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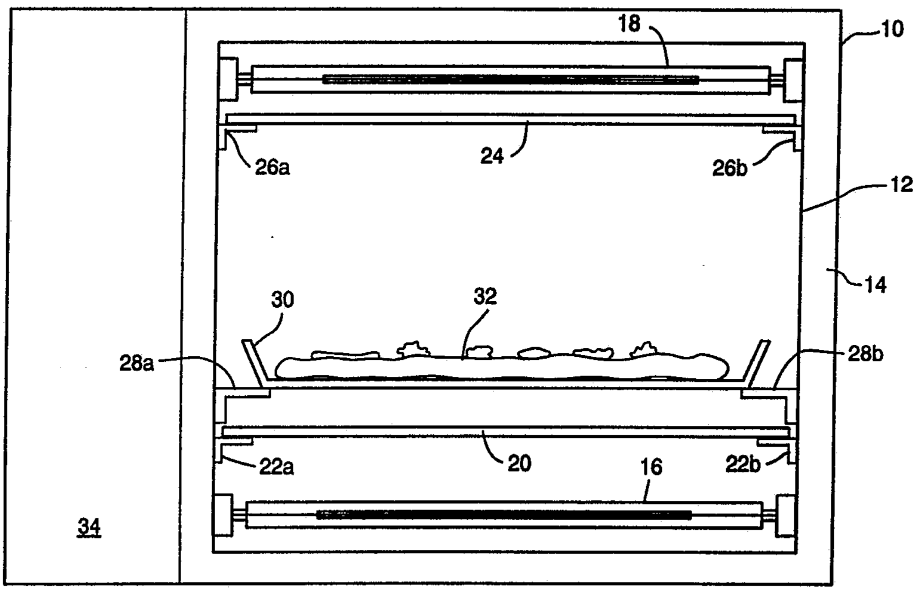


(57) Abstract

An oven using one or more quartz halogen tungsten lamps or quartz arc bulbs (16, 18) capable of producing 4KW of radiant energy of which a significant portion is in the visible light range of the electromagnetic spectrum and substantially forty to fifty percent of the radiation is in the visible and near visible range impinges visible, near visible and infrared radiation directly onto a food item (32). Radiation sources (16, 18) can be positioned above and below the food item (32) and the inner walls (12) of the oven are preferably highly reflective to reflect light energy onto the food (32). The intensity of the radiation light source (16, 18) is automatically controllable and can be varied throughout the cooking cycle.

COOKING APPARATUS USING ELECTRON AND MOLECULAR EXCITATION MODE

Cross References to Related Applications

This application is a continuation-in-part of U.S. Patent application number 195,967 filed on May 19, 1988, (now abandoned), a continuation-in-part of U.S. Patent application number 664,494 filed on March 5, 1991, and a continuation-in-part of U.S. Patent application number 07/350,024 filed on May 12, 1989, which are incorporated herein by reference.

Field of the Invention

This invention relates to the field of cooking apparatuses. More particularly, this invention relates to baking and cooking processes that are substantially faster than such processes in conventional ovens, and offer sensory improvements in quality for many foodstuffs.

Background of the Invention

Ovens for cooking and baking food have been known and used for thousands of years. Basically, oven types can be categorized in four different forms. The simplest and probably the oldest cooking resulted when man put some vegetable or grain products on a hot rock next to a fire, and cooked them essentially by the heat transfer method of conduction. With a little more refinement, an enclosure surrounding the heating element entrapped the heated air giving rise to cooking by convective heat transfer. This was the prototype for the modern gas or electric oven. In the past century, radiant energy from infrared radiation sources has been used to heat and cook foodstuffs directly. Within the past few decades, microwave radiation has proved useful in allowing very short cooking times for many types of food.

There are subtle differences between cooking and baking. Cooking just requires the heating of the food. Baking of a product from a dough, such as bread, cake, crust, or pastry, requires not only heating of the product throughout but also a chemical reaction coupled with driving the water from the dough in a predetermined fashion to achieve the correct consistency of the final product and finally browning the outside. Following a recipe when baking is very important. An attempt to decrease the baking time in a conventional oven by increasing the temperature results in a damaged or destroyed product.

