TECHNICAL REPORT

70-11-GP

AD

THE SPEED FIELD FEEDING SYSTEM

by

Major Morton Fox

and

Major Avalon L. Dungan

August 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

U.S. ARMY MATERIEL COMMAND

General Equipment
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ABSTRACT

The SPEED Field Feeding System consists of a company-size kitchen and a brigade-size bakery. Both units are all-electric, mobile, and completely self-contained for one day's operation. A 60-kW gas-turbine generator set, similar to the type used on commercial aircraft as an auxiliary power source, is located in each unit, and is the sole power source for the unit.

Microwave ovens, with their ultra-rapid cooking characteristics, are the primary cooking sources in an "integrated cooking" system. Also utilized are a forced hot-air convection oven and a large grill. These items of equipment work in conjunction with one another and represent a unique approach to cooking.

One of the most important advantages of the SPEED system over the existing system is the saving in personnel. By the use of expendable trays, flatware, and cups, which are subsequently burned in an incinerator located in the SPEED kitchen, the requirements for KP's have been reduced. Other advantages are the improved working conditions for the cook, increased mobility, improved sanitation, and on-board refrigeration.

The SPEED system is now in the Exploratory Development Phase with prototypes undergoing field evaluation. Test results, to date, have been promising.

THE SPEED FIELD FEEDING SYSTEM

INTRODUCTION

A field feeding system, "Subsistence Preparation by Electronic Energy Diffusion" (SPEED) is currently under development at the U. S. Army Natick Laboratories. It is designed as an integrated approach to provide a more effective means of feeding troops in the field. SPEED was originally based on the use of microwave energy as a primary source of cooking energy. The acronym is now more indicative of the overall goal of the project to speed all aspects of subsistence logistics.

Feasibility studies have been conducted at NLABS and by a contractor[1] using the concept of an all-electric mobile field kitchen and supporting field bakery. In the initial phase of the studies, the required technical characteristics were matched by the contractor against the most current technology and industrial capability, and a design which could be produced was proposed. After the acceptance of the design, operating conceptual models were constructed. The SPEED kitchen and bakery were first tested for food preparation for the enlisted mess at NLABS. A two-week field evaluation was conducted at Vietnam Village, Fort Devens, Massachusetts. Data collection will continue to provide a basis for a cost-effectiveness study and to allow the concept formulation to be completed. Concept formulation will provide a basis upon which to begin engineering design and service tests leading to type classification.

This report describes (1) the equipment of the SPEED kitchen and bakery, and (2) SPEED cooking and baking methods.

SPEED EQUIPMENT

Power Selection

One of the foremost questions to be answered in the design of a field kitchen is the selection of a safe, reliable cooking system. Each cooking method has advantages and disadvantages which must be carefully evaluated for logistical implications. For example, the use of liquified petroleum gas (LPG) would have many engineering advantages. However, a complete LPG distribution system would have to be added to the current petroleum, oil, and lubricants (POL) distribution system. Until recently, the use of electrically powered food service equipment was similarly impractical, since the power requirements of a company-size field mess were such that only large internal combustion generator sets would suffice.[2] The disadvantages of standard diesel generator sets are their low power-weight ratio, noise level, limited versatility, and life. An all-electric kitchen would have required a large, noisy generator mounted on a separate trailer. This problem was solved in the SPEED kitchen and bakery by using a lightweight, 60-kW gas-turbine generator, which provided a 90% weight reduction and a 60% volume reduction over military standard diesel generators. The performance and reliability of turbine generators have been demonstrated by military and commercial aircraft experience. The turbine generator used in the SPEED system is similar to the generators used with the Medical Unit Self-Contained Transportable (MUST) hospital system and as the auxiliary power unit on many commercial jet aircraft. The turbine generator sets in the SPEED kitchen and bakery are located in the forward end of the units. They are easily accessible for mounting and/or replacement, as they are mounted on pull-out slides (Fig.1). The entire turbine generator set is a module which may be completely replaced in about 30 minutes.

The availability of the compact gas turbine generator allowed SPEED designers to make use of an electrically powered cooking system with its advantages of accurate temperature control, cleanliness, relatively simple and easily maintained equipment, and good safety features. The latter advantage refers mainly to the fact that all other cooking systems utilize direct conversion of fuel to heat within the kitchen shelter with the inherent potential danger of fire and explosion. The selection of an electrical power system also made possible the use of microwave energy with its ultrarapid heating capabilities.

In addition to the above advantages of an electrical system, extensive research being conducted in the development of multipurpose and tactical electric power sources within DoD[3] indicate that an electrical cooking system should be most compatible with future battlefield power systems.

In both the kitchen and bakery, the gas turbine bleed-air is utilized to provide air-cycle air-conditioning, either heating or cooling as required. Through a system of heat exchangers, the turbine exhaust is used to heat water for sanitation. The exhaust of the turbine is also combined with the exhaust of the on-board incinerator. The high turbine exhaust temperature serves as an after burner for complete combustion eliminating all smoke. This arrangement also provides a slightly negative pressure within the incinerator allowing waste materials to be put in without danger of flames coming out the entry doors.

Support Capability

The current Qualitative Materiel Requirement (QMR) for a mobile field kitchen calls for a capability to prepare, cook, and

