

Foodservice Equipment: Technological Trends

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ABSTRACT

A major incentive for development of improved foodservice equipment is the need for energy conservation. Despite contrary popular belief, preservation of foods in the frozen form provides sufficient comparative advantages and economies to keep frozen foods in the market-place for the foreseeable future. Equipment is being developed for rapid chilling and freezing of bulk foods and for defrosting and heating those foods. Liquid nitrogen is often used. Convection, directed hot air, infrared and microwave heating are being used singly and in combination to temper, thaw and heat frozen foods rapidly and efficiently. The heat pipe concept, a space technology product, has been adapted for use in grills.

According to one foodservice equipment industry spokesman, "Energy sources are dwindling rapidly and foodservice equipment manufacturers are working as quickly as possible to develop innovations for energy conservation." Another spokesman projects new foodservice equipment developments to reduce labor and increase productivity, and expects that productivity will improve from the present 35 to 50 meals per man-hour to greater than 100 meals per man-hour within 10 years, as a result of improved food processing and food service equipment.

There is certainly adequate incentive for developing improved equipment. The rapid growth of the fast food industry, increasing labor pay rates and, more recently, the energy crisis are factors which should have been instrumental in moving manufacturers to develop more efficient, versatile and useful foodservice equipment. However, there is little apparent activity to be seen other than minor cosmetic changes to equipment. One hears lip service being given to engineering improvements, but precious little evidence can be cited of analytical studies being carried out to understand processes so that innovative engineering can be applied.

This presentation will examine, though not exhaustively, some of the activity in foodservice equipment development. The subject of energy conservation leads all others in importance, and therefore this discussion will be concerned with those processes involving heat

removal and heat application. In the latter case, some work of an analytical nature being carried out in the U.S. Army Natick Research and Development Command, which could have an effect on equipment design, will be explored.

HEAT REMOVAL PROCESSES

Arguments have been presented that energy used to freeze foods is energy wasted. The frozen food industry has been quick to point out that the freezing process is cheaper per pound than canning; that frozen food packaging is cheaper than canning because of the high fuel needs in can manufacturing and is substantially less than for refrigerated or fresh food packaging; the energy required to store fresh food may be greater than one might think. Much energy is used refrigerating portions of a product that would normally be removed or trimmed when preparing that product to be frozen. All that inedible bulk requires space, 30% to 100% more space than the frozen product: more shipping and more storage space. And there are other arguments favoring frozen foods. Londahl (1) gave the theoretical energy demand for various preservation processes (Table 1).

Needles to say, frozen foods will not disappear from the market-place for some time to come. At least in the near future, greater use of frozen foods can be anticipated. Some will be purchased from suppliers in the prepared form, and others will be prepared and frozen on site.

TABLE 1. Theoretical energy demand in heat treatment¹

Preservation methods	Energy (KWh/ton)
Cooling	15
Freezing	100
Pasteurization	130
Sterilization	225
Drying	660

¹See Londahl (1).

CHILLED FOODSERVICE SYSTEMS

A number of efforts have been made to establish chilled foodservice systems. The NAAKA¹ and AGS² hospital foodservice systems, for example, depended on rapid chilling of prepared foods, then storage at temperatures below 35 F. Claims have been made that at 28 to 30 F a storage life of 60 days is possible without significant quality loss. Neither the NAAKA or AGS systems are in use today, though the reasons for their disappearance from the scene are not entirely clear. A new chilled food process which is in limited use at present is the CAPKOLD process of the Cryovac Division of W. R. Grace and Company. Basically it is a system of rapid chilling of bulk packaged prepared foods and storage and distribution to satellite foodservice outlets. For example, soup prepared in 50-gal steam-jacketed kettles is pumped into 2-gal Cryovac plastic bags, then chilled in a tumbling unit using water as the heat transfer medium. The multiple-ply plastic bags are sufficiently tough to withstand this treatment. Chilling to 38 F takes about 20 min. By comparison, a rapid chilling refrigerator recently marketed is capable of chilling 200 lb. of product in steam table pans (2 inches deep) from 140 to 45 F in 2 to 3½ h. The time in a typical holding refrigerator is about 13 h.

