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Rochester Institute of Technology

A Thesis submitted to the Faculty of the College
of Imaging Arts and Sciences in candidacy for the
degree of Master of Fine Arts.

**The Future Wave: Redefines Contemporary Meal Preparation and
Food Shopping Protocols**

by

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May 23, 1997

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I. INTRODUCTION

The need for efficiency in food preparation becomes increasingly evident when one lives in a very busy household whose members are confronted daily with the difficulty of meshing transportation and scheduling demands, school and career demands. One shares with countless others in contemporary society a desire to rethink and to streamline certain routine tasks, paramount among them, food preparation. It was this desire which propelled an exploration of available technology and life-style trends and the subsequent design of the product presented herein. In a decade when the introduction of new products is so frequent, and product life cycles are now in months rather than years, it is curious how some products are more affected by change than others. There are several reasons for these discrepancies, such as consumer demand, trends, style, marketing and new technologies. Although kitchen appliances and peripheral products do change frequently, the extent of their change and redesign is often superficial compared to that of other consumer products such as computers. For example, it seems to be the nature of some consumer electronics manufacturers, to rush breathlessly along in their rivalry to offer the fastest, most sophisticated product, dragging the sometimes reluctant consumer along, with the ogre of obsolescence menacing at every turn. Kitchen appliance manufacturers, on the other hand, have waited shyly in appliance limbo, responding tentatively to ecological agenda, or somewhat more enthusiastically to the urging of fashion. The refrigerator, range, microwave oven and dishwasher have not changed radically for decades, and in the case of the microwave oven,

major redesign has not occurred since its introduction. Improvements have been made through the years, and features have been added, but microwave ovens still look the same, and function within the same narrow spectrum of use.

Evolution of conventions such as assignment of roles within the family structure is lagging far behind the tremendous urgency and fluidity of change which is transforming other social institutions. Intervention in the form of a versatile food preparation system designed to be utilized in a variety of settings by meal preparers with widely divergent skills and experience could help to alleviate some of the stresses in contemporary households. Many household members still struggle to fulfill traditional expectations, in spite of the blurring and blending of conventional roles in the home and in the workplace. In an article from *Human Relations* Samuel Aryee describes the tension created when home and work responsibilities vie for attention.

How do men and women balance their work and family identity? Results of the multiple regression analysis revealed a positive relationship between work and family identity for men but a negative relationship for women (Bielby & Bielby, 1989; DiBenedetto & Tittle, 1990). The implication of this finding is that married women maintain a balance between the two roles by trading-off one role for the other. However, married men face no such dilemma as the work role is coterminous with the family role. DiBenedetto and Tittle (1990) reported that both men and women in their sample expected that women will experience these trade-off demands. Gerson (1987, p.277) noted that "Women face a set of structures in which employment and family responsibilities are not only inextricably linked; they are also posed as competing, alternative commitments in which women are required to choose among a number of desired goals. Trade-offs are thus built into the structure of choice." ¹

The way people prepare a daily meal has not changed much over the past 40 years. However, life-styles, diet and family profiles have changed significantly.

1. Samuel Aryee and Vivienne Luk, "Balancing Two Major Parts of Adult Life Experience: Work and Family Identity Among Dual-Earner Couples," *Human Relations* 49, no. 4 (April 1996): 482.

The introduction of the microwave oven was the first real attempt by a product to address the problem of food preparation time. There is a growing concern among consumers of the 1990's about nutrition, health, diet and the preparation of more appetizing meals. Food preparation time more than ever before is an important issue. Two of these concerns, quality and preparation time often conflict. Alternatives such as takeout, fast food and restaurants do not present a practical or healthy solution to most families. With the turn of the century upon us, a new system of food preparation, or even a single product that is significantly redesigned to meet changing and diverse consumer needs would be a welcome introduction.

It seemed practical and appropriate to base this system of food preparation on the microwave oven, since it was the first product to address the issue of food preparation time when it was introduced to the consumer market nearly three decades ago. Although 3/4 of all U.S. households have a microwave oven, microwave cooking is still not without its problems. Despite some of the advances in today's microwave oven, it has become neither the primary nor the favored cooking appliance of American households. One significant reason is that food prepared in a microwave does not taste the same nor is its texture the same as food prepared on a range or in a conventional oven. The system of food preparation proposed in this thesis should be based on a microwave oven, yet changed radically in form and enhanced significantly in function so that it will constitute an essentially new kitchen appliance. It will use available technology and be targeted for the consumer of the early 21st century.

The process from which the design will evolve originates with the initial goals of the project. The purpose of this thesis is to design a food preparation system for the home, that will meet the needs of the consumer in the beginning of the

21st century. The system will allow for faster, more efficient and easier food preparation for the user who functions under the many time constraints of contemporary society. The system will be based on research and projections of trends in diet, life-style, demographics and the food industry. An inquiry into available technology, specifically on the microwave oven and automatic identification systems will be conducted. Proposals for the use of appropriate technology that will enhance function and marketability of the product will be made. In addition to function, human factors and aesthetics will be priorities in the design of the system. Form studies and concept drawings will be made in conjunction with current research. The process will culminate in a completed design model, as well as a graphic description of the system.

II. BACKGROUND

The objective of this project was to propose a system which would meet food preparation needs of consumers into the next decade and beyond. An investigation into relevant social trends, as well as available technologies preceded any design attempts.

The project developed in three rough stages. In stage one, an investigation was initiated into the food preparation process, including acquisition, storage, cooking, nutrition and clean-up. During stage two, the focus was narrowed to cooking, nutrition and the position of the microwave oven within the food preparation sphere. In stage three, the microwave oven was chosen as the hardware around which the system would be designed.

This report will describe how the system evolved into an organic trio composed of the microwave oven and two other components, sleekly integrated to facilitate the process of cooking, acquisition and the monitoring of nutrition; and how social factors have created a need for such a system.

Initially consideration was given to designing a seamless system which would incorporate acquisition, storage, cooking and clean-up. Someday, through the use of robotics and automation, such a system may well become a reality. Presently however, such a system would be prohibitively costly, and therefore inappropriate for selection as a design project.

Next, a more limited combination of food preparation with storage was contemplated. Designing a product with the dual function of refrigeration as well

as cooking would constitute an extremely complex assignment. Potential technical problems brought into question the feasibility and cost effectiveness of such a system. Also, the microwave oven, with its rapid cooking and defrosting functions, renders insignificant the interval of transfer from refrigerator or freezer to oven.

Although it rapidly became apparent that the inclusion of the refrigerator in the final design would be impractical, research devoted to refrigeration was valuable in understanding how appliance design is affected by market forces and technological advances. Improvements based on technological change often take years of development and testing before production implementation. Other changes which sometimes occur more readily, are aesthetic enhancements based on marketing decisions, which are in turn based on consumer style preferences.

In the current and preceding decade, many consumer products have appeared on the market which are advertised as new and better because of their exploitation of currently available technology. Some of these products adopt the latest technology for the sake of newness, and in this type of scenario, the product may be complicated and difficult to use. This may ultimately become an annoyance to the user rather than a time saver or a genuine improvement. Other products make use of the most current technology, yet are designed with a simple, easy to use interface, which in some cases disguises the more complicated technology. Some users accept a complicated interface, delight in the product's many features, and don't mind reading lengthy user manuals to figure out how to use multiple controls and features. However, they are in the minority; most users want to purchase a product that they can take out of the box and use immediately with the least fuss. They prefer a product with a simple, nonrestrictive interface. They also want something that is reliable, and performs

the task at hand with efficiency and relative speed.

The major appliances which perform the daily tasks of the food preparation process perform adequately and manufacturers are constantly improving them. Refrigerators become more energy efficient from year to year without the major changes in technology mentioned above. Improvements such as more space and better shelf design also occur from year to year. Dishwashers become quieter, more efficient and some newer models afford the consumer added conveniences such as the elimination of the need to pre-rinse dishes. Ranges and convection ovens are the oldest appliances so they have had more time to evolve. Now, most moderately-priced ovens have the self-cleaning feature; and many new ranges offer flush glass and ceramic surfaces over the cooking elements for easy cleaning. Microwave ovens are proffered with sparkling new features and improved interfaces. The convection-microwave combination oven combines the speed and convenience of a microwave, with the added ability to cook and brown food so that it tastes as if it were prepared by more conventional methods. Small appliances and gadgets such as food processors, juicers, bread makers, electric choppers and knives abound and have become safer and easier to operate and clean. These products all reflect the life-styles and target the needs of consumers. Consumers of the 1990's are looking for convenience and time saving capabilities as features in products. Products that offer consumers the ability to prepare healthier and more nutritious meals are increasing in popularity. As in the past, products that are easier to use and clean are becoming ever more popular. The ability to prepare better tasting and a larger variety of meals is also a concern of the contemporary consumer. Overall, speed of preparation, convenience, nutrition, taste, and diversity have become priorities.

III. TRENDS

Demographic Trends

The challenge of designing a product, specifically a food preparation system, that will continue to meet the needs of consumers into the 21st century, lies in one's ability to recognize relevant trends in the metamorphosis of significant societal institutions. It is important to understand, for example, that the American household will continue to change, as its members shuffle priorities, and blend and exchange responsibilities. Moving along on this tide of change is the pragmatic tendency to reexamine and discard old conventions of food selection and preparation, and an increasing awareness of nutritional and health-related dietary issues. To the designer, recognizing the vanguard in diet trends is essential because it suggests what the diet of mainstream America will be a decade from today. Other trends, extrapolated from an examination of shifting demographic statistics, are strong indications of future orientations in life-style as well as diet. A careful study of these dynamic phenomena can direct the designer in defining a specific target market, and tailoring his/her product for acceptance by that market.

It is evident that the American household has changed quite dramatically over the past quarter century. Some of the changes are quite obvious, arising from the shifts in such factors as birth rates, immigration, and mortality. Others result from economic developments such as the entrance of women into the workforce, the ensuing surge of educational priorities, and the waning of the industrial age.

Information, readily accessible from various media sources, and the technology which both serves and drives these sources, molds public opinion and broadens the scope of perceived choices.

In an article "America at Mid-Decade," Peter Francese reveals interesting demographic statistics of contemporary America. At the beginning of his article, he presents a vivid picture of the changing patchwork of American households.

The all-American household continues to fade. America's households are diverse and diverging, and so are their needs. Married couples are a bare majority of U.S. households; only about one-third of households have any children under 18 present; and nearly one-fourth of households are people who live alone. Women who live alone are 15 percent of all U.S. households, and most in this segment are elderly widows. In contrast, men who live alone are about 10 percent of households, and most of them are under age 45.

There are fewer married couples with children now than there were 25 years ago, when they were 40 percent of households. But married couples overall still dominate the affluent market; the vast majority of very-high-income households are married couples. The long-term trend of high growth in nontraditional types of households and lack of growth among married couples can only mean further fragmentation of an already highly segmented marketplace. This suggests that tracking life stage and life-changing events such as marriages, divorces, retirements, births, deaths, and significant birthdays, will, in fact, become the vital statistics behind any target-marketing program.¹

Preliminary concepts for the food preparation system, which is the subject of this report, evolved from a recognition of the diversity of the American household and the American family of the late 1990's. The product, which will be called the *Future Wave Oven*, will be described in detail in later sections. A profile of the contemporary U.S. household, as well as demographic predictions for the next decade and information about corresponding life-styles and diet trends, will set the stage for the introduction of the system.

1. Peter Francese, "America at Mid-Decade," *American Demographics* 17, no. 2 (February 1995): 24.

An effort was made to define a target market; though, because of the diversity of the American household, the product must be inclusive of a number of styles of utilization. The product was designed for a U.S. market; however, it is not necessarily limited to use in the U.S. With consideration to expanding global trade, and to the universality of a food preparation appliance, the market could easily be expanded to include other countries, with minor modifications to the product (i.e. language changes to user interface). However, when referring to the target market, it should be understood that most supporting material will be extrapolated from research of the U.S. market.

Later in his article, Peter Francese uses a graphic representation titled “Household Types” to differentiate various kinds of households in the U.S. He presents six profiles of households and charts them according to percent distribution of U.S. households by type, 1995; and percent change, 1984-1994. According to his data, the largest group is called “married without children,” which accounts for 29% of U.S. households. The second largest group is titled “married with children < 18,” accounting for 26% of the total. The third largest group is called “single persons,” which accounts for 24% of the total. Three other groups are “single parent,” “other family,” and “unrelated persons” that comprise much smaller percentages at 9%, 7%, and 5% respectively. What makes his data even more revealing is the calculation of change from 1984-1994. All of the numbers increased, but the two largest increases were in the groups “unrelated persons,” with a 44.8 percent increase, and “single parents,” with a 31.2 percent increase.² This continuing proliferation of nontraditional living situations points to an increased need for versatility and convenience in consumer products in

2. Peter Francese, “America at Mid-Decade,” *American Demographics* 17, no. 2 (February 1995): 25, Source: *American Demographics*’ calculations from Census Bureau surveys.

today's society, where traditional roles are changing and blurring, and household chores are up for grabs.

Even in traditional two parent households, dual income families are on the rise. This household situation has greatly affected consumer demand and need.

In 1967 only 6.7 million families earned more than \$50,000 a year (in 1987 dollars). By 1987 that figure had grown to 16.9 million households. These households consist of two-income well-educated professional married couples, over thirty-five. "The working woman is lifting millions of families out of the middle class," concludes a *Wall Street Journal* article.³

This passage from the book *Megatrends 2000*, suggests another very significant factor that has effected a dramatic change in the U.S. household over the past 25 years, the dual-income family. The emergence of this more affluent segment of the population greatly affects consumer decisions, and ultimately consumer products. Several other factors determine how dual-income families make decisions. In her article "Dual-Eamer Diversity," Diane Crispell examines some of the economic characteristics of working couples. One very important factor that she cites is education.

Education levels do more than determine a married couple's income. They also determine the ways married couples talk, use media, and make consumer decisions. College-educated couples are more likely than other couples to say that their big-ticket purchases are joint decisions, for example. Yet they are less likely to share the decision-making when buying food, perhaps because they are more pressed for time. To understand married customers, it helps to study the huge impact that education and income have on their consumer behavior.⁴

Since the number of women with college degrees is increasing in the U.S. as well as the number of two income families, it is probable that women will play an ever

3. John Naisbitt and Patricia Aburdene, *Megatrends 2000: Ten New Directions for the 1990's* (New York, N.Y.: William Morrow and Company, Inc., 1990), 44.

4. Diane Crispell, "Dual-Earner Diversity," *American Demographics* 17, no. 7 (July 1995): 34.

larger role in the purchasing of consumer products in the future. In the small and major appliance market, convenience and speed are features that will have strong appeal for these busy households.

The target market for the *Future Wave Oven* would be composed largely of households in medium and large metropolitan areas. These prosperous segments of society represent a large portion of society as a whole. Their residents would be most likely to pioneer acceptance of a time and labor saving device, given a timely and effective presentation. Statistics reveal that the United States is a more metropolitan country than it was in the past, and this trend is likely to continue well into the 21st century.

Three in four Americans lived in one of the nation's metropolitan areas in 1990. In 1950, barely half of Americans were metropolitan residents. Within metropolitan areas, the distribution of the population has changed dramatically as well. The suburbs are now home to 46 percent of Americans, up from just 23 percent in 1950. About one-third of Americans live in the nation's central cities, a figure that has barely changed over the past 40 years. The proportion of Americans living in the nation's non-metropolitan areas has fallen sharply, from 44 percent in 1950 to just 23 percent in 1990.⁵

These metropolitan areas represent the economic and consumer bases of the nation, and for the purpose of this thesis will represent the residencies of the mainstream American household for which this product was designed. In the effort to focus on an initial target market, income levels of the projected purchasers were determined (\$35,000-\$150,000 annually). This figure was decided upon because it represents a range that includes younger households with future earning potential, upwardly mobile families, two income families and more affluent families. From data viewed at the internet site of the *U.S. Census*

5. Cheryl Russell, *The Official Guide to the American Marketplace: The Real Facts About How Rich, Well-Educated, Healthy, Family-Oriented, Hard-Working, and Diverse We Are*, 2nd ed. (Ithaca, N.Y.: New Strategist Publications, 1995), 234.

Bureau the Official Statistics, some pertinent statistics were revealed. On the page titled "Median Income for 4-Person Families, By State," for the "Calendar Year 1994," "Fiscal Year 1997," the estimate of the "Median Income for 4-Person Families for the United States" is \$47,012.⁶ From the page "Income and Poverty: 1994 Highlights," the figure for the median income of U.S. households is \$32,264. Reference to the data states: "The data presented here are from the March 1995 supplement to the Current Population Survey, the source of official income and poverty estimates. The CPS is a sample survey of approximately 60,000 households nationwide. These data reflect conditions in the calendar year 1994."⁷

To sharpen the focus on the target market of the *Future Wave* system, data regarding the aging of the general population was gathered. Statistics reveal that there is a steady growth among certain age groups. Not only are the oldest baby boomers preparing to enter late middle age, but members of preceding generations are living longer and longer. From the book, *The Official Guide to the American Marketplace*, the author analyzes some very provocative statistics about the age of household members in the U.S. while presenting projections for the year 2005.

While households overall are projected to increase by 13 percent between 1994 and 2005, households headed by 45-to-64-year olds will grow three times as fast during those years. Households headed by both

6. U.S. Bureau of the Census, "Median Income for 4-Person Families, by State," *U.S. Census Bureau the Official Statistics* (Washington D.C.: U.S. Bureau of the Census, U.S. Department of Commerce, accessed March 1996); available from <http://www.census.gov/hhes/income/4person.html>; Internet.

7. U.S. Bureau of the Census, "Income and Poverty: 1994 Highlights," *U.S. Census Bureau the Official Statistics* (Washington D.C.: U.S. Bureau of the Census, U.S. Department of Commerce, accessed March 1996); available from <http://www.census.gov/hhes/income/highlite.html>; Internet.

45-to-54-year-olds and 55-to-64-year olds will increase by about 40 percent during the next 11 years. Behind this rapid growth is the middle-aging of the baby-boom generation. In 2005, baby boomers will be 41 to 59 years old.⁸

The food preparation unit proposed in this report was developed upon the premise that it would be practical for use by all age groups including the elderly. The interactive function of the control unit and scanner (to be discussed in Section VI) was intended to address the nutritional and health concerns which often become paramount to the older population. Components of the system will adapt easily for use by those with decreased agility and/or diminished sensory acuteness.

Although the special needs population pool promises to burgeon because of these demographic factors, a curiously contradictory phenomenon is growing alongside. The aging of this enormous group of baby boomers is predicted to further animate the vitality of the demand for products that purport to assist the consumers in maintaining a healthier life-style. Current advertising already mirrors this yearning to maintain youthful vigor, and marketers have demonstrated their eagerness to exploit these concerns by promoting numerous products such as those labelled “natural” and “fat free”. Much of this advertising is aimed at the middle-aged consumer. In an article, “The Baby Boom Turns 50,” the author describes the emergence of a very unique segment of the population, a group unlike any of its predecessors.

Three decades ago, baby boomers created the youth market. In the next decade, they will recreate that youth market among consumers in their 50's. After all, the only reason the baby boom's wants and needs were called the “youth market” is because the baby-boom generation at that time was young. Now in middle age, boomers still have many of those same wants and needs. The youth market is the boomer market, no matter what the

8. Cheryl Russell, *The Official Guide to the American Marketplace: The Real Facts About How Rich, Well-Educated, Healthy, Family-Oriented, Hard-Working, and Diverse We Are*, 2nd ed. (Ithaca, N.Y.: New Strategist Publications, 1995), 184.

age. With the boomers entering their 50's, many so-called "youthful" products, services, life-styles, and attitudes will become common among midlife consumers. Boomers will create the new "midyouth" market.⁹

Many of these products are of limited validity with respect to the twin goals of health and youth maintenance, but they merit a mention because they pinpoint the present and future concerns of a huge segment of the population. One can only assume that the market for products which prolong youth and support wellness will continue to explode.

A trend that expresses a youthful and progressive America has arisen as the turn of the century approaches. The incumbency of the first U.S. president from the baby-boom generation helps to support this image of a youthful America. New technology in telecommunications, the inception of the internet, and mainstream consumer use of personal computers, have become symbols which fortify this image and express the nation's readiness to enter the new century.

There is evidence that Americans of all ages are leading healthier life-styles and eating more nutritious foods. These trends are not confined to the young and middle-aged. Older Americans and the elderly are taking better care of themselves, and are better informed than ever with regard to health issues.

A publication of the International Food Information Council Foundation, titled "Better Eating for Better Aging," predicts the looming importance of the aging of the population.

There is no end in sight to our focus on the baby boom generation, even as we approach the 21st century.

Baby boomers will be a key factor in the coming "agequake," when the elderly will comprise a much larger share of the population. In 1980, about one in 10 persons were 65 or older. By 2030, the 65 and older will number one in five. The first "boomers" will reach age 65 in 2011.

And more people will be living longer. According to most projections,

9. Cheryl Russell, "The Baby Boom Turns 50," *American Demographics* 17, no. 12 (December 1995): 27-28.

tomorrow's 85-plus will be a fast growing group as the median age of death in the next century climbs to 84 years. That's 11 years beyond today's median lifespan of 73 years.

The needs of an aging population will shape every facet of society in the next century, including nutrition. ¹⁰

The older American's effort to stay healthy has been bolstered not only by personal accountability, but by the increased sophistication of medical science. Ironically, having achieved the objective of longer life, some of the elderly find themselves in positions of limited autonomy and increased dependence, often because of infirmities associated with old age. The burden of care which falls upon the shoulders of the families of these older Americans has become so prevalent that it has given rise to the term "sandwich generation." Time-stretched and task-burdened, these sons and daughters shuttle between work and home, where their own children await nurturing, and between those obligations and the homes where aged parents are barely managing.

Finally, elder care has begun to emerge as an employee benefits issue. Many young-to-middle age adults are finding themselves - as the "sandwich generation" - sandwiched between young children who need care and aging parents who, in many cases, have become dependent on them for support. ¹¹

As the research into trends continued, endless opportunities for the utilization of the *Future Wave Oven* were disclosed. Because, through its scanning ability, data concerning such information as nutrition, ingredients, sodium and fat content may be translated into usable information; and because cooking may be simplified and expedited, it is an ideal appliance for the aged and infirm. For all these same reasons, the care-giver or any householder who has much to do, and

10. International Food Information Council Foundation, "Better Eating for Better Aging," *Food Insight Reports* (May/June 1990): 1.

11. John P. Kohl and Daniel W. McAllister, "Businesses Dawdle: 'Sandwich Generation' Needs Special Benefits," *Business Forum* 20, no. 1, 2 (Winter/Spring 1995): 25.

little time in which to do it, would probably welcome such a radical change in a kitchen appliance.

Foremost among those to whom such an appliance might prove indispensable, is the single parent. In "Meet the Median Family," which appeared in *Time* in January 1996, Andrew Hacker, who teaches political science at Queens College in New York City, writes that although the top tier of wage earners has grown in numbers, "The fastest growing segment in the workforce consists of almost 6 million divorced or separated women, most of whom have children. These women must rely on their own earnings as few receive full support payments."¹²

Like the "sandwich generation," indeed often as one of its members, the single parent balances myriad responsibilities between work on the one hand, and home and children on the other. A better system of food preparation could definitely assist in the organization and execution of his/her household tasks.

Trends in Diet , Nutrition, and Life-style

General Awareness in Society of the Need to Eat Healthier and More Natural Foods

This area of research was very significant because it allowed for specific projections about what consumers will require in their kitchen appliances within the next decade. One problem, however, is that trends in diet and life-style are not always predictable. The increasing popularity of healthier, more natural foods can be associated with an increase in health consciousness among consumers of the 1990's. Diet and popular foods are reflected in life-styles, yet

12. Andrew Hacker, "Meet the Median Family: How Are They Doing? And Are They Better Off Than Their Parents Were?," *Time*, 29 January 1996, 42.

like other areas of life affected by popular culture, these trends are constantly changing and evolving. Just like fashion, popular music, and television, what is “in” today may not be “in” tomorrow. Considering the unpredictable nature of these trends, it was necessary to unearth some constants from which projections might safely be made. To distinguish between enduring trends and passing fads, it was helpful to consult sources such as food industry journals. Surprisingly, popular periodicals such as health magazines and women’s journals were useful as well. They clearly document the mainstream concerns of consumers in the 1990’s, and they foretell what is to come at the beginning of the 21st century. Five constants in the diet of Americans are likely to continue well into the beginning of the 21st century. These are the increasing popularity of foods and food related products that are “healthier” (with more nutritional value), foods that are fresh and more natural, foods that are easier and faster to prepare, foods that taste better, and a growing concern about food safety.

Popular Trends in Cooking

Since the beginning of the 1990’s, popular trends in American diet increasingly reflect four major areas of concern: nutrition, health, speed of preparation, and taste. In 1996, these trends are more dominant than ever before. The food industry has caught on and has begun to market more products and services that accommodate these trends. Some of these products and services help to improve the quality of life for Americans; others are questionable and of little or no value. The latter are merely marketing ploys aimed at consumers who may fall prey to deceptive advertising. An example are food products labeled “healthy” which have little or no nutritional value. Recently laws governing food labeling have become stricter, however the consumer must

still be wary when purchasing packaged food products at the supermarket.

The above mentioned areas may be interdependent; for example, concern for good nutrition supports the idea of good health. The two areas that seem to conflict the most are food preparation speed on the one hand, and nutrition and palatability on the other. Prioritizing speed often means sacrificing taste and nutritional value. The food preparation unit designed for this project addresses these problems as well as the trends that are so popular in American society today. Specific strategies will be explained later; but it can be explained here that the three components of the *Future Wave* system work together to communicate nutritional information to the user, to conserve nutritional value by adapting cooking times and temperatures, and to provide the appropriate cooking mode(s) for pleasing taste and texture.

Among prevailing dietary trends, some predominate. In the article, "Top Ten Trends to Watch and Work On," which appears in a 1994 issue of *Food Technology*, A. Elizabeth Sloan, contributing editor for *Food Technology*, succinctly summarizes ten dominant trends, and discusses each separately.

This article is the first of what we hope will be a long series of annual *Food Technology* trends reports. The top ten trends as we see them this year are: 1. Increasing role of food and food ingredients in self-medication and disease prevention; 2. Switch to "fresh" in most food categories; 3. Return to organic food production; 4. Gradual shift from animal-derived to plant-based meals; 5. Demand of "ordinary" consumers for energy-enhancing (both physical and mental) foods; 6. Desire for foods that are speedily and easily prepared, yet are tasty, fresh, and nutritionally sound; 7. Disenchantment with microwave magic; 8. Increasing inclination of consumers to eat where and when it is convenient; 9. Upgrading of the American palate; and 10. Health-based demand for products containing active cultures.¹³

13. A. Elizabeth Sloan, "Top Ten Trends to Watch and Work On: The More Things Change, the More They Stay the Same," *Food Technology* 48, no. 7 (July 1994): 89.

Of this list, the most provocative for the purposes of this report was number 7, “Disenchantment with microwave magic.” It is curious that although almost every American household owns one or more microwave ovens, it is seldom the cooking appliance of choice. There are several reasons for this and most of them have to do with palatability. Ms. Sloan writes, “But subject to the same criteria as any other food product or appliance, microwave ovens failed the taste test.”¹⁴ The microwave has become a secondary appliance, used for preparing frozen dinners, heating, warming, defrosting and other tasks which assist in the meal preparation process. It has become a mainstay in the American kitchen, and to many families it is indispensable. When it was originally introduced, its manufacturers had higher expectations of the role it would play in preparing meals. It was expected to revolutionize the process of food preparation, giving consumers the ability to prepare a meal with lightning speed. Manufacturers and developers of new microwave oven technology are well aware of the shortcomings of the microwave oven. In the two years since Ms. Sloan’s article was written, microwave ovens have continued to improve steadily, but microwave cooking is still far from perfect. Despite some of these problems, the microwave oven has great potential for becoming the primary cooking unit of the American family. It is inarguably superior in speed and convenience to any other appliance. With advancements in microwave technology (discussed in the Technology section of this report), developments which specifically address the issue of taste are being made. With consideration to these developments and to the potential for increasing the functionality of this appliance, the microwave oven affords a very promising and exciting subject for redesign.

14. Ibid., 96.

The challenge for redesign is not simply to eliminate shortcomings which preclude broader opportunities for use, but principally to introduce a wholly novel set of operations which aggressively address food selection and preparation problems in the rapidly changing lives of American householders. The system described in this report was conceived with the hope of providing important and lasting change. One hopes that it will help facilitate and enrich what one writer describes as the “country’s love affair with food.” In many kitchens across the U.S., a new sophistication has taken hold. Not only are Americans becoming more knowledgeable about nutrition and quality, but their culinary horizons have been widened, and their palates have become more refined. In a *New York Times Magazine* article from March 10, 1996, Molly O’Neill writes:

At the dawn of the New Age of Dietary Enlightenment, in about 1989, readers of the New York Times began clamoring for lean and stylish dishes. Vegetables, more vegetables. Fish. Fresh herbs. No fat, please, anything but fat. But flavor, give us flavor, and style.

The methods for producing such dishes are so time-consuming and the ingredients are so arcane that I used my family in Ohio as reality checks for recipes I devised. Back then, in the late 1980’s, they would offer editorial comment: “What the heck is cilantro?” “Poblano chilies?” “Arugula?” They’d ask how pasta is different from macaroni. They regularly advised that I check The Columbus Dispatch for ideas for casseroles that could be made in 15 minutes.

But in short order, as the country’s love affair with food continued, Kroeger supermarkets in Columbus began stocking fresh coriander and fresh chilies, arugula and organic mesclun; “pasta” entered the popular vocabulary, and healthful eating became a national religion. My family in Ohio no longer provided a stark contrast to my life in Manhattan. My mother was now apt to sing the praises of nonstick skillets and sun-dried tomatoes. What began as an affectation of the elite has, in just a decade, become a mainstream concern. Everybody wants to eat healthfully. Everybody tries to eat healthfully. Nutritional experts and Snackwell’s have supplanted Mom and apple pie.¹⁵

15. Molly O’Neill, “The Morality of Fat: In Low-Fat Theology, Dietary Prudence Is Good; A Taste For Fat Is Immoral,” *The New York Times Magazine*, 10 March 1996, 37-38.

The prosaic meat and potatoes meal of earlier days has given way to a daring exploration of the world's pantries. But while the American family's mealtimes have become more adventurous, their preoccupation with healthy foods has narrowed some of their choices. Manufacturers and packagers have begun to exploit these mushrooming concerns with claims of nutritional excellence. Sifting and verifying these claims can be simplified using the portable component of the *Future Wave* system (discussed in detail in Section VI).

Redefinition of Fast Food: Consumer Need to Expedite Food Preparation Time While Still Maintaining Food Quality

This national preoccupation with food and nutrition signals the need for new products and services that satisfy the needs of an evolving and diverse American diet. Supermarkets and food manufacturers of the 90's have responded to this trend with new products and services, but the problem of food preparation time remains. Besides frozen microwave meals, which have improved greatly since their introduction, many new food items are now marketed by food manufacturers and supermarkets to assist people who are unable to prepare every meal from scratch. These products have become popular with the consumer who would like to prepare a nutritious, tasty meal, yet has little time to do so. The term "speed scratch" cooking has become popular in the food industry. It describes a type of meal preparation that involves the assembling of store bought prepared ingredients with other ingredients in order to make a meal without starting completely from scratch. The concept is not entirely new; items such as bottled pasta sauces, salad dressings and pre-cut vegetables have been marketed for years. However, these items are becoming even more popular because a new emphasis on freshness, nutritiousness and

taste is being used to promote them. Just as manufacturers of frozen microwave dinners have followed the trend toward better quality foods, with names like Healthy Choice and Lean Cuisine so have companies which produce items that assist in speed scratch cooking.