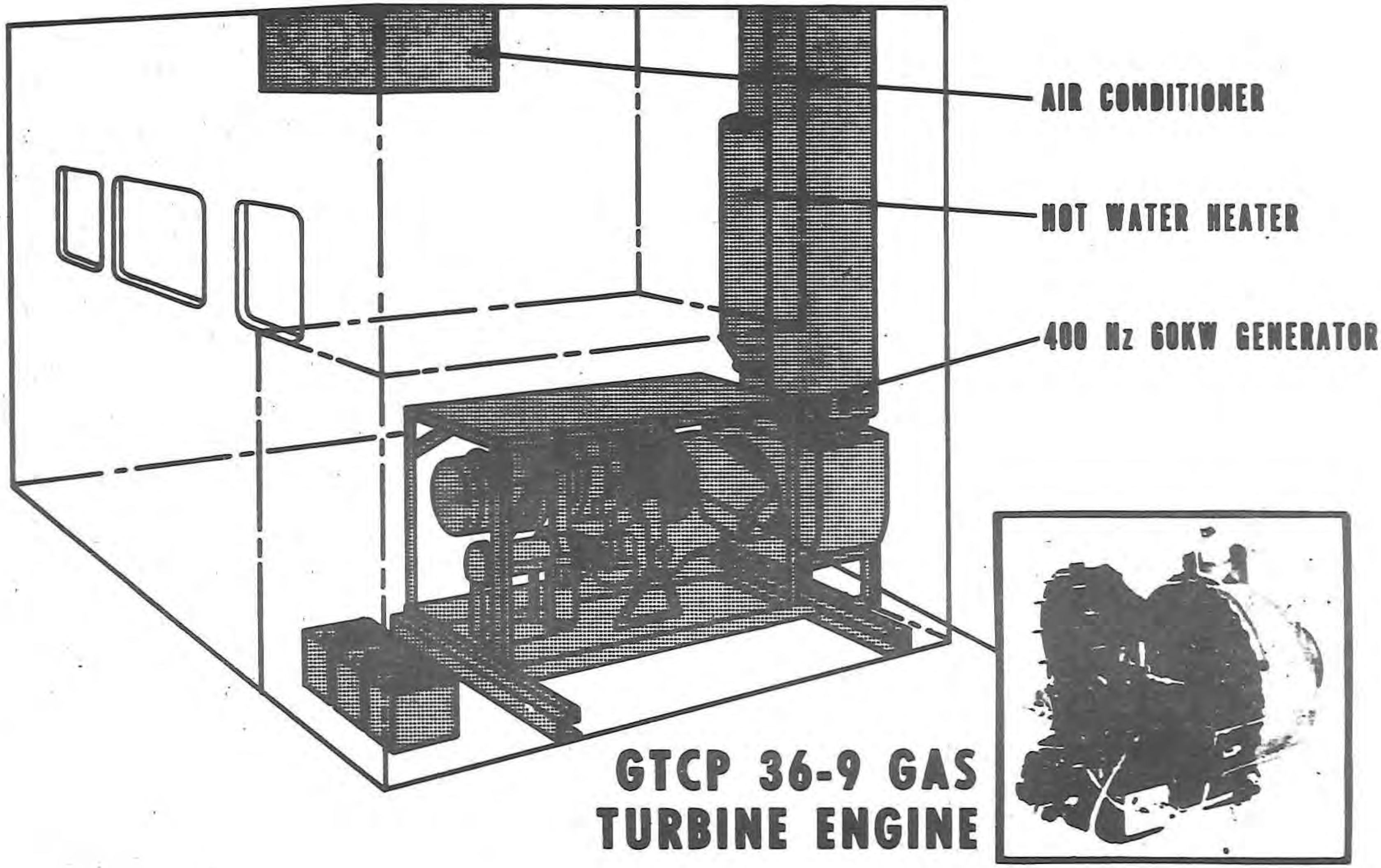

Figure 1. SPEED Power System

serve A rations, unitized B rations, or the meal, uncooked, 25-man for a unit mess of 200 men. The SPEED kitchen was designed to meet this QMR since this represents the latest stated requirement of the Army.

The SPEED bakery was designed to provide either field bread or pastries for 5,000 men or a brigade-size unit. Current field equipment has a higher support capability, but distribution of fresh bread to widely scattered units frequently presents problems. Field distribution of pastries such as pies, cakes, and cookies is not currently practiced. The provision of two SPEED bakeries to provide bread and pastries at the brigade level was envisioned to help solve distribution problems and to provide also the capability for central distribution of pastries.

Preliminary investigations indicate that there is excess oven capacity in the SPEED kitchen and that consideration may be given to elimination of the need for a field bakery. Bread and pastries would be produced at the unit level in off-hours. Both concepts will be evaluated in field testing of the SPEED kitchen and bakery.

Mobility

The SPEED kitchen and bakery are mounted in shelters or pods with outside dimensions of approximately 12' x 7' x 8'. Each unit was designed to be completely self-supporting for one day. For the kitchen this means enough food, fuel, and water to prepare three meals for 200 men. In the bakery this would include ingredients, fuel, and water to bake one day's issue of bread or pastry for 5,000 men. Additional cooling and storage racks are required outside the bakery pod. This equipment will normally be located on the prime mover.

The pods may be transported by a variety of methods, as shown in Fig. 2. They are air-transportable by either cargo plane or heavy helicopter, and the equipment has been designed to withstand stress and shocks encountered in air-mobile operations.

Although the pods may be moved by air, rail, truck, or ship, the primary method recommended for field use is by military standard transporter. This method is preferred for field use over truck-mounting, since it frees the prime mover to perform resupply missions. The kitchen has its own power and storage capabilities, and it can be dropped off by the mess truck at rendezvous points. The kitchen then continues to operate while the mess truck picks up food, fuel, and water from the Class I and Class III Supply Points. In the absence of the mess truck, it can be towed over relatively smooth terrain by the 3/4-ton cargo vehicle or 1/4-ton truck, should emergency conditions require movement.

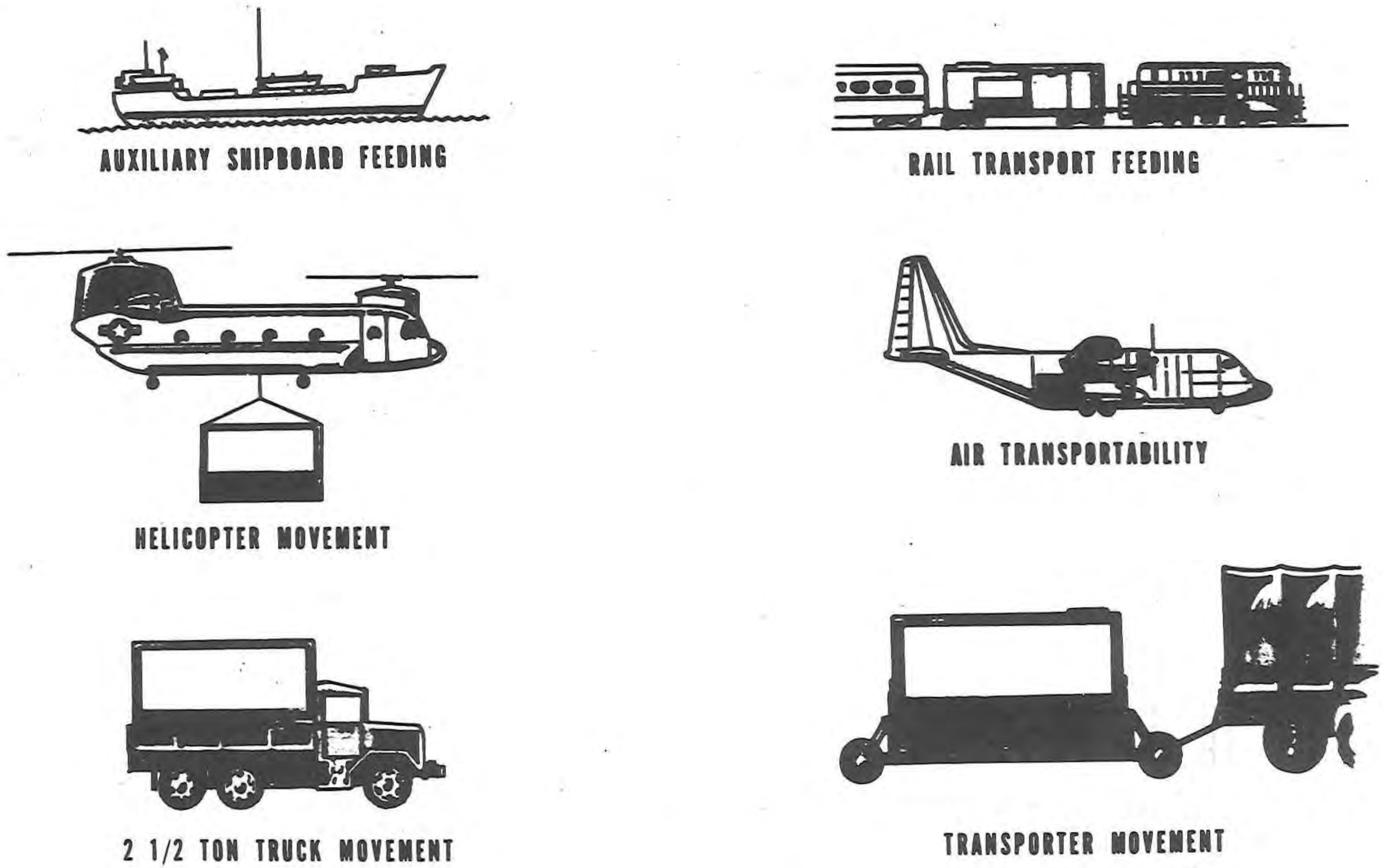

Figure 2. SPEED Transport Capability

This method also has advantages over truck-mounting in that its lower center of gravity permits movement over rough terrain, and its lower silhouette presents less chance of detection. The transporter also provides, through its system of jacks, a convenient means of leveling the pod in rough terrain areas. The transporter can be attached or detached in a matter of minutes. The same mobilization system is used with the MUST hospital system now deployed in Vietnam.

