3-1934

Choosing and Operating Electric Stoves

A. E. Baragar

E. B. Snyder

Circular 47 March, 1934

Choosing and Operating Electric Stoves

A. E. BARAGAR AND EDNA B. SNYDER
Department of Home Economics

THE UNIVERSITY OF NEBRASKA
COLLEGE OF AGRICULTURE
EXPERIMENT STATION
LINCOLN
W. W. BURR, DIRECTOR

CONTENTS

Choosing and Operating Electric Stoves

A. E. BARAGAR AND EDNA B. SNYDER

Electric stoves have undergone so many changes and improvements during the last few years that many of the experimental tests and recommendations of earlier publications may now be considered as obsolete. The purpose of this circular is to discuss electric stoves as they exist today and to present information which may serve as an aid in choosing and operating this type of cooking appliance. The circular is based on the recent Research Bulletin 68,[1] of the Nebraska Experiment Station, to which the reader who is concerned with experimental procedure is referred.

Although today the prospective purchaser is given more information than in years past, much desirable information about cooking appliances is difficult to obtain. Frequently emphasis is placed upon such features as salt and pepper shakers, mirrors, towel racks, storage space for utensils and the like, and too often the really important features are merely mentioned or neglected entirely.

When comparing one stove with another the important features are quality, working convenience, and cost of operation. The quality of a stove may be determined by observing the general construction, the thickness of the sheet-metal parts, the porcelain-enamel finish, and the metal plating. The working convenience may be determined by the dimensions, with special emphasis on the size of the cooking top and oven. The cost of operation or efficiency may be determined by carefully analyzing the surface units and the oven.

FEATURES DETERMINING QUALITY

General construction.—At first glance one stove may appear to be as well constructed as another, but a closer inspection may reveal distinct variations. Considering first the base (Fig. 1), it will be observed that there are three types. Each type may be either braced or unbraced. The framework should always be inspected, for even on some very expensive ranges the base is only unbraced band iron.

Consider next the corner joints and seams. The joints should be well rounded and tightly fitted together, for such construction assures easy cleaning and prevents the accumulation of grease. Finally it should be noted that sufficient bolts have been used throughout the stove to hold the various parts firmly together.

[1] *A Study of Five Commercial Electric Stoves,* Research Bulletin 68, Agr. Exp. Sta., University of Nebraska.

Thickness of sheet-metal parts.—It is not always possible to determine for oneself about the thickness of sheet-metal parts, although they are a feature that should not be lightly passed over. The thickness of sheet metal is customarily expressed in terms of "gauge", stove metals usually ranging between 18 and 24 gauge (0.049-0.028 inch). The oven top and cooking top should be 18 or 20 gauge and the remaining sheet-metal parts either 20 or 22 gauge. In no case should the principal sheet-metal parts have a thickness less than 24 gauge.

The porcelain-enamel finish. — Although the porcelain-enamel finish is one of the important items on a stove, it is one of the most difficult features to appraise. In judging the enameled parts on a stove one should look for a smooth, glossy surface, free from depressions and ripples, black dots, and hair lines. Black enamel at seams and other junctions is a desirable feature as it chips less easily than white or colored enamels.

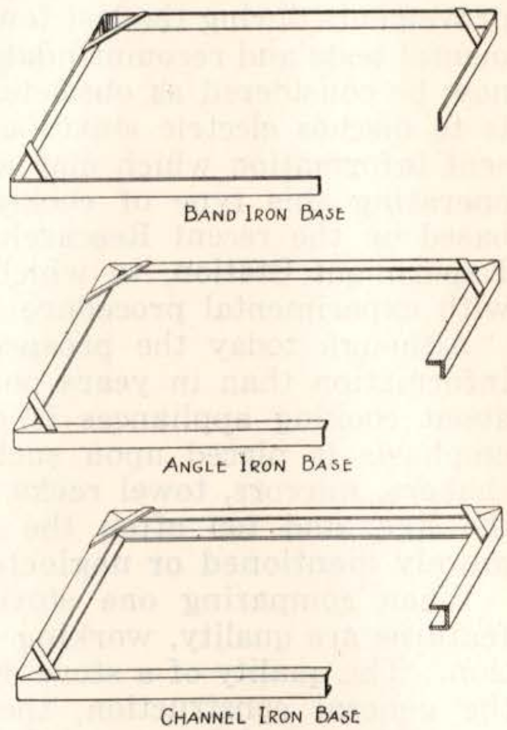

FIG. 1.—Three types of stove bases used on electric stoves.

From the consumer's point of view, porcelain-enamel finishes are desirable, because such surfaces are easily cleaned, they are not stained by non-acid foods, and the operating cost of ovens having enameled surfaces is lower than for those having japan-finished surfaces.

Metal plating.—Metal plating used around the rim of the oven door serves a definite purpose, as it helps to reduce the heat loss of the oven. At all other places on the stove such plating ordinarily serves only as decoration.

FEATURES DETERMINING WORKING CONVENIENCE

Size of cooking top and oven.—Usually when a stove is purchased, too little thought is given to the features of the cooking top and oven and it is not until the stove is put into home service that its shortcomings are revealed. On none of the present electric ranges are the cooking tops as large as one is accustomed to find on wood and coal ranges and the older gas stoves. On some ranges there is a decided crowding of working space. For instance on one of the stoves studied in our laboratory a pot roast cooking in a drip-drop iron kettle could not be centered over a rear unit, and on this same model a teakettle could not be placed on the adjoining unit while the roast was cooking.

The size of the door can not be used as a measure of the size of an oven. This will be obvious when the door is opened and the position of the heating units noted. The size of an oven is usually designated by the width measurement, such as a 15-inch or 16-inch oven, but the height and depth should also be noted. The actual working height of the oven will be the distance between the lowest rack position and the top unit, or when the upper unit is removed (which may be necessary in some cases), it will be the distance between the lowest rack position and the top of the oven.