In this demanding culinary environment, the redesign becomes a more complex matter. An article in a March 1995 issue of *American Demographics* describes some of these products.

Half of America's cooks always or frequently make their main meals mostly from scratch, according to Roper, although they may use some prepared items such as spaghetti sauce, salad dressings, and soup. This figure has remained virtually unchanged for the past six years. Forty-two percent almost always or frequently make main meals half from scratch and half from store-bought foods. One-third of cooks often make their meals mostly from store-bought items. This is the method the food industry calls "speed scratch cooking."

"Speed scratch can be a fully complete meal, like a frozen fajita kit, that requires only heating or assembly," says John Scroggins, editor of the Chicago-based newsletter *The Food Channel*. "It may be a package of frozen vegetable and sauce that requires the addition of meat. Or it may be a jar of sauce that is poured over meat browned in a skillet." Whatever it is, speed scratch is the hot trend in new food products. In the first three quarters of 1994, American food manufacturers unleashed 743 new sauces and gravies in supermarket aisles, as well as 405 entrees, 62 dinners, 25 entree mixes, 448 pasta products, 135 rice dishes, and 5 stuffing mixes, according to *New Product News* of Trend Publications, Inc., Chicago.¹⁶

With the growing popularity of these prepared foods, today's consumer is confronted with a bewildering panoply of choices. Packaging and labelling of these new products can sometimes be complicated and confusing. Although these products offer a great degree of convenience, as with all prepared foods, it pays to be a discerning shopper. Today's consumer is more likely to examine each product for nutritional values and health related factors. A system such as

16. Marcia Mogelonsky, "Cooking From Scratch Goes Full Speed," *American Demographics* 17, no. 3 (March 1995): 15-16.

the *Future Wave* can make this scrutiny faster and less tedious.

Growing Awareness of People with Different Dietary Requirements

Trends in diet and nutrition in American society are for the most part changing and evolving in positive directions. At the same time there is a growing recognition in the medical community about the importance of diet in disease prevention and in health maintenance for those who have chronic or temporary medical conditions. For example, those with chronic conditions such as hypertension, diabetes, food allergies and sensitivities must avoid certain foods, ingredients and food additives. Those with temporary conditions, for example pregnant women and people on weight loss programs, must cope with dietary restrictions as well as the necessity to get adequate amounts of certain nutrients. Even for those who are relatively free of health problems, nutritional information has become an important area of concern. As Americans become more health-conscious, they are educating themselves about wholesome food choices and prudent meal-planning. Advice gushes forth in response to this national preoccupation from such diverse sources as TV chefs, writers of cookbooks, and medical professionals. From an unimpeachable source, the *American Heart Association Cookbook*, comes this paragraph which discusses the correlation between diet and disease prevention.

Today we're more worried about our consumption of fatty foods, which may predispose us to these chronic diseases: coronary heart disease, cancer, stroke, diabetes mellitus, obesity and atherosclerosis. The scientific evidence that shows a relationship between diet and these diseases grows stronger every day. This is especially true in the case of nutrition and atherosclerosis, one of the major causes of heart attack and stroke. ¹⁷

17. Mary Winston, ed., *American Heart Association Cookbook*, 5th ed. (New York: Times Books, a division of Random House, Inc.; Toronto: Random House of Canada Limited, 1991), 3.

But chefs of every caliber are aware that components of a good meal must be selected carefully. Freshness, nutritional value, ingredients and additives are important criteria. The *American Heart Association Cookbook* outlines the importance of choosing carefully at the market.

YOUR FIRST LINE OF DEFENSE: READ PRODUCT LABELS

With fresh produce and other whole foods, you can control the amount of fat, salt and calories you add in cooking. With packaged or prepared foods, however, you have to read the ingredients list and the nutrition information to determine the kind and amount of fat you're getting, the number of calories per serving and the amount of salt in the product.¹⁸

Consideration of this aspect of the food acquisition process and the increasing popularity of packaged food products such as "speed scratch" ingredients, led to the formulation of the concept of the *Portable Information Unit*. This integral part of the *Future Wave* system has as its main function the capacity to identify ingredients, freshness dates, etc. accurately and expeditiously, and to make this information available to the user. It goes without saying that eliminating inappropriate choices will make selection an easier task.

It would be difficult to exaggerate the potential benefits for the elderly of these hand-held units. Older people may be even more restricted in their choices, not only because of chronic conditions, but simply because their nutritional requirements are different. In some cases, it may be difficult for them to read labels because of poor eyesight, or to hold and manipulate packages because of arthritis or some other debilitating condition. Nutritional requirements for the elderly comprise an important area in the field of geriatrics. The International Food Information Council Foundation explains why the elderly have different needs.

18. Ibid., 16.

There are generally recognized changes in dietary needs for the elderly. Many are related to loss of lean body mass and reduced level of activity. Less muscle tissue and lower expenditure of energy result in a need for reduced caloric intake.

When eating less food, the elderly must be careful to select nutritious foods so that their diminished intake will provide the nutrients they need. In general, women require fewer calories, yet have nutrient requirements similar to men, and must be especially mindful of their food choices.

Normal changes associated with aging result in higher requirements for some nutrients such as vitamin D, which is necessary for proper calcium absorption. The elderly typically get less exposure to the sun and have reduced capacity for skin synthesis of vitamin D, a major source of this nutrient.¹⁹

Several other clusters within the population share the necessity of strictly monitoring food ingredients. In literature from The Genesee Hospital Food and Nutrition Services, titled "Diabetes and Meal Planning," the guidelines include incorporating sufficient carbohydrates and fiber in the diet, and reducing fat, salt and sugar intake.²⁰

Similar literature provided by the same source titled "4 Gram Sodium Diet," is aimed at the hypertensive patient. Eliminating sodium from the diet may seem very straightforward, but it can be very difficult. Sodium is a natural component of many foods, and a common added ingredient in many processed foods and seasonings.²¹ In order for the patient to adhere to these diets, every ingredient must be carefully selected and all labels attentively scrutinized. Maintaining a special diet becomes even more difficult when members of the same household are following different regimens. Problems of food selection are then

19. International Food Information Council Foundation, "Better Eating for Better Aging," *Food Insight Reports* (May/June 1990): 2.

20. The Genesee Hospital Food and Nutrition Services, "Diabetes and Meal Planning" (Rochester, N.Y.: The Genesee Hospital), 2.

21. The Genesee Hospital Food and Nutrition Services, "4 Gram Sodium Diet" (Rochester, N.Y.: The Genesee Hospital), 1.

compounded, as are cooking and preparation times.

The diets described above are usually of permanent duration, but situations exist when a diet must be modified for a limited period of time, as during pregnancy or for a weight loss program. The pregnant woman must be sure to get enough vitamins and minerals, and to monitor her intake of certain foods. Labelling and nutritional information take on a special significance in this context. In a publication of the International Food Information Council Foundation titled *Healthy Eating During Pregnancy*, December 1995, cosponsored by the March of Dimes Birth Defects Foundation, the importance of proper nutrition during pregnancy is discussed.

Pregnancy is one of the most nutritionally demanding periods of a woman's life. Gestation involves rapid cell division and organ development. An adequate supply of nutrients is essential to support this tremendous fetal growth.²²

During pregnancy, an additional intake of 300 calories per day is recommended, as well as a total of 60 grams of protein, 1200 mg of calcium, 30 mg of iron and 400 micrograms of folic acid daily.²³ A system that could assist in tracking these requirements would be invaluable.

Of the numerous medical conditions that are in some way related to diet, the food allergy has received considerable attention during the '90's. Food allergies may be difficult to diagnose, because allergens may be present in complex foods or food combinations. The following passage is part of the section titled "Defining Food Allergy" from the publication *Understanding Food Allergy*, obtained from the International Food Information Council Foundation.

22. March of Dimes Birth Defects Foundation and the International Food Information Council Foundation, *Healthy Eating During Pregnancy* (White Plains, N.Y.: March of Dimes Birth Defects Foundation; Washington, D.C.: International Food Information Council Foundation, December 1995), 1.

23. Ibid., 7-9.

A food allergy is any adverse reaction to an otherwise harmless food or food component that involves the body's immune system. To avoid confusion with other types of adverse reactions to foods, it is important to use the term "food allergy" or "food hypersensitivity" only when the immune system is involved in causing the reaction.

There are several different types of adverse reactions involving the immune system, which helps the body resist disease. In the case of the food allergy, "immediate hypersensitivity" is the most clearly understood. This reaction involves three primary components: food allergens, immunoglobulin E (IgE), and mast cells and basophils.

A food allergen is the part of a food that stimulates the immune system of food-allergic individuals. A single food can contain multiple food allergens, the majority of which are likely to be proteins, not carbohydrates or fats.²⁴

The benefit of using a device to assist in accurate and speedy identification of an ingredient or a prepared meal component would depend on the amount of information available for retrieval in the symbology. Manufacturers are packing more information in these symbologies, and will probably realize that they can command a larger clientele by providing more information in this manner. However, until these changes are fully implemented, a scanner programmed with a database of relevant information can be quite as efficient.

In the section "Food Allergy Management," from the same publication *Understanding Food Allergy*, some guidelines are delineated for those diagnosed with allergies.

To successfully follow an elimination diet, individuals must become adept at reading food labels. By law, a list of ingredients in each food product should be listed on the label. Labels should be rechecked periodically, as product formulations sometimes change. Specific information about food ingredients or manufacturing also is available from food companies by contacting them at the address or phone number on the label.²⁵

24. American Academy of Allergy and Immunology and the International Food Information Council Foundation, *Understanding Food Allergy* (Milwaukee, WI: American Academy of Allergy and Immunology; Washington, D.C.: International Food Information Council Foundation, April 1995), 2-3.

25. *Ibid.*, 8-9.

Although nutritionists and other members of the medical community are constantly modifying their recommendations for healthy eating, some constants remain. Decreasing fat and cholesterol intake as well as sugar and sodium are some of the primary goals of today's informed consumers. The food label has become an invaluable implement in eliminating unwanted ingredients in the diet. An article from a recent issue of *Nutrition Today* titled "Consumer Nutrition and Food Safety Trends 1996: An Update" outlines some key issues that are important to today's consumer. The third issue discussed is fat content.

3. Fat Stays First with Consumers. At 65%, the highest level to date, fat remains the number one nutrition concern of consumers, according to the 1995 Food Marketing Institute Trends Survey.⁷ In the Food Marketing Institute/Prevention 1995 Shopping for Health Survey,⁸ fat content is the primary reason for not purchasing certain foods; 77% of shoppers stopped buying food products because of the amount of fat listed on the nutrition label. The release of the Surgeon General's Second Report on Diet and Health in early 1996 is bound to direct more attention to dietary fat issues. In 1988, when it was first released, it set a precedent for dietary recommendations in the United States.²⁶

The Food Industry

The food industry has responded to the trends discussed in the preceding pages with a variety of products and services. In some cases adaptation was necessary. In other cases the industry was able to capitalize upon these concerns with the introduction of a new product. Convenience, good nutrition, taste and freshness are touted in advertising and packaging. In the midst of all the hype, there is a kernel of real concern, and an effort to improve, always

26. Kathleen E. McMahon, "Consumer Nutrition and Food Safety Trends 1996: An Update," *Nutrition Today* 31, no. 1 (January/February 1996): 22.

motivated by the profit margin.

Adapting to New Consumer Needs and the Changing Diet of Consumers

A telephone interview was conducted with Andrea Zuegal, Special Projects Coordinator for the Wegmans Food Markets in Rochester, NY. One of her responsibilities at Wegmans is to write "Customer Education" literature. The following are some highlights of questions posed to her with paraphrased and abbreviated responses:

What are some of the most popular trends in the food industry today?

- Fast, easy to prepare meals, yet healthy
- Taste is an important aspect
- Vital to food is the fresh, natural aspect
- Growing awareness of food safety (bacteria, salmonella, etc.)

Are people buying more or less prepared food than they were 5 or ten years ago?

- Prepared foods are a growing trend
- Speed scratch cooking- a term used in the food industry to describe a partially assembled meal that takes the consumer very little time to prepare (examples bagged salads, pre-chopped frozen vegetables, pasta sauces that ingredients such as vegetables can be added to)
- Fully prepared meals that simply need to be reheated in a microwave
- In a survey conducted at 4:00 in the afternoon 66 percent of people surveyed did not know what they were having for dinner that evening

Are foods like frozen microwave dinners becoming more or less popular?

- Their popularity is not increasing but not decreasing
- They have improved in both taste and nutrition (no longer like the TV dinners of the past)
- New brands that emphasize the "healthy" aspect are becoming more popular

What is more important when a customer makes a decision to purchase a particular food, taste or nutritional value?

- Both are important, but people won't buy something just because

it is healthy . . . it must also taste good

Are your stores stocked much differently depending on location and customer base?

- Very much so . . . Marketplace location - emphasis on natural and easy to prepare foods
- Irondequoit - large Goya section and exotic fruits and vegetables
- Pittsford - many Kosher products

Are meats becoming more or less popular?

- After the health food trends of the 70's and the indulgence of the 80's, new trends are becoming popular
- Leaner meats
- New ways to prepare them so they are healthier
- Company's priority is to give customers more nutritious foods

Does Wegmans have any special services such as electronic ordering, delivery, electronic accounts, etc. for customer convenience?

- No, not at this time.

Would your stores ever consider implementing these types of services?

- Wegmans is always willing to make changes that will increase customer satisfaction. If customer demand were high enough we would consider it. A few supermarkets around the country now have similar services. ²⁷

The interview confirmed many assumptions that had been made based on previous research in this area and also initiated inquiry into some more specific issues. Some information was forwarded by Ms. Zuegel; one article of note is from a recent *New York Times* titled "As the Shopping Cart Turns." It is about how today's supermarkets are changing to accommodate the busy schedules of today's consumers. A relevant passage from the article describes the DeWitt Wegmans store: "The DeWitt store, which opened in November, is the prototype in the company's 50-store chain based in Rochester. But Wegmans is not the

27. Andrea Zuegal, Special Projects Coordinator for the Wegmans Food Markets, interview by author, January 1996, Rochester, New York, telephone.

only cutting-edge supermarket operation promoting prepared foods and what the industry calls 'assisted cooking.' ”²⁸ Hence, many supermarkets are now trying to adapt to the changing needs of their customers.

Examples of the Newest Supermarkets and How They Have Adapted to the Contemporary Needs of the Consumer

The newest supermarkets of the 1990's are emphasizing convenience more than ever before. They are larger, more extensively stocked and offer more services to consumers. The supermarket is taking a more active role in the daily meal preparation process of its customers. In some cases, services such as fully prepared meals are offered for those who have no time at all to prepare dinner. In other cases partially prepared meals or prepared side dishes are available. These stores also stock a large variety of the "speed scratch" ingredients discussed previously. These are either prepared by the supermarket itself or by branded food companies. In contrast to fast food restaurants, these new supermarket services not only emphasize convenience, but also taste and wholesomeness. A passage from the article, "As the Shopping Cart Turns" highlights some of the newest trends in the supermarket industry.

"The growth of prepared foods is happening in supermarkets all over the country, in all sorts of neighborhoods," said Tim Hammonds, the president of the Food Marketing Institute in Washington, a supermarket trade association. "For years, we watched fast-food restaurants take dollars away from supermarkets. Now, we see an opportunity to expand sales."

Indeed, Ukrop's, a chain of 23 stores in Virginia, offers more than 100 prepared items daily, including dinner for two in a bag - an entree, salad and bread, for \$8.99. Byerly's, based in Minnesota, has a home economist in each of its 10 stores to answer shoppers' questions and a cooking school

28. Carol Lawson, "As the Shopping Cart Turns," *New York Times*, 31 January 1996, sec. C, p. 1.

in its St. Louis Park, Minn. flagship store. Among the classes: "Vous Etes en Provence."²⁹

Examples of New Product Introductions

Numerous products have been introduced over the past decade. While some products are beneficial to the consumer for reasons of convenience, nutrition or both, others are of dubious quality. Products which are more convenient and quick to prepare may lack nutritional value. Expense is another important factor that must be weighed by the consumer. The speed scratch products discussed earlier may be worth the additional cost for the busy family. However, purchasing a partially or fully prepared meal may be warranted only on the occasional very late night at the office. In any case, supermarkets and the food industry are now giving their clientele an increasing variety of options for preparing their daily meals. In the article "Top Ten Trends to Watch and Work On," the author describes some of the new products and the manner in which they are marketed.

The marriage of fresh and convenience is perhaps the most important purchase motivator in the supermarket today. According to Information Resources (Buss, 1993), refrigerated, prepared salads and coleslaw soared 79% to \$452.9 million for the quarter ending March 28, 1993. The value-added craze has already crossed over to the fruit section. Miniature vegetables such as baby peeled carrots (now sold in vending machines); fresh cut celery, carrot and sweetpotato snack sticks; fresh stir-frys, soups, and stew mixes; are also "hot" in the fresh category.

Perhaps the most dramatic impact of the move to fresh will be its influence on packaged food products. Some categories such as spaghetti sauce and salsa have already begun to migrate to the fresh state. In others, manufacturers will be forced to find ways of making packaged good products appear fresh and flavorful.³⁰

29. Ibid., p. 1, 6.

30. A. Elizabeth Sloan, "Top Ten Trends to Watch and Work On: The More Things Change, the More They Stay the Same," *Food Technology* 48, no. 7 (July 1994): 91.

Products That Contribute to Good Health

In the past packaged foods were less desirable to consumers who wanted wholesome and fresh ingredients in their meals. In general they were considered of lower quality. Current trends in the food industry have caused these connotations to fade. Packaging has improved significantly and packaged foods are in many cases more desirable because of their convenience, versatility and the information contained on the food label. In the article titled "Eat Your Vegetables" from the October 1995 issue of *American Demographics*, the author discusses some new produce products.

In the 1990s, purveyors of fresh vegetables are borrowing a leaf from their frozen-vegetable counterparts. They are now attracting shoppers who want convenient produce by selling pre-washed, pre-cut fresh vegetables in plastic bags. In other words, they are selling fresh vegetables the way consumers always purchased frozen ones. Convenience offerings in the fresh produce department include pre-cleaned, pre-sliced fresh carrot sticks; pre-shredded cabbage for cole slaw; and pre-washed broccoli and cauliflower florets. Some companies sell lettuces and other fancy salad ingredients complete with packets of salad dressing.³¹

Packaging, however, no longer means simple plastic bags. In *Food Technology*, April 1996, Theodore P. Labuza, professor of food science at the University of Minnesota, describes a number of technologies which have been developed to slow the deterioration of fresh packaged foods, and monitoring systems which determine the duration of a product shelf life. In "An Introduction to Active Packaging for Foods," Labuza writes:

A variety of packaging technologies are being developed to provide consumers with high-quality, minimally processed foods that have a long shelf life. Among these technologies in which packaging plays an active role in protecting fresh or minimally processed foods are edible moisture barriers

31. Marcia Mogelonsky, "Eat Your Vegetables," *American Demographics* 17, no. 10 (October 1995): 10.

to prevent moisture loss of fresh cut vegetables and fruits; edible oxygen barriers to stop enzymatic browning; ethylene scavengers to slow senescence; oxygen scavengers to create a low-oxygen atmosphere and slow metabolism; zeolite surface films to inactivate microbial growth on the food surface; tuned infrared films that radiate energy to inactivate microbes; sachets and edible films that transmit microbial inhibitors such as ethanol or sorbate; and films that scalp or scavenge off-odors.

Technologies which can be used for processed foods include edible barriers to slow moisture transfer between ingredients of different water activity; oxygen scavengers to slow oxidation of lipids; carbon dioxide scavengers; and odor scavengers.

Other types of active packaging include microwave susceptor films which can be used to create high-surface-heat environments for French fries, bakery goods, and popcorn; microwave doneness indicators; steam-release films; extreme-temperature integrators to indicate abuse conditions; and time-temperature integrators to indicate loss of shelf life during distribution.³²

Some of these technologies are in limited use today because they are still quite expensive. The TTI, or time temperature indicator, is used in a supermarket chain in France in its delis, and by Italy's Barilla for filled pasta, but most companies find the device too expensive at the present time. Some other technologies are generally effective in extending shelf life, but tend to upset the delicate balance among microorganisms and vegetable products, as well as slightly affecting nutrients and flavors.³³

In packaging, the partnership between the packaging itself and the label has become more intimate. Labelling can include freshness indicators, and cooking instructions. Packaging may also include boil-in bags, microwave susceptors, doneness indicators, and temperature indicators for use in the microwave. More information about these devices will be included in the section concerning technology. However, deciphering the portion of the label which represents the

32. Theodore P. Labuza, "An Introduction to Active Packaging for Foods," *Food Technology* 50, no. 4 (April 1996): 68.

33. *Ibid.*, 70-71.

first interaction of the consumer with the product, the list of ingredients, nutrients and other substances, has become an impossible chore. Beatrice Trum Hunter, in her May '90 article for *Consumers' Research Magazine*, quotes John la Rosa of the American Heart Association as saying that " 'You need a doctorate to understand (food) labels,' remarked John la Rosa, past president of the American Heart Association's committee on nutrition." Trum goes on to give reasons for this statement.

The food label format, with measures in grams and International Units, may be understood by nutritionists and dietitians, but does not make for quick, concise, and clear access to nutritional information for the busy shopper. The current format is confusing and not helpful to those who read labels for specific information regarding fats, sodium, sweeteners, etc. One industry survey found that more than one in five shoppers is on a medically-restricted diet. Nor is the format easily understood by those who have reading difficulties, including non-English speaking individuals, the visually impaired, and the semiliterate.³⁴

Trum then discusses proposals for improving the food label with the comfort of the consumer as the final goal. Some of these suggestions have been graphics, such as pie graphs, or stylized symbols, such as a salt shaker with a bar slash across it. Color coding of packages with commonly restricted ingredients has also been proposed.³⁵

Although all of these innovations seem better than the endless paragraphs of ingredients printed in tiny letters, it would seem that including this information in a 2-D bar code or a matrix code available to be scanned and processed within specific parameters according to the user's needs, would result in greater efficiency. If this is not immediately possible, a scanner programmed with relevant data could easily sift out and approve (or reject) supermarket selections.

34. Beatrice Trum Hunter, "Food Label Format," *Consumers' Research Magazine* 73, no. 5 (May 1990): 8.

35. *Ibid.*, 8-9.

One Stop Shopping

The concept of one stop shopping is not an entirely new one. Malls, large supermarkets, and shopping centers have flourished in suburban locations for decades. However, the appearance of the most contemporary supermarkets has changed significantly. They are not only larger and better stocked, they have also become more service oriented. They offer a variety of products and services in response to consumer demand for convenience. Another passage from the article "As the Shopping Cart Turns" describes a Syracuse NY Wegmans store.

At 123,000 square feet, nearly three times the size of the average supermarket, Wegmans is like a mall with an abundance of tempting food and services. Shoppers can drop off dry cleaning, have a make-over at the makeup counter, fill prescriptions, rent videos, develop film, order flowers, buy groceries and eat lunch, dinner or weekend brunch - a new plateau in one-stop shopping. The store, open 24 hours a day, is so big - it has 34 checkout lanes - that it offers shoppers maps and benches for rest stops. ³⁶

Although this is not a description of a typical nineties supermarket, it does suggest the direction in which these stores are headed and perhaps foreshadows the stores of the first decade of the 21st century. The key to the success of these larger supermarkets is convenience and variety. General grocery items as well as specialty items are sold. Whole sections of some stores are devoted to specialty items such as ethnic foods and baked goods. While shopping for a quick, weeknight meal solution, the customer can also transact other business and avoid the necessity of running another errand such as a trip to the pharmacy. Some dread parking in a huge lot and searching an enormous crowded store for a few items. These shoppers prefer a more serene shopping experience. Although these are certainly legitimate concerns, one stop shopping has gained

36. Carol Lawson, "As the Shopping Cart Turns," *New York Times*, 31 January 1996, sec. C, p. 1.

ground because of its obvious advantages for the growing number of time-constrained, dual-income households.

On-Line Shopping

One of the newest and most innovative services offered by some companies is on-line grocery shopping. With increasing numbers owning personal computers and using the internet, the use of this service may become more common in the years to come. Although the number of companies that provide this service is still very small, there is a great potential for growth. It presents the consumer with the ultimate degree of convenience. Electronic orders are placed via the internet, and groceries are delivered directly to the home. An article in the January 1996 issue of *American Demographics* describes some of these services.

Aimed at two-income households with more money than time, the services charge a fee to have someone pick up groceries for you. Like old-fashioned home delivery, a live human being still has to take the cans and boxes from store shelves to your door. The difference lies in how you place the order, and through whom.

Shoppers Express of Bethesda, Maryland, and Peapod of Chicago offer slightly different versions of essentially similar electronic shopping services. Both companies contract with local grocery stores to offer the service. Shoppers Express can be reached through America Online, while Peapod has developed its own software to guide shoppers through virtual supermarkets. The basic process is the same for both services. Shoppers peruse store inventories in printed or online catalogs and place their order online.³⁷

These services may not be practical or economical for all families. Some may simply prefer to choose their own groceries. Though such services cater to the discriminating customer, some may argue that food selection requires more

37. Tim Cavanaugh, "Bread from the Cybermarket: Grocery Delivery to Homes May Make a Comeback, with the Help of Modems.," *American Demographics* 18, no. 1 (January 1996): 15.

personal oversight. Another drawback is the added expense of, in effect, hiring a personal shopper. Whether the fee is a service charge, membership fee or delivery charge it can add substantially to the weekly food budget. There are several other similar on-line services including the SMART-FOOD CO-OP of Cambridge MA and the Loam Company in partnership with Tops Friendly Markets. While it appears that the demand for this type of service is growing, on-line grocery shopping will probably remain a specialized service used by a select group of affluent householders. The increasing number of large one stop shopping supermarkets discussed in the previous section, supports the idea that Americans prefer direct participation in grocery selection. One imagines the shopper zipping down the grocery isles, scanner in one hand, whipping selections into the cart with the other. In this context, the device can lessen the anxiety of the twice-weekly frenetic label-reading supermarket safari. Less expensive than on-line shopping or prepared meals, more wholesome than fast food or takeout, these ingredients may be brought home and heated or cooked in the most convenient manner in the enhanced microwave oven component of the *Future Wave* system, which will even process information for the cooking process.

IV. TECHNOLOGY

Innovation: New Features vs. Marketing Ploys

Manufacturers of home appliances make fairly frequent but often superficial changes in their products, seeking to promote new fashions in what may be called “kitchen chic.” New homes with smaller kitchens and more open floor plans, have focused attention on work areas, particularly kitchens and their stationary and mobile components. Though many of the changes are aesthetic or gimmicky, others are more substantive. Refrigerators have become more environmentally friendly, with improved compressors, fans, motors, airflow and defrost cycles. Ranges are now available with induction cooktops; and dishwashers have improved efficiency with electronic controls.¹ Change is taking place, but the pace is plodding rather than dramatic.

The appliance which seemed to offer the most promise for such change is the microwave oven. It seemed, at its inception, poised to discharge the cooking needs of late twentieth century households, with its speed, lower energy consumption, and conservation of nutrient values. It has never completely fulfilled its promise. Moreover, its integration into the total food preparation environment is virtually at a standstill. It is used as an auxiliary appliance, mainly for heating and thawing, and usually when using a major appliance is inexpedient. Furthermore, its exterior form has remained static - the metal box

1. Joan Mees, “Revolution in the Kitchen,” *Food Technology* 38, no. 11 (November 1984): 104-107.

with the door which opens sideways. Physically, as well, the microwave is awkward and in the way, not easily integrated into the food preparation triangle. The opportunity to exploit its potential would appear to be not only in the improvement of the oven function itself, but in partnerships with other exciting technologies; and a reassessment of its functions with respect to a target clientele would seem to be in order.

An article coauthored by Ira Magaziner, business consultant, and adviser to various government agencies, was written for the *Harvard Business Review* in 1989. In it, Magaziner describes the early recognition by Japanese manufacturers such as Matsushita, and by Chu of the Korean company Samsung, of the importance of the microwave oven, particularly with respect to the U.S. market. According to Magaziner, U.S. appliance makers like GE awoke to the profit potential of this product only after the Japanese began to export microwave ovens in quantity to the U.S. Magaziner writes,

Few U.S. appliance makers saw promise in it. Even though it was the first new major appliance in a generation, it seemed unnecessary. Most U.S. households already had an oven. Who would want two?

The product seemed ideal for Japan, however a nation of small houses and small kitchens. Moreover, Japanese cooking relied heavily on reheating, a strong point of microwaves. But even though a few U.S. companies saw the microwave's sales potential in Japan, they weren't interested. Exporting to distant markets wasn't worth the trouble.

That's how the Japanese became the first big manufacturers of microwave ovens. They seized the technology, began perfecting it, and soon went beyond their backyard. They saw export as an opportunity, not a burden. They pushed the product overseas, harvesting a windfall when the world market took off, going from 600,000 ovens in 1970 to 2.2 million in 1975.²

For my purposes, two very important ideas emerged from the study of this article. The first was that the Japanese initially, and subsequently the Koreans,

2. Ira C. Magaziner and Mark Patinkin, "Fast Heat: How Korea Won the Microwave War," *Harvard Business Review* 67, no. 1 (January/February 1989): 85.

took the trouble to adapt the oven expressly for the huge U.S. market, both with respect to its operational features and to its price. Price was controlled by deliberate and gradual streamlining of production methods, mainly through automation and efficiency of product design.

However, the most valuable concept which I took away from this narrative is that of the importance of foresight and flexibility. For example, the Koreans, whose production and sales were growing phenomenally in the early to mid 80's, were constantly striving to attract a larger clientele. During these years, anticipating the possible saturation of the U.S. market, they set their sights on Europe, and began to position themselves to capture an important share of that market. Magaziner asks S. D. Lee, an engineer from Samsung,

What are Samsung's most lasting lessons? Two things, Lee says. First, management by target. Set a goal, then meet it no matter what- even if it means working through the night for a week. Second, always think several years ahead; ask where things will be next decade.³

He continues,

In most companies, only the sales force travels. Samsung, like many foreign companies, sends engineers abroad to learn buyers' habits too. That's why Jang, head of production, was sent on regular marketing trips to the United States. Jang remembers flying in with a dozen engineers from Suwon for an electronics show in Las Vegas. At one point, he took a side trip on his own, visiting stores such as Sears and talking to salespeople. He asked what models were most popular, what features attracted consumers. Spotting a woman buyer, he asked her what she looked for in a microwave oven.

Why couldn't he rely on Samsung's marketing people? An engineer has to see some things for himself, he explains. . . . He seeks more than technical knowledge-something subtler, a feel for America's tastes, its character, its people.⁴

3. Ibid., 90.

4. Ibid., 91-92.

Bearing in mind that this article is a chronicle of success, often in the face of great odds, there are important lessons to be learned from studying it. One is that it would seem prudent for the designer and manufacturer not only to improve and refine existing appliances, but to seek out aggressively and develop new technologies. The designer must be sensitive to shifts and adjustments in social institutions and to resulting changes in household and workplace imperatives. Daring to anticipate trends and to nudge technology along in fresh directions in response to them, the designer can truly fulfill his/her mission.