Kitchen Equipment

Figure 3 is an exploded view of the kitchen pod. Although the design is not considered as fixed at present, it has been carefully arranged from a human engineering viewpoint to maximize the cook's efficiency. The cooking equipment, which consists of the microwave ovens, convection oven, and grill, is considered an integrated cooking system, with each item used to perform certain functions.

The microwave ovens (Fig. 4) in the SPEED kitchen and bakery were developed specifically for the SPEED Project, and are the largest batch-type electronic ovens manufactured in the United States for cooking food. Through several engineering innovations, a very uniform energy distribution was obtained within the oven cavity. Six kW of microwave power from four 1.5-kW magnetrons is introduced into the oven cavity through four rotating irises. An aluminum grating below the rotating irises further disperses the energy by reflecting approximately 40% of the energy towards the rear of the cavity and 60% of the energy straight down into the cavity. A baffle at the back of the oven cavity directs the energy to the lower part of the oven and up under the food to effect a type of bottom feed. Serving as a shelf for the food products is a metal grate, which has relatively narrow spacings between the grates at the rear of the oven and wider spacings toward the front of the oven. A uniform distribution of the energy to the bottom of the product is provided. With this manner of dispersing the energy, an approximate 50% top feed and 50% bottom feed is obtained with a minimum amount of variation in the energy level throughout the horizontal plane of the oven.

These ovens are used for prime cooking and baking utilizing raw ingredients. They are also used to reheat precooked and thermally processed foods. A discussion of microwave cooking action and specific SPEED cooking techniques will be discussed in greater detail in subsequent paragraphs.