FEATURES DETERMINING COST OF OPERATION

Surface units and surface cooking.—Special emphasis has been placed on the section which discusses operating cost, for it is seldom that enough information is given to make a careful and accurate comparison of different surface units and ovens. Instead of the technical term "efficiency", the "operating cost of the unit" will be used in this circular to compare different units, since all of the data presented in the following pages have been obtained from actual cooking tests.[2]

The surface units may be divided into two classes—open units and inclosed units. The open units may be easily recognized, since the heating element, which is in the form of spiral wire, is directly exposed. When electricity passes through the wire the heating element becomes hot. This is evident by the bright red appearance of the wire when the maximum heat position, HIGH, is used. For the MEDIUM switch position only part of the element is heated, the hot wire again having a bright red color while the unheated wire is dark. For LOW all of the heating element is again used, but because of the dark color of the wire, the presence of heat is evident only when the hand is held above the unit. For the units studied, the elements were so arranged that a uniform distribution of heat was attained for all three switch positions. Simply from the color of the wire it may be inferred that a unit operating on the MEDIUM switch position uses less electricity than on HIGH, and, when it is on LOW, less electricity is consumed than on MEDIUM. In fact, for

[2] The electric rate used to compute the operating cost was 4 cents per kilowatt-hour.

equal periods of time, a unit on MEDIUM uses just half as much electricity as on HIGH and when on LOW it uses just one-fourth as much electricity as when on HIGH. Expressed in terms of cost, for equal time periods, it costs just one-half as much to operate a unit on MEDIUM as on HIGH and one-fourth as much on LOW as on HIGH. From the standpoint of cost alone, it is evident that a unit should be operated on LOW and MEDIUM as much as possible.

With the inclosed units the various heat conditions are not so evident, as the heating element is incased in metal, usually iron or sheet iron. The heat is transferred through the metal casing to the utensil. Of course the heating wire must be electrically insulated from the iron casing; that is, the insulator must prevent electricity from passing to the metal casing, but at the same time allow the heat to flow through. This is done by using magnesium oxide or some other substance which will conduct heat but not electricity.

Various types of open and inclosed units are shown in Figures 2 to 11. Except for the unit in Figure 6 the only

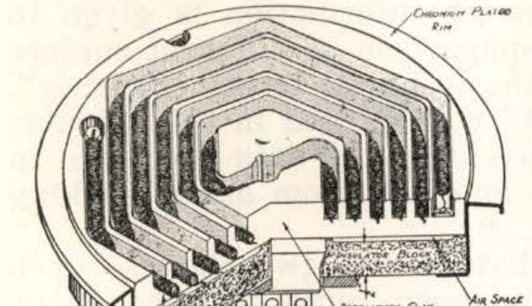

FIG. 2.—Open unit with asbestos insulator block ½ inch thick.

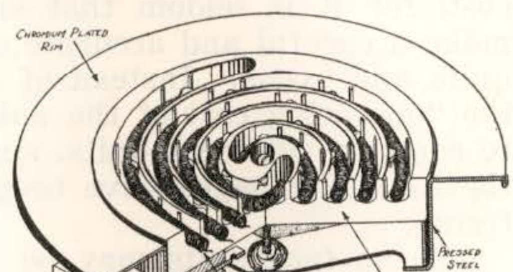

FIG. 3.—Open unit, no insulator block.

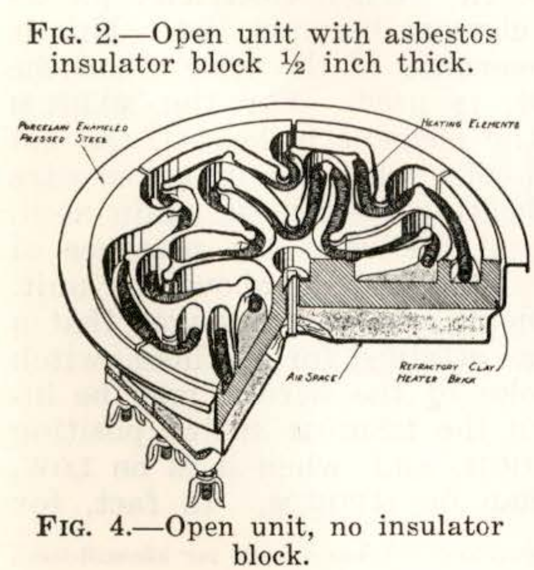

FIG. 4.—Open unit, no insulator block.

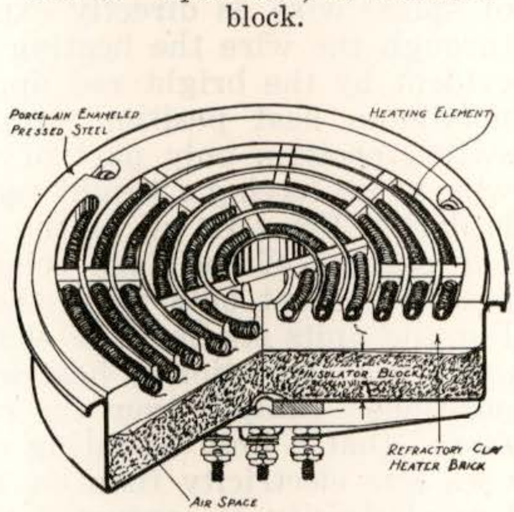

FIG. 5.—Open unit, composition insulator block 1 inch thick.

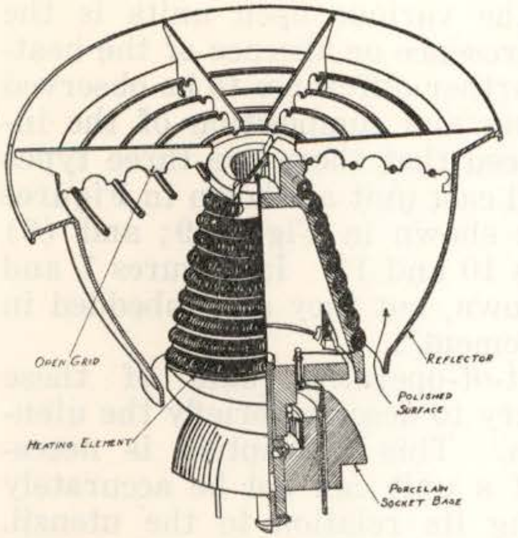

FIG. 6.—Open unit having a metal reflector.

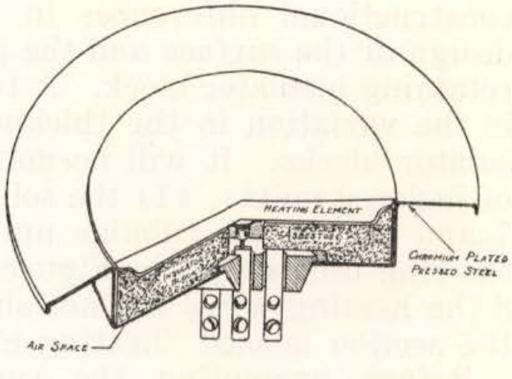

FIG. 7.—Solid-cast unit, asbestos insulator block ½ inch thick, unit surface slightly concave downward.