The Microwave Oven

At this juncture, it may be worthwhile to understand some of the history of the microwave oven, and its evolution into the appliance of today. The microwave oven was developed by the Raytheon Company during the years 1946-1952 after a fortuitous discovery by one of their engineers. The technology for the oven arose out of research into radio wave detection systems or radar, which took place during World War II. Radar was made possible with the invention of the magnetron which generates electromagnetic power at very high frequencies.

One day in 1946, Dr. Percy Spencer, an engineer with Raytheon Company was testing a magnetron tube when he reached into his pocket for a candy bar. He discovered that the chocolate had melted to a soft gooey mess. Well aware that microwaves generate heat, he wondered if the candy had been critically close to radiation leaking from the tube. He'd sensed no heat. Too intrigued to be irritated over a soiled pair of trousers, he sent out for a bag of popcorn kernels, placed them near the tube, and within minutes, kernels were popping over the laboratory floor. . . .

Raytheon set out to develop a commercial microwave oven, and within a few years announced the Radar Range- which in size more closely resembled a refrigerator, though its actual cooking space was quite modest. The Radar Range suffered from a problem characteristic of all electronic devices before the advent of microminiaturization: most of its bulk housed vacuum tubes, cooling fans and a Medusan tangle of wires. Although some

Radar Ranges sold to restaurants, from the consumer standpoint the product was unmemorable.⁵

Spencer's oven employed two magnetron tubes, a power supply, a power control system, a metal box and a timer. Microwave ovens in general use today use this basic model, although most employ microprocessor chips for such refinements as clocks, sensor applications, and multiple step processes. Simply put, microwave ovens convert electricity into microwave energy by means of the magnetron. These microwaves cause water molecules in food to oscillate and change polarity billions of times per second generating heat from the friction of the molecules.⁶ This heat cooks food. A definitive study by Charles Buffler, *Microwave Cooking and Processing: Engineering Fundamentals for the Food Scientist* describes the process.

Before the microwave electric field is applied, all the water molecules in the food are thermally agitated in a random fashion corresponding to the initial temperature of the sample to be heated. When the field is applied, the molecules all attempt to orient themselves in the initial field direction. As they do, they collide randomly with their neighbors. When the field reverses, they attempt to reverse direction and further collisions occur. These collisions add to the background thermal agitation, which we then perceive as an increase in temperature. Energy is thus extracted from the oscillating electric field by the dipoles and is transferred to other molecules by the collisions. . . .

Microwave interaction with polar molecules such as water is the second form of microwave interaction. For foods it is the predominant microwave interaction, except in highly salted foods such as ham.

Microwaves are *not* heat. Microwave fields are a form of energy, and microwaves are converted to heat by their interaction with charged particles and polar molecules; their agitation is defined as heat.⁷

5. Charles Panati, *Extraordinary Origins of Ordinary Things* (New York: Harper and Row, 1987), 125-126.

6. Michael Gikas, "Some Hot Values in Microwave Ovens," *Home Mechanix*, April 1996, 45.

7. Charles R. Buffler, *Microwave Cooking and Processing: Engineering Fundamentals for the Food Scientist* (New York: Van Nostrand Reinhold, 1993), 7-8.

In general, microwave cooking has been shown to require a significantly lower expenditure of energy than conventional cooking methods. However such factors as magnetron specifications and changes in capacitor value affect this efficiency. John E. Gerling, president of Gerling Laboratories, in his article, "Household Microwave Oven Technology," in the *Tappi Journal*, March 1990, writes of oven variations.

There is a variation in power output from oven to oven because of variations in the component values of the capacitor and differences of the performance characteristics of the magnetron. (The transformer and high-voltage diode are manufactured in such a way as not to introduce any oven to oven variations.) The capacitor has the greatest effect because there can be considerable variation from lot to lot for a given capacitor manufacturer and even more variation from manufacturer to manufacturer. With all factors taken into account it is not unusual to see the power output of a series of identical models have a range of output from 575 W to 675 W, with a 625-W specified value.⁸

Load volume, shape, temperature and position, as well as the vessel's shape, size, and specific heat are important considerations in the effort toward satisfactory use of the microwave oven. Robert F. Schiffman, president of R.F. Schiffman Associates, Inc., emphasizes the importance of mass size, moisture content, density, physical geometry and conductivity and specific heat as important elements in the functioning of an oven. He recommends careful vessel design and selection to those engaged in product development.⁹ Oven and cavity size also affects functioning to a significant degree.

The size of the oven cavity also has an influence on performance characteristics, particularly uniformity of heating. Oven cavities at the present time range in size from 0.4 ft³ to 1.5 ft³ for countertop microwave

8. John E. Gerling, "Household Microwave Oven Technology," *Tappi Journal* 73, no. 3 (March 1990): 205.

9. Robert F. Schiffmann, "Microwave Foods: Basic Design Considerations," *Tappi Journal* 73, no. 3 (March 1990): 209-212.

ovens and up to 3.5 ft³ for wall-type built-in ovens. The larger the cavity, the larger the number of mode patterns that can exist within the cavity, and, generally speaking, the easier it is to achieve uniform heating.¹⁰

Buffler states that cavity geometry has “no known relationship” to the absorption of power in a load.¹¹ However, when microwave energy operates within a synergistic relationship with other heating sources including radiant electromagnetic energy, this architecture can be integral to function.¹² This relationship and other novel developments form the basis for an innovative proposal for microwave oven use which will be discussed later in this report.

Innovations and enhancements of the microwave oven since its inception nearly fifty years ago offer only tantalizing hints of its potential for conversion from use as a minor auxiliary appliance to an indispensable food preparation unit. The rotating platform, familiar to most users, permits a more uniform power absorption by the load than does the stationary platform. Combination microwave-convection ovens constitute an attempt to address the problem of load size and shape, as well as a particular food or recipe's lack of tolerance to rapid heating rates. This year, for example, Goldstar is offering an oven with three cooking modes: microwave, convection or a combination of both with twelve programmed cooking options. Panasonic's NN6805 has sensors that monitor cooking and heating. The Samsung MS-674G includes a gas sensor which measures the moisture emitted by the load in order to assess doneness. When the moisture reaches an acceptable level, power is cut off automatically. Sharp

10. John E. Gerling, “Household Microwave Oven Technology,” *Tappi Journal* 73, no. 3 (March 1990): 198.

11. Charles R. Buffler, *Microwave Cooking and Processing: Engineering Fundamentals for the Food Scientist* (New York: Van Nostrand Reinhold, 1993), 42.

12. The Rubbright Group, Inc., “*Thermalizer*” *Electromagnetic Oven: A Microwave Research Center Development* (Eagan, MN: The Rubbright Group, Inc., 1991), 2.

has provided an alternative to the side-swinging door in its R-9H94B with a door that opens down. Like the Panasonic and the Goldstar, it is equipped with a sensor, and like these models, it is pricier than the average oven. Frigidaire's 96 offerings feature more color choices, a curved sculptured design, a wide range of sizes, convection-micro models and built in cabinetry. ¹³

Despite many of the advancements in microwave oven technology, food cooked in a microwave oven still does not have the texture and appearance of food prepared by conventional methods. Because of this, combination ovens have become popular. They combine microwave energy with other heat sources. The most popular is the microwave-convection combination. It offers the speed and convenience of a microwave oven with the added ability to crisp and brown foods. However, other alternatives are also in production or under development. In an article titled "Increasing Appliance IQ," by David Simpson, Contributing Editor to the publication *Appliance*, an oven that uses both microwave and radiant energy is discussed.

This is not an untried concept, of course. European manufacturers, in particular, offer models that combine microwave, radiant, and sometimes convection cooking. But the approach taken by the Magic Chef brand differs. For one thing, the appearance and features are basically that of a conventional U.S. 30-inch range. Just as important, the company has developed controls and operating procedures that simplify user choices, despite the added capabilities. And while the oven will operate in a radiant-only mode, it will not operate in a microwave-only mode. ¹⁴

The exploration into the possibility of making more radical changes has motivated research which has led to the issuance of several patents during the

13. Michael Gikas, "Some Hot Values in Microwave Ovens," *Home Mechanix*, April 1996, 45-47; Frigidaire News, "Frigidaire Introduces New Line of Microwaves with the Features and Look Consumers Want: 15 New Models Available in 1996 Frigidaire Microwave Line," *Frigidaire News* (Dublin, Ohio: Frigidaire News, January 25, 1996, accessed March 1996); available from <http://www.frigidaire.com/NEWS/7news13.html>; Internet.

14. David Simpson, "Increasing Appliance IQ," *Appliance* 52, no.4 (April 1995): 40.

present decade. With the goal of reducing production costs, the Japanese developed a plastic cabinet. With plastic cabinets as well as with plastic cavities, safety problems with insulation, grounding and electrical shock hazards must be resolved before such devices may be brought into production. Inverter-type power supply systems have also been patented by Japanese manufacturers, Panasonic and Sharp, in an effort to reduce the volume and weight of their ovens. Various companies and developers are also improving performance control systems. These developments include cookbook scanners, cookbook programming, scales, thermometers and probes. Combination ovens, which circulate hot air and steam for vegetable and fish cooking, have also been developed. Many of these innovative devices are not yet available on the U.S. market, since some still await government approval. ¹⁵

The aforementioned attempts to conquer the shortcomings peculiar to microwave cooking are part of the forty-odd year battle to lift the microwave oven out of the very narrow use niche to which it has been consigned. Two of the main drawbacks of microwave cooking are uneven heating and unappealing textures which result from the acceleration of the cooking process. In order to be able to create strategies for dealing with these problems, the food industry has explored various methods of temperature measurement including infrared radiometry, or scanning a warm surface to produce a complete thermal image. Because of the varying emissivity of materials, this tool is usually restricted to measurement of heating patterns after the product is removed from the oven. ¹⁶

15. John E. Gerling, "Household Microwave Oven Technology," *Tappi Journal* 73, no. 3 (March 1990): 205-206.

16. Kenneth A. Wickersheim, "On-Line Measurements in Microwave Ovens," *Tappi Journal* 73, no. 3 (March 1990): 224.

Fiber-optical temperature probes have proven to be more useful in microwave food packaging development, since they allow for temperatures to be monitored during oven use. These techniques have led to the invention of susceptors, which alter the heating patterns on loads, and produce more palatable, evenly heated meals and snacks. Susceptors made from film of electrically conducting metal absorb the microwave energy and are heated strongly. The heat is conducted into the food in a way that produces a dryer or crustier surface.¹⁷

Ideal microwave packaging products must be tailored to the surface heat flux, interior cooking, and moisture venting and flavoring needs of a particular type of food. We propose that the microwave packaging industry use heat flux (peak heat flux and x-minute maximum temperature, where x-minute is the maximum cooking time for the intended use) and microwave transmission/reflection (percent forward power) to specify the functional performance of microwave packaging materials. By using functional specifications based on the heating behavior of microwave packaging materials, the industry will be better able to ensure safe operating temperatures and the quality of the microwaveable food products.¹⁸

Two problems have been recognized regarding the use of susceptors in microwave food processing. One is the possibility of the leaching of contaminants from the film to the food with which it is in direct contact. After an FDA investigation found some materials to contain higher than acceptable levels of benzene, manufacturers revised processes to reduce the contaminants to safer levels.¹⁹ The other problem is that susceptors, when laminated to paperboard, may ignite. This is solved by designing the film so that the metal film ruptures when heated, decreasing conductivity. Secondly, the film is designed

17. Ibid., 224-229.

18. Hua-Feng "Hank" Huang, "Specifying and Measuring Microwave Food Packaging Materials," *Tappi Journal* 73, no. 3 (March 1990): 218.

19. Charles R. Buffler, *Microwave Cooking and Processing: Engineering Fundamentals for the Food Scientist* (New York: Van Nostrand Reinhold, 1993), 120-121.

with a resistivity which causes temperature to self-limit.²⁰

Moving far beyond the use of simple susceptors, the packaging industry has attained a respectable level of sophistication in the development of new materials. In an article entitled, "An Introduction to Active Packaging for Food," in an April '96 issue of *Food Technology*, Theodore P. Labuza describes consumer convenience technologies which transcend mere printed directions and even address food contamination and safety problems.

A microwave doneness indicator on the surface of a microwave food package can show a visual time/temperature-dependent color change to indicate the end of the cook time. For example, a wax that serves as a carrier for a blue dye will melt at a set temperature, and the dye from pools at both ends of the tag will begin to diffuse toward the center until the entire tag is colored blue. The time required for diffusion can be correlated with the time required for adequate microbial inactivation at the slowest heating point within a food/package system in a typical consumer microwave oven.

Microwave susceptor films for use in microwave ovens provide a high heat surface. They have thus become important packaging materials for popcorn, pizza, and French fries intended for use in microwave ovens.

Temperature indicators on packages can also tell the consumer when products are ready to be used. For example, a heat indicator on syrup packages tells when the syrup is hot and ready to be used if heated in a microwave oven.²¹

In another *Food Technology* article from August 1995, Donald Pszczola, Associate Editor, reports on systems; some of which facilitate the cooking of palatable fare, others of which provide data on freshness.

A microwaveable packaging system makes possible the further use of the microwave oven as a cooking appliance. It features a pattern of openings that allow controlled heating, browning, and crisping of foods.

Information systems are built into packages to indicate what is happening

20. Ibid., 92-93.

21. Theodore P. Labuza, "An Introduction to Active Packaging for Foods," *Food Technology* 50, no. 4 (April 1996): 71.

to the product as it passes through the distribution channel. These systems include time-temperature integrators to indicate loss of shelf-life.²²

In the June '92 *Tappi Journal*, John McCormick, a microwave film specialist with A. D. Tech of Taunton MA, tells of two interesting developments in the packaging industry which could help to solve the problem of uneven microwave heating: the dome-lens Microlens and the diffuser film Accuwave.

The purpose of the dome (referred to as a dome-lens and named Microlens) is to redirect sufficient microwave energy toward the center of the food container and hence the food to be heated. This redirection of microwave energy compensates for the natural tendency of food extremities to heat before the center. By providing the correct amount of compensation, the contained food heats more evenly. . . .

A microwave diffuser film is a food packaging material which controllably reflects (or equivalently transmits) a desired fraction of microwave energy. Accuwave can be incorporated into microwave food packages or employed as a lidding material.

The control provided by the diffuser film may be in the form of general reduction per unit area of the microwave energy penetrating a surface or by causing different areas of the package to reflect varying percentages of the microwave energy.²³

Other concerns, besides the effectiveness of packaging, are a mixture of fact and outdated information. Although the microwave has been called the safest appliance in the kitchen, there are safety issues to which the public must be educated. These include interference with communication and electronic systems, exposure of users to microwave radiation, the safety of the cooking or preparation process, and the safety of the prepared and processed food.

As to the first concern, the frequencies allowed for microwave cooking are strictly regulated by the FCC, and manufacturers must demonstrate that

22. Donald E. Pszczola, "Packaging Takes an Active Approach," *Food Technology* 49, no. 8 (August 1995): 104.

23. John A. McCormick, "Historical and Recent Attempts to Solve the Uneven Microwave Heating Problem with Packaging," *Tappi Journal* 75, no. 6 (June 1992): 75.

emissions from their ovens fall below FCC limits.

All ovens have a special interlock circuitry to ensure that the oven cannot be operated with the door open. By federal regulation, this interlock circuitry includes a backup interlock which senses whether or not the primary interlock is operating properly. If an attempt is made to operate the microwave oven with the primary interlock disabled or damaged then the interlock monitor will cause a fuse contained within the oven to fail, preventing further operation until the oven has been serviced.

The door of the oven is subject to a special set of design requirements and contains microwave circuits which control the leaking of microwave energy between the surface of the door and the microwave cavity to safe levels. . . .

The safety features of a microwave oven are regulated by three different agencies: the Center for Devices and Radiological Health (an agency of the Food and Drug Administration), which imposes standards to prevent the operator from being exposed to harmful radiation; the Federal Communications Commission, which imposes regulations to prevent the oven from interfering with other electronic equipment; and the Underwriters Laboratory (UL), which has established a set of standards designed to keep the oven from being a fire or electrical hazard. Consequently, the modern microwave oven is one of the most reliable and safe appliances available on the market today.²⁴

Therefore the widespread fear that pacemakers might be compromised by leakage from microwave ovens may be laid to rest because of the 1968 guidelines, and because of improvements in pacemakers, which now have electrical shields to prevent such interference.²⁵

A common problem which must be taken seriously is that of uneven heating caused by differential microwave absorption within a load due to its dielectric and/or geometric properties. These may cause superheating, eruptions and explosions. To avoid these problems, certain strategies must become habitual during microwave cooking. These include methods such as starting with cold

24. John E. Gerling, "Household Microwave Oven Technology," *Tappi Journal* 73, no. 3 (March 1990): 198-199.

25. Charles R. Buffler, *Microwave Cooking and Processing: Engineering Fundamentals for the Food Scientist* (New York: Van Nostrand Reinhold, 1993), 110.

water, using vessels with sloping sides, stirring several times during the cooking process, and being careful not to exceed recommended heating durations. Users must also maintain vigilance in handling containers of food which may vent steam upon being opened. They should also be aware that certain components of combination foods may heat up significantly more than others, and therefore present a danger of scalding or burning to the cook or consumer.²⁶ Since microwave cooking takes a very short time, cooking times should be set carefully, and directions of packaged foods should be followed to the letter. Following these rules will eliminate the possibility of internal runaway heating which leads to flaming.²⁷

Finally, improvements in engineering now permit the use of metal vessels and foil without oven damage. However the possibility of arcing or ionization still exists under certain conditions. More than one metal piece should not be used at one time, nor should metal dishes be placed close to metal cavity walls. If these admonitions are not heeded, the resulting arcing could cause slight damage to the cavity walls.²⁸

Through all these improvements, manufacturers and engineers have been seeking to put the microwave into a more intimate relationship with the appliances in the kitchen triangle, stove, refrigerator and sink. None have come close to utilizing its full potential. Even conventional appliances developed during the first part of the century remain basically unchanged. It remains for powerful social forces which have been discussed earlier to give impetus to real innovation in food preparation, which, one is confident, may include a variant of the design

26. Ibid., 114-116.

27. Ibid., 114-117.

28. Ibid., 117-119.

presented here.

In the search for a product which would maximize the potential of the microwave oven, its speed and efficient energy use, one may be disappointed in the meager gains the technology has made, both in acceptance and performance. By contrast, such forward reaching designs as the *Thermalizer*, by the Rubbright Group, Inc. appears to be an encouraging and promising design initiative.

The *Thermalizer's* patented design is unique, incorporating a small cylindrical shape, and a semi-cylindrical door which tracks within the oven cavity, preserving the integrity of the space it occupies. It measures 9.75 inches or 248 mm in height exterior, 7 inches or 178 mm interior height, and 9.25 inches or 235 mm in interior width. Even more important than aesthetics and space-saving considerations is the way its select sources of energy work together.²⁹

The Microwave Research Center has applied new state-of-the-art computer simulations to its extensive understanding of microwave energy, to control two modes of energy to maximize electromagnetic microwave distribution. These two select modes of energy work in synergy in the cylindrical cavity, eliminating the need for rotating foods and reducing edge overheating, two of the negative characteristics of current microwave oven cooking. Specified diameters are required to optimize the evenness in electromagnetic microwave energy throughout the cavity to provide for evenness of heating and avoidance or elimination of hot spots in foods.

Microwave, the primary form of electromagnetic energy in the *Thermalizer*, provides much of the desired speed in cooking. Induction, the secondary form of electromagnetic energy, provides for crisping and browning the bottom and sides of foods, which are impractical with microwave energy alone. An induction heating coil in the base of the oven is used with induction pan(s) to produce conductive heat used in many food preparation steps, and is not currently available in combination with microwave energy in any other appliance.

The third heating component is radiant electromagnetic energy, emitted

29. The Rubbright Group, Inc., *"Thermalizer" Electromagnetic Oven: A Microwave Research Center Development* (Eagan, MN: The Rubbright Group, Inc., 1991).

from the top of the oven to provide browning and crisping of upper food surfaces. The radiant energy source enhances the performance of the induction or microwave energy by producing the browning desired in some cooked foods. The circular cavity design provides a means to focus the radiant energy on the food without the need to heat the cavity. Use of induction and radiant energy in synergy with microwave energy is unique. It is theorized that this cooking means will reduce food preparation and heating times typically encountered with traditional ways of cooking.

The Thermalizer will have state-of-the-art humidity sensory to monitor various aspects of the cooking cycle. The small cylindrical shape has the added benefit of enhancing predictable internal airflow, promoting sensor reliability. With known sensor technology, and with the various combinations of heating means controlled through one- or two-button controls, the Thermalizer will provide operating convenience and simplicity to the consumer.³⁰

Cleaning of this oven will also be easy with its removable, dishwasher-safe components. Although it is powerful (800 watts), it “consumes 10% less electric power than larger microwave ovens.”³¹

Automatic Identification and its Various Applications

A decade after the invention of the magnetron, military and industrial groups began a search for data collection technology which would satisfy the need for faster input of information for processing by digital computer. In 1962, Sylvania/GTE introduced a system of pattern recognition in which an optical scanning system read a label encoded with red and blue bars on a black background. The bars and the background represented information which was collected from moving freight cars to provide data to the railroad industry. By 1968, Sylvania had formed the Computer Identities Corporation, which launched and refined a product. The label was now black and white and had been greatly reduced in

30. Ibid., 2-3.

31. Ibid., 13.

size, and the white light scanning device was replaced by a helium-neon laser. These improvements facilitated the use of this technology by commercial and industrial organizations, notably grocery distribution operations and the automobile manufacturers.³² The obvious benefits of such an efficient method of capturing data soon resulted in the implementation of applications for grocery checkout terminals, automotive assembly control, marathon race management and specimen tracking for medical purposes.

David Jarrett Collins, in his book *Using Bar Code: Why It's Taking Over*, provides insight into reasons for the rapidly burgeoning use of this technological phenomenon.

What if bar code had never been invented? How would our world be different today? Without grocery scanning, checkout lines would certainly be longer and food prices higher. Fewer product choices would be on the shelves, since store inventory could not be taken every day. Restocking from the distribution center to the local store would take an extra day or more without bar code carton labels and automatic laser scanning. Cars would cost more, too. Today's new Ford or Chevy has over twenty bar code labels on component parts, which are read by dozens of laser scanners from the time an engine block starts down the assembly line until your custom-made new Blazer is delivered to the dealer down the street.

Bar code has also begun to infiltrate our personal lives. For example, the New York City Marathon has over 25,000 runners competing on a Sunday each November. Every runner wants his or her exact finish time listed in the paper the following morning. Using bar code, each competitor's time in hours, minutes, and seconds, in exact finish order, reaches the New York newspapers by 7:00 P.M. that evening, minutes after the last runner crosses the finish line. In another example, nine years before AIDS was identified as the scourge of our time, some farsighted administrators in health care began a worldwide program to bar code whole blood donations and strictly control their testing, processing, and distribution. Without bar code control the AIDS epidemic would have brought far more grief and devastation to society than it has.³³

32. David Jarrett Collins and Nancy Nasuti Whipple, *Using Bar Code: Why It's Taking Over*, 2nd ed. (Duxbury, Massachusetts: Data Capture Institute, 1994), 12-15.

33. *Ibid.*, 7.

Because of the accuracy and speed with which bar codes and scanners report information to host computers, the technology has been enthusiastically welcomed into the commercial-industrial marketplace. Like many products of genius, its design is elegantly simple. The device consists of symbology, most often a series of black lines and white spaces conveying a numeric (or alphanumeric, as in Code 128) message; and a second component, a scanner. The third component of the system is the communications method with which the collected data is decoded and/or moved to a central processing unit.³⁴

Although the simple horizontal sequences such as the UPC and Codabar are in general use today, the trend to packing more and more information into symbologies received a push in 1984, when the Automotive Industry Action Group published an application standard of four, stacked, Code 39 bar codes. Then, in 1988, Intermecc Corp. designed Code 49, a two-dimensional symbology which stores information along the height as well as the length.³⁵ Over twenty different 2-D symbologies are available, and the choice often comes down to whether the labels need special printing technologies and/or special scanners. Codes 49 and 16K, for example, may be printed with standard printing technologies, and may be scanned using modified moving beam laser scanners or CCD scanners. The article "2-D Bar Codes: More Options, New Ways to Manage Inventory Data" in a September 1996 issue of *Modern Materials Handling*, by Gary Forger, Senior Editor, discusses the 2-D symbologies.

34. Adams Communications, "2-Dimensional Bar Code," *2-D Bar Code Page, Bar Code 1* (Adams Communications, 1995, accessed February 1996); available from <http://www.adams1.com/pub/russadam/stack.html>; Internet.; Jonathan Cohen, *Automatic Identification and Data Collection Systems* (London, New York: McGraw-Hill, 1994), 3-14.

35. Adams Communications, "2-Dimensional Bar Code," *2-D Bar Code Page, Bar Code 1* (Adams Communications, 1995, accessed February 1996); available from <http://www.adams1.com/pub/russadam/stack.html>; Internet.

A conventional bar code acts as a unique identifying license plate for inventory. Only a small number of characters can be printed in this linear format before the bar code becomes too long for practical use. And once the bar code is scanned, a computer-resident database must be accessed to obtain any details about the inventory.

In direct contrast, 2-D symbologies are intended to be small, stand-alone databases. While there are several ways to encode data in such a compact format, there are two generally accepted types of 2-D symbologies.

Stacked symbologies build (stack) rows of bars and spaces, placing them one on top of the other. Both laser and charge coupled device (CCD) scanners read the data by moving across the symbol in a consistent orientation. Examples are PDF417 and Code 49.

Matrix symbologies dispense with bars and spaces and encode data in a checkerboard pattern of shapes from squares to hexagons and circles. Each symbology uses a finder pattern such as a bull's eye (MaxiCode) or "L" perimeter (DataMatrix) to orient the scanner. As a result, there is no right-side-up or upside-down orientation to these symbols. They can be read by omnidirectional and CCD scanners at any angle.³⁶

Scanning devices, as well, have become a more diverse group. This group now includes fixed laser scanners, e.g. supermarket tabletop scanners, wand scanners or light pens, hand-held laser gun scanners for awkward applications such as curved or irregular surfaces or wrapped objects, and CCD scanners with which the symbological image is transferred to an array of tiny photo detectors.³⁷

CCD stands for Charge Coupled Device, a semiconductor that has a plurality of light sensitive areas. A CCD can have a single linear set of light sensitive areas or the areas can be arranged in a 2-dimensional array. The device is used in a wide range of products, including video cameras and barcode readers.

CCD Scanner

A bar code reader that uses a CCD to pick up the image of a barcode. These scanners can read barcode without contacting the symbol like a laser scanner, but they cannot usually read the symbol at distances greater than

36. Gary Forger, "2-D Bar Codes: More Options, New Ways to Manage Inventory Data," *Modern Materials Handling* 51, no. 11 (September 1996): 38-39.

37. David Jarrett Collins and Nancy Nasuti Whipple, *Using Bar Code: Why It's Taking Over*, 2nd ed. (Duxbury, Massachusetts: Data Capture Institute, 1994), 43-65.

4 inches.³⁸

The CCD scanner has proven to be most useful in interpreting the more complex symbologies. In the internet site, *Bar Code 1* and on the page entitled "2 Dimensional Bar Code," it is stated, "Two-dimensional code systems have become more feasible with the increased use of moving beam laser scanners, and Charged Coupled Device (CCD) scanners."³⁹ A list of a number of 2-D symbologies such as MaxiCode, DataMatrix, Code 49 and Code 16K, which can be read with this device, is then given.

Scanners now incorporate data entry terminals, which link the scan function and the ultimate processing of incoming information. Scanners, including laser gun light pens, may be attached to a terminal which is programmed specifically for the task at hand. The data may be transmitted to a host computer which gathers and reprocesses this data within a more complex and comprehensive database.

It is obvious that the improvement of this technology, and the increases in message density, permit commercial operations to access and use more data in shorter time periods. Less obvious, perhaps, is the intriguing possibility of use on the personal level, in the home, by the elderly and disabled, and even in busy households where all members are able-bodied. The visually impaired or those with other physical or mental disabilities are sometimes unable to select groceries or prepare meals in a conventional manner. Any household, coping with a busy work week, civic obligations and leisure activities, may occasionally

38. Adams Communications, "Bar Code Glossary of Terms," *Glossary of Terms Page, Bar Code 1* (Adams Communications, 1995, accessed February 1996); available from <http://www.adams1.com/pub/russadam/barglos.html>; Internet.

39. Adams Communications, "2-Dimensional Bar Code," *2-D Bar Code Page, Bar Code 1* (Adams Communications, 1995, accessed February 1996); available from <http://www.adams1.com/pub/russadam/stack.html>; Internet.

need a nutritionally sound, but easy-to-prepare meal to tide it over until Friday. Packaging which is marked with pertinent information such as nutritional values, sodium, fat, and calorie content and cooking instructions, can save time and effort, and can give back a sense of control and independence. Used in tandem with a personal scanner, bar codes containing this type of information and perhaps more, could provide an alternative to hit-or-miss food preparation and nutrition, and improve, even for those without disabilities, the education they bring to food choice and preparation.

With regard to the type of scanner to be used by the disabled, there are several which have been developed which have reached high levels of sophistication in their ability to process and communicate information to the user. Talking bar code readers such as ScanTELL, DigiCite, and HandiScan are three of these useful devices. ScanTELL consists of the following three components: the Bar Code Scanning Module, the Database Application, and the Voice Synthesizer.⁴⁰ Literature provided by Compusult Limited describes ScanTELL:

ScanTELL consists of the following three components:

1. The Bar Code Scanning Module inputs Universal Product Code (UPC), Code 39, and other bar code symbologies from labelled items via laser beam or contact type scanners, converts the codes to ASCII data, and then transfers these data to the ScanTELL Database Application.
2. The Database Application extracts item information from the relational database. It also allows importing, manual entry, and editing of bar codes and related information, plus database maintenance.
3. The Voice Synthesizer accepts item data from the ScanTELL Database Application and provides clearly audible output of the relevant information. It also generates "spoken" prompts, and guidance to the user.⁴¹

40. Compusult Limited, "ScanTELL 'The Talking Bar Code Reader' " (Mount Pearl, Newfoundland, Canada: Compusult Limited), [company literature], 1.

41. Ibid.

DigiCite converts information through a pattern recognition algorithm and transmits it as digitized speech.⁴²

DigiCite operates like a digital still image camera by using imaging technology to capture snapshots of LED readouts. In fact, the prototype employs a commercial, off-the-shelf digital still image camera. A pattern recognition algorithm is applied to a captured image to determine the display characters. Output from the device is in the form of digitized speech. DigiCite is hand-held, portable, and battery powered. It is easy to use, requiring only one hand to operate and, once positioned over the display, a single button to trigger the device.⁴³

HandiScan scans omni-directionally having been developed for use by the visually impaired.⁴⁴

When the user scans a UPC code with the SP*ACE scanner, the software searches its database for an item with a matching code. When the item is found, the computer's sound card converts the description into vocal output. Instead of opening a can to find out what's inside, a visually impaired user can now hear the information they need, including cooking instructions and nutritional information, by simply passing the item in front of the scanner. This new tool has enormous potential for making the sighted world more accessible to people with visual impairments.⁴⁵

From this abundance of technological offerings; scanners, bar codes, and vastly improved microwave ovens, the designer has only to select those collaborators which will work together smoothly and economically. "How," he must ask himself, "can these technologies best be utilized to improve the quality of life for as many as possible?"