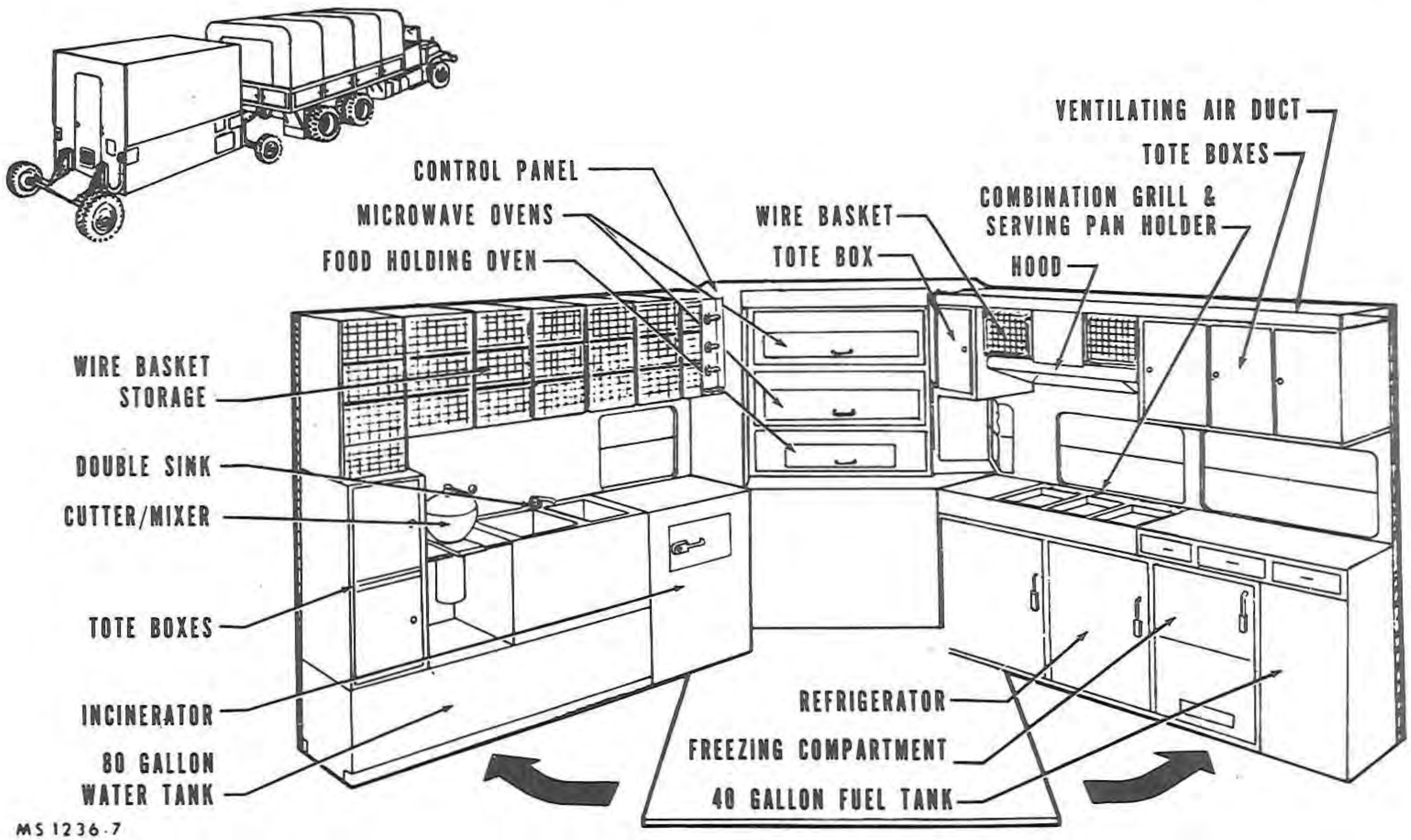

Figure 3. SPEED Kitchen

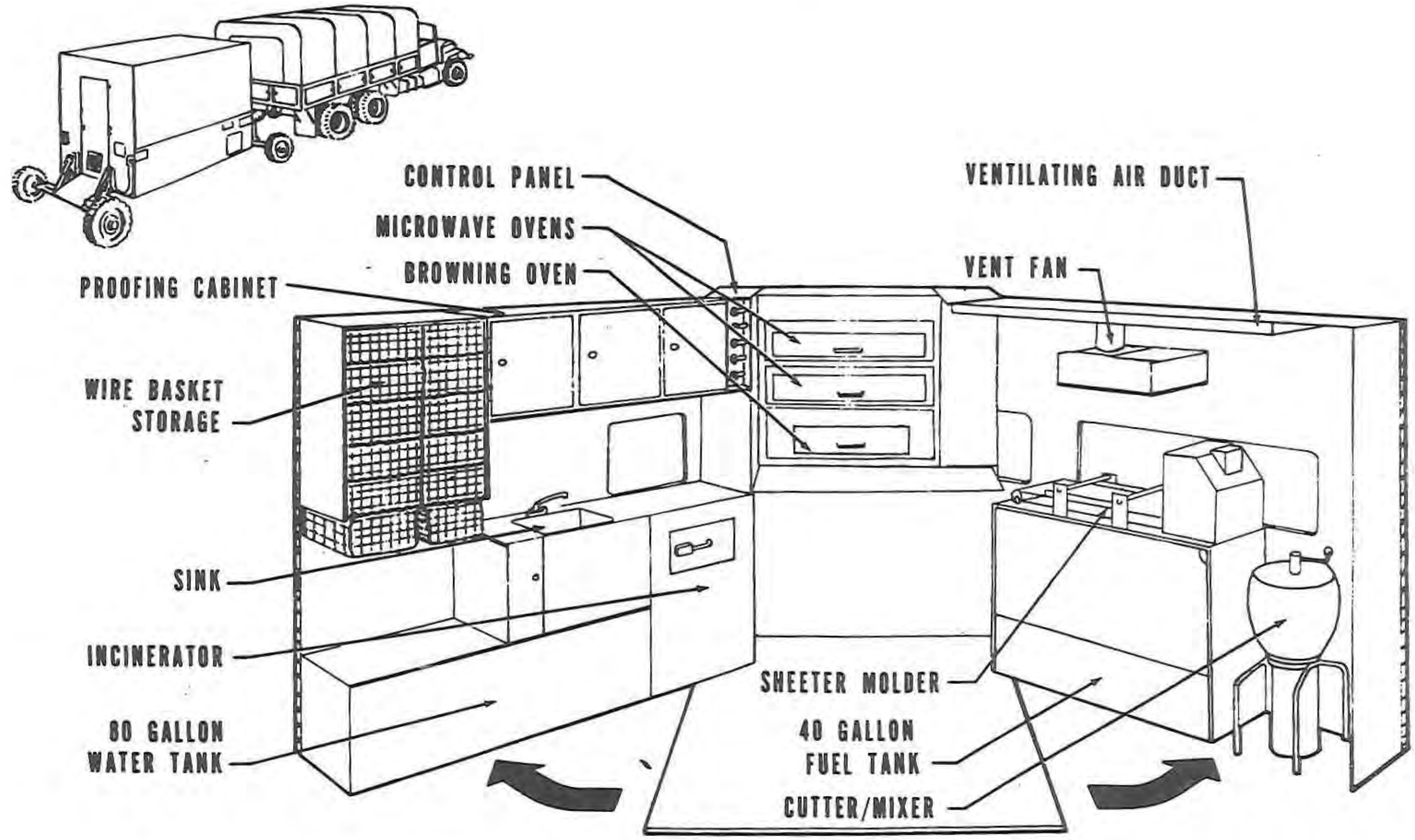

Figure 4. SPEED Bakery

A forced air convection oven is located below the microwave ovens. It is used in conjunction with the microwave oven in the SPEED kitchen and bakery. One of its primary functions is as a holding oven after microwave heating to allow the energy to equalize throughout the product. This is especially true in thicker masses, where the energy only penetrates to a certain depth and then heat must penetrate further into the product through conductive heat transfer. The driving heat of the convection oven is more efficient in performing this task.

Other functions of the convection oven are (1) to act as a holding oven to keep food warm until it is ready to place on the serving line; (2) to impart the characteristically dry outer surfaces of certain products such as steaks, chops, and breaded items; (3) to brown bread and other baked goods. When cooked in the microwave oven, the steak, chops, and breaded items are usually succulent on the inside and still retain a certain amount of moisture on the outside. For this reason, they are placed in the convection oven to allow the fast moving hot air to dry their surfaces.

The grill has several functions. When used in combination with the microwave oven, thin meat cuts, such as steak or chops, are seared on the grill and then transferred to the microwave oven to finish cooking. For the a-la-carte breakfast now standard in the Army, French toast, pancakes, and eggs are prepared conventionally and served directly from the grill. For other meals, the grill serves as the heat source for the serving line. A substitute item for the grill is currently under evaluation for inclusion in future models of the SPEED kitchen. This is a tilting, braising pan which will give the added capability of shallow fat frying, braising, and stewing.

A refrigerator is located in the area under the grill on the serving line. It has 22 cubic feet of 38° F. storage space and two cubic feet of 0° F. space for the perishable portion of the ration. A system of baskets on slides provides good organization and storage of various perishable ration components. The refrigeration unit is powered by a 12-volt d.c. battery when the turbine generator is shut down.

The 40-gallon fuel tank is located on the serving line side of the pod. Design objectives were to provide fuel to prepare 600 meals or to operate for one day.

A very versatile piece of equipment is located on the opposite side of the pod. This is a 15-quart vertical cutter-mixer (VCM), which is similar in action to a home blender. It is used for a variety of functions, such as mixing, chopping, and blending. For example, its extremely high speed allows thorough mixing of prepared cake mix in approximately 15 seconds. Another example of its versatility is its use in reconstitution of dehydrated potato granules. The potato granules are placed in the mixing bowl, then boiling water is added and mixed for about one minute. A smooth, fluffy product is produced, which is at the proper temperature for serving.

A unique feature of the kitchen is an incinerator which can burn up to 65 pounds of garbage, packaging material, and expendable service per hour. This feature allows the use of expendable paper plates, cups, and plastic flatware. Sanitation of mess gear by immersion heaters or "mess kit laundries" is eliminated. There are two access doors, one on the outside for disposal of waste by diners, and one on the inside for kitchen waste and packaging material. Complete combustion of incineration by-products is obtained by using the turbine exhaust as an after-burner. The incinerator employs the principle of cooling by transpiration. Air is forced through a laminated wall of slotted stainless steel and silica fiber. This absorbs heat conducted across this wall and carries it back into the incinerator. Internal temperatures may run as high as 1700° F. without the external temperature exceeding 125° F.

A two-compartment sink, with a hot and cold water mixing faucet, provides the cleaning facilities for internal kitchen operations. Sanitation requirements have been substantially reduced by using the same pans for cooking and serving. The cooks perform all clean-up in the course of their regular duties. The use of the incinerator and the reduction of cleaning requirements have substantially reduced the need for KP's.

The water tank holds 80 gallons. Water requirements are drastically reduced by use of expendable service and dual-purpose cooking and serving pans, so that this amount is normally adequate for one day's operation.

Approximately 65 cubic feet of basket storage space is provided for the nonperishable portion of the ration. The baskets in this area and those in the refrigerator are interchangeable. Hold-down straps are provided to maintain stability while traveling.

Air-conditioning equipment is provided to either cool or heat the pod, as required. The cooling is accomplished using turbine bleed air and air-cycle air-conditioning. Heating is provided through a heat exchanger on the turbine exhaust.

Insulated containers are provided for movement of hot foods to troops unable to return to the kitchen.

Bakery Equipment

Figure 5 is an exploded view of the bakery pod. The microwave ovens, convection oven, incinerator, turbine generator, and air-conditioning equipment are identical to those described in the kitchen.

This unit is designed to produce bread or pastries for a brigade or 5,000 men. Two such units, each with a two-man crew, would be required to produce both bread and pastries.

