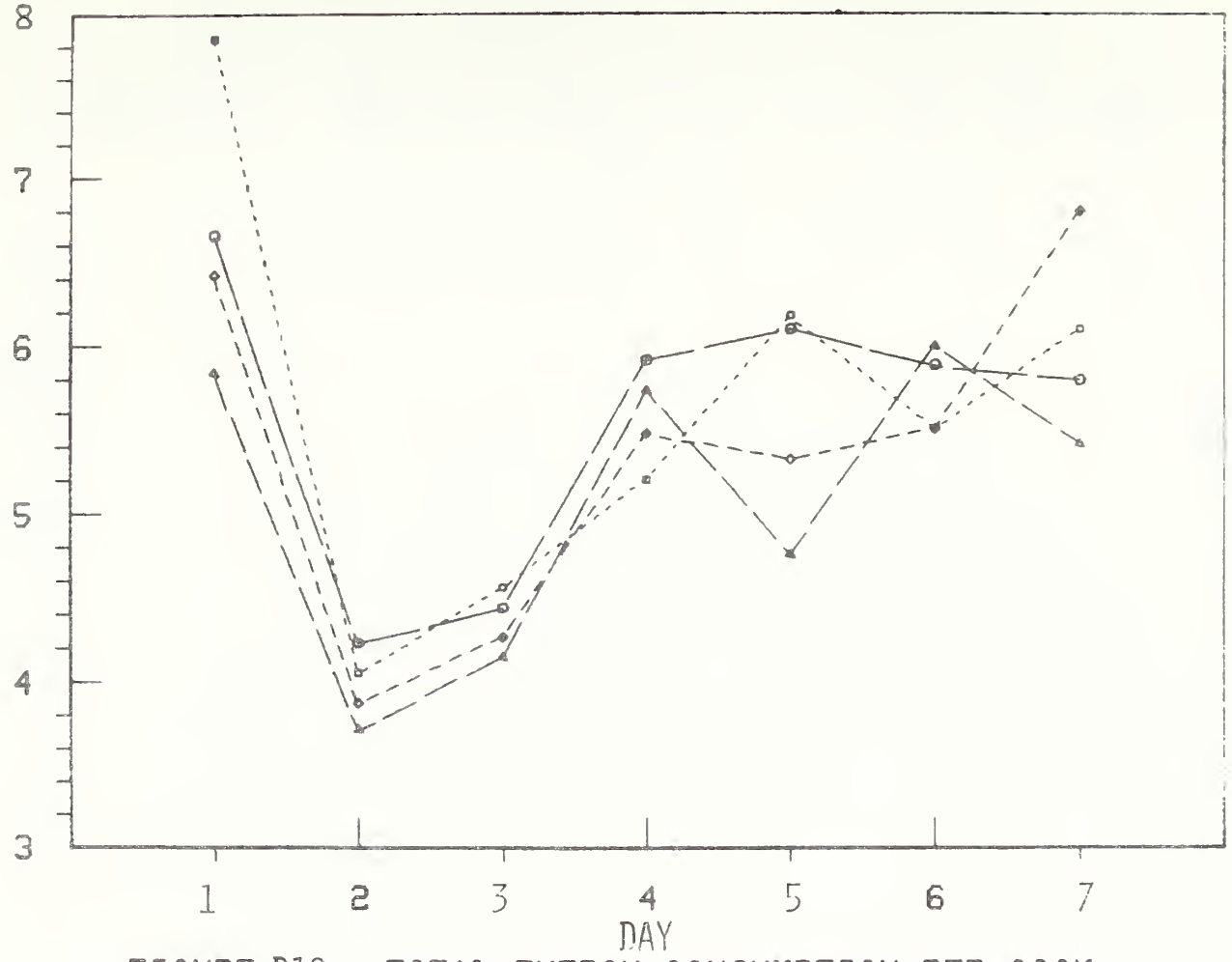


FIGURE D19. TOTAL ENERGY CONSUMPTION PER COOK PER DAY FOR GAS RANGE 5.