42. Compusult Limited, "DigiCite 'The Talking Display Reader' " (Mount Pearl, Newfoundland, Canada: Compusult Limited), [company literature], 1.

43. Ibid.

44. Adams Communications, "School Project Helps Visually Impaired People Identify Packaged Food Items," *Bar Code News, Bar Code 1* (Adams Communications, 1995, accessed February 1996); available from <http://www.adams1.com/pub/russadam/news1.html>; Internet.

45. Ibid.

V. GOALS

Design Objectives

The main objective of this project is to design a food preparation unit, based on a microwave oven. This design will include a faster and simpler interface than that of currently available microwave and conventional ovens. The system will allow for more complex food preparation tasks, more appetizing food, improved food aesthetics and the capability of monitoring nutritional information.

System Goals

The food preparation system proposed in this report, including its development and final design, will be described in detail in "Section VI." However, it will be useful to define some of the factors which led to its inception. The proposal for the *Future Wave* system was a natural outgrowth of three avenues of research, both formal and informal, into societal trends and the forces which are shaping them, the manner in which manufacturers and designers have been responding to household needs created by this dynamic, and finally, an exploration of both currently available technology and other far-reaching proposals, some of which still hover expectantly in the richly creative domain which lies between drawing board and production line.

Investigation into societal trends was initiated with the recognition that typical household patterns were being transformed. Change was accelerating, and the

fabrication of coping strategies and mechanisms was lagging far behind. There were more and more households being managed by dual earners, single parents, the elderly, and members of the sandwich generation.

More formal research into these phenomena (Section III) supported the validity of these perceptions, and showed that these trends are expected to gather strength and escalate as this century fades and as the 21st dawns.

These societal trends continue to gain impetus, in large part, from the information deluge which pours into our homes and our consciousness, both supraliminally and subliminally. Our options expand as our physical world contracts, shrunk by the relentless presumptuousness of communications and the media.

From this constant flow of information and propaganda, it is not difficult to distinguish a few dominant themes, and inferentially, the main concerns of readers, listeners and viewers. Books and shows about health, good nutrition and cooking skills are ubiquitous, and every talk show features cooking segments. Magazines include articles which update traditional recipes by using low-fat or “speed scratch” ingredients. TV chefs help to expand the aesthetic horizons of the family cook, and often modify recipes by abbreviating procedures, or substituting healthier ingredients.

The preoccupation with living well and healthily, and keeping old age at bay, reflected in these articles and programs, has been long recognized by the food industry (Section III). They have aggressively exploited this widespread concern, by offering products which help consumers solve the problem of how to prepare wholesome, pleasing meals in simpler, shorter ways. Larger, more convenience-oriented supermarkets and on-line grocery shopping are examples of the way the food industry has adjusted to changing life-styles. Food processors and

manufacturers increasingly dangle before the shopper a tempting array of pasta sauces, salad dressings and partially prepared meals, all labelled to attract the health-conscious. While these products and services represent a positive response by the food industry to a consumer craving, there is a definite need for more help, both in the food selection process, and the meal preparation routine. It remains for kitchen appliance manufacturers and designers to step into the breach with some imaginative solutions.

The hour when parents come home from work, and children return from after-school activities or day care, is usually meal preparation time. At this hour, time spent commuting, homework concerns, and interaction among family members have often sapped the enthusiasm and wrested the attention away from preparing the evening meal. Even the most organized among us sometimes gaze blankly into the refrigerator in response to the question, "What's for dinner?"

The goal of the proposed system is to help the user perform this everyday task of meal preparation, including selection of ingredients, more efficiently and in a less haphazard fashion with respect to meal planning, assembly and nutrition.

It would be unrealistic to believe that an appliance or food preparation system will meet all cooking needs. However, the concept of a conventional appliance, the microwave oven, enhanced for greater versatility, and linked in a unique symbiosis with other useful technologies such as scanners and data processing units, began to emerge as an exciting possibility after a disappointing survey of available appliances. Although many innovative and positive changes have occurred in the industry, none have ventured far enough or succeeded in offering enough support to the busy meal preparer of the late 1990's.

The system proposed herein is intended to fill a need for just such support. Convenience items such as "speed scratch" ingredients, more traditional foods

packaged with labelling modified to work with personal scanners or simply incorporated into a database, and frozen microwaveable products may be chosen and cooked or heated using this system. It is expected that this appliance will carry much of the food preparation burden during the normal workweek when conventional methods are too time-consuming, and simple microwave ovens fall short. Not intended to replace all conventional cooking, it will provide an expedient and reasonable solution to a difficult problem.

Since most Americans reside in medium or large metropolitan areas, families are usually within driving distance of some of the newest supermarkets or convenience centers. However, despite the one stop convenience offered by these stores, grocery selection and checkout time, to say nothing of highway traffic, often disrupt tight schedules. One of the objectives of the *Future Wave* system's scanning function is to expedite such tasks as choosing products at the supermarket without the tedium of label-reading, grocery checkout, generating shopping lists, and, of course, daily meal preparation.

With the number of dual earner households on the rise, the need for convenience in food preparation will continue to be a priority. Many households contain members who have different mealtimes, because of schedules, or even different diets, for reasons of health or preference. The *Future Wave* system is intended to give these families viable options to a reheated main meal that may have been missed, takeout food, pizza delivery or a trip to the local fast food restaurant.

A faster more efficient way of preparing meals, combined with information retrieval and delivery, could assist in preparing more appetizing and nutritionally sound meals in less time. The demographic factors discussed earlier in this report determined the system's key functions. The system must benefit a diverse

group of consumers, and must be versatile enough to function effectively in several types of households including those of elderly, dual income, and single parent families. Therefore, one of the system's goals is to accommodate a wide variety of age groups and household types. For this reason, the system had to be designed to adapt to different cooking modes, and to provide users with specific nutritional information. Eliminating some of the steps in food preparation, such as the reading of cooking instructions, will be especially helpful to the elderly and to older children, who must sometimes prepare a simple meal when parents are late. Information available through improved packaging and bar coding could deliver cooking time and other pertinent information directly to the device, so that the user need not enter it manually. This would not only speed preparation time, but also eliminate errors.

When the related area of food packaging was examined, it was found that many innovative and positive changes have taken place (Section IV). Government guidelines have caused manufacturers to include more information on package labels. But lists of ingredients and paragraphs of cooking instructions can be an awkward way to deliver information. The *Future Wave* system would have the capability to exploit the latest in automatic identification technology for more efficient delivery of information. Implementation of the more sophisticated 2-D bar code would give packaging more importance, and could help to make the food selection process a more informed and explicitly personal operation. Modifications to informational labelling will be suggested as part of this proposal. Packing more information into bar codes could lead to more universality and ease in the use of the scanner module, although the system can function using select product databases. Encoding more data in 2-D codes for retrieval by personal scanners is an idea whose time has come. With the industry already moving toward more intelligible labelling, some movement in the direction

of 2-D codes should prove mutually beneficial for industry and consumer. As in any system which seeks improvement, cooperation among all interdependent areas of the industry could result in progress and profit for all.

Scanning Ability, Bar Code Technology and its Benefits

The *Future Wave* system has been designed to have the capability to process dietary and nutritional data in such a way that it may be utilized to meet the specific needs of the user. The employment of scanners to harvest data from food packages, and then to transmit this information to the user and/or to the control unit of a cooking device, bestows the ability to access and use enormous amounts of information about food choices in a very effortless manner. The scanning module might be programmed to reject products which contain sugar or fats, or to keep a log of daily caloric intake. With easy access to accurate product information, and a painless method of fitting this data into a larger framework, the user will find it less difficult to adhere to a particular diet or style of cooking.

This capability of personalizing the system by programming it to track specific ingredients is an extraordinarily useful feature, particularly for those with health concerns. For example, a person with hypertension might be most concerned about daily sodium intake. The system could be programmed to identify its presence in a list of ingredients, and to note it on the display. The sodium content of each subsequent meal could then be added to the first to give the user a cumulative value at the end of the day (or of any chosen time period). This function of identification would be equally useful in the case of a user with a food allergy. When the package is scanned, a warning on the screen could notify the user that the product contains the allergen. This feature could also assist users who need to increase their intake of a particular nutrient, as is often the case

during pregnancy. This function can be performed prior to purchasing an item at the grocery store, using the *Portable Information Unit* or prior to preparing a meal using the scanner and display of the *Future Wave Oven*.

In addition to providing product information to the user, information contained in the bar codes of packaged items would assist in the actual cooking process. For prepared or semi-prepared meals, cooking and defrosting times as well as other oven settings would be contained in the bar code. Scanning would prompt the system, when set to automatic mode, to prepare the item according to the commands. The bar code reader will decode cooking instructions, and the system's control unit will program the oven settings automatically according to these instructions. This function will be especially helpful with preparing frozen microwave dinners or with meal components such as sauces, mixes or "speed scratch" ingredients. This feature will eliminate the need to read instructions on packaging and to manually enter oven settings.

Besides retrieving and processing information scavenged from food packages, the unit will have the ability to store, edit and update information such as recipes, including cooking times and oven settings. Once these recipes are stored, the user need simply bring them up on the display, and assemble ingredients, while the control unit sends such information as defrosting or cooking times, temperature, and weight of a particular recipe, directly to the cooking module. In this way, the user will be better able to prepare the meal strictly in accordance with specific dietary requirements as to quantity, and with exact adherence to ideal cooking and heating conditions.

The use of scanners by individual consumers is still uncommon, but the technology has enormous potential for use on the personal level. The portable scanner module, which will retrieve and process information found on food

packaging, is integral and indispensable to the *Future Wave* system. The ScanTELL product, discussed in Section IV, is one innovative product developed to assist the disabled. It uses discrete databases because the grocery industry currently uses the Universal Product Code or other linear bar codes which relate very narrow snippets of information mostly for the benefit of the retailer. Although the *Future Wave* system would function well using a linear bar code and product databases, the use of a more information intensive bar code such as the Data Matrix Code would allow the system to reach its full operating potential. The use of a two dimensional code, essentially a portable database, would permit a seamless system for delivering information directly to the appliance, and in turn to the user, increasing the system's effectiveness a hundredfold.

The grocery industry has tried use of various automatic identification technologies mainly to facilitate checkout, and make it less time-consuming. The following passage describes the Portable Personal Shopper System.

Symbol Technologies developed the scanning system in cooperation with Albert Heijn, Europe's largest grocery chain, and TNO Product Centre, a Dutch engineering firm. Symbol Technologies retains the right to market the technology worldwide.

Here's how the system works: Customers are issued a magnetic frequent-shopper card. When they arrive at the store, they place the card in a dispenser unit that unlocks one hand scanner unit. The scanners were designed to look user friendly, Riso said, more like a telephone handset than a scanning gun.

As customers shop, they scan each item as they take it from the shelf. For items without bar codes, such as produce, the shopper scans a code on a shelf label or a chart picturing the fruit or vegetable. Each item goes into a cart lined with a plastic tote that can be taken home, cutting down on bagging and handling time.¹

Since this article was written, similar systems by both Symbol Technologies and other companies have been installed in supermarkets in the U.S. An article

1. Tim Triplett, "Scanning Wand Makes Checkout Lines Disappear," *Marketing News* 28, no. 14 (July 4, 1994): 6.

from the *Daily News Record* discusses both two dimensional bar codes and radio-frequency tags.

If 2D bar coding sounds like an exhibit at Epcot Center, then radio-frequency tagging is even more cutting-edge.

Like the 2D bar code, the RF tag would also replace a linear bar code. But unlike the 2D bar code, RF technology is totally foreign to conventional SKU coding.²

The article concludes with a passage that describes a trial of RF tagging.

The RF technology was first demonstrated at retail in a Pick and Pay supermarket in South Africa three years ago in a cumbersome, but nonetheless interesting, experimental setup. Shoppers picked and bagged their groceries before going to the checkout. When they wheeled the laden cart through, large radio receivers on either side of the cart and above the shopper's head recorded the signals emitted by each item without the shopper's removing anything from the cart. Then she simply paid her bill and left.³

For the purpose of this system, the use of the 2-D bar code is suggested for increased efficiency in the reporting of information. Although other technologies could be used, the bar code is the dominant technology used in retail packaging. Implementation of 2-D bar coding, although a major upgrade, would be more practical than conversion to an entirely new technology. 2-D technology has been slow to replace the linear bar code; however, the advantages of its ability to store large amounts of information in a small space are obvious. Some pharmaceutical companies have implemented 2-D technology and others have used it on a trial basis. In the article, "A New Dimension in Bar Codes," Bert Moore describes an application of Data Matrix in which this information-intensive symbology is employed to report quantities of essential data about certain medications.

2. Matt Nannery, "New and Newer Technology Mushrooms at IQ 1996. (2D Bar-Codes and Radio-Frequency Tags for Retailers)," *Daily News Record*, 21 March 1996, 4.

3. Ibid.

SmithKlein Beecham is using Data Matrix to comply with new FDA regulations that require verification of label content for all pharmaceuticals, including over-the-counter medications. The UPC bar code on such a product identifies the product but does not indicate the label content. The Data Matrix symbol, meanwhile, has both.⁴

These descriptions of cutting-edge technologies were included to give the reader a sense of how fast developments take place, with so many exciting technologies to build upon. The trials of checkout applications, while narrow in scope, hint at the much broader application which will be used in the *Future Wave* system. The *Future Wave* will incorporate a similar scanning feature, but will take it much further than the checkout lane.

The benefits of a technology that makes shopping more convenient are obvious. In an age in which information is accessed and processed in milliseconds, one must ask why the consumer should not reap the benefits of this speed in the most pragmatic ways. The *Future Wave* system pushes these technological tools much further into the consumer's everyday life. Bar-code will be used not only for cashing out and store inventory, but for household inventory, ingredient analysis, and cooking instructions. The function of home inventory is a possible extension of the system. Each time a product is scanned before use, the product is automatically deducted from the household inventory. This type of record keeping would cut down on the time it takes the user to decide what is needed at the next purchase date. It would be especially useful in larger households, which keep a large stock of groceries. An automatic grocery list could be generated at any time, and could, of course, be manually edited, adding new items or deleting unwanted ones.

The system will have the capability of reaching far beyond the insular household to operate in conjunction with other systems. With the emergence of

4. Bert Moore, "A New Dimension in Bar Codes," *Byte* 20, no. 11 (December 1995): 68.

new services such as on-line grocery shopping, a possible link to the home PC would allow data from the system to be downloaded directly to a store account via the internet. In this way, an accurate order could be placed directly from the *Future Wave* system to a store account without manual entry. Another scenario might be access of other product databases made available through the internet. More extensive product information and recipes could thus be accessed from diverse sources and stored in the system's memory. To sum up, an important goal of this system proposal is to utilize as much available technology as possible to make life simpler and more comfortable for its users.

Proposed Technology

Since the proposed system centers around a microwave oven, the problems associated with microwave cooking must also be addressed. An exploration of the most advanced and effective microwave technologies was undertaken in preparation for this proposal. One advancement which will be implemented in the *Future Wave* proposal is the use of the inverter power supply. In the article "Household Microwave Oven Technology," John E. Gerling discusses some of the benefits of the inverter power supply.

Inverter power supply. The inverter or high-frequency power supply for the magnetron is a type of power supply that has technically been available but not introduced for reasons of cost and reliability. I have seen announcements that two Japanese manufacturers, Panasonic and Sharp, have introduced microwave ovens with inverter-type power supplies in Japan, and so it appears that the time of the inverter power supply is now here. The inverter power supply permits the microwave oven to have less weight, occupy less volume, and have superior performance characteristics as far as line-voltage regulation and variable power features are concerned.⁵

5. John E. Gerling, "Household Microwave Oven Technology," *Tappi Journal* 73, no. 3 (March 1990): 205.

In the article "The Open Door: Microwave Oven Technology-Future Trends," Gordon Andrews, principal of Gama Consultants, discusses high frequency technology.

Microwave appliance engineers are considering the merits of high frequency *inverter* and *switch mode* magnetron power supplies.

High frequency technology introduces a more refined method of controlling microwave output power, allowing the operator to set the particular power level required on a linear basis. Typically, a dial (potentiometer) or suitably converted electronic controller is used. Control is achieved by creating a high frequency (20kHz to 50kHz) situation. The magnetron supply is controlled on a much faster time base than currently used with the conventional *duty cycle* method incorporating a diode, capacitor, and transformer.⁶

The possibility of using an inverter power supply gave the designer more latitude of choice because of the resultant feasibility of reduced size and weight. The improved performance of the high frequency power supply, including more finely tuned power output, will give the *Future Wave Oven* significantly more adaptability than the conventional microwave oven. Working in conjunction with the *Future Wave's* scanning and processing functions, these attributes can vastly improve the microwave oven's efficacy as a primary cooking device.

Another product which has become fairly common in high-end product lines is the combination microwave-convection oven. The *Future Wave*, with its proposed inverter power supply could be offered in a version with a microwave-convection combination of cooking modes. This option would round out a product line, and would carry a higher price tag for the user who is willing to pay for increased versatility.

Another feature which is proposed for the *Future Wave* is variable power, which will expand the use potential of the unit by giving it an increased capability

6. Gordon Andrews, "The Open Door: Microwave Oven Technology-Future Trends," *Appliance Engineer* 48, no. 2 (February 1991): 107.

to prepare complex meals. Joseph Durocher in his April 1994 article “Catch A Wave,” discusses variable power. He describes the benefits of this feature for the user who will use his/her oven for more than just heating or reheating.

Variable power controls alter the output of the magnetron or turn the magnetron on and off during the variable power cycle. Setting the variable power levels is typically done by touching the number pad part of the control panel on your microwave oven. Some models allow you to associate a power level with a set segment of the cooking cycle while other ovens allow you to completely customize the power setting and length of each cooking segment.⁷

Depending on the method of preparation and the complexity of the meal being prepared in the *Future Wave Oven*, manual entry of these settings could be limited and in some cases eliminated. If a prepared meal were being heated, all the necessary settings could be abstracted from the bar code, and thus there would be no need for manual entry by the user. It should also be noted that the use of an inverter power supply optimizes the performance of the variable power feature.⁸

A subcomponent of the system, which will improve the quality of meals prepared in the *Future Wave Oven*, is the proposed use of moisture and temperature sensors. Applications of this technology have become more common in recent years, although they are commonly used in more expensive ovens. John E. Gerling discusses the use of sensors in microwave ovens in his March 1990 article titled “Household Microwave Oven Technology.”

Some sophisticated ovens take over the job of oven control through the use of various sensors which determine when the product to be heated is ready for serving. Such sensors utilize the temperature of the product, the initial weight of the product, moisture evaporated from the product,

7. Joseph Durocher, “Catch a Wave,” *Restaurant Business* 93, no. 6 (April 10, 1994): 148.

8. John E. Gerling, “Household Microwave Oven Technology,” *Tappi Journal* 73, no. 3 (March 1990): 205.

temperature of the exit air, aromatic gases given off by the product, color changes, weight loss, cavity field change, and audible sounds in the cavity. In these cases, the operator enters the type and amount of food being heated and the desired end results.⁹

The communication of such information from sensors to the control unit will sharpen the capacity of the *Future Wave Oven* to produce a palatable and well cooked meal.

Another important consideration is the amount of power the oven needs to perform its operation. Since the *Future Wave Oven* is intended to play a very large role in the daily food preparation tasks of the family, it will have a relatively high wattage rating, specifically in the 900 to 1000 watt range. In an August 1996 issue of *Consumer Reports*, the significance of oven wattage is discussed.

You'll also need to consider wattage, the number that tells you how much power an oven delivers and therefore how fast food will cook. Large and family-sized ovens generally have the highest wattages.

Claimed wattage in the ovens we tested ranged from 525 to 1100. (Actual wattage proved to be about as claimed.) In practical terms, a six ounce cup of room-temperature water will take about two minutes and 20 seconds to boil in a 600-watt oven and one minute and 20 seconds in a 1000-watt oven.¹⁰

These figures may not seem significant at first glance when one compares them to the length of time it takes to heat and cook by conventional methods; however the benefits of a faster oven become readily apparent in a busy household where the oven must perform a large number and variety of preparation tasks. Since speed of preparation has also been a primary concern from the outset of this project, the stipulation of a high wattage rating for the *Future Wave Oven* is clearly justified.

Most medium to large microwave ovens are now equipped with a turntable so

9. Ibid., 197.

10. "Which Make Zapping a Snap?," *Consumer Reports* 61, no. 8 (August 1996): 43.

that the food being prepared is cooked more evenly. The *Future Wave* will have a rotating base inside its cavity that performs the same function as a turntable in traditional box-shaped ovens. Since the interior cavity is cylindrical, the entire base of the cavity will rotate. This feature will optimize the space of the interior cavity as well as allow for easier cleaning of flush surfaces.

Employment of the aforementioned technologies, in conjunction with the scanning and information retrieval capabilities of the *Future Wave* system, will give the product a position squarely in the food preparation mainstream, a status that has always eluded the conventional microwave oven.

A narrative form was chosen to present these goals, since the process was germane to the development of the proposal. Each element of the system arose from an understanding of a need perceived in daily life, and an accompanying bafflement at the under-utilization of valuable technology. Though some ideas were rejected as too extravagant, e.g. a refrigeration component, the other components of the system fell in place, and every day new roles suggest themselves for each of them.

Product Interface and Operation

The *Future Wave* system was designed to have multiple functions and to be versatile enough to handle simple heating tasks as well as complex meal preparations. Despite the intricacy of its functions, the product interface will be easy to use and uncomplicated. A primary goal was to eliminate as many cumbersome tasks as possible from the meal preparation routine. When using the oven's scanner to cook meals or ingredients with pre-written cooking instructions, the user need simply scan the item when the oven is in automatic mode and place it in the cavity. The two sliding doors also will open after the item

is scanned automatically. This feature eliminates fumbling with doors while holding a plate of food. The user will no longer have to free his/her hands or search for a place on the crowded counter to place the item when opening the oven door. It would be convenient if the doors closed automatically once the item is placed in the oven cavity. This could be accomplished by using motion sensors. However, it could present a hazard, especially to children. For this reason it is proposed that the door will not close unless the user presses the start button. This safety feature would eliminate the possibility of catching one's fingers between the doors. Most importantly, the rotating doors have an advantage over those which swing outward, since when open they will not intrude into the countertop workspace. Thus, not only is there a gain in usable workspace, but more options for positioning of the oven are created.

The control panel may also be used in a manual mode when the scanner is not involved in programming the oven automatically. When used in this way, operation will be similar to that of a conventional microwave oven. Cooking times and other oven functions will be entered on the numbered control panel. Features such as automatic cooking settings for specific foods and automatic defrost settings will be available on the control panel. To simplify operation and to eliminate the need for a separate keypad and large display, a combination touch screen control panel/display is proposed. One of the main functions and benefits of the *Future Wave* system is its ability to retrieve information from product packaging and communicate it to the user. This information will be viewed on the touch screen window and any input from the user will be made through the same user interface. This window on the oven's control unit will be the primary interface of the system. A display on the *Portable Information Unit* will be more limited, displaying information pertinent to the food acquisition process. Instead of a touch screen, it will simply be controlled by touching one of two buttons; one with

the on/scan/add functions and the other with the off/subtract/new display functions. The function of each of these buttons will be determined by the information viewed in its display window. Specific examples of display information will be discussed in detail in the following section. For more extensive user interaction with the system such as the addition of databases or internet connections, a possible link to the home PC could be made as outlined in the preceding “System Goals” section.

The *Portable Information Unit* will also have the capacity to update information stored in the control unit of the oven, as for example in the context of taking inventory. All of the items purchased at the supermarket may be added to the inventory stored in the memory of the oven’s control and processing unit. By simply plugging the *Portable Information Unit* back on its hanger beneath the oven’s touch screen window, the user will be able to download information using the oven’s touch screen control panel. In the same way data may also be transmitted from the oven to the *Portable Information Unit*. When the unit is plugged into its hanger on the oven, the unit may be programmed to perform certain functions such as that of identifying a certain ingredient. After programming, the *Portable Information Unit* will alert the user to the presence of this ingredient in each item scanned at the grocery store. This interface allows for exchange of data between the oven and the portable unit. The operation of both units is easily coordinated, and similar scanning operations may be performed either at the supermarket or at home. The more limited interface of the *Portable Information Unit* will allow for quick and accurate ingredient identification and assistance in label reading. Specific examples of the type of information will be given in the following section.

Not only is the interface of the *Future Wave* system user-friendly and

uncomplicated, the oven is very easy to maintain. The curvilinear form, with its smooth surfaces, facilitates easy cleaning of the oven's exterior. The touch screen panel may simply be wiped clean. The doors may remain in the open position with the oven off and the interior light on, for cleaning of the interior cavity. The dual-split rotating doors, facilitate the cleaning of the inside surfaces of each door. With one door in the open position, the user may clean the back surface of the closed door. If the oven were designed with one door, the door would have to be removable for cleaning of its back surface.

The preceding discussion about the *Future Wave* system; its scanning ability, proposed technology, and product interface outlines some of the key features and system capabilities that will work together to achieve the proposed design objective. Design features were revealed here in order to clarify the goals. The manner in which these individual goals are brought to fruition in the context of this design proposal will become more apparent once the development of the final design is discussed in the next section. Visuals, sketches and photographs of the final model will aid in the demonstration of the product's development. However, before proceeding with a discussion of form and design development, it is necessary to outline briefly the goal of creating a unique product identity.

Product Identity Goals

In order to meet the design objective stated at the beginning of this section, the *Future Wave* system will have an identity that separates it both aesthetically and functionally from the basic household microwave oven. The goal of creating this identity was not to disguise its function as a microwave oven, since the microwave's speed and operational efficiency gave rise to the preliminary concept which formed the basis for this proposal. However, in order to design a

product that will play a larger role in daily household meal preparation, the functions of the microwave oven needed to be greatly enhanced. For this reason, the *Future Wave* system will constitute a distinct system of food preparation, as opposed to a glamorized oven adorned with more gadgets or some cosmetic features. The interaction among its three basic functions; cooking, information retrieval and information processing, confer upon the *Future Wave* the identity of a totally new appliance. The interrelationships among its three main components; the oven, its scanner and control unit, as well as the *Portable Information Unit*, amplify the separate capabilities of each component. These capabilities go beyond putting food in the oven and cooking it as fast as possible. They allow the user to bring the system's operation right to the supermarket shelves, and also address tangibly the nutritional and health requirements of the particular user.

The unique forms of each of the three components will be discussed in detail in the next section. However, it is necessary to stress the importance of a major change in form. The three cylindrical forms that compose the product constitute a departure from the unwieldy box shape of the typical microwave oven. This change is significant not only for practical reasons, but also as an effort to make a powerful design statement and to definitively disassociate the *Future Wave* from the connotations which burden the conventional microwave oven. It will be demonstrated in the next section how this change in form greatly enhances function, but for now it is enough to say that a radical change in form will allow for a more convincing product identity.

The identity of the *Future Wave* system also offers great possibilities for expansion into a product line. The product was developed as the result of projections about the needs of a target market (Section III). An effort was made to be inclusive of a wide variety of household types, yet it is impossible for one

product to answer the needs of every consumer. With modifications to the system, various versions of the product could be made. Changes to the interface to incorporate other languages besides English could create an expanded market for the product, both in the U.S. and abroad. Smaller and more economical ovens could be offered for smaller households, individual users or small apartment dwellers. Larger ovens and combination ovens would be targeted toward the family with very demanding food preparation tasks. Another possible change would be to modify the product interface significantly to include voice output from the control unit delivering messages and product information to the visually impaired. Further modification to incorporate voice recognition would allow for voice input to complete the cycle of interaction with the system. Though these possibilities for system expansion would amplify function for a specific group of users, the system would retain its unique identity. Its form would remain essentially unchanged and the trio of components would collaborate within the same parameters.

VI. DEVELOPMENT

Concepts

Previous sections describe the designer's journey toward recognition of the discordant clash of social change and static conventions of household management. These struggles, repeated every day in countless households, challenged the designer to try to play a small part in restoring some harmony to this area of incompatibility among cultural forces. Food preparation, in particular, seemed to be a matter for concern, and to demand a more sophisticated and technologically enlightened approach. Heedful of this demand, the designer began an exploration of available technology, and arrived early at a seminal conceptualization of a progressively different food preparation system.

Interestingly enough, a preliminary system diagram shown in Figure 1 already contains the three main components; cooking module, control unit, and scanner/identification interface, which would comprise the final design of the *Future Wave* system. Although the form was later transformed dramatically, and many refinements of function were introduced, a basic format had clearly been generated, and a commitment made to take full advantage of available technologies.

In these early studies, the oven and its satellites are still rigidly boxlike, but the final form had still to be negotiated. The extent to which the form would depend on the relationship of the new food preparation system with other kitchen appliances and cabinetry needed to be determined. Would the new system be

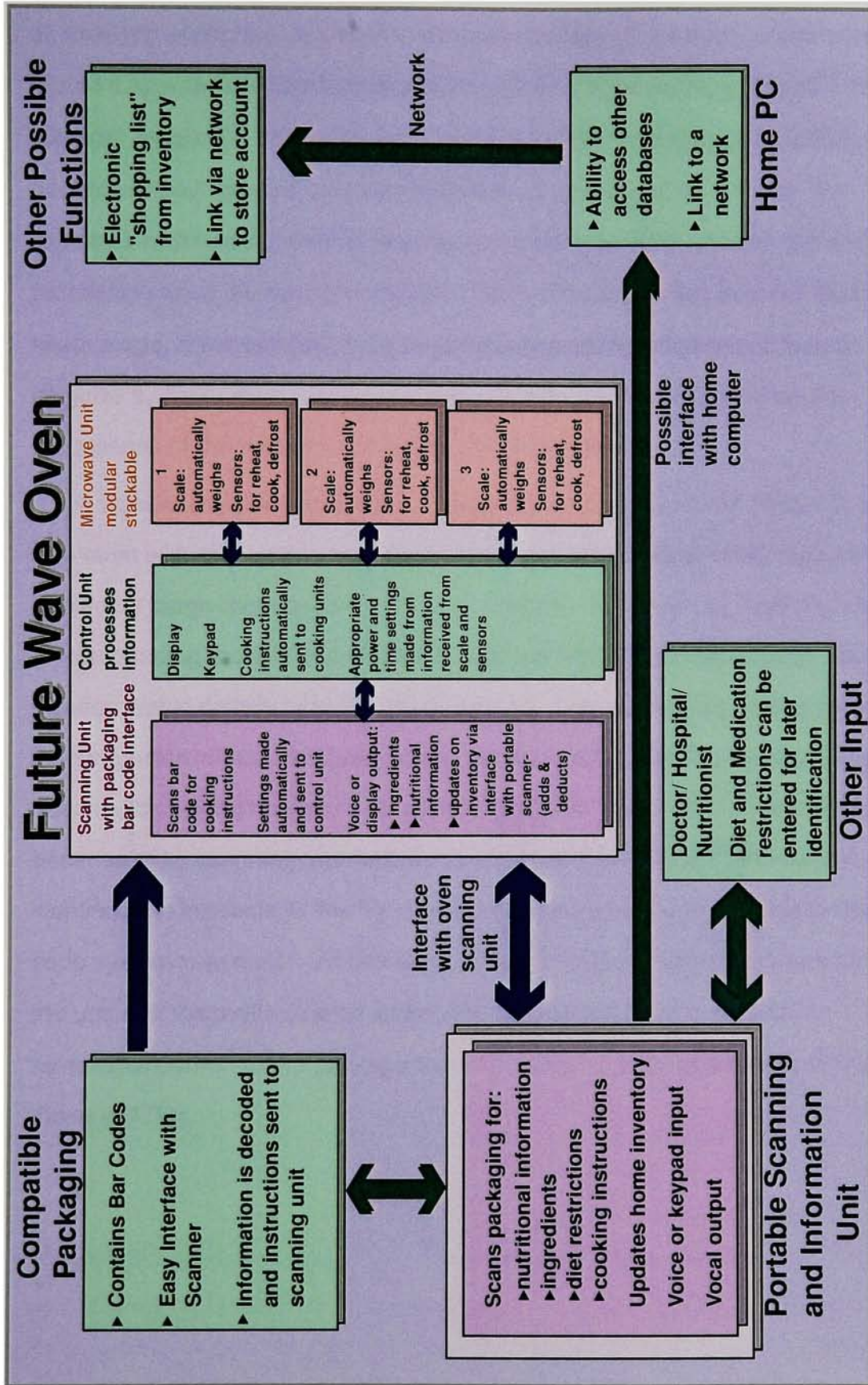


Figure 1. System Diagram

an auxiliary appliance, or would it replace a traditional oven-range combination? Would it operate interdependently with traditional appliances, or would it stand in splendid isolation? The answers to these questions would strongly influence decisions about location and size and, indeed, exterior form. During this exploration, the basic system functions of cooking and information gathering and processing were always participants in decisions concerning exterior design. At every stage, an effort was made to announce each function rather than to disguise it. By making function an integral part of form development, the uniqueness of the system was meant to be celebrated.