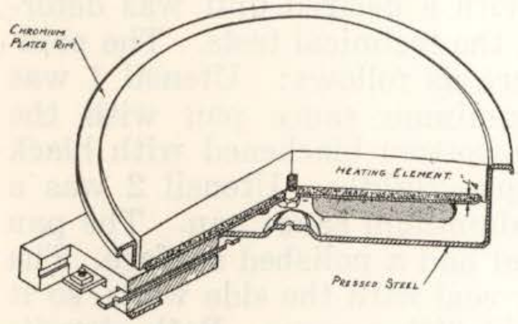

FIG. 8.—Solid-cast unit, asbestos insulator block ¼ inch thick, unit surface slightly concave upward.

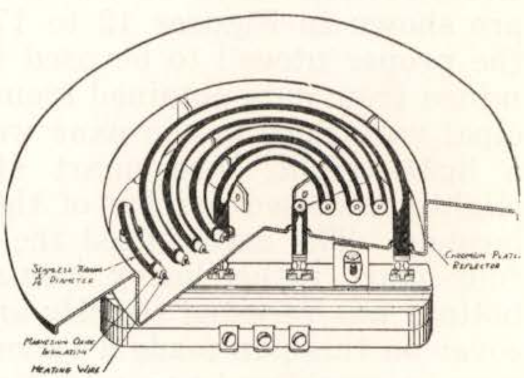

FIG. 9.—Tubular unit.

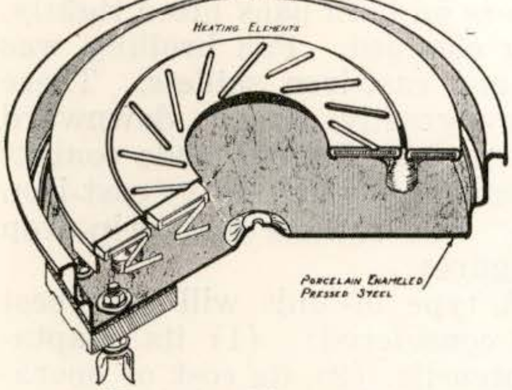

FIG. 10.—Ring unit.

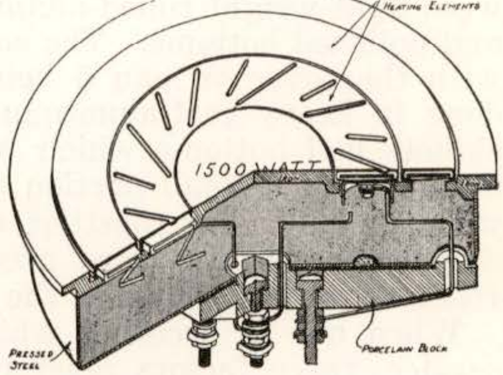

FIG. 11.—Ring unit secured to a cast-iron frame.

constructional differences in the various open units is the design of the surface and the presence or absence of the heat-retaining insulator block. A further difference to be observed is the variation in the thickness and composition of the insulator blocks. It will be noticed that there are three types of inclosed units: (1) the solid cast unit as shown in Figures 7 and 8; (2) the tubular unit shown in Figure 9; and (3) the ring unit shown in Figures 10 and 11. In Figures 7 and 8 the heating wires are not shown, but they are imbedded in the section labeled "heating element".

Before presenting the cost-of-operation data of these various units, it will be necessary to describe briefly the utensils used in this investigation. This description is necessary, for the operating cost of a unit can not be accurately determined without considering its relation to the utensil. Aluminum, porcelain-enameled, and iron utensils were used. Cross-section views of the aluminum and enameled utensils are shown in Figures 12 to 17. In the actual cooking tests the proper utensil to be used with a desired unit was determined from data obtained from the technical tests. The principal variations in the pans were as follows: Utensil 1 was a light-weight, three-quart aluminum sauce pan with the slightly recessed portion of the bottom blackened with black lacquer. The cover fitted the pan tightly. Utensil 2 was a four-quart, rather heavy, cast-aluminum sauce pan. The pan bottom was recessed slightly and had a polished surface. The cover on this pan made a vapor seal with the side walls, so it may be considered as a very tight-fitting cover. Both utensils 3 and 4 were high-grade enameled pans, pan 3 having a three-quart capacity and pan 4 a five-quart capacity. The bottoms of each pan were greatly recessed and uneven. Neither cover fitted the pans tightly. Both utensils 5 and 6 were light-weight rolled-aluminum stock kettles with recessed and polished bottoms. The covers on both pans fitted tightly, with the cover on pan 5 being clamped. Pan broiling was done in heavy cast-aluminum and cast-iron skillets. These skillets had bottoms which were greatly concave downward so that only a small portion of the pan bottom made contact with the unit. For roasting, numbers 8 and 9 heavy cast-iron drip-drop roasters were used. The skillets and drip-drop roasters are not shown in the figures.

When one is deciding which type of unit will give best service, three factors must be considered: (1) its adaptability to the various kinds of utensils, (2) its cost of operation, and (3) its time of heating. In other words the most suitable unit will perform well when used with several kinds

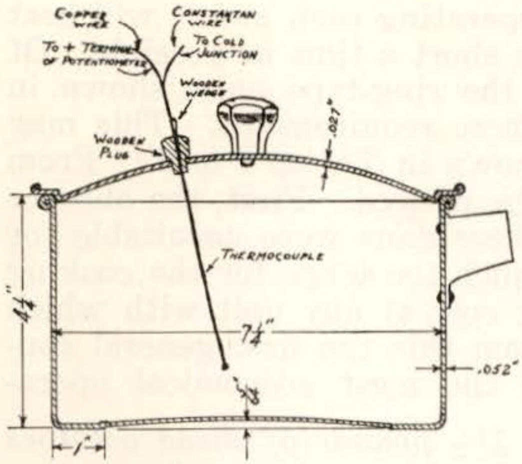

FIG. 12. — Three-quart aluminum sauce pan. The recessed portion of the bottom of this pan was blackened. The thermocouple was used to measure the temperature of any substance in the pan.

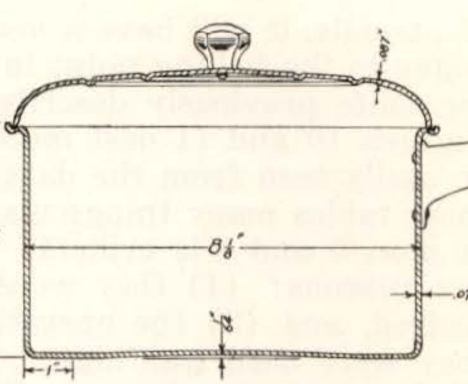

FIG. 13. — Four-quart cast-aluminum sauce pan. Pan bottom was polished.