INNOVATING FREEZING EQUIPMENT

Food freezing equipment for use in small foodservice operations has been limited until recently to freezer chests or cabinets meant primarily for storage, not freezing. A pair of relatively innovative systems are worth mentioning. Victory Metal Manufacturing Division of McGraw Edison has a combination liquid nitrogen-mechanical blast freezer which will cool a batch of food in 2-inch deep pans from 140 to 45 F in 2 h and then freeze the product to 0 F in 1 to 1½ h. A mechanical blast freezer will accomplish the same task in about 8 h. This compares with about 26 h in a conventional freezer. The Teckton, Inc., liquid nitrogen freezer is a vertical unit which occupies approximately one-eighth the floor space of a tunnel unit of comparable capacity (Fig. 1). A typical unit moves product, in trays, into the top of a vertical stack. The trays then descend stepwise down the stack

while liquid nitrogen is introduced through nozzles in vertical manifolds at the corners of the stack. The escaping nitrogen gas acts to precool the trays in the upper part of the stack as they are descending.

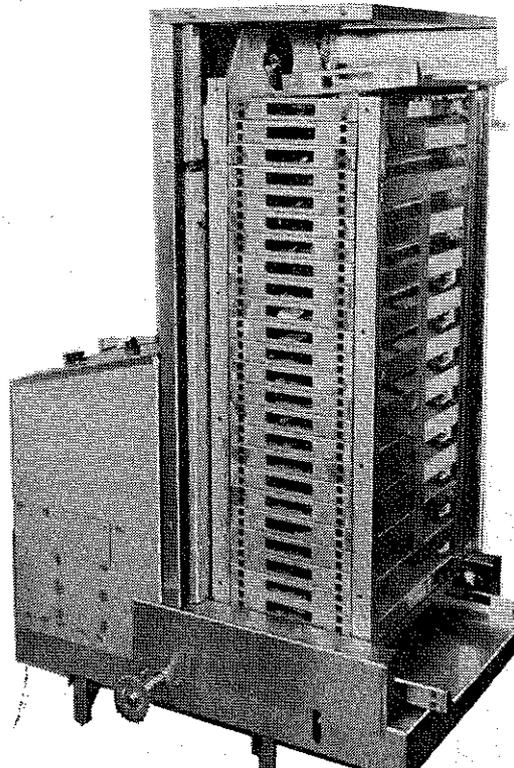


Figure 1. Liquid nitrogen freezing unit (courtesy of Teckton, Inc., Wellesley, MA).

HEAT INPUT PROCESSES

Convection ovens are widely used for heating frozen prepared foods, and there are many models on the market. A number of them have been evaluated under full and partial load conditions to determine their effectiveness. Results of tests of one model are given in Table 2. A full oven load was heated with the oven temperature set at 325 F, and thermocouples were placed in one pan on each shelf to monitor temperature changes. There were substantial differences in heating rate from shelf to shelf, so that to insure that food in all pans reached 160 F, some were seriously overheated.

¹NAAKA Hospital, Stockholm, Sweden.

²AGS stands for Anderson, Greenville and Spartanburg Hospitals in South Carolina.

TABLE 2. Effect of pan position on heating rate of frozen food in a convection oven¹.

Location of temperature sensing probe	Front (F) or Back (B)	B	B	F	F	B	B	B	F	F	F
Right (R) or Left (L)		R	R	L	L	R	R	R	L	L	L
Shelf No.		3	5	6	10	1	7	9	2	4	8
Total time (min) from initial to 160 F		120	121	128	131	133	139	142	142	147	160
Temperature this probe when:	Fastest at 160 F	160	158	142	134	138	122	121	110	112	92
	Slowest at 160 F	206	204	203	202	202	188	182	191	178	160

¹Frozen food: Oatmeal, 6 lb./pan, 8F; oven load: 4 pans/shelf, 40 pans/oven; oven temperature: 325 F

Energy consumption also was measured when frozen food was heated in a preheated oven as well as in the same oven operated from a cold start. Actually less heat was consumed in the latter case (12.97 kWh vs. 14.29 kWh); and when the preheat time was taken into consideration it took much less time to heat from a cold start (116 min vs. 86 min). These results should not be construed to mean that all convection oven designs will give the same results, nor that convection ovens are not useful for heating prepared foods, but merely to point out that there is room for improvement.

Infrared ovens are somewhat faster than convection ovens, but are limited in capacity to a single steam table pan (12 × 10 × 2½ inches). An exception is the Foster "Recon" oven which received some notoriety a few years ago. Models were available with capacities of two, six and 20 steam table pans. Quartz tube infrared heating elements were disposed between the shelves, and the radiant energy was pulsed according to a predetermined program while refrigerated air was directed across the pans to prevent surface scorching. Heating cycles of 60 min for 3-inch frozen food thicknesses were claimed.