A significantly different approach to the problem is shown in Figure 2. A full-size oven with microwave and convection capabilities could totally replace the traditional range-oven used in most households. The choices of full-size, built-in or freestanding models offered limited opportunity for form exploration since location would dictate form to a great degree. This version eliminates the need for a separate microwave oven, and gives microwave capabilities to the main household cooking appliance. It differs from other microwave-convection models because of its scanning interface integrated with control panel and display. The identification interface in this figure was suggested before a decision to use a bar code system was made. At this stage of the design, consideration was given to the use of a magnetic strip on which information would be encoded. A removable portion of the package would be swiped through a reader similar to those in ATMs.

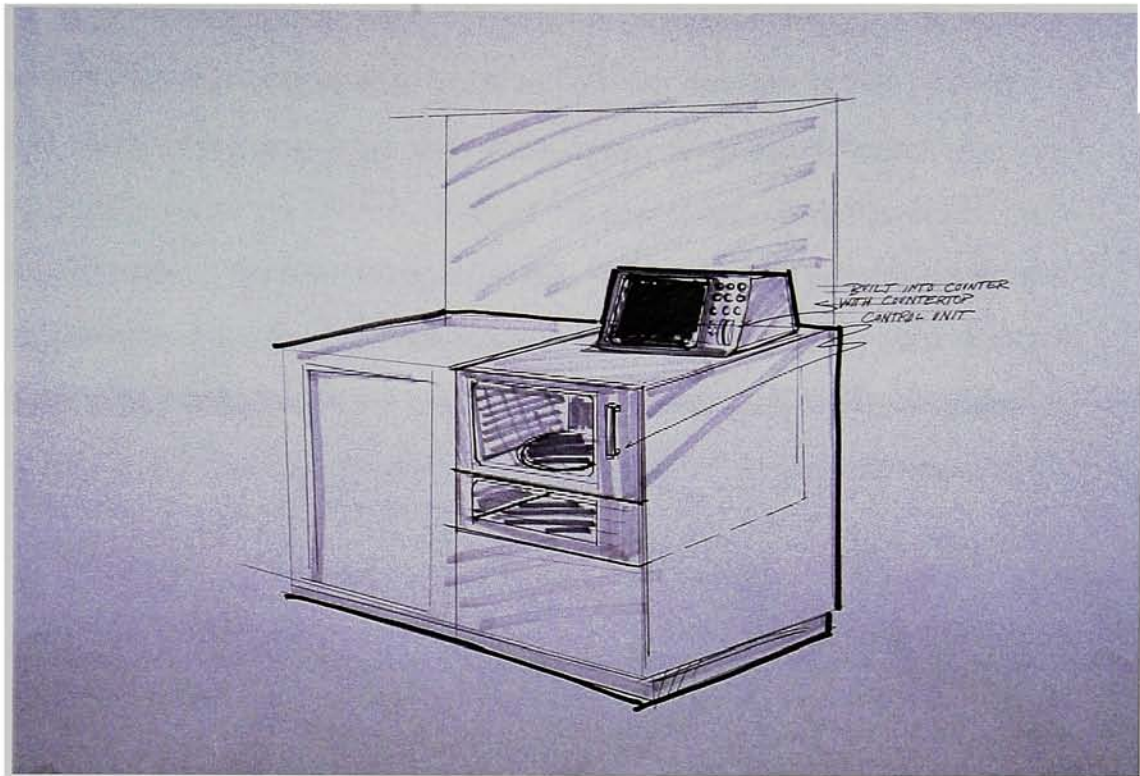


Figure 2. Concept for Full Size Oven

A variation of the concept in Figure 2 is depicted in Figure 3. A cooking unit with multiple cooking cavities which pull out like drawers, is built into a counter. In this design, the use of more than one cooking cavity would restrict the size of each because of the 36 inch height of the countertop. This size would, in turn, limit the size of the item being prepared. A control panel with flip-up display is shown here, but if the unit were combined with a cooktop, the controls would have to be positioned to the rear of the countertop. This built-in concept combined originality of function with somewhat limited risk in terms of form.

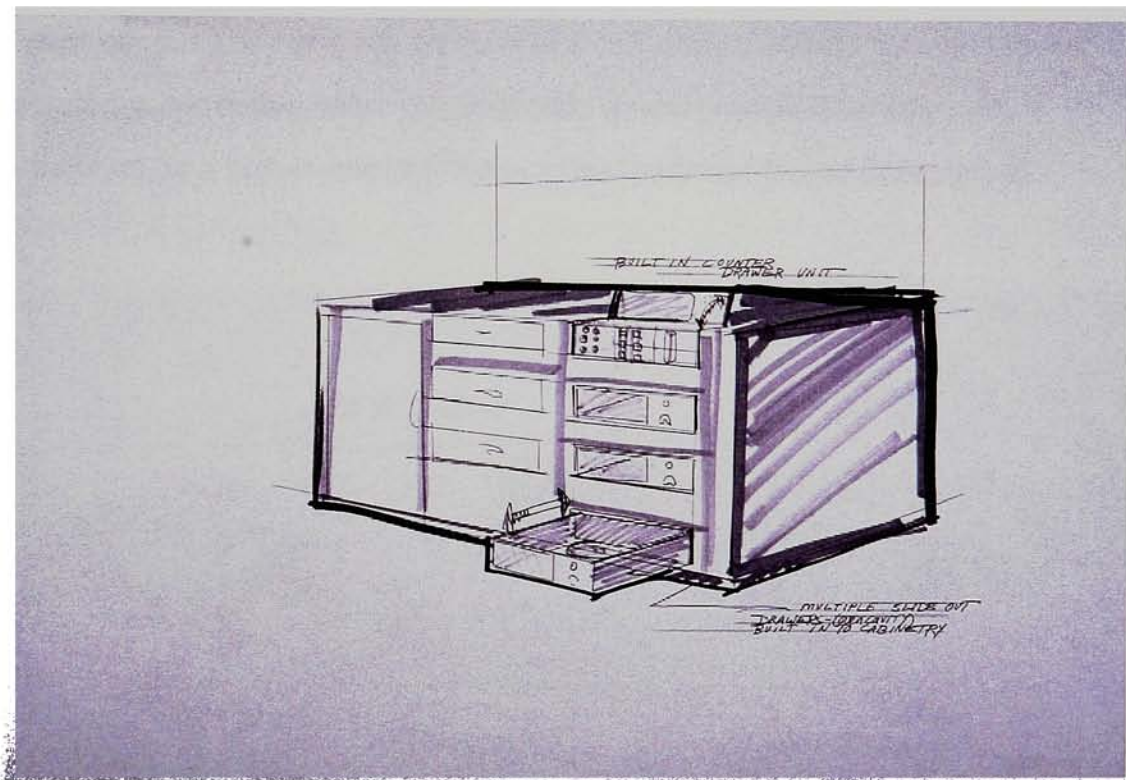


Figure 3. Concept for Full Size Unit with Pull Out Drawers

However, limiting the market by introducing an innovative concept in terms of such encroachment seemed unwise. Asking consumers to make the leap from countertop microwave oven to a large, built-in appliance was deemed impractical.

The countertop microwave oven is an entrenched concept, and its replacement market is very large.

Figure 4 describes two possible locations, one mounted below the upper cabinets, and the other built-in above the range with an integral exhaust fan - placements very common among current microwave oven models. However, similar placement of the proposed system would severely circumscribe any investigation of form, since a boxlike shape would be virtually dictated by the need to conform to traditional cabinetry. Fitting the food preparation system into the kitchen as a built-in appliance was ruled out early in the evolution of the design because of these limitations and of the choice to forge form and function into an organic union. More pragmatically, a new product is usually not introduced as a built-in unit until it has achieved broad-based acceptance.

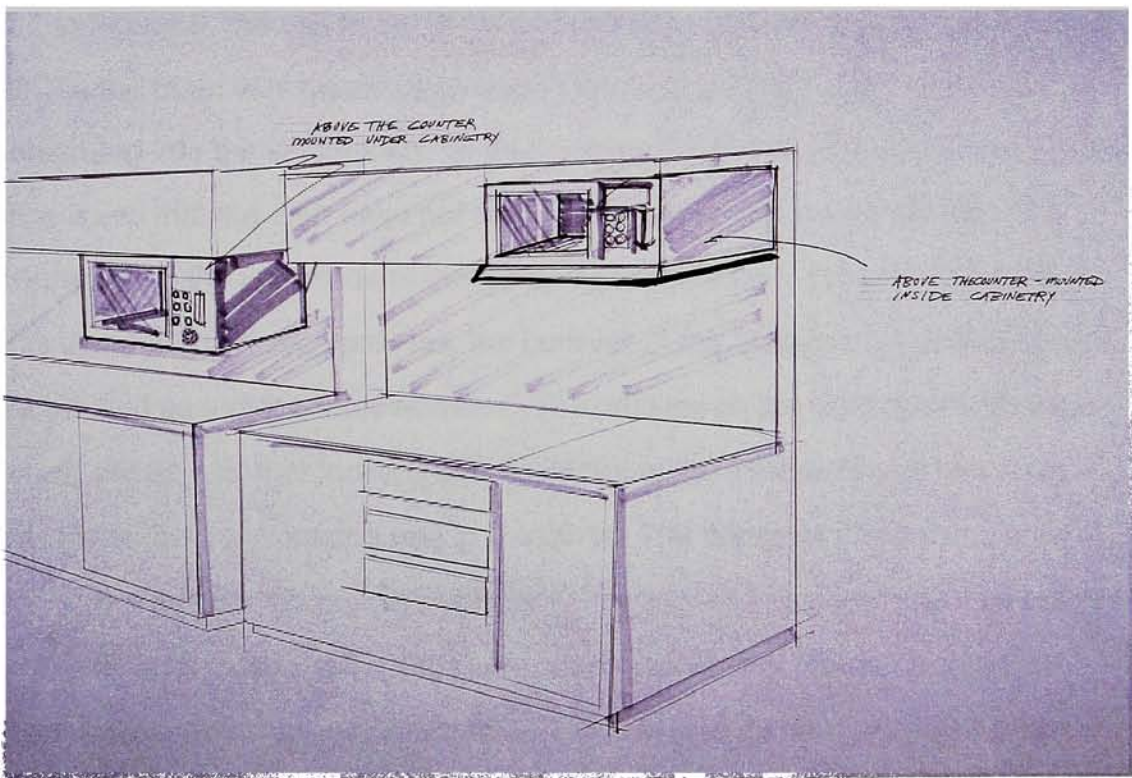


Figure 4. Concepts for Above the Counter Units

Figures 5 and 6 depict wall-mounted units. This positioning offers more opportunity for variation in contour and dimension since cabinetry is only tangentially involved. Figure 5 presents three versions from left to right. On the far left is a height adjustable unit (A). One cooking cavity adjusts vertically for users of different heights. All controls, including the scanning system with a large display window, are located to the left of the cooking site. The second version is built into the wall and has a slide-out utility shelf and a separate control center with large display located over the cooking cavity (B). At far right, a rendition with multiple cooking cavities which are vertically adjustable is shown (C). Each oven in this version could be designed to be operated independently, perhaps by more than one user, by programming the control panel appropriately. The interface suggested here is a display with flip-open keyboard. This type of interface was replaced by the much simpler touch screen selected for the *Future Wave* system.

In Figure 6, the unit to the left is wall-mounted and vertically adjustable (A). Unlike the other wall mounted concepts, the display and control unit are integrated into the whole form. In this interpretation, the door of the cooking unit flips up so that the user need not step back to swing the door outward. The display is on the underside of the flip-up lid which covers the control panel. At this stage of the design process, the concept of the *Portable Information Unit* is introduced as a detachable scanner. The drawing on the right shows an oven which enlists a corner location (B). Mounted at the intersection of two walls, it swings on hinges from one wall to the other. The separate display and control panel moves from side to side independently as well. This unit might be utilized in two different preparation areas, or even in partitioned rooms. It could be rotated from a kitchen work area to a dining alcove. Although the wall mounted oven is interesting and offers some opportunities for originality of configuration, its very specificity would restrict its potential market.

Figure 7 advances the topic of a mobile unit. Such a unit could be moved from room to room for heating a dish at the dining table, for example, or even to an outdoor location. A small refrigerator mounted beneath the oven could be used to store ingredients for a particular meal. This would eliminate shuttling ingredients back and forth from storage to cooking area. At the top of the page, stacked cooking units sit on a cart-like base (A). To the far left, a cylindrical unit on a base which adjusts vertically rotates a full 360 degrees on its mobile stand (B). It has a flip-up display/control panel and a detachable portable scanner. Its adjustability gives it multiple possibilities for positioning, and permits its operation in a variety of settings. The sketch to its right is a reversion to the traditional boxlike form, which is stationary on a wheeled base, which itself may be moved from place to place (C). Beneath the oven is a storage space for ingredients and utensils. To the right and slightly above the center drawing, is a mobile unit with three cooking cavities and conventional side-hinged doors (D). This concept demonstrates how the oven and its base may be totally integrated in form, rather than as distinct and separate components. To the far right, for contrast only, is an oven much like the common countertop model, which is, however, mounted on an adjustable base (E). Examination of the food preparation system as a mobile appliance was an intriguing exercise, but a certain awkwardness and bulkiness seemed unavoidable. Like the wall mounted unit, its potential market would be too narrow and specific.

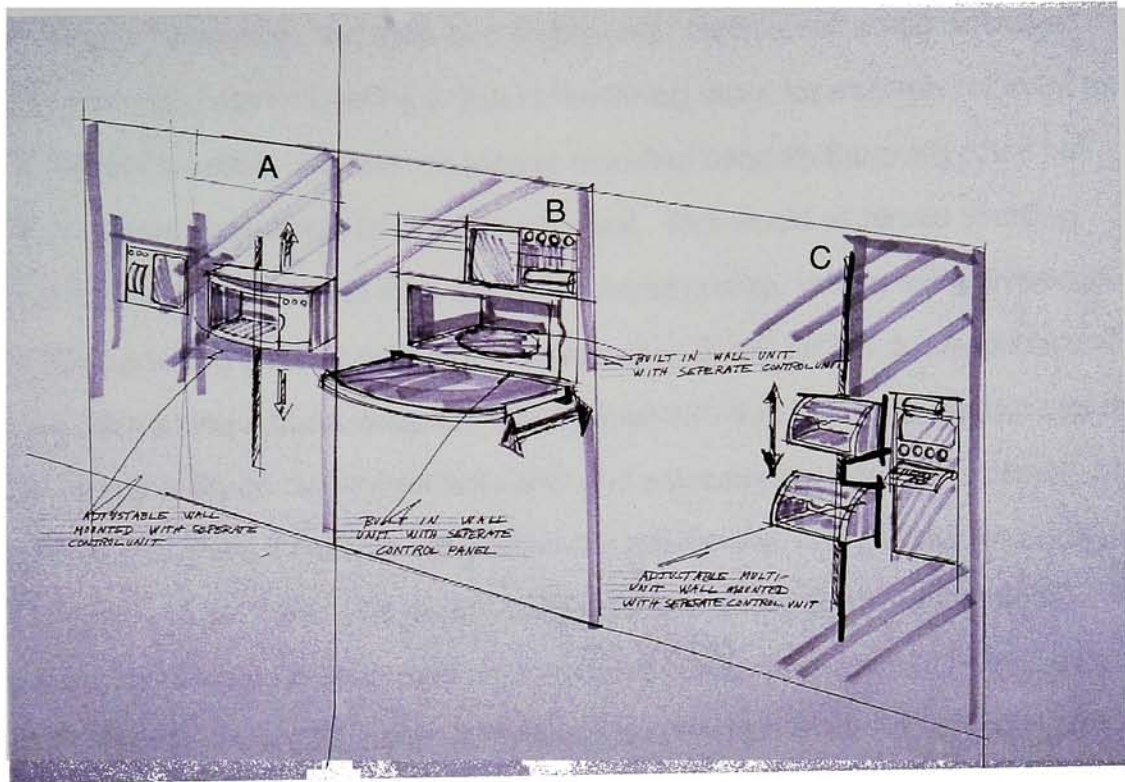


Figure 5. Three Concepts for Wall-Mounted Units

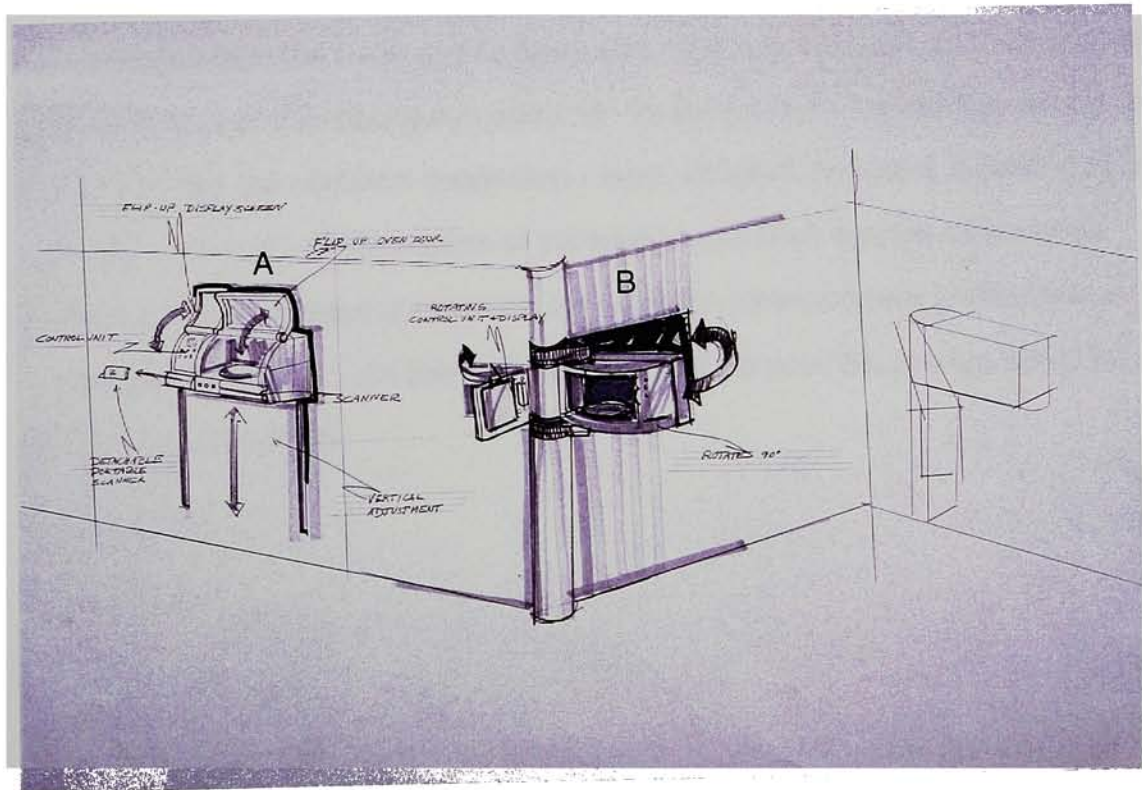


Figure 6. Two Concepts for Wall-Mounted Units

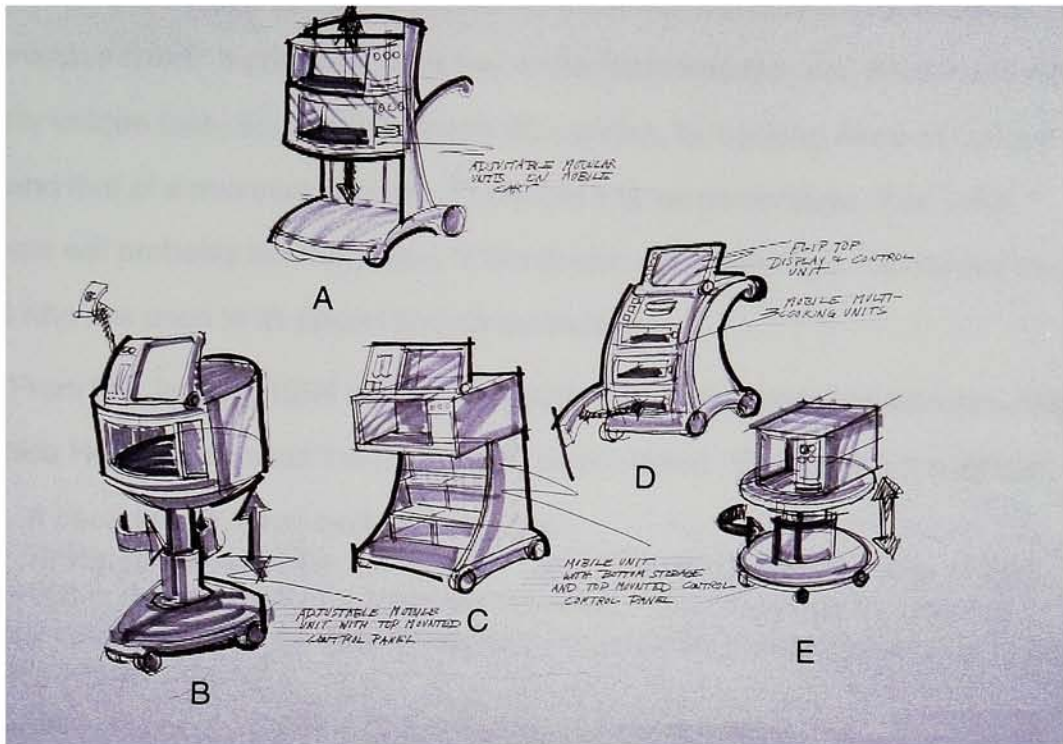


Figure 7. Concepts for Mobile Units

The *Future Wave* system is distinct in many ways from the conventional microwave oven. It promises to deliver better performance, and possesses many totally unique features. Despite these differences, its cooking function centers around that of a microwave oven. Therefore a large percentage of its initial buyers will probably be comprised of those who are replacing a microwave oven, and who are used to its speed and convenience.

From the January 1994 article, "Stepping Up," in *Dealerscope Merchandising*, Monica Hogan discusses the microwave oven market. She begins the article:

A decade ago, everybody wanted one.

Today, nearly everybody has one. The microwave oven business of the 1990s is driven largely by replacement sales. The challenge for retailers and vendors alike is to give consumers a compelling reason to step up to an upgraded product.¹

Therefore, although the form of the *Future Wave Oven* will be as unique as its function, it was decided fairly early in the design process that a countertop format would be chosen for the final design model. The popularity and versatility of the countertop microwave oven as well as its potential for form development were the primary reasons for this decision. Radical change in size or location conventions could stand in the way of its acceptance. From the 1995 article "Microwave Ovens Gain Universal Acceptance," Susan Reda discusses the results of a survey by the market research firm Leo J. Shapiro & Associates.

The majority of respondents, 70 percent, indicate that they would prefer to buy a countertop model that can be easily moved around the kitchen. The rest want an over-the-range model.²

1. Monica Hogan, "Stepping Up: Vendors Vie for Market Share of Replacement Sales.," *Dealerscope Merchandising* 36, no. 1 (January 1994): 140.

2. Susan Reda, "Microwave Ovens Gain Universal Acceptance," *Stores* 77, no. 10 (October 1995): 39.

In Figure 8, countertop models are based on a rectangular shape. The two sketches at the top left are closely related to today's typical microwave oven, and are included for the sake of comparison (A, B). The model at the top right has a rounded anterior section and a door which slides up like the panel of a rolltop desk (C). To the right of the opening is the control panel with a detachable portable scanner. The advantage of this type of door is that it does not invade countertop workspace when opened. In the sketch at the lower left, the rectangular box at the back of the unit has disappeared, and the rounded lift-open door is hinged to the back panel (D). This curve would curtail the space within the cooking cavity to an unacceptable extent. At the lower right, the box shape is modified with a semicircular curve at one end (E). This curve would accommodate a flexible, sliding door which disappears into the recess when in

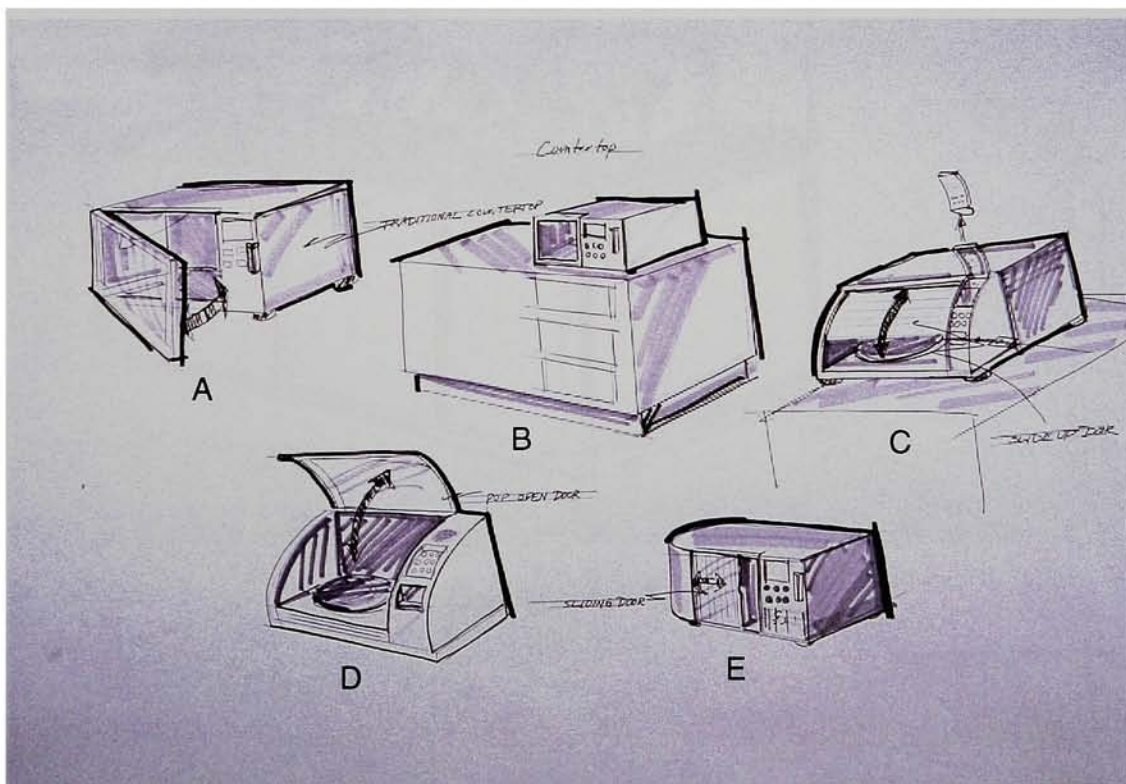


Figure 8. Concepts for Countertop Units

the open position. This same type of door was used in the final design of the *Future Wave Oven*, although the doors of the *Future Wave* are rigid and semi-cylindrical in shape.

The design shown in Figure 9, again based on the rectangular profile of the conventional microwave oven, has a circular platform which allows the oven to rotate to free counter space when not in use and is vertically adjustable. Display window, magnetic strip reader, and/or bar code scanner are placed to the right of the oven door, as are the touch pad controls of many microwave ovens.

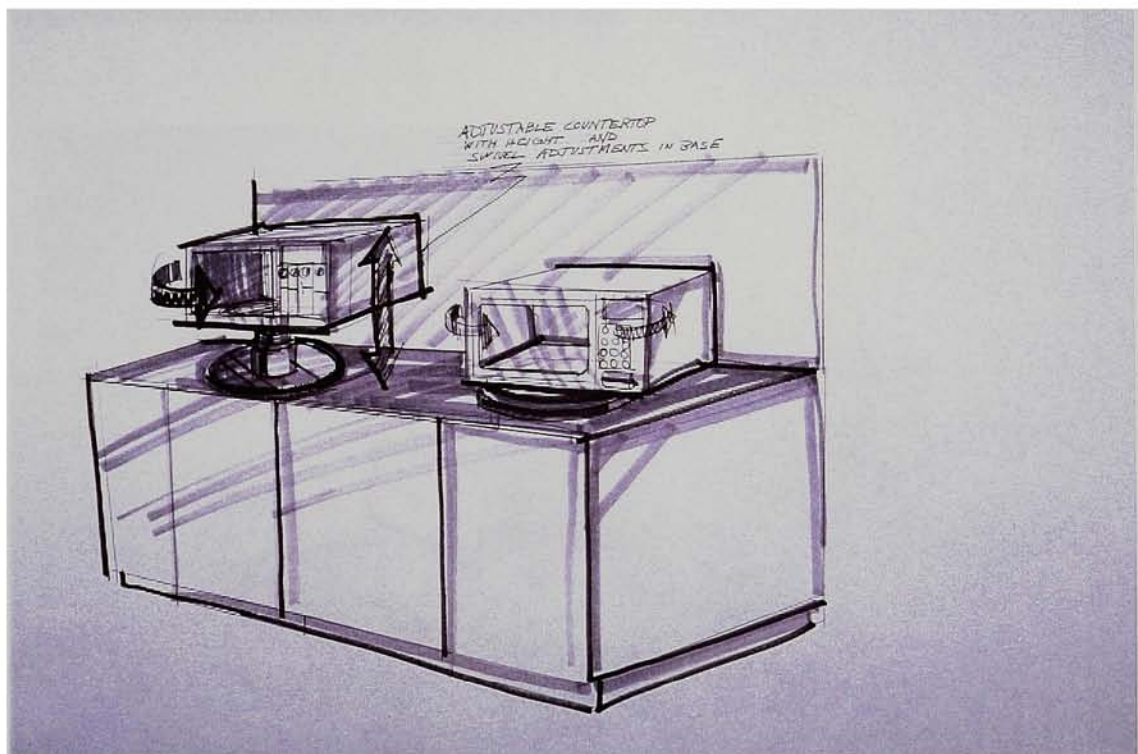


Figure 9. Concepts for Rotating Units

In Figure 10, the sketch at the bottom right suggests a less boxlike form for the front section and door (A). Just to its left is a similar treatment, but the door and control panel are separate (B). To the left above this sketch, is a concept in which the doors at the top of the unit are vaulted in a curve forming a roof-like enclosure (C). The larger door contains a display window, and the smaller door allows access to the portable scanning module. Clockwise to the right is an oven with two small cooking cavities (D). It is a box, in spite of some rounding of corners and edges, and the use of arched shapes for its subcomponents. The concept to the right has stacked cooking cavities (E). The control module has begun to separate from the cooking module.