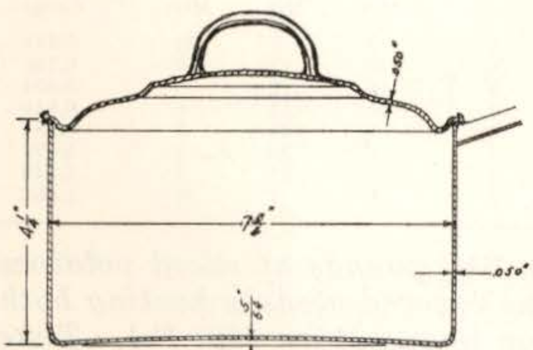

FIG. 14.—Three-quart green-enameled sauce pan.

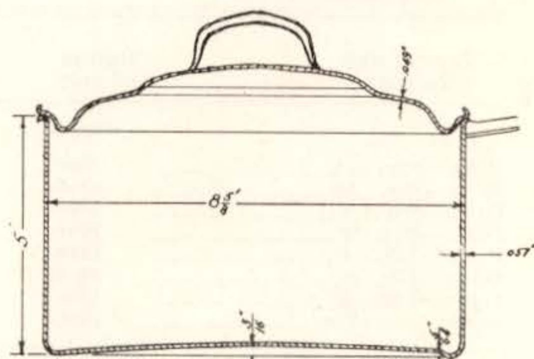

FIG. 15.—Five-quart white-enameled sauce pan.

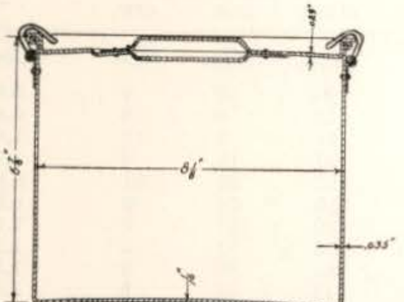

FIG. 16. — Six-quart rolled-aluminum stock kettle, polished bottom.

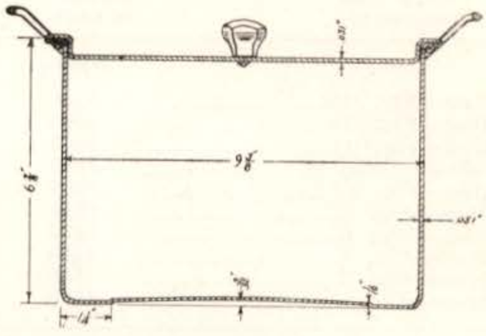

FIG. 17.—Eight-quart rolled-aluminum stock kettle, polished bottom.

of utensils, it will have a low operating cost, and it will heat water to the boiling point in as short a time as possible. Of the units previously described the ring-type units shown in Figures 10 and 11 best meet these requirements. This may be easily seen from the data shown in Tables 1 to 5.[3] From these tables many things may be noticed. First, the absence of pans 5 and 6 is evident. These pans were unsuitable for two reasons: (1) they were much too large for the cooking desired, and (2) the operating cost of any unit with which they were used was high. From this the first general conclusion may be drawn. For the most economical opera-

TABLE 1.—*The cost of cooking 1½ pounds of sliced potatoes in ½ cup of water in various covered utensils heating both unit and potatoes from room temperature (68° F.). Time required—30 minutes. Electric rate 4 cents per kilowatt-hour.*

Type of unit referred to	Rating of unit	Utensil number	Time for each switch position HIGH	LOW	OFF	Cost
	Watts		*Min.*	*Min.*	*Min.*	*Cents*
Ring—Fig. 11	1000	1	9	7	14	0.728
Ring—Fig. 10	1100	1	9	11	10	0.796
Open—Fig. 5	1000	3	10	12	8	0.804
Open—Fig. 2	1000	3	11	19	0	0.940
Open—Fig. 4	1250	3	8	17	5	0.984
Open—Fig. 6	1300	1	6	22	2	0.992
Open—Fig. 6	1300	4	7	21	2	1.048
Solid cast—Fig. 8	1500	2	8	7	15	1.052

TABLE 2.—*The cost of cooking 3½ pounds of sliced potatoes in ¾ cup of water in various covered utensils heating both unit and potatoes from room temperature (68° F.). Time required—30 minutes. Electric rate 4 cents per kilowatt-hour.*

Type of unit referred to	Rating of unit	Utensil number	Time for each switch position HIGH	LOW	OFF	Cost
	Watts		*Min.*	*Min.*	*Min.*	*Cents*
Ring—Fig. 10	1100	1	11	10	9	0.916
Ring—Fig. 11	1000	1	12	9	9	0.960
Ring—Fig. 11	1500	2	10	2	18	1.012
Tubular—Fig. 9	1200	2	11	15	4	1.084
Ring—Fig. 11	1000	2	12	20	13	1.148 [1]
Open—Fig. 5	1000	3	15	18	0	1.208 [2]
Open—Fig. 6	1300	1	10	17	3	1.232
Open—Fig. 4	1250	3	13	12	5	1.284
Open—Fig. 5	1500	4	11	10	9	1.344
Open—Fig. 6	1300	4	12	15	3	1.348

[1] Total time 45 minutes.
[2] Total time 33 minutes.
[3] These tables are not to be considered as a complete analysis for various units and pans. Where a complete analysis is desired the reader is referred to Research Bulletin 68.