Obviously much shorter heating cycles are possible if foods are heated from a chilled or tempered state. The heating time is about 50% less than that for frozen foods. Special thawing cabinets are available which are designed to maintain a constant temperature of 45 F. Thawing cycles as short as 12 h are claimed.

TEMPERING AND THAWING SYSTEMS

Tempering differs from thawing in that the final temperature desired is 28 to 30 F or slightly lower. Much less energy is required to temper; however it must be made up in the heating step. Experimental tempering cabinets have been built for the U.S. Army Natick Research and Development Command, which monitor the food surface temperature while balancing heated and cooled air so that product surface temperature does not exceed 28 to 30 F. Under such conditions tempering from a hard frozen condition has been accomplished in 3½ to 4 h for 5-lb. quantities in disposable aluminum pans.

Microwave equipment is also available to temper frozen foods, and cycles as short as 15 min are common with such systems. Quite a few conveyerized microwave systems capable of tempering several thousand pounds per hour are in use today. Smaller batch units which could find use in many foodservice operations are now available (Fig. 2).

Convection oven heating has the disadvantage that an entire oven load is ready at one time but can only be used a pan at a time. An alternative is continuous conveyerized heating using the "Jet Sweep" principle described in U.S. Patent No. 3,844,213 (Fig. 3). The technique is also being employed in conjunction with

microwave energy in a food vending unit (Fig. 4) built for the U.S. Army Natick Research and Development Command. The device has a capacity of 600 food portions, 50 each of 12 different selections. The user, or customer, may select up to three items, typically the components of a complete meal. Each selection is mechanically moved from freezer storage into a heating chamber which has both microwave and directed hot air, "Jet Sweep," heating capability. Three heating chambers side by side permit each component selected to be heated at a rate appropriate to its composition and to the correct serving temperature. To accomplish this, the heating program for each item is controlled by a processor³. The product is also moved back and forth on an oscillating belt during heating to insure more uniform microwave as well as hot air heating. The hot air system is used mainly for those food items which require surface crisping, such as fried chicken and French fried potatoes. The product must be exposed for crisping to occur, thus a special package design is required to protect the product during freezer storage. One approach which gives good results is to use a shrink film overwrap on a die-cut open top cover. When exposed to the directed hot air, the film splits and immediately shrinks back exposing the product. After all items have been properly heated, they are mechanically moved to the delivery shelf. The total process from selection to delivery may vary from 1 to 2.5 min.

SPACE AGE TECHNOLOGY

An element, which derives from space age technology and is being evaluated for food service equipment potential, is the heat pipe concept. A heat pipe can be used for heating or cooling purposes. In the heating mode, heat is applied to one end. This causes a heat transfer fluid inside the hermetically sealed pipe to evaporate. The vapor then condenses at the cold end to give up heat. The condensed liquid then returns to the heating end by capillary action in a wicking material bonded to the inside of the pipe (Fig. 5). A number of prototype grills have been built using the principle (Fig. 6). The advantages are very rapid heatup — about 5 min — and rapid recovery when a load is placed on the grill. The heat pipe grill also exhibits a uniform temperature over its entire surface. A conventional field grill with comparable capacity of the prototype would use considerably more fuel.

Research in heat transfer is being carried out at the U.S. Army Natick Research and Development Command. This work is related to development of a better understanding of the meat roasting process, to eventually design an oven which will give more consistent results, better quality, higher yields, and use energy more efficiently. A mathematical model was developed first to describe the meat roasting process. The model takes into consideration the initial and final product temperature, oven temperature, thermal conductivity of the meat,

³TI Programmable Control System, product of Texas Instruments, Inc., Attleboro, MA 02703.