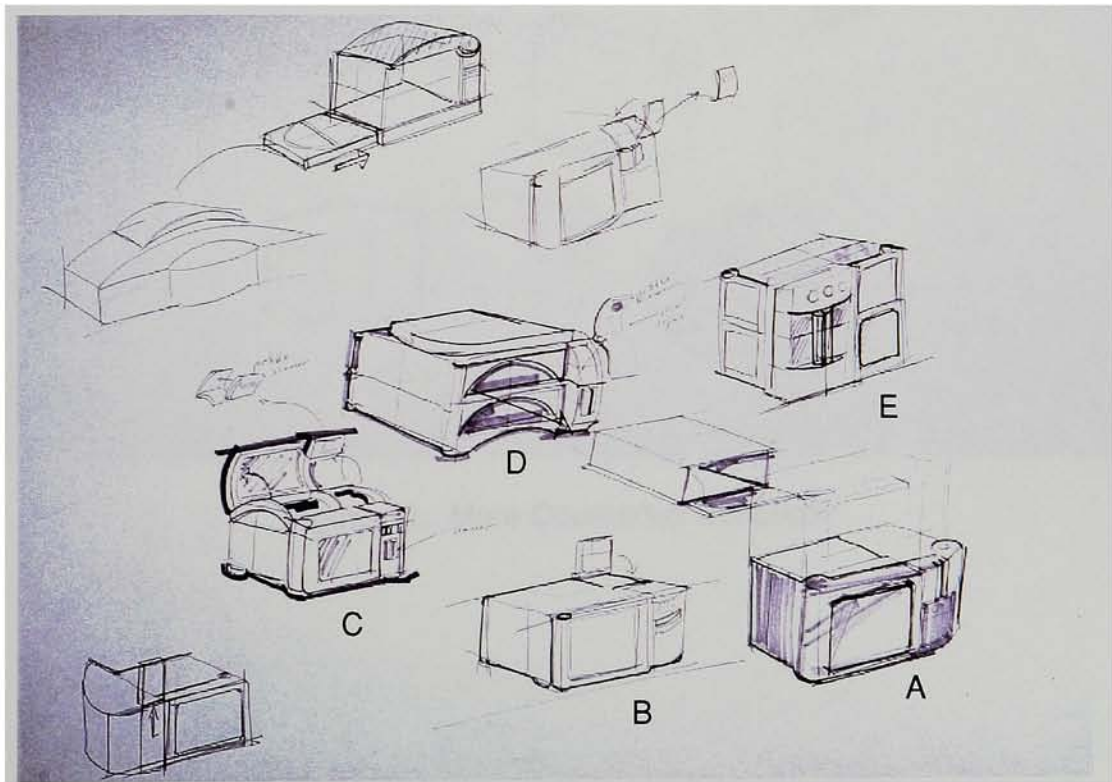


Figure 10. Countertop Concepts

Figure 12 shows an attempt to reconcile the cylinder and the box by situating the control unit in the cylinder and the cooking cavity in the box. Various openings and doors are suggested for displays, hidden control panels, and scanners. This concept while seriously considered for a long period of time, was later abandoned for a simpler, easy to maintain interface.

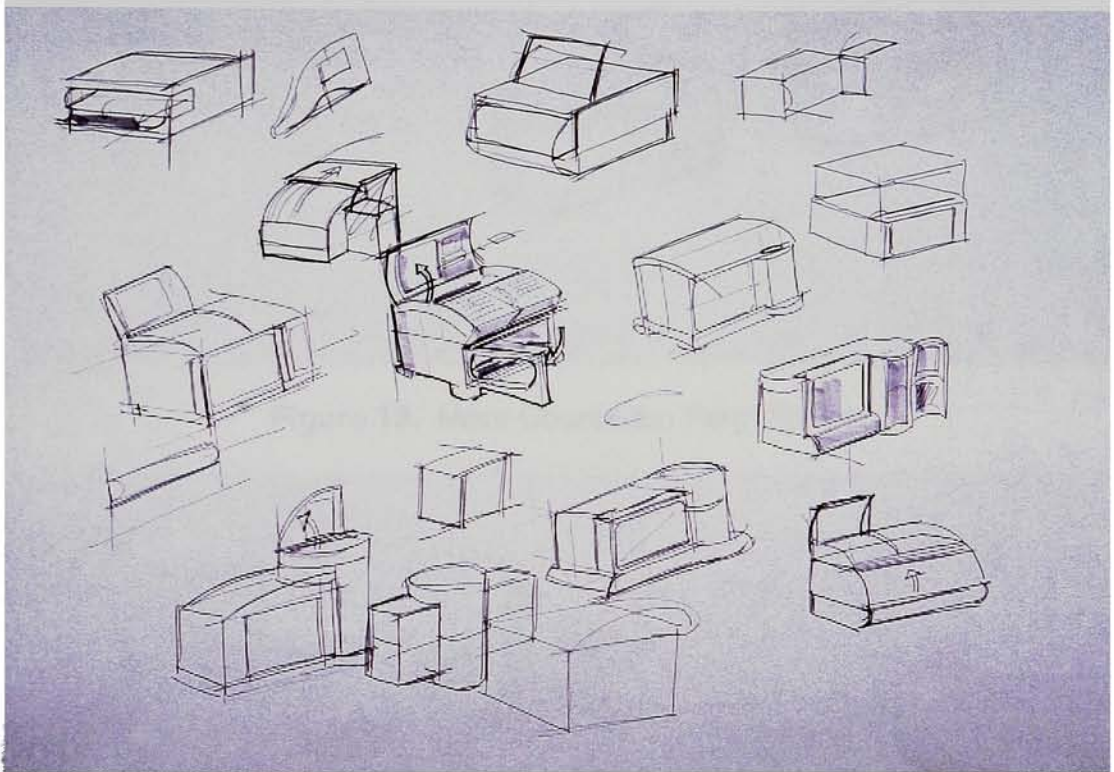


Figure 12. Countertop Form Studies

Figures 13 and 14 show more attempts to relate cylinder and box. In Figure 13, one concept has a flexible sliding door which would be accommodated within a semi-cylindrical curve in one wall. In the other sketch, a traditional door swings outward.

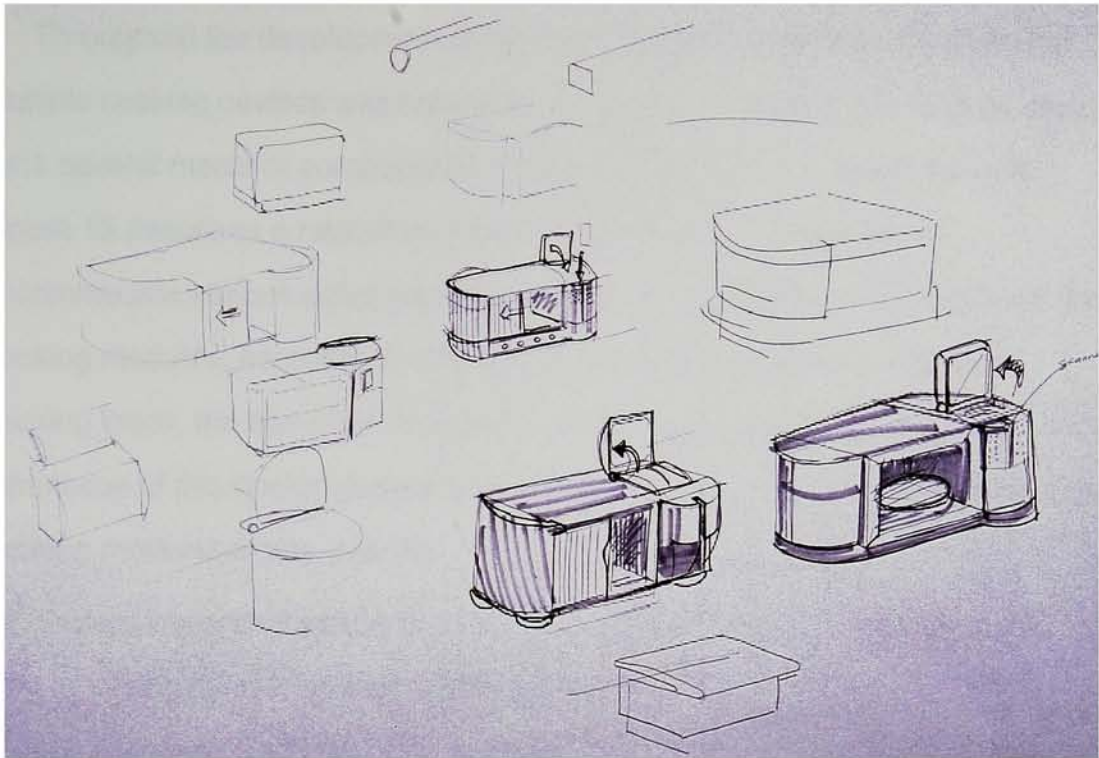


Figure 13. More Countertop Form Studies

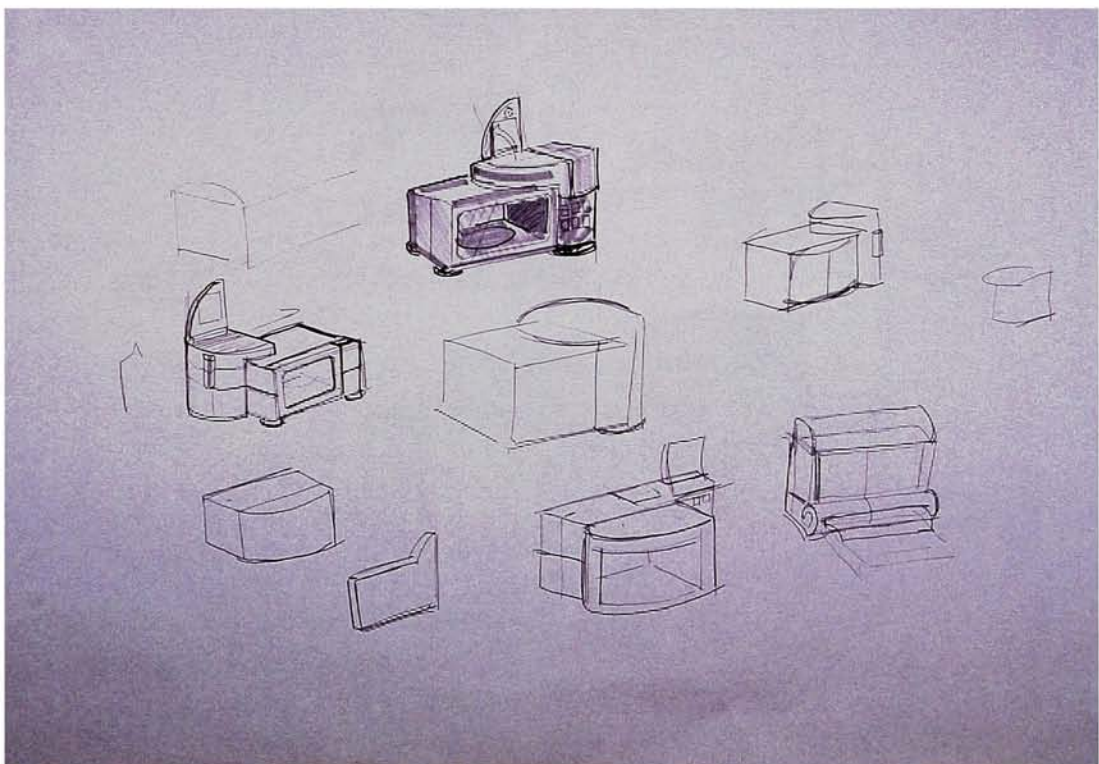


Figure 14. Variations of Countertop Form Studies

Throughout the development of the food preparation system, the theme of multiple cooking cavities was replayed. An appliance fitted in this manner could cook several meals or components of meals simultaneously, it was thought. Figure 15 describes a related concept of a modular unit which would accommodate various sized cooking modules. This sketch shows a unit with two cooking modules, each detachable for cleaning and storage (A). For large cooking loads, the two small modules would be replaced by one large one. An adaptation of this design depicts a vertically adjustable unit which would accept cooking modules of any size (B).

Separating each function of the system into discrete modules was the first step in freeing the design from the prosaic homeliness of the conventional microwave oven. Each function; cooking, control and scanning; although

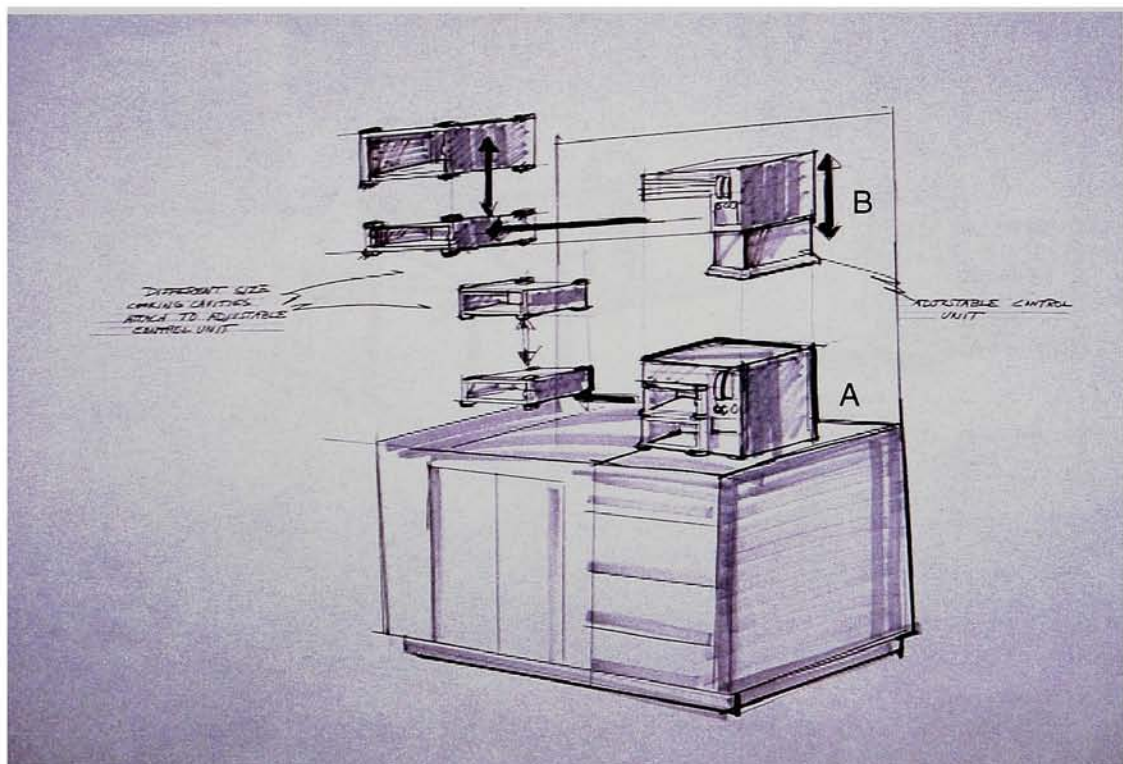


Figure 15. Concepts for Modular Countertop Units

interdependent, may reside separately and unambiguously in a discrete site. The designer was beginning to tinker with this concept.

Figure 16 demonstrates some concepts of modularity. Interlocking cylindrical and semi-cylindrical shapes define the separate functions. The two sketches on the left suggest two concepts for a modular unit with slightly different control interfaces (A). The half-cylindrical forms represent the control units, to which cooking modules may be attached (or detached). One of the concepts has a scanner for each cooking module; the other has one scanner for both modules. On the right, similar units have vertically adjustable control units to accept various sized cooking modules (B).

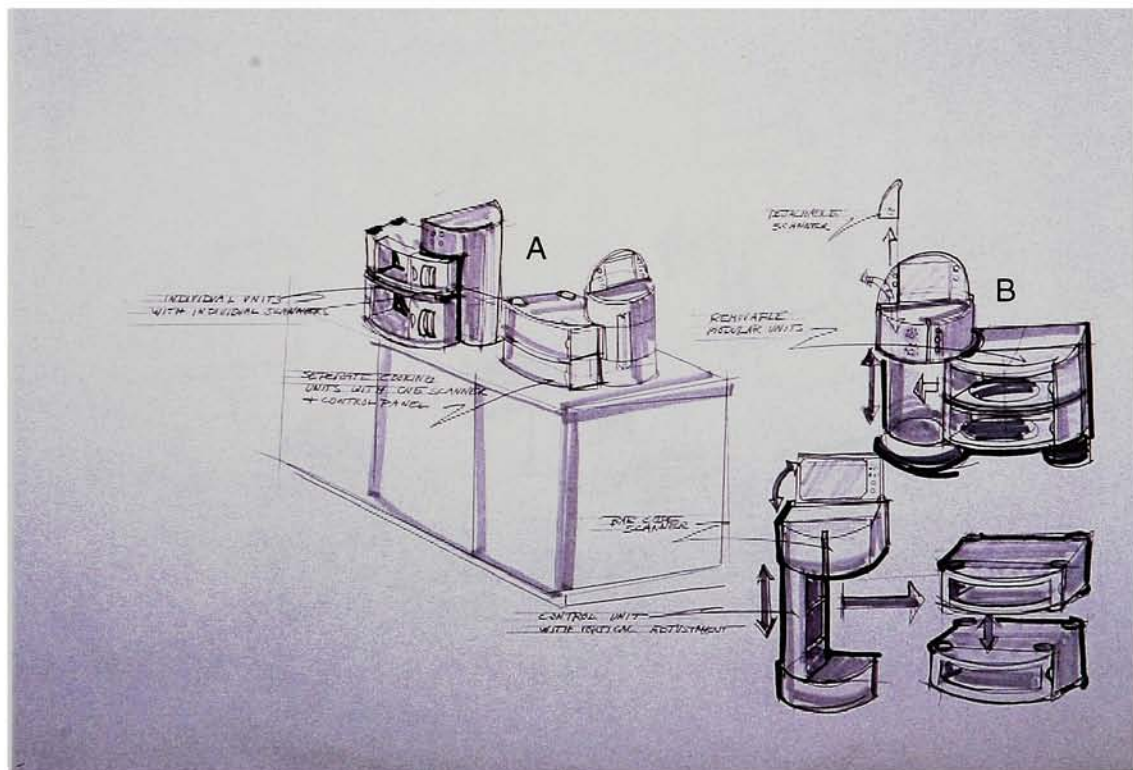


Figure 16. Concepts for Cylindrical Modular Countertop Units

Figure 17 contains a variety of modular and non-modular concepts. The sketch on the bottom left side of the page is another modular concept that has a door that flips up atop the control unit revealing a display (A). Above this sketch and slightly to its left is a similar non-modular unit with one cooking cavity (B). To the right are some different concepts that suggest a hinged flip-up door (C,D). This sloping door would permit access to the oven cavity from the top as well as the front, facilitating load placement. This type of configuration is made possible because microwave power can be out-sourced from different points in the cavity. John Gerling writes,

While the microwave power generally comes into the top of the oven cavity, newer designs have it coming in from the sides, rear, or bottom of the oven cavity; in some cases, it is introduced in two places simultaneously.³

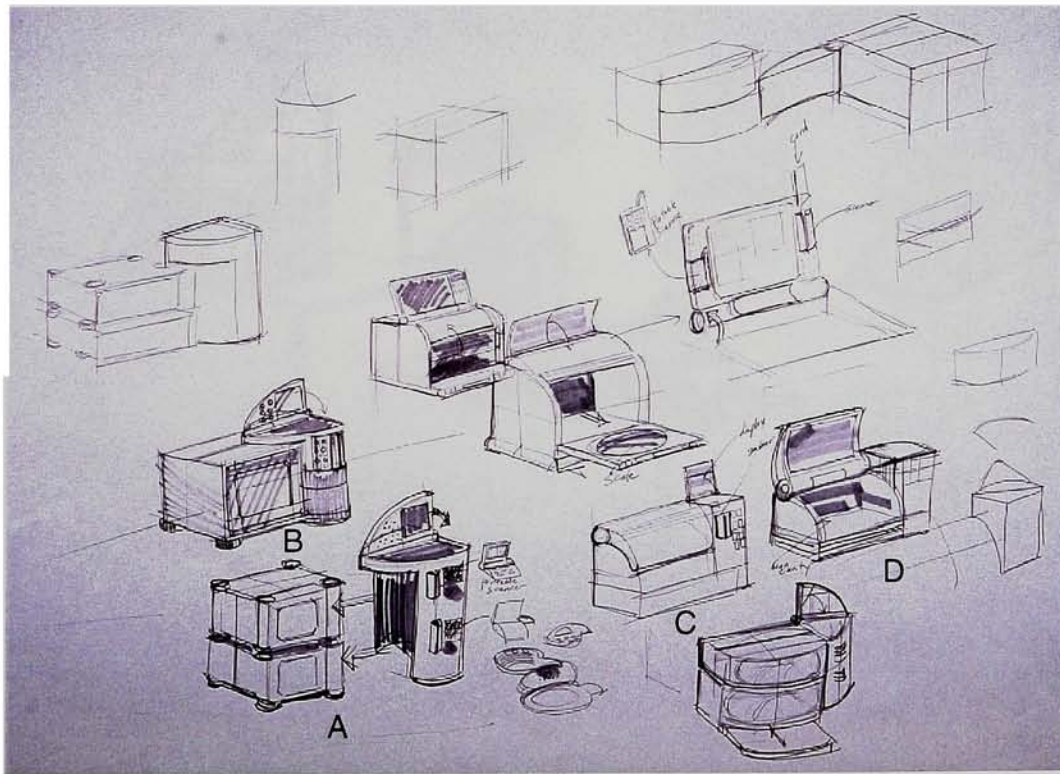


Figure 17. Door Concepts for Countertop Units

3. John E. Gerling, "Household Microwave Oven Technology," *Tappi Journal* 73, no. 3 (March 1990): 198.

In Figure 18, to the far left, curved wedges form the stacked ovens (A). This unit would make use of the easy access opening that was shown in figure 17, but would have sliding doors rather than a hinged flip-up door. To the right is a modular tower with three cooking modules within a curved facade (B). The control unit atop the stacked modules is based on the same form as the modules. To the right the cylindrical control unit and the short, broadly rounded oven seem mismatched (C). Directly above, a non-modular unit is based on an upright cylinder (D). Atop its stacked ovens, a hinged door reveals the display. To the right, another stacked unit has control panel and base display at countertop level for easy viewing (E). Curved corners and cylindrical feet support its boxy shape.

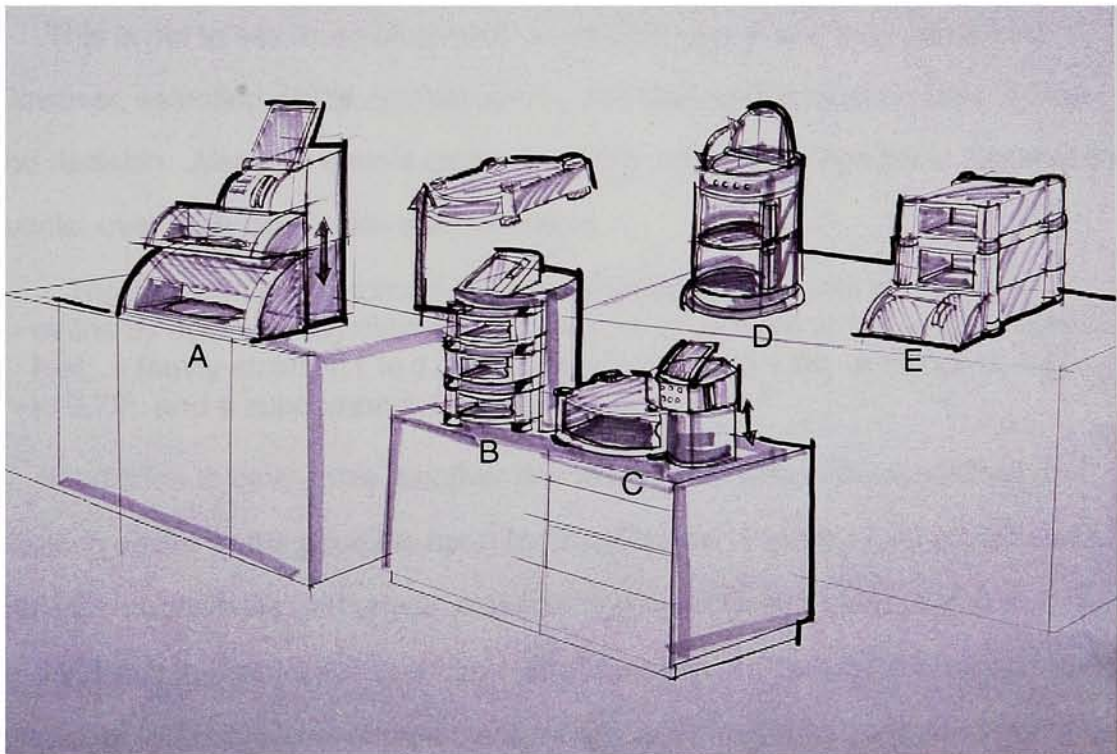


Figure 18. Concepts for Countertop Units with Stacked Cooking Modules

Although the multiple cooking oven persisted as a recurring theme in these

preliminary concepts, it was eventually decided that the advantages of this type of structure were far outweighed by the limitation it would impose on the size of the cooking cavities. The determination that the *Future Wave Oven* would be a countertop model automatically limits the maximum height of the unit. Most kitchens have cabinets above the counters, and the average distance between them and the countertop is 14 to 16 inches. This would greatly reduce the acceptable range for vertical dimensions of the appliance and render it virtually useless for all but the smallest loads. *Consumer Reports*, August 1996, rates ovens within categories of size.

We tested 28 microwave ovens in various sizes and ranging in price from \$90 to \$240. Manufacturers told us that when it's time to buy an oven, people are most interested in size and wattage.⁴

This is not to say that consumers buy the biggest ovens they can afford. However, selecting a size appropriate for available space must be factored into the decision. Also, the oven's cavity should be reasonably spacious. Later in the article, oven size categories are discussed.

The Association of Home Appliance Manufacturers sorts microwave ovens by how big they claim to be inside. A large oven is 1.4 or more cubic feet; a family-sized, 1.1 to 1.39; a mid-sized, 0.8 to 1.09; a compact, 0.60 to 0.79; and a subcompact, 0.59 cubic foot or less.⁵

In addition to cavity size, another drawback to an oven with more than one cooking cavity is the possible need for modification of technology and/or use of multiple magnetrons and power supplies. Technological advances (Section IV and V) have improved the speed and effectiveness of microwave cooking. These advances will more than compensate for any advantages to be gained from the simultaneous operation of multiple ovens.

4. "Which Make Zapping a Snap?," *Consumer Reports* 61, no. 8 (August 1996): 43.

5. Ibid.

Preliminary Design

The final form of the *Future Wave Oven* was not an amalgam of preceding studies. These studies document a struggle to find a path leading away from staleness. They show a recognition that system components, as envisioned, would not reside comfortably in a rectilinear, boxlike package. The uniqueness of system functions and the interrelationships among its components were not at home in a conventional receptacle. Therefore, a deliberate effort was made to house components to display each function and celebrate the novelty of their interrelationships.

In many conventional appliances generally, the viewer's attention is arrested at the front of the form, and other sides remain irrelevant. The face plates of VCR's and stereo components, for example, engage the viewer with lighted displays and controls, and other visible exterior surfaces have little aesthetic importance. Most microwave ovens, with their touchpad controls and flat LED displays, are perceived two-dimensionally as well, except during the few minutes it takes to load and unload the cavity. The user's interest is drawn to the one surface of interest; that which contains the interface, the appliance facade. Although these appliances are three dimensional objects, they are for the most part viewed two-dimensionally as one might view a flat piece of artwork. The other four surfaces are often crudely or carelessly finished. Most kitchen appliances, such as refrigerators and ranges, are mainly comprehended by scanning their frontal planes. The days of the splendidly sculptured stove are long gone. Giving importance to all planes with a sculptured, graceful form would seem to purchase aesthetic veracity for the *Future Wave Oven*, and contribute to its flexibility of use location. The decision to reveal all surfaces carries the obligation to render appealing every view of the appliance. Form studies

described in previous pages illustrate an explicit and deliberate progression away from the rectilinear, box shape and toward an interpretation of the appliance as a free standing, sculptural composition, a curvilinear arrangement comprised of a medley of cylindrical columns. Thus, curvilinear and cylindrical forms were chosen for their simple appeal. It was also important to avoid tiresome flamboyance since appliances are in use and on view for a long time.

The following sketches represent the preliminary design stage of the evolution of the final form of the *Future Wave Oven*. They constitute a progressive effort to refine the basic form of three intersecting cylinders of different sizes, and to organize them into a coherent entity. The three interconnected forms needed also to serve as a literal statement of the system's functions and of their interrelationships. The recurring, swooping curve unites the two smaller support cylinders with the larger cylindrical cooking component in a sculptural union. This curved form also serves to support the largest cylinder, which is suspended slightly above the countertop surface. Even at this stage of the development the display/control panel, though vaguely sketched, is prominently featured, showing the importance of the system's information component.

Figures 19 and 20 depict various options for placement of system components. These sketches put the scanning function in the smaller flanking cylinder and the control unit with display in the larger cylinder. Although it was fairly certain at this point that the oven would have a single cooking cavity, the two-cavity configuration was lingering as an option. The curved band flowing from left to right girding the two cylinders has been reiterated, and was repeated through to the final design phase.