TABLE 3.—*The cost of cooking 3 cups of sliced carrots in ½ cup of water in various covered utensils, heating both unit and carrots from room temperature (68° F.). Time required—30 minutes. Electric rate 4 cents per kilowatt-hour.*

Type of unit referred to	Rating of unit	Utensil number	Time for each switch position HIGH	LOW	OFF	Cost
	Watts		*Min.*	*Min.*	*Min.*	*Cents*
Ring—Fig. 10	1100	2	8	6	16	0.640
Open—Fig. 2	1000	1	8	12	16	0.656
Ring—Fig. 11	1000	1	8	7	15	0.660
Tubular—Fig. 9	1200	2	7	9	15	0.692
Ring—Fig. 11	1000	2	9	6	15	0.708
Open—Fig. 4	1250	1	7	8	15	0.720
Open—Fig. 2	1000	4	10	10	10	0.744
Tubular—Fig. 9	1200	3	7	13	10	0.768
Open—Fig. 5	1000	4	10	10	10	0.776
Open—Fig. 5	1000	3	10	10	10	0.776
Open—Fig. 6	1300	1	6	19	5	0.920
Open—Fig. 6	1300	4	7	18	5	0.992

TABLE 4.—*The cost of cooking 4 cups of sliced cabbage in 4 cups of water in various uncovered utensils. Cabbage added to boiling water which had been heated with unit on* HIGH. *Electric rate 4 cents per kilowatt-hour.*

Type of unit referred to	Rating of unit	Utensil number	Time to heat water to boiling with switch on HIGH	Time to cook cabbage HIGH	LOW	OFF	Cost	Remarks
	Watts		*Min.*	*Min.*	*Min.*	*Min.*	*Cents*	
Ring—Fig. 10	1100	1	10	4	0	7	1.068	Last 3 min. water was scarcely boiling
Tubular—Fig. 9	1200	1	9	3	5	4	1.168	Gentle boiling on LOW
Open—Fig. 2	1000	1	14	3	6	3	1.232	Boiled only in center of pan on LOW
Ring—Fig. 11	1000	1	13	4	0	7	1.260	Water boiled more evenly on solid units
Open—Fig. 5	1000	3	15	4	4	2	1.332	Water would not boil around outside of pan
Open—Fig. 6	1300	2	13	10	2	2	2.096	Water would not boil around outside of pan

tion of the unit, only those utensils which fit the units and which have a capacity just large enough to hold the desired quantity of food should be used. Second, all of the cooking was done on units of small watt rating. Stoves are equipped with units of various heating combinations such as "1000-watt open, 2100-watt tubular, and 1200-watt tubular", "2250-watt solid cast, 1500-watt solid cast, and 1200-watt open", and "1500-watt ring, 1500-watt open, 1000-watt ring, and 1000-watt open", but both the experimental and practical cooking

TABLE 5.—*Cost of cooking a 4-pound chuck roast in a covered drip-drop roaster on various units. Electric rate 4 cents per kilowatt-hour.*

Type of unit referred to	Rating of unit	Time on each switch position HIGH	MEDIUM	LOW	OFF	Cost	Remarks
	Watts	*Min.*	*Min.*	*Min.*	*Min.*	*Cents*	
Ring—Fig. 11....	1000	27	0	94	30	3.436	Tender roast
Tubular—Fig. 9	2100	8	0	0	0	3.512	Used only for searing; cooking completed on 1000-watt open of Fig. 2. Well done, tender, brown
Open—Fig. 2	1000	5	14	121	25		
Open—Fig. 6	1300	15	4	111	20	3.836	
Solid cast—Fig. 8	1500	19	0	76	44	4.086	For economical use this unit needs careful attention

tests showed that for economy the units of small rating should be used whenever possible. It is true that the larger units heat the food more rapidly than do the smaller units, but it is also true that they cost more to operate. As is shown by Tables 1, 2, and 3, the total time required to cook potatoes and carrots was 30 minutes, so nothing was gained in time by using the larger units to heat the food in the beginning. The advantage of units of small watt rating was again shown in pan-broiling steaks. The steaks were broiled in the skillets on "1300-watt open" units, "1500-watt open and solid" units, on "2000-watt open and solid cast" units and on "2250-watt solid cast" units. On the 2000-watt and 2250-watt units careful attention was necessary to prevent the steaks from burning. In general it may be safely said that 1000-watt units should be used whenever possible and that there is no need for units larger than 1500 watts. It can be stated also that whenever possible the smaller utensils should be used, since the smaller units are small in diameter as well as small in rating. Third, it will be noticed that some surface cookery was done in open pans. Unfortunately not all surface cooking can be done in closed pans. When it is necessary to cook in an open pan, the food should be covered with sufficient water to allow for excessive evaporation. However, this type of cooking should be avoided as often as possible, for it is much more expensive than covered-pan cooking. This is definitely shown in Table 4. For covered-pan cooking only sufficient water should be used to prevent the food from sticking to the pan. It was found that ordinarily one-half cup to three-fourths cup of water was sufficient for the vegetable cooking in covered pans.

Before summarizing the various factors governing the choice and operation of surface units, it will be well to say a word about the operation. One should use the unit on HIGH only to heat the water and food to the boiling point and should then continue the cooking with the switch on LOW and when the cooking is almost completed turn the unit off entirely so that the heat stored in the unit may be utilized to the fullest extent. It is only by this method that an electric stove may be favorably and economically operated under the present cost of electricity, for one must bear in mind that once the water reaches the boiling point the cooking proceeds just as rapidly when the water is gently boiling as when it is violently boiling. The modern electric ranges are built so that they are more efficient than other types of cooking equipment, but to make use of this efficiency, the operator of the stove must always bear in mind the relative costs of cooking on HIGH, MEDIUM, and LOW.

It is beyond the purpose of this circular to verify each statement in the following summary on surface units and the utensils used with them. If verification is desired the reader is again referred to Research Bulletin 68. From the experimental and practical tests the following conclusions have been drawn.

1. The ring and tubular units are the most adaptable and are recommended for general use. They are economical to operate and the desired heating of food is more rapid with these units than with open and solid-cast units of similar size. Although these units do not store as much heat as the open and solid-cast units of similar size, they are on HIGH much less time than the other types of units so that in general their total energy consumption is less and hence their operating cost is less.

2. Of the open units, that shown in Figure 5 is the most economical to operate. When a purchaser of an electric stove already has a variety of pans and does not wish to buy those recommended for electric stoves, such as are shown in Figures 12 to 17, the open units probably would have a slight advantage over the other types, in as much as the relation of the pan bottom to the open unit is not as important as it is to the inclosed units. When open units are used, the unit will be more efficient and cost less to operate with black-bottomed aluminum pans and enameled-ware pans than with pans having a bright polished bottom.[4] For all cooking the open-type unit shown in Figure 6 was more expensive than the other open units of similar rating.

[4] For reason, see Research Bulletin 68.

3. In general the solid-cast units are not to be recommended, for the relation of the utensil to the unit is too vital. To obtain the maximum efficiency with these units, it is necessary that the pan bottom make absolute contact at every point on the unit surface. Because of the surface conditions of the unit or the surface condition of the pan, such contact is not obtainable except with specially made utensils. For long continuous cooking, such as for pot roasts or dry beans, these units may compete favorably with other types of units, but for all short-time cooking such as for potatoes, carrots, cabbage, etc., they are expensive to operate.