The vertical cutter-mixer (VCM) in the bakery has a 40-quart capacity. It provides the same ultrarapid mixing capabilities of the smaller model found in the SPEED kitchen. Using the VCM, bread ingredients are mixed in about 80 seconds. The extremely high speed (2,000 rpm) produces a smooth, warm dough and very uniform distribution of yeast. This method of mixing eliminates the first proofing step of the conventional baking process.

A sheeter-molder is provided for rapid molding of bread and sheeting of pastries after mixing in the VCM. After panning, the bread goes into the proofing cabinet for 20 minutes and then into the microwave oven for baking. An oven load of six 1-1/2-pound loaves is baked in about nine minutes. Bread coming directly from the microwave oven has the appearance of unfinished "brown and serve" bread or rolls, although it is fully baked. Two alternatives are provided at this point. Bread may be browned in the bakery convection oven, or issued unbrowned and browned in the convection oven of the receiving unit.

Versatility

The SPEED kitchen was designed specifically to satisfy the requirements for a military field feeding system, but as shown by Fig. 6, many other uses can be envisioned. For example, it could be used as an auxiliary feeding source on board a ship that had been converted to a troop transport, but which had limited galley space. SPEED kitchens could be used in disaster feeding and other situations where suitable commercial or private facilities are inadequate or need to be supplemented.

SPEED COOKING AND BAKING METHODS

Feasibility Study

When the microwave oven first appeared on the commercial market, it was thought to signal a major revolution in food service operations. It was quickly learned that conventional techniques for