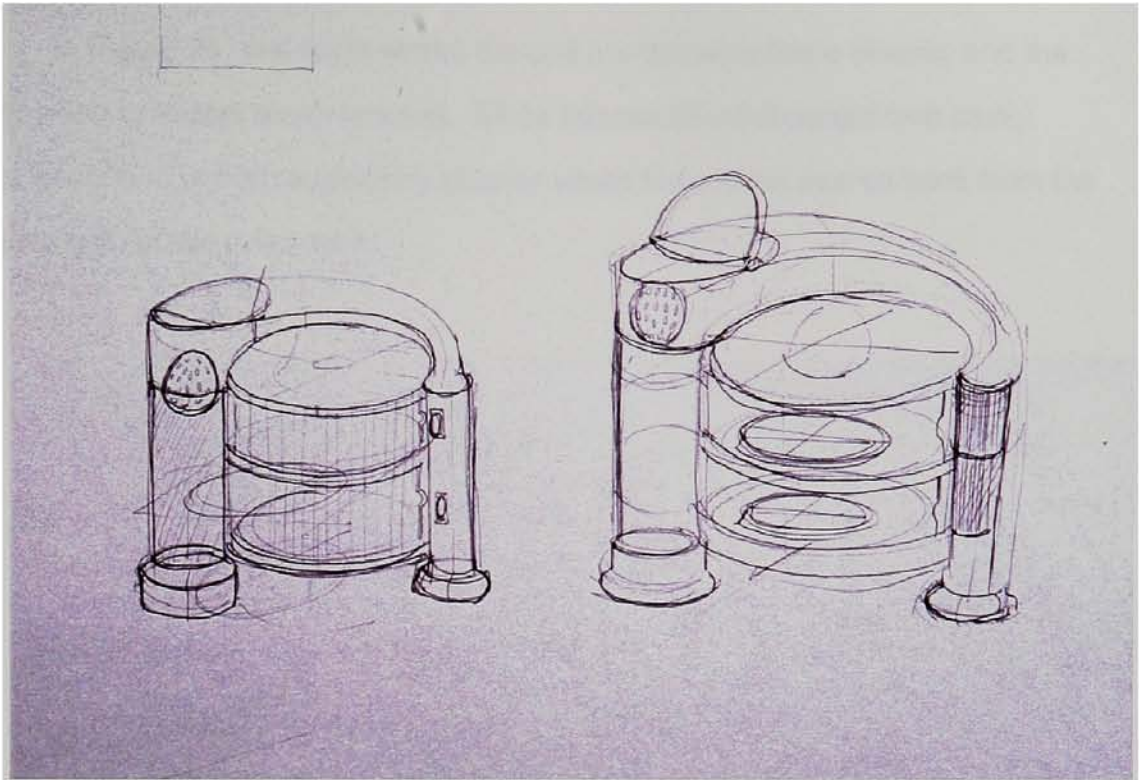


Figure 19. Studies for Placement of System Components

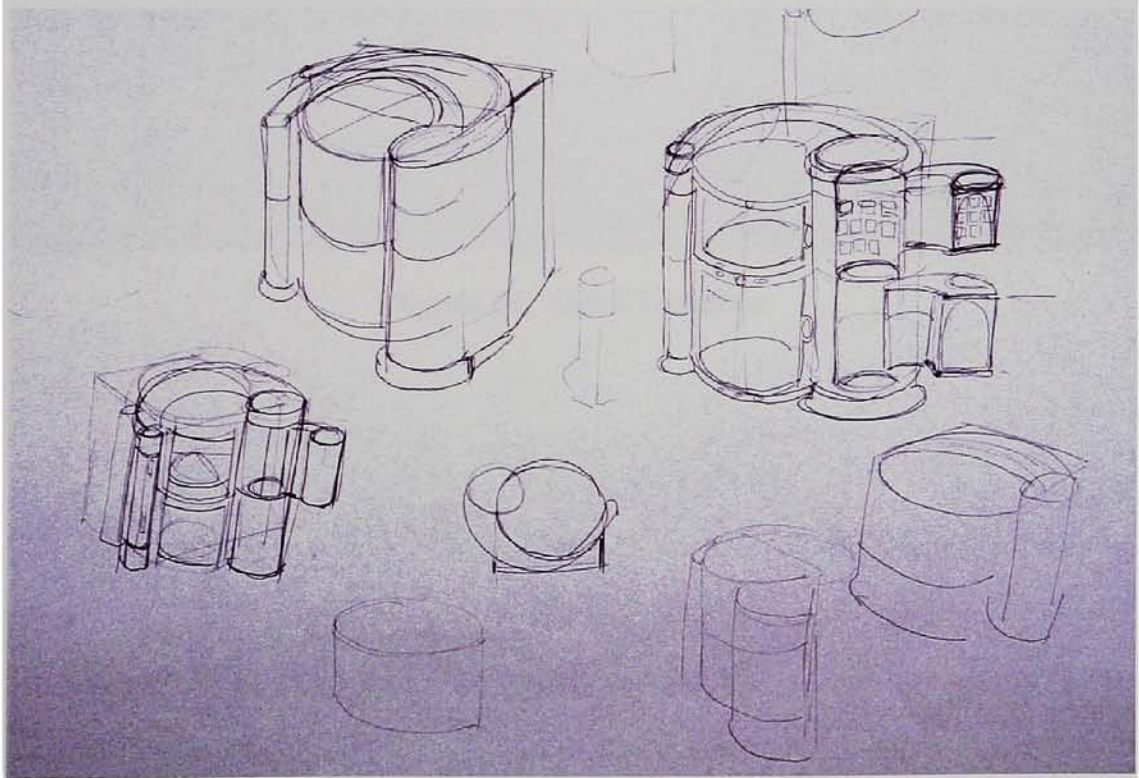


Figure 20. More Studies for Placement of System Components

In Figure 21, this band wraps the unit components more closely, and the flanking cylinders move forward. Since this modification would limit cavity access, one or both subsidiary shapes would have to be moved back from the proximity of the oven door.

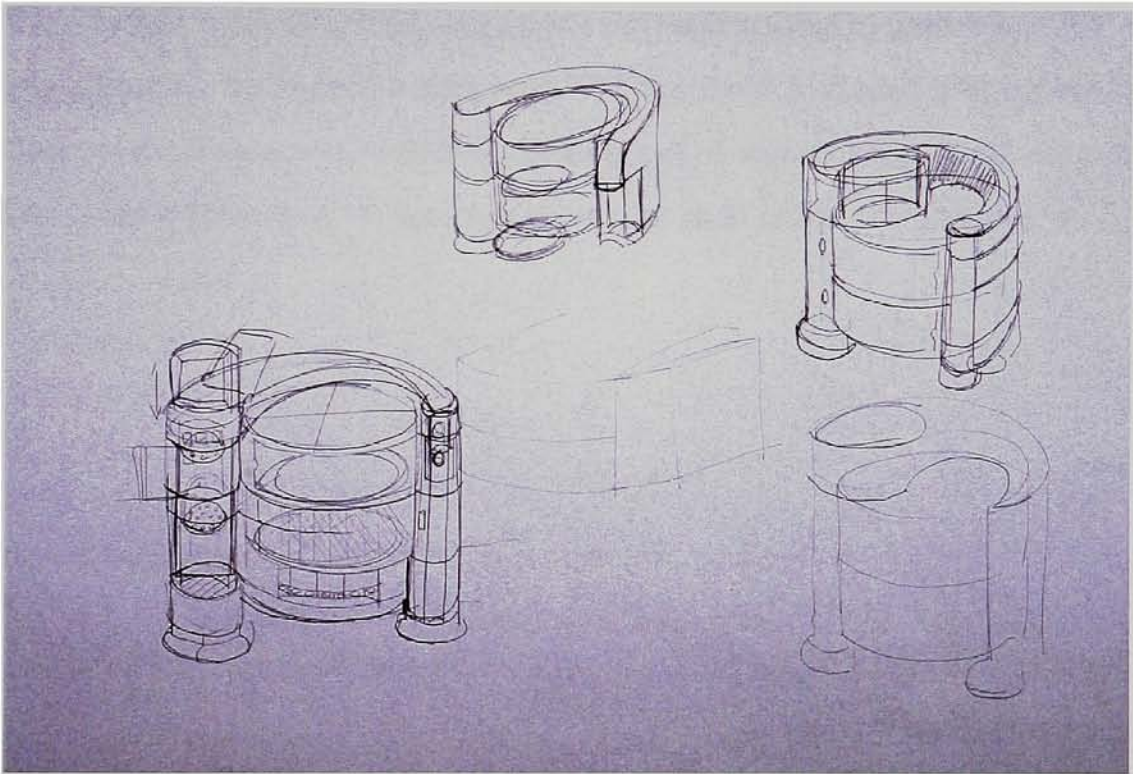


Figure 21. Form Sketches

In Figure 22, the larger flanking cylinder moves to the right side of the cylinder where all controls would be located. Doors cover the display and portable scanner, hiding the user interface and protecting these surfaces from soiling. Later simplification of the interface eliminated the need for protective panels and removed an obstacle to easy access to the controls. Another disadvantage to covering the display and scanner is the boring aesthetic which results from the absence of a focal point. Placing the display window prominently results in a more visually interesting composition. Pragmatically as well, an open display leaves little doubt in the mind of the user as to operational procedures.

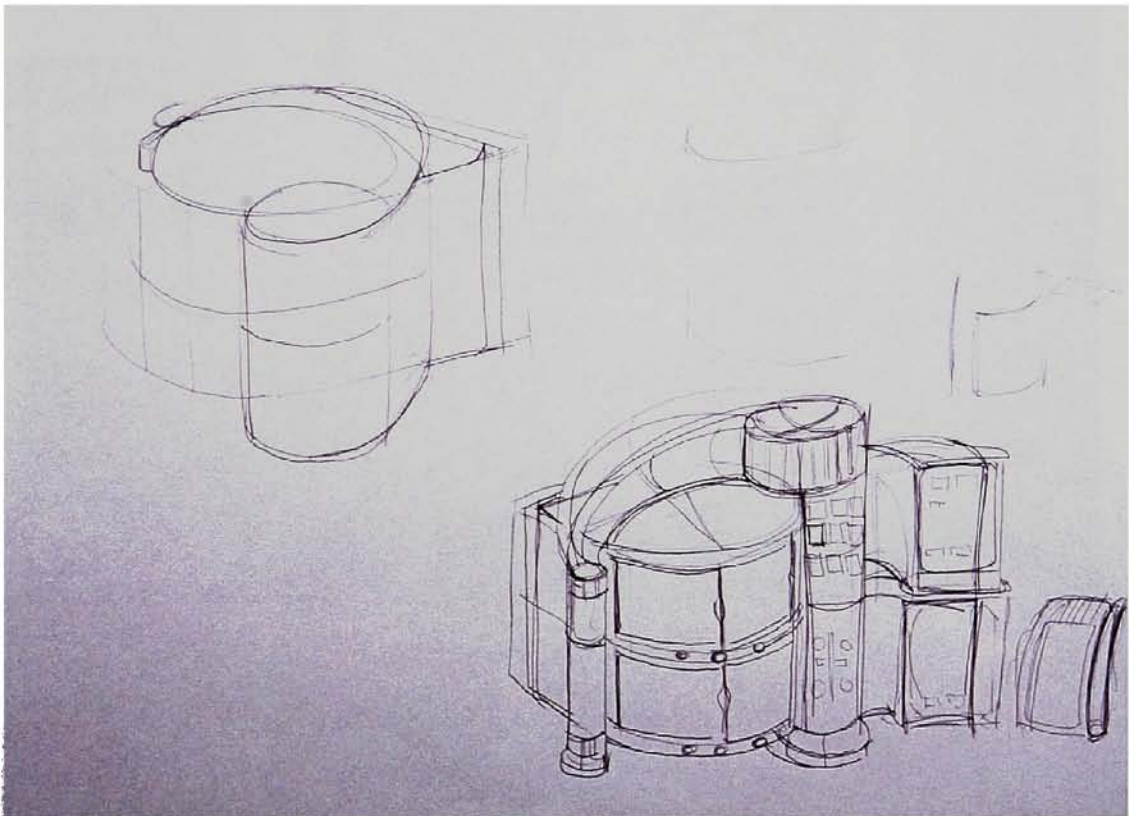


Figure 22. Sketches for a Unit with Doors

Figure 23 bears close resemblance to the final design of the *Future Wave Oven*. However, the manner in which the three cylinders intersect remains vague. A much larger, curved band envelops the modules, overlapping the top surface of the larger cylinder. Though the larger of the flanking cylinders is at the left here, it migrates for good to the right in the final design.

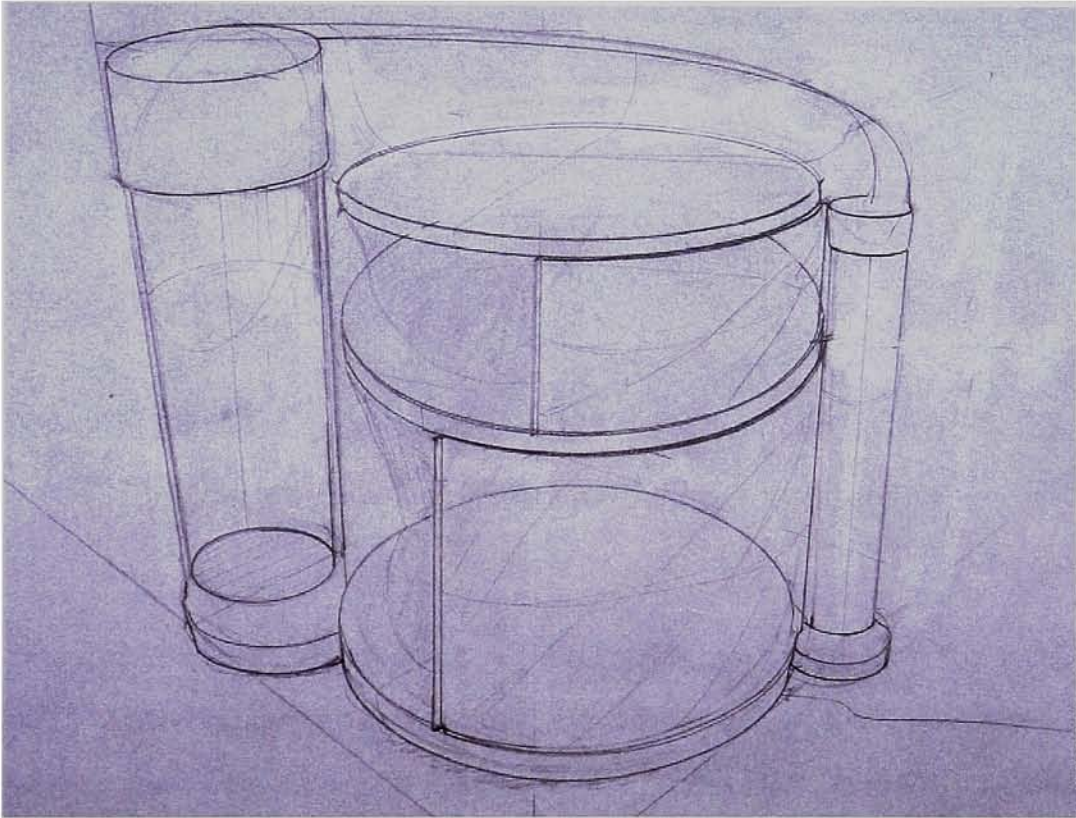


Figure 23. Study

The detachable *Portable Information Unit* is located on the smaller, right cylinder in Figure 24. The display, with hinged lid, is situated at the top of the cylinder at right. Here a suggestion of a frontal location for the control interface presages the touch screen window of the *Future Wave Oven*.

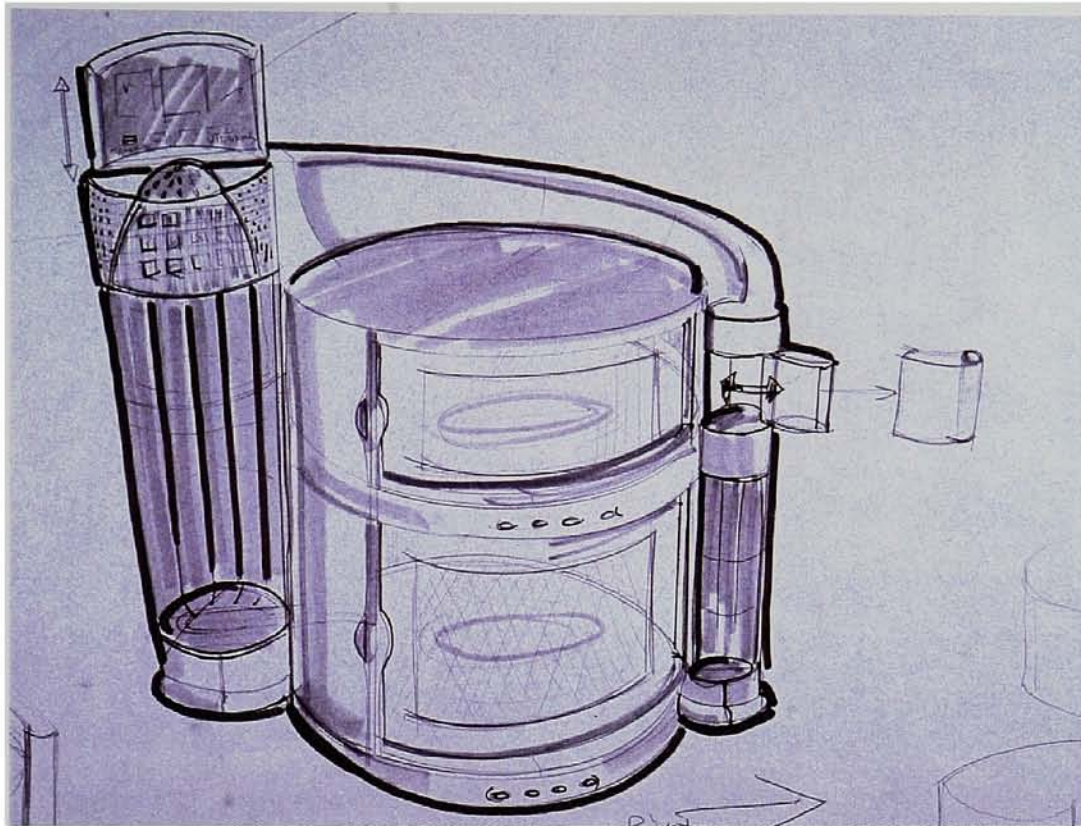


Figure 24. Study for Placement of System Components

Figures 25 and 26 approach closely the final design except for the hinged panels for covering display and controls. Here the oven's scanner would be located on the inside surface of the top covering panel. On the inside surface of the bottom covering panel, a cradle would hold the *Portable Information Unit*.

At this stage of the form development, the configuration of the structure had been resolved. The larger flanking cylinder stands decisively to the right and forward. The smallest cylinder at left is a supportive structural element which no longer houses scanner or information components.

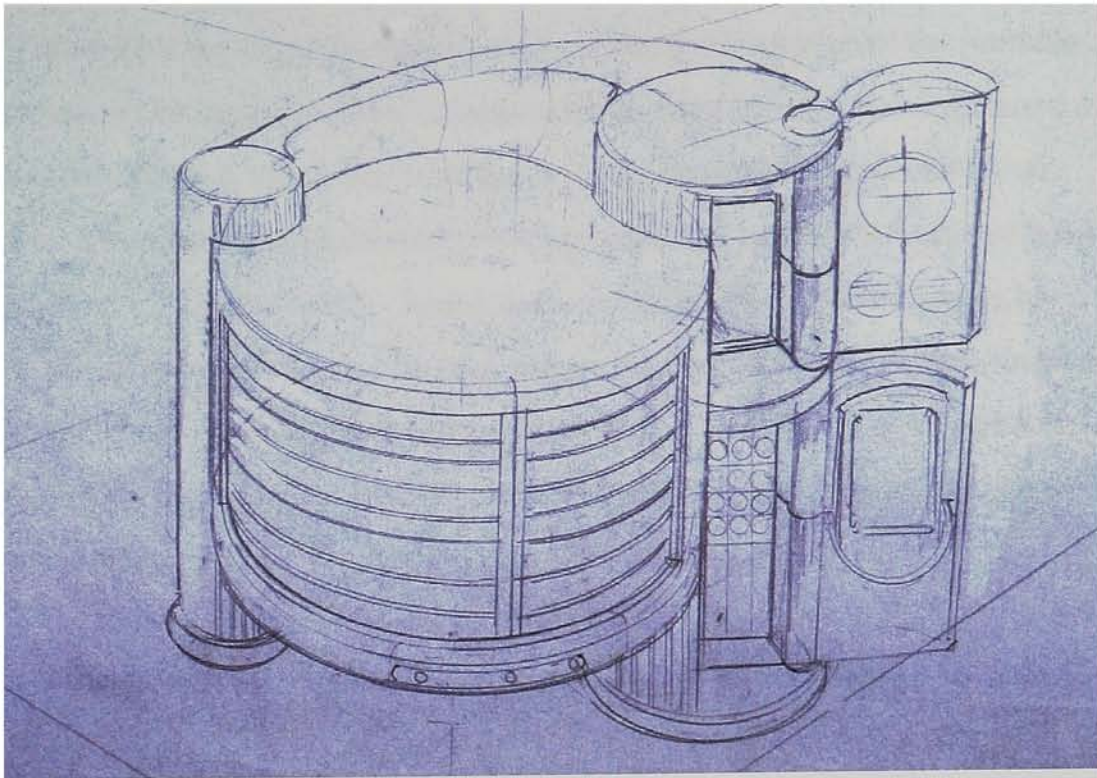


Figure 25. Study for Placement of System Components Behind Doors

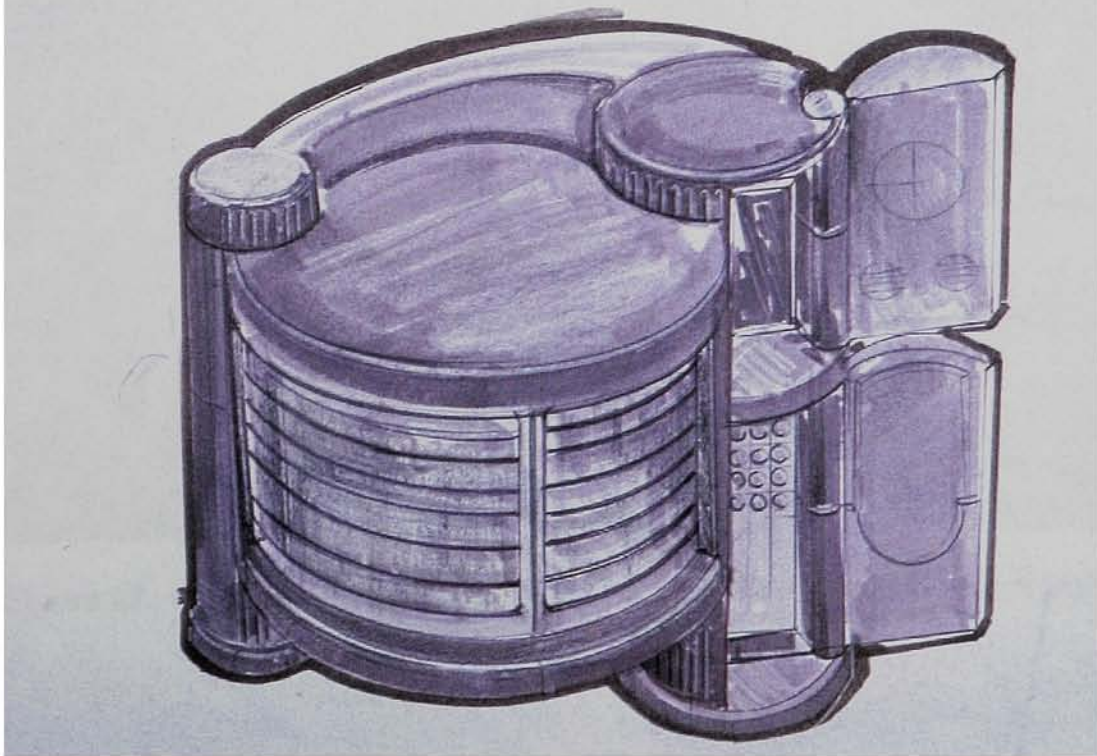


Figure 26. Appearance Study

Figure 27 is an elevation sketch which suggests the location of the *Portable Information Unit* on the inside of a hinged panel. Here the unit was envisioned as a very thin, flat unit, rectilinear in shape, and hinged in the manner of a cellular phone. This sketch suggests such a folding apparatus which when opened would extend twice its folded length. Separate display and control buttons would be used on this type of unit. For the final design, however, a much simpler interface was chosen with a display and two control buttons. This choice made possible the option of designing a more compact unit than had been dictated by former space requirements.

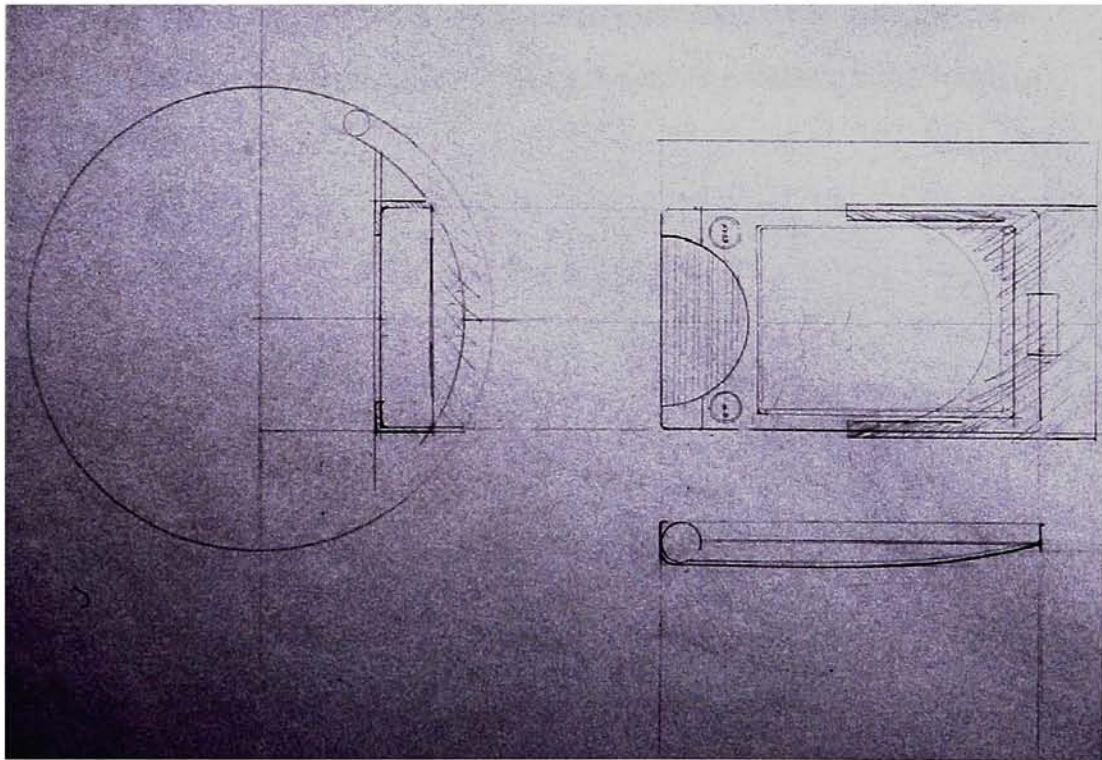


Figure 27. Elevation Sketch of Possible Location of *Portable Information Unit*

For simplified use, the entire user interface of the *Future Wave Oven* is sited at the front of the cylinder to the right (Figure 28). The oven is shown as a single cooking unit with one large cooking cavity. The curved band and the three cylinders intersect and communicate in approximately the same manner as in the design's final resolution. Figure 28 shows a transitional phase from preliminary to final design. Hinged enclosures have disappeared, and combination control panel/display is now inset at the top of the right hand cylinder. The contrasting shape of the display window gives the eye a resting place and a focal point. This window will be the site of all user-system interaction. The shape of this display window eventually dictates the form of the *Portable Information Unit* that will be located just below the display window in the lower half of the cylinder. The cylinder is divided approximately in half vertically by a narrow band running

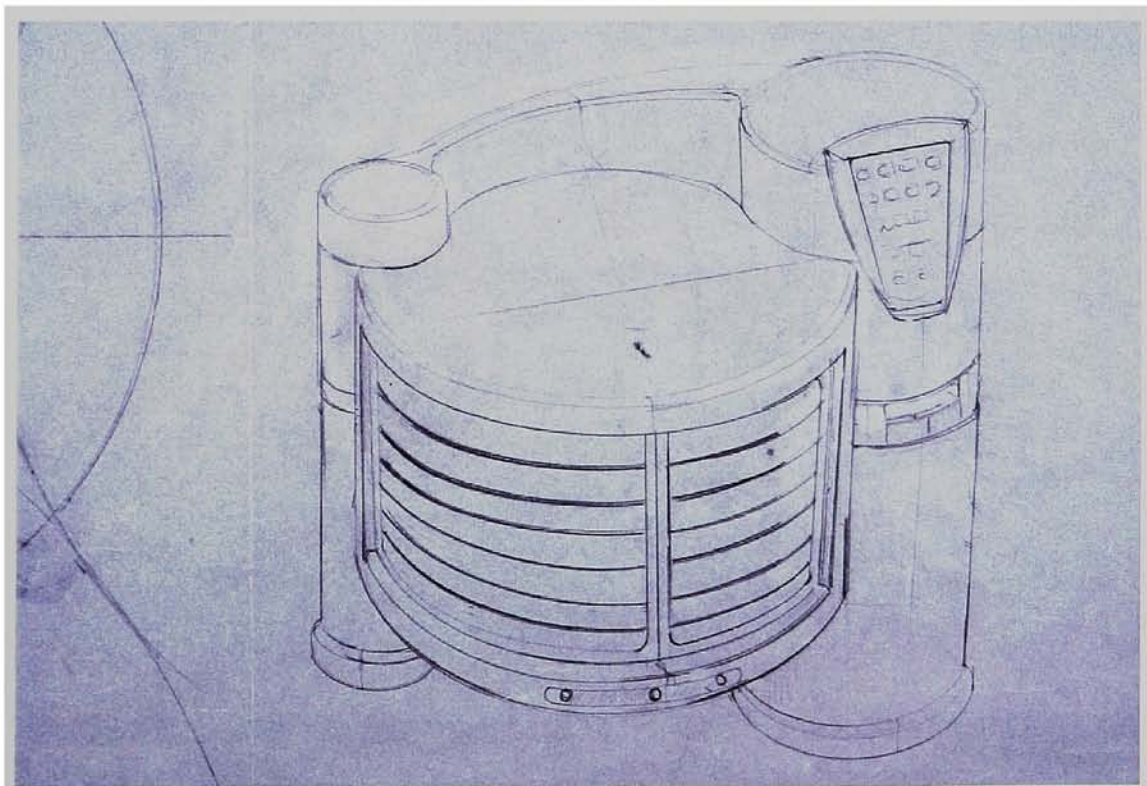


Figure 28. Preliminary Design

around its circumference. This band is reserved for the oven scanner. The user will simply orient the package bar code in front of this band prior to preparing its contents.

Figure 29 shows the final location of the *Portable Information Unit*. Positioning the unit in a niche was considered. However, storing it in this way would make the device difficult to grasp. Even with hollows on the sides of the niche for fingers, some users would be discouraged by the necessity for a somewhat complex maneuver. These finger indentations would also disrupt the smoothly tapering shape created by the juxtaposition of display and *Portable Information Unit* below. The possibility of dropping the unit while nudging it out of

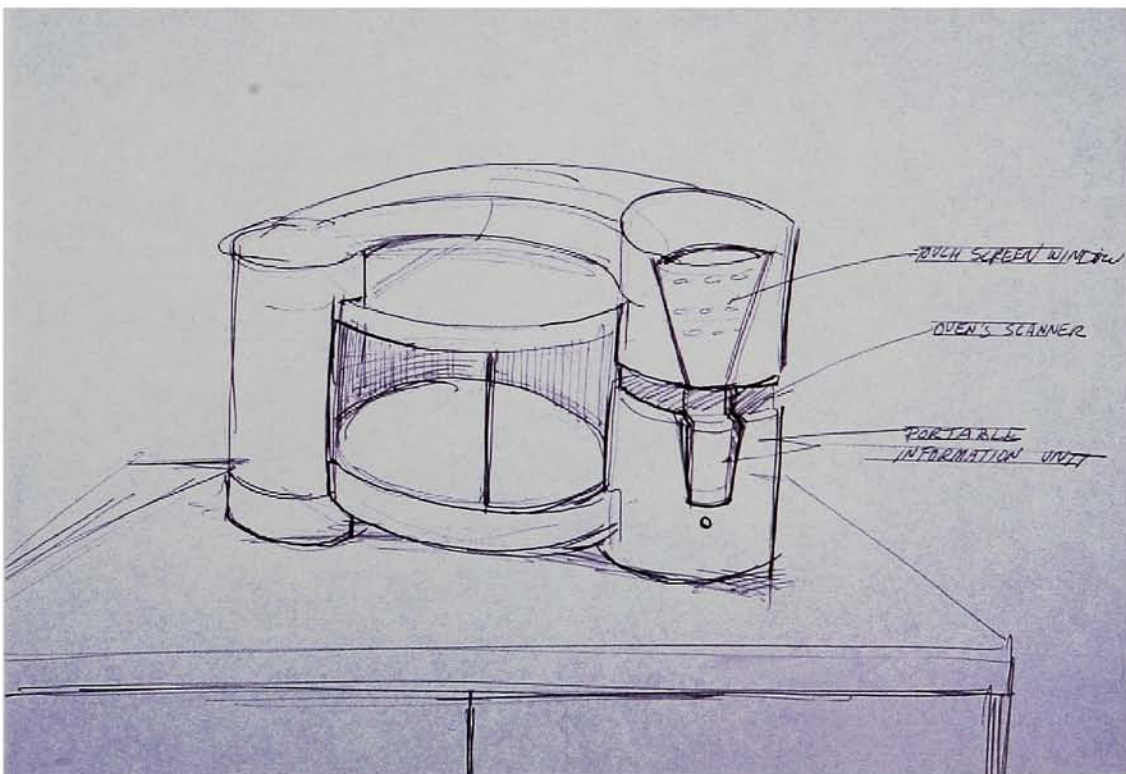


Figure 29. Sketch Showing Approximate Position of *Portable Information Unit*

its mooring was another deterrent. Finally an exterior hanger was devised which would facilitate use.