4. Pans which exactly fit the unit, make good contact with the unit surface, and are just large enough to hold the desired quantity of food should be obtained. It is especially important that the cover fit the pan tightly.

5. For economical operation of any unit, the unit should be on the LOW and OFF positions as much as possible. For cooking done with boiling water, the LOW switch position will in most cases furnish enough heat. Water which is gently boiling is just as hot as water which is violently boiling, and when the water boils violently, heat is being wasted through an excessive evaporation of the water. Where small amounts of water are used, unit, pan, water, and food should be heated together. Whenever possible the 1000-watt and 1200-watt units should be used. For all cooking that does not require an uncovered pan, the pan should be covered with a tight-fitting lid. By this method the heat loss due to the evaporation is reduced.

6. As a last reminder, it must be pointed out that unless the operator of an electric stove learns to use the surface units wisely, this type of equipment can not be successfully used in competition with gas.

Ovens.—The oven of an electric stove is usually featured as the major selling point of the stove, for these ovens are designed primarily to bake with stored heat. This is not without justification, for, compared with the ovens on other cooking appliances, electric ovens appear to be superior. The features of construction which determine the merit of an oven are (1) the size of the oven, (2) the exterior finish, (3) lining, (4) the heating elements, (5) the insulation, (6) the door construction, and (7) the thermostat.

The size and exterior finish, which includes plating, have been previously discussed. In ovens there is an added feature from the point of view of both working convenience and efficiency that must be considered, and that is the oven lining.

The lining that is chiefly used is porcelain enamel, but the interiors of some ovens are finished with aluminum or chromium-plated sheet metal. From the point of view of cleaning, an enameled lining is preferable, as aluminum and chromium stain easily. On the other hand enamel chips while aluminum and chromium do not. As for preventing heat loss, the aluminum and chromium linings have a slight advantage because of their bright polished surfaces. However, for practical purposes and when carefully used, enameled linings are very satisfactory.

To the majority of people a good oven will be one that is not only easy to clean but one which heats rapidly and retains the heat for a considerable time with a uniform distribution of heat. The time required to heat the oven to a desired temperature will depend upon both the size of the heating units and the amount of material which must be heated. This material is composed principally of the material in the unit and the insulation in the oven walls. Ordinarily two heating elements are used, one at the top of the oven for broiling and pre-heating and one at the bottom for baking. In most ovens the bottom unit is covered with a plate of sheet iron which acts as a baffle, and this is advisable.

Most of the oven units are the open type, although one stove on the market uses a tubular unit. Various types of heating units are shown in Figures 18 to 22. It will be noticed that the heating wires in the unit of Figure 19 are laid in grooves in a porcelain block. This block is used for the additional storage of heat since the oven with which this unit is used operates upon a different thermostat principle from that of the other ovens. This oven is heated to the maximum desired temperature and then the thermostat permanently turns off the unit, so that all cooking must be finished on stored heat. Any of these units will distribute the heat uniformly throughout the oven. All of the units were rated at 1500 watts except that shown in Figure 21, which was rated at 2000 watts.

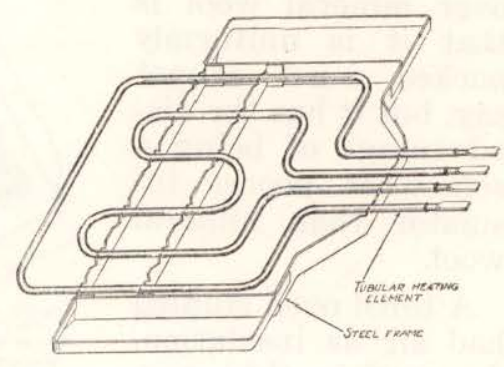

FIG. 18.—Tubular unit, oven A.

After producing the heat, the next thing is to retain it. This is accomplished by insulation. The insulation most commonly used is mineral wool, or, as it is sometimes called, rock wool. Only the best grade of wool should be accepted. An inferior product may be recognized by the multitude of small beads distributed throughout the wool. Ask the salesman to show a sample of this insulation, for since insulation adds materially to the cost of a stove, the purchaser has a right to obtain only the best. An objection that has been made to this type of insulation is that it settles. This is hardly justifiable for such small walls as are used on stoves. To verify this point one of the ovens studied was dismantled and no such settling was found. To be effective this type of insulation should be from 1¾ to 2 inches thick and of uniform density. For insulating ovens with solid materials, mineral wool is perhaps the best. Another insulating material that is occasionally employed is asbestos-cell. This material is built up of layers of corrugated asbestos, forming air cells about ¼ inch in size. The insulation is cut into blocks and fitted into place. Its advantage over mineral wool is that it is uniformly packed and cannot sag, but it has the disadvantage of being a somewhat poorer insulator than mineral wool.

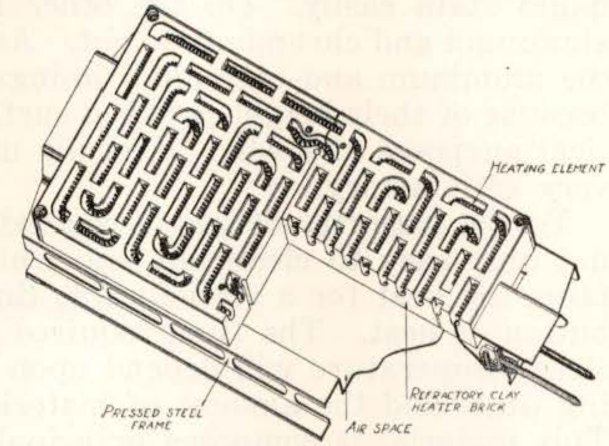

FIG. 19.—Open unit having refractory clay heater block, oven B.

A third oven studied had air as insulation. As used in this oven air proved to be a poorer insulator than either mineral wool or asbestos cell, but this undesirable feature was more than offset by the cheap operating cost of the oven.

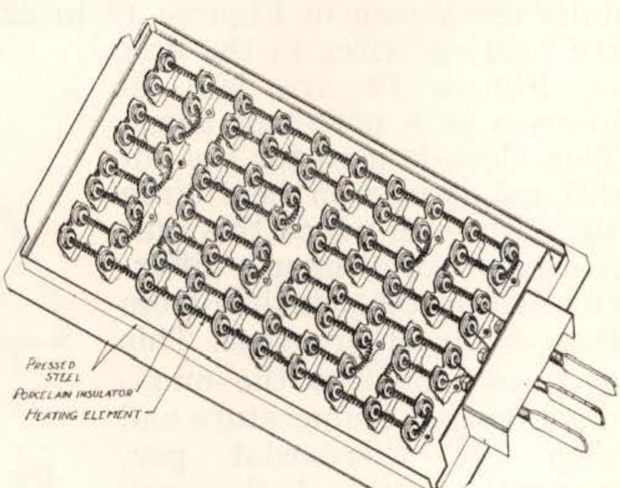

FIG. 20.—Open unit, oven C.