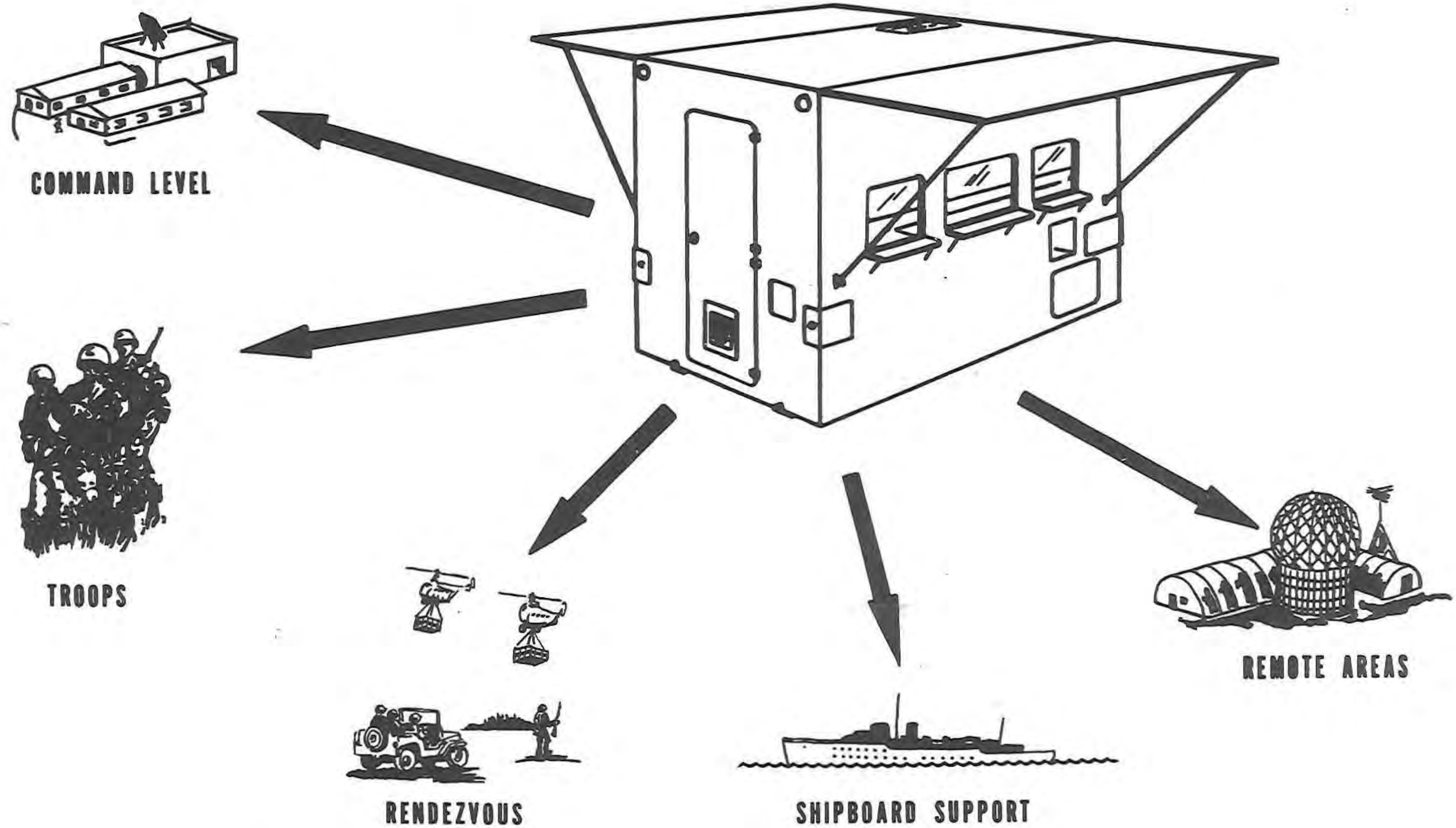

Figure 5. Versatility of Uses

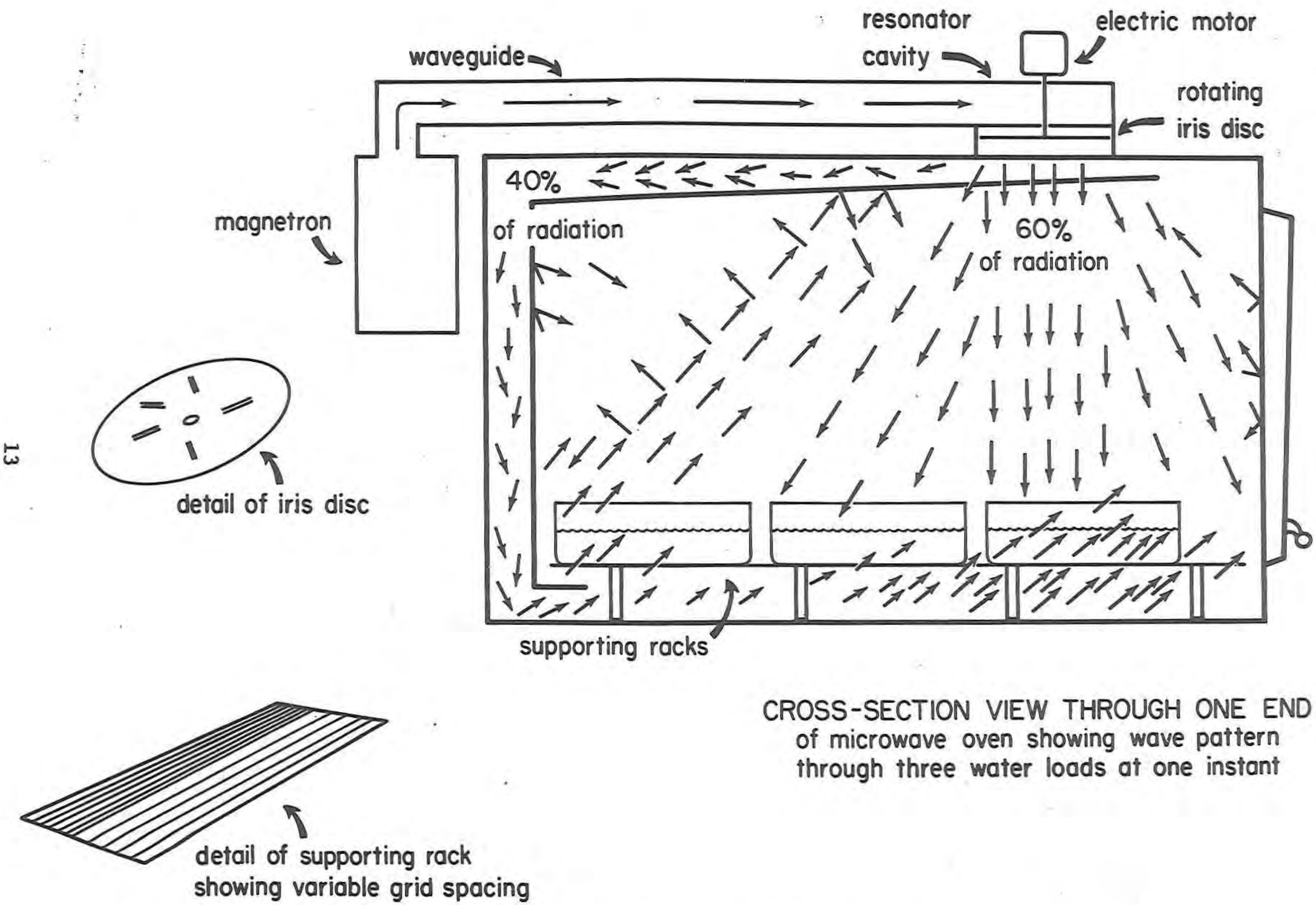

Figure 6. Illustration of Microwave Oven Wave Pattern

cooking and baking were not applicable to microwave ovens and that it was not simply a "faster oven". In a normal or conventional cooking process, regardless of whether it is baking, boiling, or frying, heat is applied only to the surface of the food being cooked. The rate of cooking is dependent upon the heat transfer by conduction from the surface throughout the rest of the food mass. In microwave cooking, the principle is completely different. There is no heat generated within the cavity except in the food itself. The microwaves dependent upon their frequency penetrate the food to a certain distance. Within this distance the energy of the microwave is released generating heat inside the food mass. It is theorized that this heat results from the rapid realignment of polarized molecules within the alternating microwave field. Since the frequency of the microwaves in the SPEED oven is 2450 MHz, the agitation of molecules would occur 2450 million times per second. The primary constituent which the microwaves act upon is thought to be the water molecule; other food components are affected, but at different rates.

The SPEED System[4] was originally envisioned and designed for maximum use of convenience foods (characterized by fully prepared entrees which would simply be heated and served). However, it was determined that some thought must be given to the necessity of preparing meals from fresh or A-type rations in the event of non-availability of special convenience foods in the combat zone. Using commercially available microwave ovens, various methods and procedures were tested to determine the feasibility of preparing both the A and B rations. The results of these tests verified the findings of earlier researchers in that conventional procedures were not suited for use with the microwave ovens, and that fresh foods could best be prepared using the microwave in combination with a convection oven and grill. With some notable exceptions described below (such as roasts and bread), it was determined that the best results would be produced by a system of "integrated cooking". Integrated cooking is defined as a system of producing menu items from fresh foods by utilizing a combination of the most efficient aspects of the microwave oven, hot air convection oven, and electric grill. Items produced by this system were served to a panel of officers, non-commissioned officers, and other personnel to determine their acceptability. There was no significant difference found between foods conventionally prepared and those produced by the integrated cooking system.

<u>Cookery Principles in the SPEED System</u>

A. <u>Meat Cookery</u>. Roasts of beef have been one of the more difficult meat items to cook properly in the microwave oven. Early researchers have reported on the high shrinkage and dry product associated with microwave cooking of roasts. After extensive experimentation, techniques were evolved for the microwave preparation of roast beef at 2450 MHz (Fig. 7).

(1) The roast must be completely thawed (preferably to approximately 40° F.). Microwave energy has a greater affinity for the polarized water molecule than for the ice molecule. Therefore, the thawed part of the roast may become completely cooked while the center still has ice crystals in it.

(2) The geometry of the roast should be as uniform as possible. The ideal configuration would be a cylindrical shape with no greater than a four-inch diameter. Since the depth of penetration of the microwaves is frequency dependent, this appears to be the largest thickness feasible when using an oven operating at 2450 MHz. This thickness allows sufficient time for conductive heat penetration to center of the roast without overcooking the outer portion.

(3) The energy must be cycled into the roast. In the large 6-kW SPEED oven, which can cook 40 pounds of roast beef (the quantity for 100 men) at a time, the roasts are given an initial cycle of high power for 10 minutes. Then they are turned over and allowed to stand for 10 minutes to allow heat equilibration from the outer portion to the center of the roast. The final cycle in the microwave oven is for 20 minutes on medium power, after which they are immediately transferred to the convection oven. The center temperature of the roasts when transferred to the convection oven should be between 110° F. and 130° F., depending upon the thickness of the roast. Initially, the temperature of the outer portions will be much higher than the center, and this heat will travel inward by conduction until the center temperature reaches approximately 150° F. after 20 minutes in the convection oven.

The roasts prepared in the SPEED kitchen have an excellent profile with a characteristic brown coloring on the outside, well done on the ends, and pink in the center. The average loss on SPEED prepared roasts is between 20% and 25% as compared to conventional mess-hall cooking of 30%.

Pork roasts and lamb roasts are easier to prepare than beef roasts in the SPEED kitchen as they are normally smaller in diameter and of more uniform configuration. The same cooking principles apply to them: fast initial heating with microwave energy, and heat equalization throughout the product aided by the heat of the convection oven.

In the cooking of thin meats, such as steaks and chops, not enough heat is generated in the short time that the meat is in the