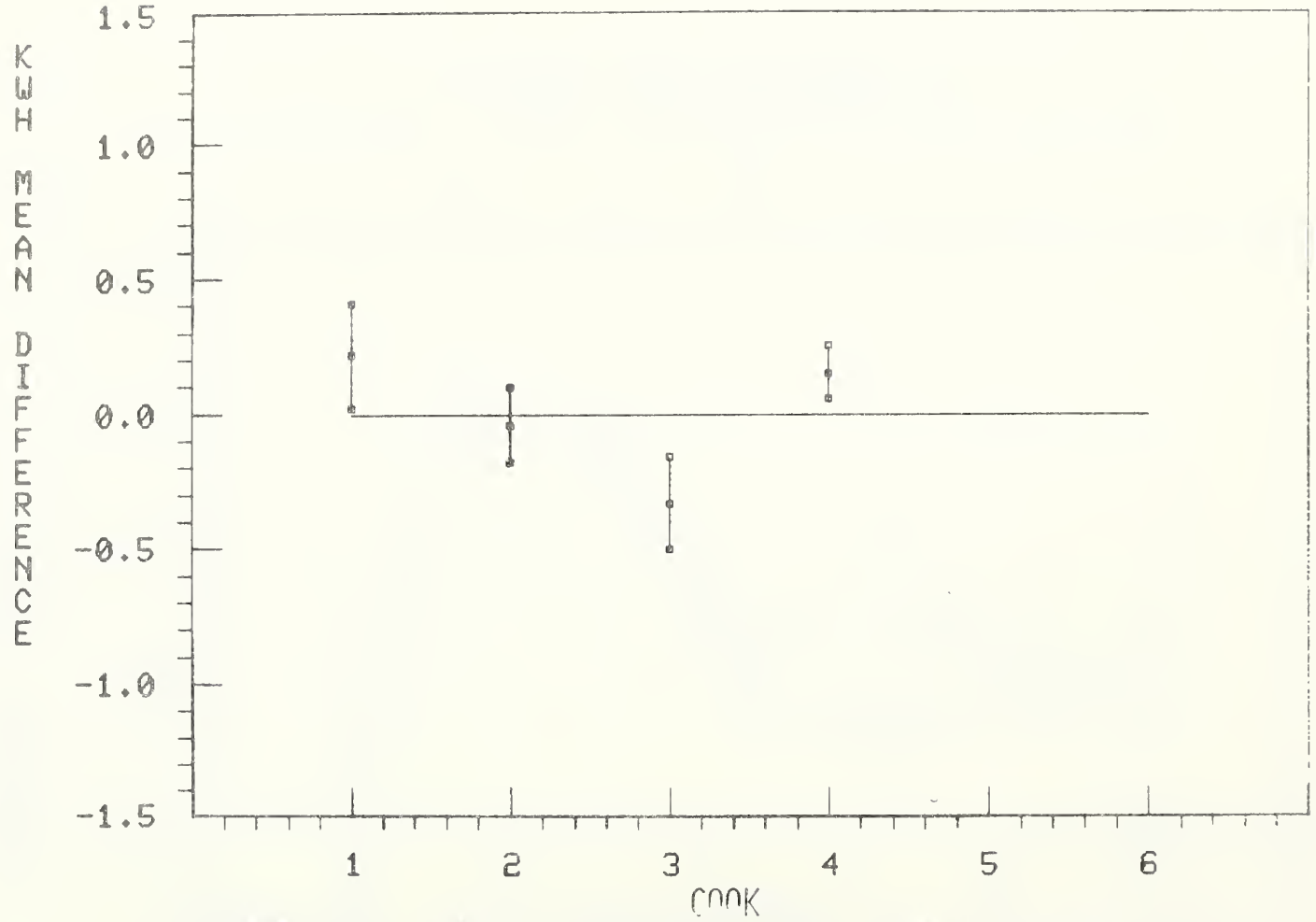


FIGURE D20. MEAN DIFFERENCE PER COOK FROM THE DAILY MEAN ENERGY CONSUMPTION OF ALL COOKS USING GAS RANGE 5 AND THE STD. DEVIATION OF EACH DIFFERENCE.

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

In support of the national appliance energy conservation program, the National Bureau of Standards (NBS) has been developing, evaluating, and recommending standard methods for measuring appliance energy efficiency. This report describes a study where 58 non-professional cooks prepared 21 standard meals each on kitchen ranges, and compares the results with a laboratory test method which does not utilize such cooks. Ten different ranges were tested--five gas and five electric. The results are (1) the rank order (least to most efficient) correlations between laboratory measured efficiency and energy used by cooks were not significantly different, (2) the cooking practices of the 58 cooks were sufficiently alike that no major modification to the laboratory test method was required, (3) homemakers showed greater variability in energy use than did laboratory tests with the same ranges, (4) energy consumption labels on appliances should include information about that variability, and (5) evaluation of range efficiencies could be done with only three to five energy intensive meals.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; seperated by semicolons)*

Appliance; cooking; efficiency; energy; human factors; kitchen ranges; labeling; stoves; test methods

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