Next to insulation, attention should be given to the door construction. Enough heat may be lost because of faulty door construction to more than offset the advantages gained by good insulation. One should notice particularly whether there are cracks between the door and the oven and whether or not the door lock keeps the door tightly closed. It is advisable that there be a large area of contact between the door and the oven in order to insure a snug-fitting door.

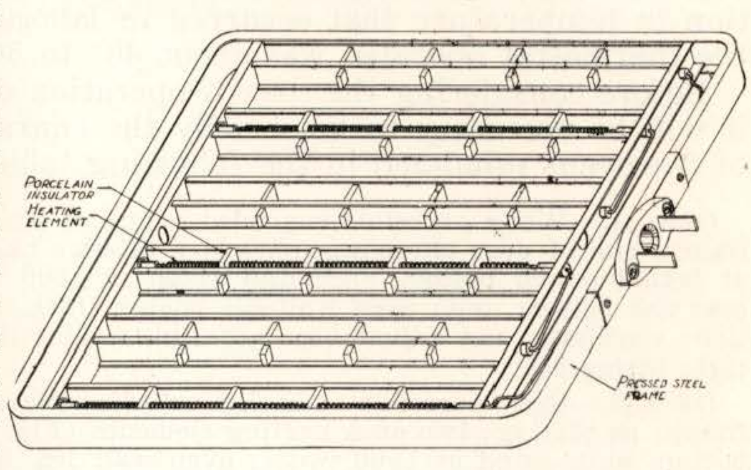

FIG. 21.—Open unit, oven D.

Finally, one of the most desirable features on the modern oven is the automatic heat control. The thermostat or automatic heat control is a device which is used to keep the temperature of the oven as uniform as possible. Because of its principle of operation, the temperature is never constant for any particular thermostat setting, but fluctuates between certain high and low points. However, when the temperatures are averaged for a definite period, it is found that the average temperature remains constant. Two features about a thermostat must be considered: (1) its sensitivity, that is, the difference between the highest and lowest temperature for any setting, and (2) whether the actual oven temperature is the same as that shown on the dial or the temperature indicator. Usually the dial setting does not agree with the actual oven temperature for all settings. With some thermostats the oven temperatures are too high at 500° and 550° F. and too low at 350°, 300°, and 250° F., while other oven temperatures and dial settings agree for temperatures above 350° and 400° F. but are either too high or too low for temperatures below 350° F. The experimental results showed that any of the above cases might be found for any heat

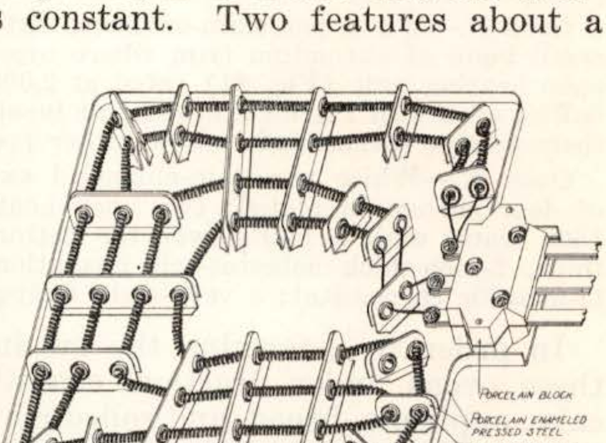

FIG. 22.—Open unit, oven E.

regulator. If actual baking seems to indicate that the oven temperatures are not correct, the operator of the stove should ask the sales representative of the stove manufacturer to check the oven temperatures with a sensitive thermometer and then reset the thermostat if necessary. The usual fluctuation in temperature that occurred in laboratory tests before the thermostat operated was about 40° to 50° F.[5]

Before considering the cost of operation of different ovens, it will be necessary to list briefly the characteristic features of the ovens tabulated in the following tables.

Oven A.—White porcelain-enameled exterior; blue porcelain-enameled lining; rim of door chromium plated; a tubular heating unit (Fig. 18) at both top and bottom, each unit rated at 1500 watts, with a baffle over the bottom unit; oven wall 2⅛ inches thick, mineral wool insulation; ventilation not adjustable; spiral bi-metallic thermostat and fairly tight fitting door.

Oven B.—Gray porcelain-enameled exterior; black porcelain-enameled lining; no plating; two open heating elements (Fig. 19) with baffle over bottom unit, rated at 1500 watts; oven wall 1¾ inches thick, mineral wool insulation; adjustable ventilation; flat bi-metallic thermostat in oven door and fairly tight fitting door.

Oven C.—White porcelain-enameled exterior; blue enameled lining; no plating; two open heating units (Fig. 20) rated at 1500 watts with a baffle over the bottom unit; oven wall 2 inches thick, mineral wool insulation; adjustable ventilation; spiral bi-metallic thermostat and a poorly fitting door.

Oven D.—White porcelain-enameled exterior; chromium-plated lining; small band of chromium trim where oven and door make contact; one open heating unit (Fig. 21) rated at 2,000 watts at bottom of oven; no baffle; oven wall 1⅛ inches thick, air insulation; no ventilation; nitrogen thermometer thermostat and a rather poorly fitting door.

Oven E.—White porcelain-enameled exterior; aluminum lining; rim of door chromium plated; two open heating units (Fig. 22) rated at 1500 watts with a baffle over the bottom unit; oven wall 2¾ inches thick, 2-inch-thick asbestos-cell insulation; adjustable ventilation; flat bi-metallic thermostat; a very tight fitting door.

In order to determine the merits and operating costs of these ovens under practical conditions, sponge cake, butter cake, apple pie, bread, and rolled rib roasts were baked in each oven.[6] The results of the baking are shown in Tables 6 to 11. The tables show in all cases oven D was the cheapest to operate. The only reason for this is the short time and hence the

[5] For further information on the thermostats, the reader is referred to Research Bulletin 68.

[6] The recipes for the cakes, pie, and bread are given in the appendix.