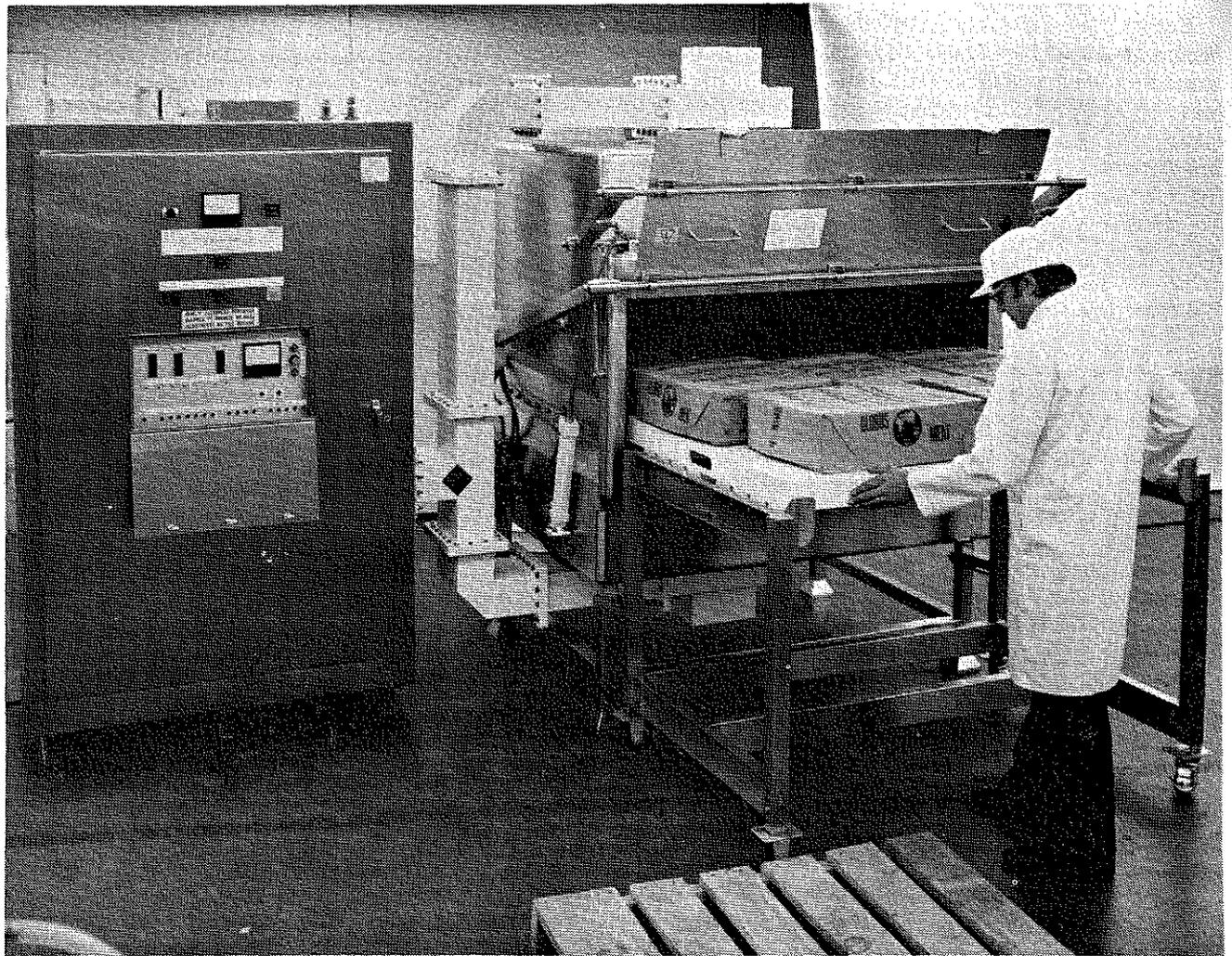


Figure 2. Microwave batch tempering system: operating frequency 915 MHz (courtesy of Raytheon Company, Waltham, MA).

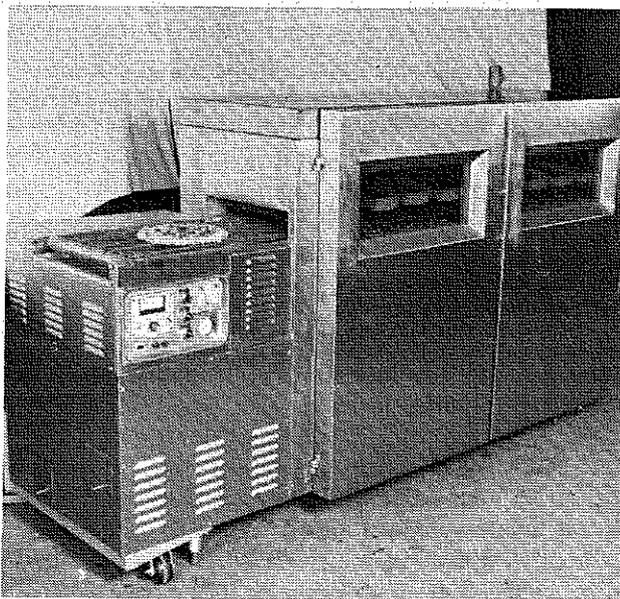


Figure 3. "Jet Sweep" heating concept, applied to heating pizza pies.