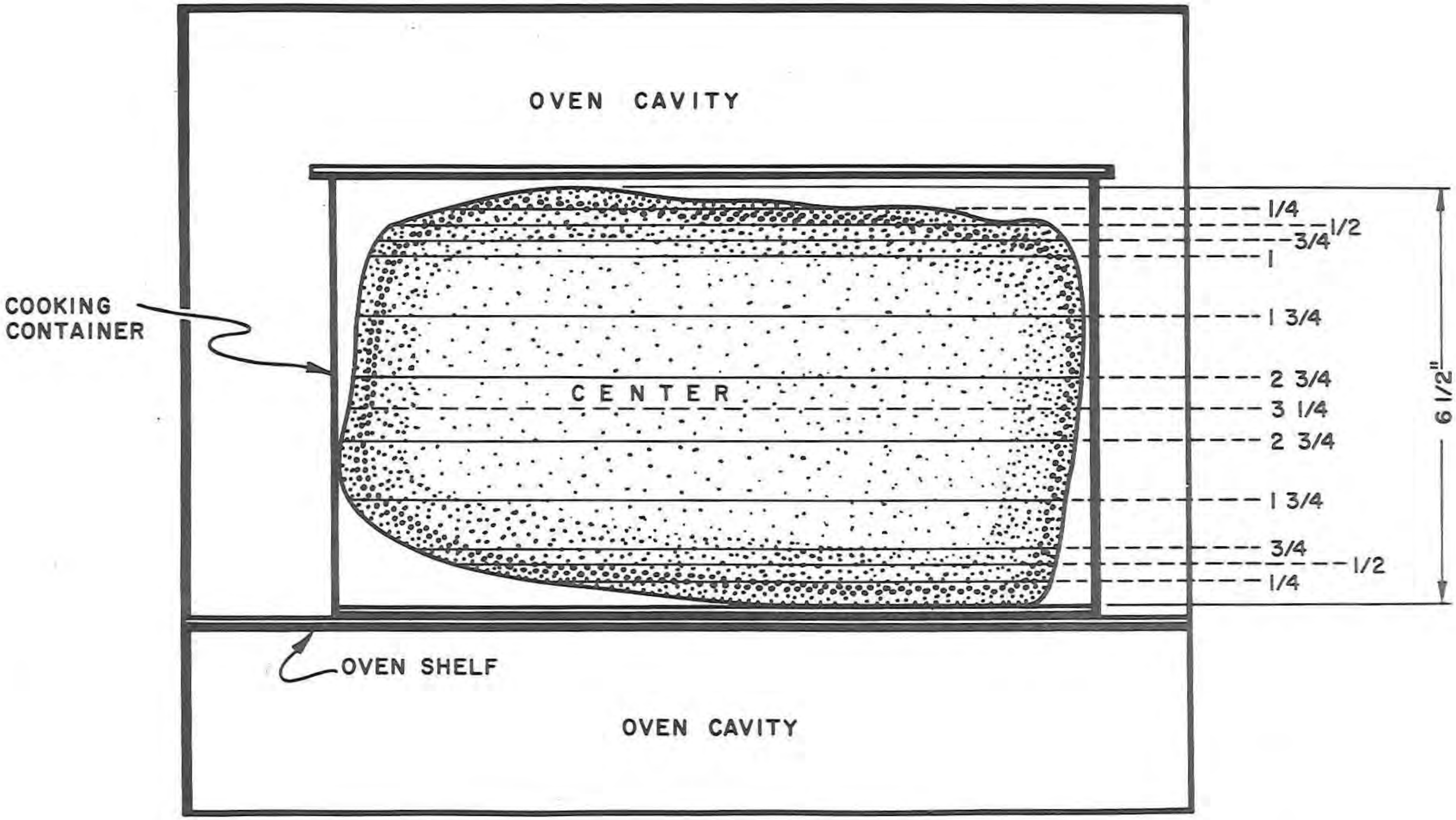

Figure 7. Microwave Energy Penetration in Roast Beef

microwave oven to brown the outer surfaces. Therefore, prior to being placed in the microwave oven, they are seared on the grill on each side This can be done just prior to cooking or can be done earlier, and the chops or steaks can be refrigerated until ready to cook.

Stews and casseroles lend themselves very readily to microwave preparation as the products are immersed in a semi-liquid medium, and the microwaves heat the medium as well as the product. This speeds up the cooking process and reduces the chances of drying out the product.

Cooking whole poultry in the SPEED kitchen is difficult because of the configuration of the product, i.e., the small diameter of the legs and large diameter of the breast. A fabricated turkey roll is cooked without difficulty by microwave energy and results in a very moist product. An excellent oven-fried chicken is prepared by using the convection oven in conjunction with the microwave oven. The convection oven is used after microwave heating to finish the product and to give it a crispy brown appearance and texture.

Barbecued chicken is also easily prepared in the microwave oven. In all cases, poultry comes out very succulent when properly cooked by microwave energy.

In cooking vegetables, a minimum amount of water is added -- just enough to create a steam atmosphere in the covered container. The microwave energy cooks the vegetables from the inside as the steam atmosphere cooks them from the outside. Preparing canned vegetables is merely a reheating operation, and microwave energy is used most efficiently for reheating such products.

B. Bread and Pastry Baking. Early efforts in microwave baking resulted in dry, tough products. After several months of experimentation with various bread formulas and baking techniques, a highly acceptable product was obtained. Modifications to the standard Army bread formula included increasing the quantities of yeast and shortening, addition of an emulsifier and a dough conditioner, and elimination of the non-fat dry skim milk and the egg solids. The emulsifier aided in retaining moisture in the product, and the dough conditioner made the crumb softer. Proof time was reduced by increasing the yeast content, changing the mixing procedure, and increasing the proofing temperature. The ingredients of the bread formula were mixed for 80 seconds in the 40-quart vertical cutter-mixer. After the loaves were molded, they were proofed for 20 minutes at 160° F. The rapid mixing of the ingredients in the VCM (2,000 rpm) gave an excellent dispersion of the yeast throughout the product, and this, coupled with the increased yeast and higher proofing temperature, reduced the proofing time to 20 minutes. The bread was then baked, six loaves per oven, for nine minutes on medium power. The entire bread-making process from opening the bag of flour to baking the first oven load took less than one hour.

Cake baking presented similar problems, which were resolved by adding ingredients to the cake mix. There was, however, one new problem encountered in cakes, due to the porous characteristic of the product and the configuration of the sheet pan used for baking. This is known as the "edge effect". The microwave energy continuously bounces around inside the oven cavity until it is absorbed by the cake (Fig. 8). The energy not only comes in from the top and bottom but also from the sides. This means that at the perimeter of the cake the energy is entering from three sides, thus causing faster cooking in this area. To overcome this, the baking containers have been modified by placing aluminum foil around their outer perimeters to shield the energy from coming in from the sides. Work has also been done with metal pans, which allow the energy to come into the product only from the top. This has shown great promise.

Pies were baked in the microwave oven with only one real problem, the browning of the bottom crust. As with microwave baked bread, pies are browned in the convection oven.

Comparative Cooking Times

Table I below compares preparation and cooking times of specific food items by the SPEED Field Feeding System and the current Army Field Feeding System. The times were computed using the standard Army recipes and the quantities required to feed 100 men.

With meat products, the ratio of SPEED time to conventional time varies between 1 to 3 and 1 to 6, depending upon the item being prepared. The SPEED cooking time includes the convection oven as well as the microwave oven. The time saved in the bread operation is probably the most noteworthy. Another interesting item is the premix cake. In the SPEED kitchen, cake can be prepared for 100 men in 20 minutes.