TABLE 6.—*The cost and time required to bake a large sponge cake. Baking started in a cold oven. Electric rate 4 cents per kilowatt-hour.*

Oven	Thermostat setting	Time required	Cost
	°F.	*Minutes*	*Cents*
D	325	32	1.9
A	325	60	2.9
B	325	60	3.7
C	325	81	4.0
E	325	60	4.0

TABLE 7.—*The cost and time required to bake medium-sized butter cake. All ovens preheated. Electric rate 4 cents per kilowatt-hour.*

Oven	Thermostat setting	Time required	Cost		
			Preheat	Bake	Total
	°F.	*Minutes*	*Cents*	*Cents*	*Cents*
D	350 375	50	0.71	1.50	2.21
A	350	63	1.94	1.70	3.64
B	350 375	50	3.47	0.21	3.68
C	375	53	1.87	2.03	3.90
E	350	78	1.85	2.06	3.91

TABLE 8.—*The cost and time required to bake a large apple pie. All ovens preheated. Electric rate 4 cents per kilowatt-hour.*

Oven	Thermostat setting	Time required	Cost		
			Preheat	Bake	Total
	°F.	*Minutes*	*Cents*	*Cents*	*Cents*
D	450 375	36	1.46	0.98	2.44
A	450	27	2.82	1.06	3.88
E	425	39	2.29	1.65	3.94
C	450	37	2.42	1.97	4.39
B	450 475	43	4.36	1.15	5.51

TABLE 9.—*The cost and time required to bake 1 loaf of bread. All ovens preheated. Electric rate 4 cents per kilowatt-hour.*

Oven	Thermostat setting	Time required	Cost		
			Preheat	Bake	Total
	°F.	*Minutes*	*Cents*	*Cents*	*Cents*
D	450 375	60	0.98	1.96	2.94
A	400 350	60	2.33	0.96	3.29
E	400	60	2.09	1.60	3.69
B	350 375	50	3.47	0.45	3.92
C	400	60	2.05	1.98	4.03

TABLE 10.—*The cost and time required to bake 6 loaves of bread. All ovens preheated. Electric rate 4 cents per kilowatt-hour.*

Oven	Thermostat setting	Time required	Cost		
			Preheat	Bake	Total
	°*F.*	*Minutes*	*Cents*	*Cents*	*Cents*
C	450 400	60	2.05	3.98	6.03
D	500 400	86	1.24	4.82	6.07
E	400	57	2.09	4.71	6.80
B	350 375	42	3.23	3.75	6.98
A	400 350	66	2.33	5.04	7.37

TABLE 11.—*The cost and time required to roast a 4½-pound rib roast. Ovens D and E preheated. Electric rate 4 cents per kilowatt-hour.*

Oven	Thermostat setting	Time required	Cost		
			Preheat	Bake	Total
	°*F.*	*Minutes*	*Cents*	*Cents*	*Cents*
D	500 400	142	1.26	5.34	6.6
C	425 375	180	......	......	7.6
E	450 350	134	2.52	5.48	8.0
A	400	180	......	......	8.3
B	500	180	......	......	8.9

small amount of electricity needed to preheat this oven. However, two serious objections arose with this oven: (1) the baked products obtained did not compare in quality with those produced in ovens A and E, and (2) the thermostat did not accurately represent temperatures below 450° F., the lower thermostat settings being more inaccurate than the higher ones. From the point of view of agreement between thermostat settings and oven temperatures and the quality of the baked products, ovens A and E were the most satisfactory. For all baking the heat regulators were set at temperatures recommended by the manufacturer. These temperatures were given in the recipe and instruction book accompanying each stove. Where two thermostat settings are given, the first one indicates the temperature to which the oven was preheated and the second one the baking temperature. The advantage gained by using part of the preheating energy for baking is shown in Table 6. However, since most baking requires an oven preheated when the food is placed in the oven, this reduction in operating cost can not usually be utilized.

Biscuits baked in all the ovens showed that the oven temperatures were uniform at 500° F. However, it is to be noted that biscuits baked on a baking sheet in oven D could not be browned, but when baked in pie tins a satisfactory product was obtained. The baking sheet apparently prevented the proper distribution of heat in the upper part of the oven.

During all the baking, the oven door was opened as little as possible. The results showed that with increased opening of the door there was a corresponding increase in the cost of operation. After the food has been placed in the oven having an automatic temperature control, the door should not be opened until the food is ready to be removed.

Summary.—When choosing an oven, it is desirable to obtain one having the following features:

1. The exterior finish should be a high-grade porcelain enamel fused on sheet metal of the proper thickness. The rim of the oven door should be chromium or nickel plated.

2. Porcelain-enameled linings are probably preferable for most people, although either aluminum or chromium plated linings should be satisfactory.

3. The oven should be large enough to fill the needs of the ordinary family baking. A 16-inch oven with correspondingly large heights and depths should probably be set as a standard.

4. Two 1500-watt heating units are recommended. The units should be large enough to heat the oven quickly, but they should not use an excessive amount of electricity. A baffle should be used over the bottom unit.

5. An oven may be excellently insulated with 2 inches of mineral wool of uniform density. As insulation, air is excellent if the oven wall is properly constructed.

6. There should be a large area of contact between the oven and the door and the door should fit the oven tightly. This may be obtained with a carefully constructed door and a tight door clasp.

7. To obtain accurate temperature control it is essential that the thermostat be of high quality and carefully adjusted. The dial of the heat control should be calibrated so that for each setting it indicates accurately the actual temperature which the thermostat maintains in the oven.

For all automatically controlled ovens there is only one thing that the operator can do to vary the baking costs, and that is to open the oven door. The insulation will retain the heat and the thermostat will cause the unit to be on as little as possible to maintain proper oven temperatures, but savings obtained by these features may be more than offset by too frequently opening the door. When baking, the important precaution to observe is, do not open the oven door any more than is necessary, and ordinarily the door will not need to be opened until the food is ready to be removed.

APPENDIX

Sponge cake	6 egg whites, 6 egg yolks, 1 cup sugar, 1 cup pastry flour, salt, lemon.
Butter cake	½ cup butter, 1 cup sugar, 2 eggs, ½ cup milk, 1¾ cups flour, 2½ teaspoons baking powder, salt, vanilla.
Apple pie	1¾ cups flour, ½ cup lard, ½ cup sugar, 18 ounces sliced apples.
Bread	1 cup water, 4 to 5 cups flour, 1 teaspoon salt, 1 tablespoon fat, 1 tablespoon sugar, 1 cake compressed yeast. A single loaf when baked weighed approximately 1¾ pounds.
Biscuits	3 cups Bisquick flour—milk to make soft dough.

[7½M]