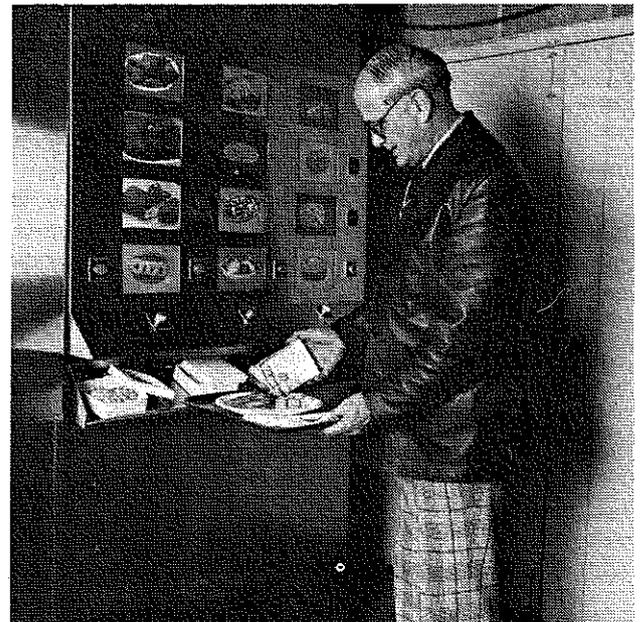


Figure 4. Untended meal heating unit.

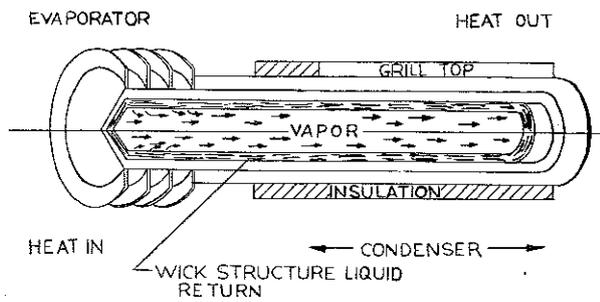


Figure 5. Heat pipe concept.

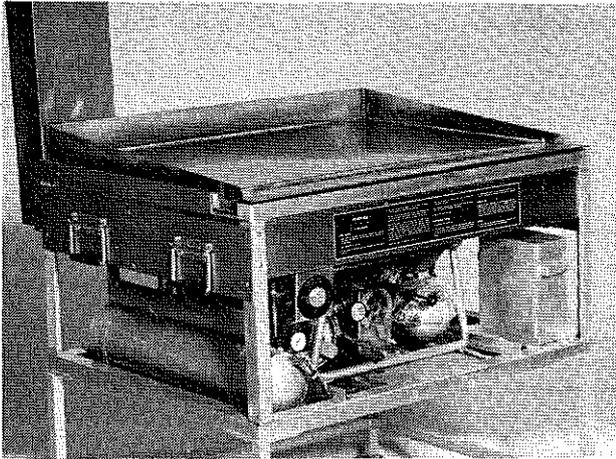


Figure 6. Heat pipe grill.

surface evaporation, the dimension of the roast and changes in the dimensions during roasting. When microwave energy was used, dielectric property data were obtained as a function of temperature and microwave frequency.

Cooking studies were carried out in a research oven that is a pressure cooker to which has been added microwave capability at both 915 and 2450 MHz, a radiant heat source in the oven top and bottom, pressure control at 3 levels (5, 10 and 15 psig), and control of all functions through an IBM card reader.

The best beef roasting results were obtained at 300 watts of microwave power at 915 MHz. Roasts weighing about 8 lb. were cooked from a refrigerated condition to 140 F in about 1 h. The yield of cooked meat was 85% or better under these conditions.

SUMMARY

This is only a beginning. The knowledge and the tools are at hand to identify the ideal conditions for processing almost any food item and for designing equipment to place calories precisely where they are required to achieve optimum results in terms of quality, yield, and energy efficiency. We have not always had the incentive in the past. We do now and it is imperative that we make the effort to apply our knowledge in this direction.

ACKNOWLEDGMENTS

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REFERENCES

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