Figure 30 is a photograph of a form study from which the final form of the *Portable Information Unit* resulted. The convex form of one surface fits nicely in the palm of the hand. Designed to conform to hands of various sizes, its tapered width allows for flexibility of positioning depending on user comfort. The tapering shape serves an aesthetic purpose as well. Hanging beneath the display, the unit completes the tapering “V” shape, extending from top to bottom. As will be demonstrated in the final design, this blunted “V” shape is also echoed in the display window of the *Portable Information Unit*.



Figure 30. Form Study for *Portable Information Unit*

Final Design

The Future Wave Oven

The final design of the *Future Wave Oven* may be viewed in the following photographs. Figure 31 is a photograph of the display for the *Future Wave* system exhibited in the *Graduate Thesis Show* at the Bevier Gallery, Rochester Institute of Technology. The exhibit was held from April 29th to May 8th 1996. The *Future Wave Oven* and the *Portable Information Unit* are located on a countertop to replicate the positioning of the oven in a kitchen setting. Directly above the countertop is a lighted display demonstrating six possible scenarios for use of the *Future Wave System*. The six bits of information are contained in lighted windows which simulate the touch screen display window on the *Future Wave Oven*. The information in these windows relate the type of captions that the user might find in the display window of the *Future Wave* system control unit. This information is presented as it would be reported on the actual interface. In many cases the display further prompts the user to make a decision based on data retrieved from packaging. For example, in one window the scenario presented reports, "Easily monitor your daily nutritional needs without searching for information on packages." The information on the simulated touch screen window reads, "This item contains 300 calories, with 50 calories from fat. It also contains 20 mg of cholesterol and 520 mg of sodium. This is above your requested daily allowance for cholesterol and sodium for one meal. Do you wish to ignore this message and continue cooking?" The user must then make a decision based on this advisory. This is one example of the type of interaction that may occur between the user and the system. Other possible scenarios, will be discussed at the end of this section.



Figure 31. Display in *Graduate Thesis Show*

The remainder of the view is composed of an abbreviated written description of the system, six boards of development drawings, as well as props in the oven and on the countertop. Figure 32 is another view of the display. For the purpose of viewing the display window of the *Portable Information Unit*, it is shown in this display, detached from its hanger, at the lower right corner of the oven.



Figure 32. Another View of Display in *Graduate Thesis Show*

Function

At this juncture, to clarify the function of the system, it will be necessary to give a description of each component of the *Future Wave* system. Figure 33 is a view of the *Future Wave Oven*, with *Portable Information Unit* attached. On the right side, the larger cylindrical form, which flanks the large center cylinder, contains the three components of the system interface. This housing will be referred to as the control unit of the system because it is the site of the control interface and the oven scanner as well as the point of connection for the *Portable Information Unit*. This control unit is, thus, where all product information is recovered, all user input is made, all information is downloaded from the *Portable Information Unit*, and all data is processed and made available for access. Thus it represents the location of the system brain which controls and supports the



Figure 33. *Future Wave Oven with Attached Portable Information Unit*

actual process of cooking which takes place in the cooking module.

The most prominent feature of the control unit is the touch screen display window inset into the upper half of the cylinder (Figure 34). This window functions as both control panel and display. The user will retrieve information from product packaging by viewing it in this window after scanning the bar code.



Figure 34. Touch Screen Display

The control panel will change according to the information being displayed and processed by the system. When requesting specific information about an item, as for example, caloric content, the user would touch the screen at the point labelled “nutritional information.” The system will then prompt the user to indicate the type of nutritional information sought. At this point, the user simply touches the screen button that reads “calories.” Thus, the system displays information

and requests input from the user in a logical progression as data obtained from bar codes is being processed for the user. Requests for input by the user may be bypassed by the system if the user makes a pre-entered request for specific information to be displayed every time a package is scanned. For example, a user may want to know the sodium content of each item scanned prior to preparation. This information will be displayed automatically without a user request each time a bar code is scanned. The display window also functions as a control panel with a numbered keypad and the functions; cook, auto scan, door open, nutritional information, defrost, cancel and start. This standard keypad is seen until operation begins. Once function is selected, the displays change, and appropriate data and control panels (or screens) invite further user-system interaction.

Directly beneath the display window is a dark gray band slightly inset into the cylinder running horizontally around the circumference of the control unit. It may be viewed clearly in Figure 35 on page 122. This band is the oven's scanner. There is no need to pick up a separate scanning gun with one hand while holding the package in the other hand. The user need simply orient the package's bar code in front of the band for scanning. Its location at approximately the halfway point of the vertical dimension of the control unit allows for scanning of different sized items (Figure 36, page 123). If it were located too high on the control unit, the scanning operation would be awkward for larger items because lifting would be required and upper cabinets might interfere. If it were located too low on the cylinder, the countertop would impede the orientation of some packages depending on the location of the bar code. A central, unobstructed location presented the best possible location for the scanner.



Figure 35. Scanner

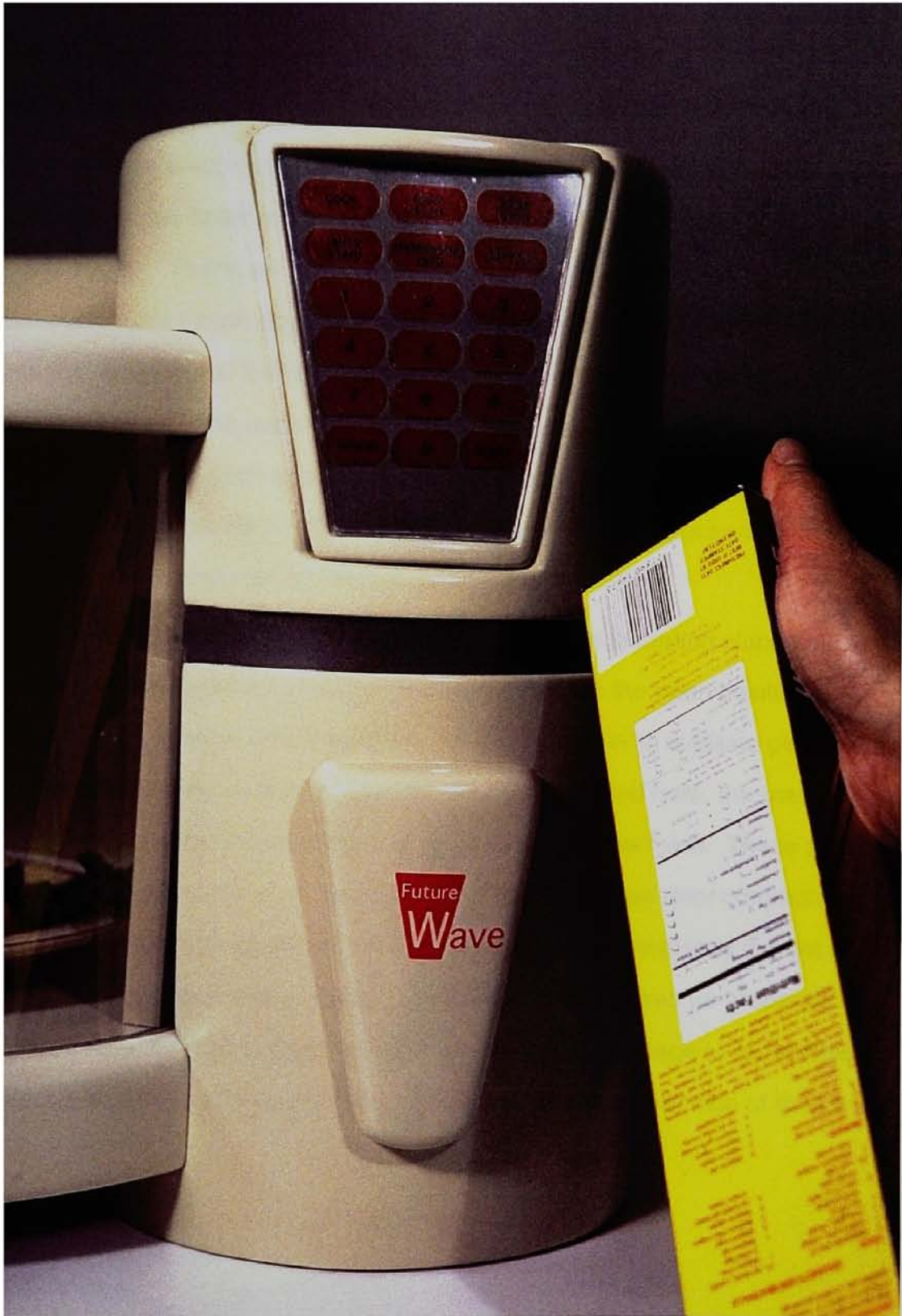


Figure 36. Scanning Operation

The large, cylindrical form to the left of the control unit tower is the cooking module of the *Future Wave Oven*. Its cooking cavity is accessed through two retractable sliding doors. The doors may be opened by pressing the “door open” prompt on the touch screen window. Also, when the oven is set to automatic scanning mode, scanning the package bar code will cause the door to open automatically. This is an especially useful feature when preparing a microwaveable frozen dinner. The user is merely required to scan the bar code, pop the dinner out of the box, put it in the oven, touch the start button, and the doors will close. The oven does all the rest; and settings which are normally entered manually, such as cooking times and power levels, are made automatically. This information is decoded from bar code data and processed by the system’s control unit, which then programs the settings.

Figure 37 is a view of the *Future Wave Oven* demonstrating placement of food in the oven’s cooking cavity. The doors retract to the open position automatically and the light illuminates the oven’s interior to facilitate placement of the load (item to be cooked or heated). As demonstrated here, the user does not need to free a hand to open the door or fiddle with a door latch. These sliding doors are practical for many reasons. Opening the hinged door common on most microwave ovens requires that the countertop space immediately in front of it be free of utensils and other objects. If this space is being used for preparation tasks, it must be cleared before oven use. Another advantage to retractable doors is that the cavity opening may be accessed from either side of the oven.



Figure 37. Placement of Food in Oven Cavity

In a conventional microwave oven the load may be inserted from only one side. The *Future Wave's* design permits placement of the oven anywhere on the countertop, and all countertop space around it may be utilized. In addition to these advantages, this door design eliminates the possibility of accidentally brushing against an open oven door, catching one's clothing or possibly damaging the door. The doors were also designed to facilitate cleaning. Each door opens independently allowing for cleaning of the back surface of one door while the other door is in the closed position (Figure 38).



Figure 38. Cleaning of Doors

When the cooking phase is finished, an audible signal sounds notifying the user. The doors remain closed and the oven light stays on until the user touches the “door open” button. Once the load is removed from the cooking cavity, the “door open” button changes to a “door close” button on the touch screen. The user need simply touch the button and the doors close, light is extinguished, and the oven is in the “off” mode.

When the *Future Wave Oven* is in cooking mode, the base of the oven’s cavity will rotate performing the same function as the turntable in a microwave oven, that of cooking food more evenly. Of course, when the cooking cycle finishes or is interrupted, or if the doors are opened, the rotation will stop . This design eliminates the need for a separate turntable that would reduce interior space. This feature also facilitates cleaning of the oven’s interior.

Form

The *Future Wave Oven* is housed in three intersecting cylinders of different sizes. The largest of these, centrally positioned, is reserved for the oven module. The next largest, at right, is occupied by the control unit with docking for the *Portable Information Unit*; and the smallest, at left, functions as a support element both architecturally and proportionally. All are embraced by a comprehensive element of support in the form of a bold curve which suggests the unfurling of a scroll (another cylinder). This curving band which overlaps the top of the oven module, narrows as it flows from around the control unit to wrap the supporting pillar at the left (Figure 39).



Figure 39. Curving Band

The tallest part of the oven at the very top of the cylindrical control unit measures 14.875 inches. The width of the entire appliance is 21.5 inches and its depth is 16 inches. Because it is not rectangular, these dimensions vary at different points around the structure, so dimensions are given for the highest, deepest and widest points of the appliance. It occupies about as much or even less space than a large or family-sized microwave oven. Depending on the manufacturer, countertop space occupied is comparable to that of a mid-sized microwave oven. Its vertical dimension is two to three inches higher than a mid-sized model, however, due to the height of the control unit.

To underline its functional importance, the control unit is larger, taller and protrudes more than the left flanking cylinder. Its diameter is 7.875 inches and its

height is 14.875 inches compared to the corresponding support element which is 14.125 inches high and 3 inches in diameter. In the upper half of the control unit is the touch screen display window which tapers along its 5 inch length from 4 inches wide at its very top to 2.5 inches at its bottom. Below the control unit is the oven's scanning band, which is .690 inches in width. It separates the display from the *Portable Information Unit* station directly below it. It is inset slightly so it appears to cut into the cylinder, creating two incised edges around the circumference, and restating the radius at the top of the cylinder. These accents create an appealing but serene dynamic as the form is scanned vertically. These subtle inflections contribute interest to the composition, while directing attention to the user interface.

When attached to its hanger, as it is in Figure 40 (page 130), the *Portable Information Unit* echoes the blunted V -shape of the display window and completes the tapered shape which extends the length of the control unit. When detached, its form is repeated in the shape of the hanger.

The interior of the oven cavity is 8 inches high and its base is 14 inches in diameter, in essence giving the oven a 14 inch turntable. The opening to the interior of the cavity is 12.5 inches when the doors are completely retracted. Although the interior cavity is smaller in overall size than today's larger models, its cylindrical shape utilizes this space to the fullest. Any size receptacle that will fit inside will rotate on the turntable/base.



Figure 40. *Portable Information Unit Attached*

An August 1995 article in *Consumer Reports* titled "Microwave Ovens" discusses interior space of microwave ovens.

How much room? Manufacturers tend to claim every last cubic inch of interior corner space for capacity of their ovens. We don't take those claims at face value, because the turntable almost always diminishes useful capacity considerably-and all the ovens must have the turntable in place to operate. Large ovens with a claimed capacity of 1.1 to 1.6 cubic feet actually have useful space of 0.7 to 1.1 cubic feet. Mid-sized ovens with a claimed capacity of almost a whole cubic foot actually have little more than half a cubic foot of real cooking room.

Only the mid-sized *Magic Chef* has a turntable that can be set *not* to revolve. So, with the corners of its oven theoretically available to hold food, the *Magic Chef* has 0.8 cubic foot of usable space-exactly as claimed. But it provides a half a cubic foot with the turntable rotating.¹

The cooking module of the *Future Wave Oven* is suspended from the countertop surface 1.125 inches. Aesthetically, this gives the structure a buoyant lightness. The two flanking cylindrical towers and slotted intersections of the structural elements perform the function of physically supporting the central cooking module. This intersecting configuration was devised not only for keeping the composition in dynamic balance, but to limit the overall width of the unit without making the cavity opening too small. In addition to these considerations, the flanking right cylinder needed to be positioned as prominently as possible since it houses the control unit and all user interface. The four structural components and their co-dependency within the framework of the system serve a literal purpose as well. The intimacy of their interrelationships is a metaphor for the manner in which the system's functional components collaborate to achieve the objectives of fast, easy, wholesome food selection and meal preparation.

1. "Microwave Ovens," *Consumer Reports* 60, no. 8 (August 1995): 515.

shopping trip. Using the oven's touch screen display, the user can determine which items to purchase. This information may be downloaded to the *Portable Information Unit* in the form of a ready-made shopping list. This feature will be especially useful in large households where extensive home inventories must be tracked.

The *Portable Information Unit* provides an essential link in the cycle of function of the *Future Wave* system. Its portability gives coherence to the information application of the system by allowing operation in settings, usually retail locations, outside the home. Its functions of label reading and synthesis and dispensing of information are so ergonomically frugal that they will be of the greatest assistance to all population segments whose need for support has been previously identified, such as two-earner and single parent households. The elderly, visually impaired, and otherwise physically handicapped will be able to make appropriate food choices without label reading or unnecessary handling of awkwardly sized or shaped packaging. Only pertinent data requested by the user will be shown in the display. For those with chronic illnesses, or with conditions such as food allergies, the unit can prevent accidental selection of products containing potentially harmful ingredients. In this way, the device can offer significant support, and contribute to greater independence for members of these populations.

As previously shown, those who follow special diets will have an important new tool which will help them to make faster and more accurate selections at the supermarket. For many users the *Portable Information Unit* will save time, possibly money and inconvenience.

The Future Wave Portable Information Unit

Function

The *Portable Information Unit* is docked at the *Future Wave Oven* on its hanger when not in use. Figure 41 shows the unit being detached from its location on the control unit. Information may be downloaded to the control unit when it is plugged into its hanger. This is especially useful when it is being used for home inventory record keeping. After a trip to the supermarket, a record of all of items purchased may be downloaded to the control unit, where this list will be added to a comprehensive inventory already stored in the system's memory. Subsequent use of these items will cause them to be deducted automatically from standing inventory. In this way a shopping list may be generated for the next



Figure 41. *Portable Information Unit Detached*

As figure 42 shows, the user need simply orient the top of the *Portable Information Unit* at the package bar code, and press the right hand button to add the item to stored inventory. If the unit has been programmed to reject or give a warning about a specific ingredient, it will exhibit this alert in its display.

The following is an example of the type of information that might be shown after scanning a package. A particular warning cautions that the product contains milk and 600 mg of sodium, two ingredients which the user may need to avoid. The display will then instruct the user to press the button on the right again if he/she wishes to make the purchase anyway, or the left hand button to reject it. The grocery list for that particular errand would reappear as the default screen, until the next item is selected and scanned. Each item selected for purchase will be removed from the grocery list and stored in the unit's inventory. If the user accidentally adds an item to the inventory, or decides not to purchase something after scanning, it may be rescanned using the left (delete) button, and removed from the inventory. Finally, by pressing the right button twice consecutively, the user may, at any time, bring up a dollar total for all items selected up to that moment. This feature will be helpful for those on a budget or with a cash limit for each shopping trip.

The *Portable Information Unit* will also speed the checkout process if the store is equipped for this type of automatic checkout. The user will simply need to hand the *Portable Information Unit* to the cashier and the unit will be plugged into a terminal at the cash register where purchase data will be downloaded. This would save checkout time because the items would not need to be rescanned by the clerk. Use of this feature would, of course, depend on the store's implementation of this type of system. As discussed in "Section V," various types of checkout systems have been tried in supermarkets, with the



Figure 42. Scanning Operation of *Portable Information Unit*

store supplying the scanner to the customer. Although this feature would increase the serviceability of the *Portable Information Unit*, it is not one of its primary functions. It was originally conceived to assist the user in the selection process described in the preceding paragraphs and in home inventory management. Thus, it could perform these functions totally independently of such specialized supermarket checkout systems.

Form

The *Portable Information Unit* is 5 inches long, 3 inches wide at its very top and 1.5 inches wide at its bottom. It is small enough to fit in a shirt or trouser pocket, or, certainly, any handbag or briefcase. Its tapered width will be comfortable for users of widely varying levels of adroitness and strength, as well as those within a wide range of palm size. By grasping it slightly higher or lower along its length, various hand sizes are accommodated. Its two large control buttons will still be easy to reach with the thumb for one handed operation. Its symmetrical design adapts easily to operation by both left handed and right handed users. Its convex side fits comfortably in the palm of the hand and provides a balanced and secure grip. The scanning operation demonstrated in Figure 42 is very easy to perform because of the manageable form of the unit. The user can hold the item in one hand, orienting the bar code in front of the unit's top surface. With the unit in the other hand, concave side up, the user can view information on the screen while simultaneously using the control buttons. Thus, it is a one step operation unless a warning or restriction is viewed in the display. Then, with one or two more decisions by the user, the operation is complete.

Figure 43 shows the concave side of the *Portable Information Unit*. This surface conforms to the curve of the cylindrical control unit, furnishing for it a flush mounting on the hanger, which also follows the curve. This surface also provides a more comfortable, less bulky contour when placed in a pocket, concave side against the body. Aesthetically, it balances the opposite, convex surface of the unit in a gratifying counterpoint.

The shape of the unit is repeated in its display window, which is 2 inches wide at the top, 1.5 inches wide at the bottom, and 2.25 inches long. It is inset approximately .375 inches from the surface. This design element is functional in a number of ways. First, it protects the display from being scratched or damaged; second, it aids in privacy of viewing and shields it from annoying reflections; third, it accommodates the female terminal connection (at the very top of the unit) when coupled to the male terminal on the oven's hanger; and fourth, it once again protects the display when mounted on the oven.



Figure 43. *Portable Information Unit*

When mounted on the front of the control unit, the *Portable Information Unit* provides a secondary focal point to the system interface, the main focus being the oven's touch screen window. Its smaller form repeats and continues the taper of the touch screen window, drawing the eye from top to bottom of the control unit. When detached, its hanger is configured to the exact (two dimensional) size and shape of the *Portable Information Unit*; therefore the integrity of the composition is maintained even when the unit is removed (Figure 44). Thus one does not get the impression that something is missing as one would if the hanger were a simple open terminal connection or empty cradle-device. The blunted "V" shape, derived from the control unit's touch screen window delineates the system interface. It is repeated in the shape of the *Portable Information Unit*, its display window and its hanger.



Figure 44. *Portable Information Unit and Hanger*

Therefore, the *Portable Information Unit* will offer to the user an up-to-date resource for expediting the food acquisition process. The unit's slender, lightweight, organically molded form is compatible with easy portability. Its capacity for harvesting, processing, and delivering information, provides a nearly effortless context in which to plan and gather the makings of quick, wholesome meals.

Scenarios for Use

The *Future Wave* system can assist with food preparation tasks in a variety of diverse situations. The following pages will demonstrate some common scenarios where using the system can be of great benefit. Life-style, diet, food preferences, and nutritional requirements will be unique to the particular user; therefore, it would be impossible to list every distinct situation in which the *Future Wave* system may be used. However, some common examples will be useful to clarify how the system might operate to improve the food preparation process.

One feature that will be helpful to all users is the system's ability to monitor daily nutritional needs. Diet plays a very large role in health maintenance, and more and more people without chronic health problems make a conscious effort to eat foods low in fat. These people may also be concerned with other ingredients and additives contained in their meals, as well as the number of calories. The *Future Wave* system can be very useful in reporting the contents and nutritional value of a daily meal. If the meal is a prepared, microwaveable dinner, the user can easily glean pertinent information from packaging, such as calories, fat content and sodium content. In the case of "speed scratch" ingredients such as sauces, mixes, dressings and packaged vegetables, the device can dispense information in a "per serving" format. The user must simply

use the touch screen window and press the “nutritional information” button after scanning the package’s bar code. This will prompt the system to display another screen with a control panel specifically related to nutritional information. The system will ask for selection among such options as calories, cholesterol, vitamins, etc. If for example, the concern is fat and cholesterol content, the system might be programmed to display this information each time an item is prepared or scanned by the *Future Wave* system. This would eliminate the necessity for manual requests for this information before every meal preparation. An example of a message of this type would be: “The item contains 350 calories, with 60 calories from fat. It also contains 25 mg of cholesterol. This is above your requested daily allowance for cholesterol in one meal. Do you wish to ignore this message and continue preparing?” The user may further personalize the system by programming in restrictions and limits. The system will then automatically inform the user that a certain limit has been exceeded in cholesterol intake, for example, and then give the user the option of continuing with preparation or choosing to terminate.

For the user who has a chronic illness or condition, strict adherence to a diet may be necessary. The *Future Wave* system can assist this type of user in selecting foods appropriate to the special diet. “Section III” contained a discussion of some conditions requiring special diets, such as hypertension and diabetes. An example of how the system can advise such users was one of the six possible scenarios given as examples in the exhibition display of the *Future Wave* system. The sample display window read, “Warning: The item contains sulfites,” which was previously entered as a restriction. “Do you wish to view a complete list of ingredients for this item?” In this scenario the display window automatically warns the user of the presence of the allergen. This type of warning will be especially useful when selecting groceries at the supermarket. In

the same way that the oven's touch screen display alerts the user, the *Portable Information Unit* may be programmed via the oven's control panel to recognize and convey the information. Scanning an item during grocery selection will prompt an automatic warning of the presence of the unwanted ingredient. This would save the time and inconvenience of reading ingredient lists on every package, and virtually eliminate the possibility of error.

The *Future Wave* system can also provide a reliable method of measurement for daily intake of specific nutrients. This can be especially useful to pregnant women who have specific nutritional requirements. This scenario was also one of the six examples given in the exhibition display. The display window read, "Message: The item contains 6 grams of protein, 200 calories, and 7 grams of iron. This meal represents 10% of your daily protein requirement, and 23% of your daily recommended iron requirement. If this is your first meal, 54 more grams of protein and 1300 more calories are recommended."

The *Future Wave* system may be adapted to meet the separate needs of several members of the same household. If dietary restrictions apply to each of several users, the system may be programmed to recognize personal identification numbers. Entry of the PIN will then be required before the system will operate. This feature is necessary as a system check, particularly when serious health issues are involved. Operating within the guidelines of another user's dietary guidelines, the system could not give appropriate information. Of course, if household members have no dietary restrictions, the system need not be programmed to operate in this manner.

The *Future Wave* system will also assist the user in the actual cooking process. As discussed earlier in this section, certain packaged foods and meals would have cooking instructions encoded in their bar codes. These instructions

would be processed by the control unit and then oven settings would automatically be made. This would automate the whole meal preparation process for some of the less complex tasks such as cooking a frozen microwave dinner or components of a more complex meal. The system can serve in other important areas connected with the cooking process, as for example, that of food safety. Another scenario that was provided as an example in the exhibition stated, "Warning: The internal temperature of the meat being prepared has not reached 160 degrees F. The hazard of E.coli poisoning has not been eliminated. Please continue cooking for 10 more minutes at the same settings." In this example, whether or not the oven settings were made manually or automatically via the scanning system, the specific parameters required to eliminate this hazard may not have been considered. Therefore, these specifications may be programmed into the system, and temperature sensors will send data back to the control unit measuring the internal temperature of the meat at the end of the cooking cycle. If the requirements are not met, the control unit will inform the user and list appropriate settings to be entered manually by the user in order to complete the cooking process. In this way the unit may be programmed to perform specific system checks during the cooking cycle.

Another example given in the exhibition was one of home inventory management. The *Portable Information Unit* plays a very large role in this operation. In the preceding discussion of the *Portable Information Unit*, this function was described. When the unit is returned to its hanger on the oven's control unit, a screen will appear on the oven's display asking the user if he/she wishes to download the purchases to the system's stored home inventory. Once this data is downloaded, the inventory is automatically updated. When the unit is detached in preparation for the next shopping expedition, the system will ask if the user wishes a grocery list. Unless manually edited, this list will consist of

items automatically deleted from the system's record when they were scanned prior to preparation. In this case the message displayed might read, "Your current list was last updated on March 11. Do you wish to view the list before today's grocery list is sent to the *Portable Information Unit*?" or "Do you wish to view the list before placing your order to your electronic account?"

These scenarios demonstrate how the *Future Wave Oven* and its interrelated functions of cooking, data retrieval, and data processing, work within the confines of the kitchen to make food preparation an easier, safer and more enlightened process. They also provide some examples of how these functions leave the confines of the kitchen within the hardware of the *Portable Information Unit* and operate outside the home to make tasks such as food selection, home inventory management, and checkout more accurate and speedy. Finally, the individual pieces of system hardware have been orchestrated to work in unison to provide very individualized and personalized solutions to some common problems connected with the tasks of food selection and preparation.

VII. CONCLUSIONS

In retrospect, the germ of the idea for a novel kind of food preparation system originated during the execution of everyday chores; waiting in the grocery checkout line, putting together a hasty meal, and driving in Friday night traffic to pick up takeout. At first, plans unfolded tentatively, but once the main components were fitted together, the challenge to design a device which was practical, workable, and graceful in form became a firm commitment.

After this decision, research opportunities came in a flood; on the internet, from bookstores and library shelves, from manufacturers and research laboratories, and from publishers of technical journals. The task became one of sifting through all of these resources to find the most innovative yet practical technologies for implementation within the system.

At an early point, the project became too ambitious, and the plan to include a storage and/or refrigeration component had to be abandoned. At that point, the design proposal became more compact and balanced. The three components meshed more smoothly, and the concept of function grew more taut and refined.

Having definitively selected the integrants of the system, the next step was to seek out the best of each technological participant, those which would fit comfortably into an organic whole. Automatic identification systems with bar codes and diverse types of scanners have proved to be of such efficiency with respect to time, data access, and disposition of manpower, that improvements are constantly being made, and new uses are being found for them. Upgraded technologies are also plentiful and available in the microwave oven field of

research.

It was possible, therefore, to select a basic trio of components which would interact with delicacy and thrift. It was also possible to include in the proposal a list of optional elaborations upon the essential theme (It seemed wise to keep the inauguration of the system as straightforward as possible).

The appeal of such a system would, of course, not only be in its efficiency of function, but in its elegance of form. The intent was for form to flow naturally from function, to explain it, and to interpret it. The shape was an explicit departure from the dogmatic and traditional shapes associated with appliance configuration. There was an effort to conserve the purity of the form's correlation with function, and to avoid any hint of theatricality.

At the last, the writing of this proposal clarified both its origins and its goals. It helped in the synthesis of research, and brought order to a multitude of subtopics which had been articulated less than clearly. It supported the reasonableness of the design, and gave hope that it would actually be used some day soon.

This project concluded with the affirmation of a number of assumptions which had been made during its initial stages. The first assumption was that household management in the area of food preparation should be simplified because of the increasing encroachment of competing obligations. The second was that technology exists to make this streamlining possible. Thirdly, it was postulated that a system could be designed which would not seem too complex, futuristic and threatening to the consumer. This would be done by basing the system on a familiar appliance. Fourthly, this appliance could be upgraded and surrounded by auxiliary components which the user would be able to operate by means of a simple interface. Fifth, the system could help to improve the quality of life by saving the precious time of the able-bodied and conserving some considerable

measure of independence for the old and physically challenged. Sixth, it would provide information about nutrition, and it would save household resources by keeping track of purchases and curtailing wasteful trips to the supermarket. The seventh assumption was that, because of its improved functions, the meals cooked in the appliance would be appetizing, and the time saved by the device could be used to savor them. Last, but certainly not least, the designer was hopeful that the exterior form would be pleasing, and that, rather than seeming to intrude, it would contribute some aesthetic consonance to the assemblage of kitchen appliances.

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