Determining Cooking Times

The question of how to determine cooking time using microwave energy presented itself as soon as recipe development began. In conventional cooking a time-temperature-weight relationship exists, while in microwave cooking there is a time-energy-weight relationship. A method has been developed where all cooking instructions have been reduced to kilowatt minutes per pound of product. All SPEED microwave ovens would be calibrated so that the exact wattage

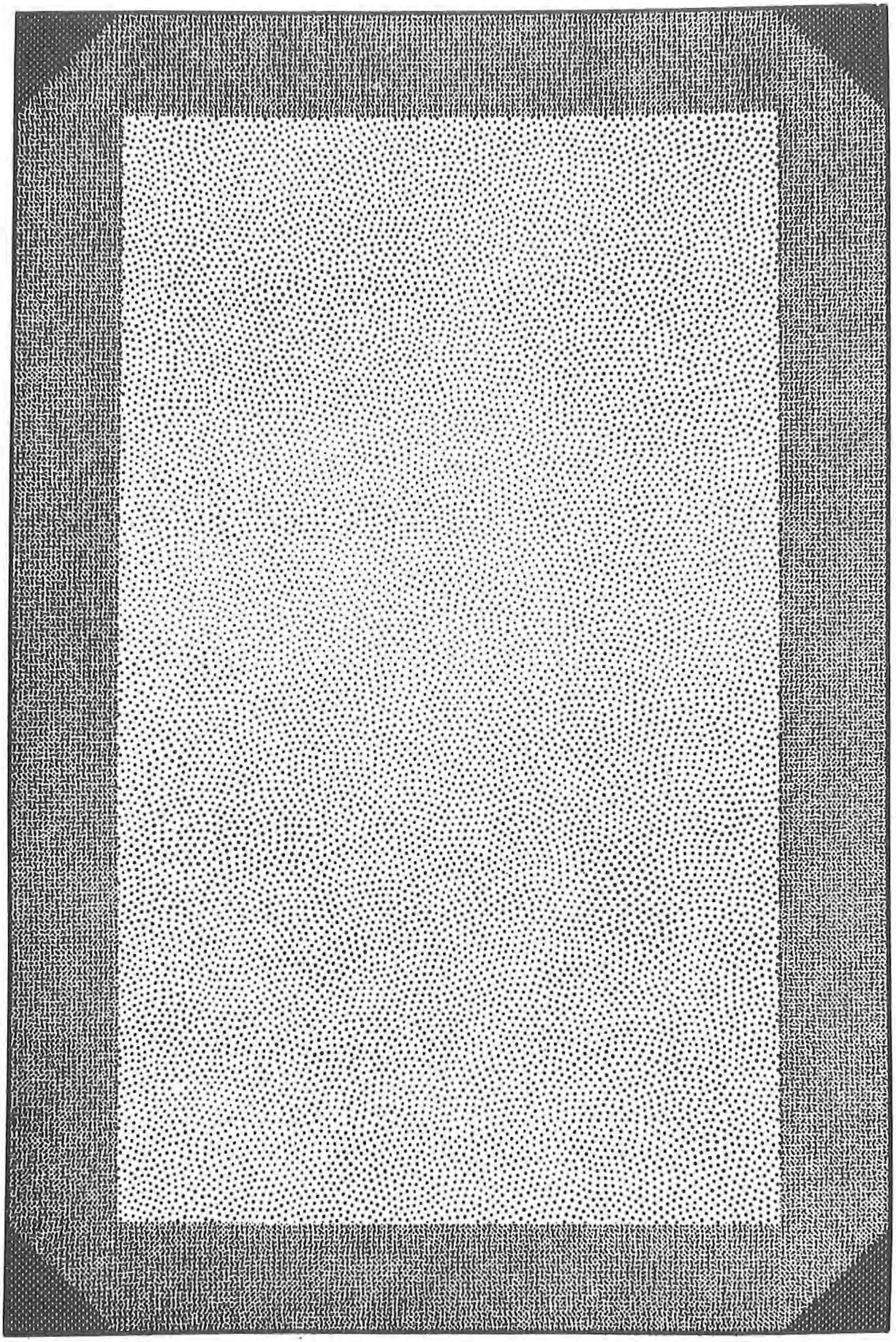

Figure 8. Edging Effect in Baked Products

TABLE I

COMPARATIVE COOKING/BAKING TIME IN MINUTES

MEAT AND POULTRY

200 Servings	Conventional Cooking	SPEED Cooking	SPEED Savings
Roast Beef	180	30	150
Roast Lamb	195	33	162
Roast Pork	210	39	171
Pork Chops	85	28	57
Turkey Roll	225	55	170
Beef Stew	180	50	130
	BREAD AND PASTRY		
Loaf Bread	56	29	27
Rolls	40	24	16
Cake	60	14	46
Brownies	50	16	34
Pie	70	51	19
Cream Puffs	70	44	26

NOTE:

In both cases the ovens used accommodated the same amounts of food.

is known, and all the cook will have to know is the weight of the product. The recipe will tell him to cook the item in the microwave oven at a certain power setting (low, medium ,or high) for so many minutes per pound of product.

Cooking Containers

One problem encountered when cooking with microwaves is that of a suitable cooking container. It is not advisable to use metal containers in a microwave oven because of the possibility of arcing within the oven cavity, and because the metal reflects the microwave energy allowing the food only to get cooked from the top open side of the container.

There is a commercially available ceramic which is transparent to microwaves and is able to withstand very high temperatures. This material is presently being used in the SPEED kitchen, even though it is relatively bulky and fragile. The Plastics Division of the Clothing and Personal Life Support Equipment Laboratory at NLABS is investigating different plastic materials for possible use in cooking containers. Some of the commercial plastics, e.g., high density polyethylene, polypropylene, some of the polystyrenes, and melamine, were found to be transparent to microwaves but were unable to withstand the high temperatures generated by the melted fats of the meats being cooked. Plastics that had not been used before in conjunction with food were investigated. Polyphenylene Oxide (PPO) was one material which had good heat resistance but displayed a fatigue factor, and after several weeks showed evidence of cracking. Another plastic investigated was a polycarbonate material called Lexan. This material has proved satisfactory for most of the SPEED cooking requirements, with the exception of the meat items.

The one container problem that has not yet been resolved is that of a container in which to cook meats which will withstand the temperatures of the hot meat fats. Several new plastics under investigation for this container show promise. They are polysulfone, poly(4-methylpentine-1), and a trimelitic anhydride. All three can withstand high temperatures for limited periods of time; however, only poly(4-methylpentene-1) has been approved as a food contactant by the Food and Drug Administration [Code of Federal Regulations, Title 21, Section 121.2501 (a)(3)(ii), revised as of January 1, 1969].

CONCLUSION

The SPEED system is still undergoing evaluation. Some of the more important areas of exploration include its potential application to "convenience foods" and improvement of the basic microwave oven design. It is further planned to evaluate the inclusion of an airline type coffee maker and an ultrasonic dishwasher for cleaning conventional mess trays. Much developmental work is still to be accomplished, including economic application considerations. However, the feasibility of a self-contained mobile electric kitchen has been demonstrated. Also, considerable knowledge of practical applications of microwaves to cookery has been made available to the food service industry. It has been and should continue to be a profitable investment in the future feeding of the Armed Forces.

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13. ABSTRACT

The SPEED Field Feeding System consists of a company-size kitchen and a brigade-size bakery. Both units are all-electric, mobile, and completely self-contained for one day's operation. A 60-kW gas-turbine generator set, similar to the type used on commercial aircraft as an auxiliary power source, is located in each unit, and is the sole power source for the unit.

Microwave ovens, with their ultra-rapid cooking characteristics, are the primary cooking sources in an "integrated cooking" system. Also utilized are a forced hot-air convection oven and a large grill. These items of equipment work in conjunction with one another and represent a unique approach to cooking.

One of the most important advantages of the SPEED system over the existing system is the saving in personnel. By the use of expendable trays, flatware, and cups, which are subsequently burned in an incinerator located in the SPEED kitchen, the requirements for KP's have been reduced. Other advantages are the improved working conditions for the cook, increased mobility, improved sanitation, and on-board refrigeration.

The SPEED system is now in the Exploratory Development Phase with prototypes undergoing field evaluation. Test results, to date, have been promising.

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