In general, there are problems when one wants to cook or bake foodstuffs with high-quality results in the shortest times. Conduction and convection provide the necessary quality, but both are inherently slow energy transfer methods. Infrared radiation can provide faster heating rates, but it only heats the surface area of most foodstuffs, leaving the internal heat energy to be transferred by much slower conduction. Microwave radiation heats the foodstuff very quickly in depth, but during baking the loss of water near the surface stops the heating process before any satisfactory browning occurs. Consequently, microwave ovens cannot produce quality baked foodstuffs, such as bread.

Summary of the Invention

An oven for the high-speed, high-quality cooking and baking of food items includes a means for impinging high-intensity visible, near-visible, and infrared radiations onto a food item, thereby cooking the item at accelerated rates comparable to microwave cooking, while maintaining the browning of infrared cooking and the quality of conduction-convection cooking.

It has generally been believed that radiation with wavelengths much shorter than 1.35 μm is not of much value in cooking or baking processes. This presupposition is based on the fact that water is the major constituent of most foodstuffs and water is essentially transparent for wavelengths of electromagnetic radiation less than about 1.35 μm. This region of low energy absorption in water includes the visible (.39 to .77 μm) and the short infrared (.77 to 1.35 μm) which we term "near-visible". The absorption characteristic of water in the visible and near-visible regions of the spectrum is illustrated in the graph of Figure 1 using data compiled from the Handbook of Optics. Because of the low absorption, radiation at these wavelengths provides very poor energy transfer to the water, especially in the visible range where less than one percent of the radiant power is converted to heat in a one centimeter depth of water. For this reason, one of ordinary skill in the art would be predisposed to cook with the longer infrared wavelengths to heat the water in various foods.

Accordingly, another mode of cooking must be utilized in the present invention. The foodstuff molecules themselves have very definite bands of absorption in both the visible and near-visible regions. In the visible region this absorption shows up as food color. For example, tomatoes absorb all of the blue and green components of the white light that illuminates them, and they reflect the red portion back to the eye. Hence we see a "red" tomato. This color absorption is due to the excitation of specific electrons that make up the molecules in a particular foodstuff, and it is this absorption that makes it possible to use intense visible and near-visible radiation to heat the foodstuff molecules directly. If one provides a sufficiently intense source of visible and near-visible radiation in conjunction with the longer infrared radiation, a novel and very effective cooking apparatus results. The low absorption of visible and near-visible radiation allows the energy to penetrate the foodstuff and heat it deeply like microwave energy. By contrast the longer infrared radiation does not penetrate very deeply and acts as a very effective browning agent. By combining these sources of radiation into a single cooking process it is possible to produce a very rapid and highly efficient method of cooking and baking a wide variety of foodstuffs.

As an illustration of the effectiveness of this combined direct heating process one can consider a simple example. A cup (8 oz.) of pure water in a transparent container can be heated to boiling in a time of 35 seconds in our oven using 8 KW of power. This can be compared to the 210 seconds that it takes to heat the same cup of water in a standard 600 watt microwave oven. Since water is transparent to the visible and near-visible radiations, virtually all of the heating is produced by the infrared longer than 1.35 μm. If that cup of water is replaced by an identical cup of water, but with a teaspoon of instant coffee added to color it, the boiling time is reduced to 25 seconds in our oven, while the microwave oven still requires 210 seconds. The coffee molecules themselves are directly absorbing the impinging energy, and the visible and near-visible radiations are contributing to the heat rise.

Radiant cooking methods can be classified by the manner in which the radiation interacts with the foodstuff molecules. This interaction is illustrated for various wavelengths in Figure 2. For example, starting with the longest wavelengths for cooking, the microwave region, most of the heating occurs because of the coupling of radiant energy into the bipolar water molecule causing it to rotate and thereby absorb energy to produce heat. Decreasing the wavelength to the infrared regime, we find that the molecules and their component atoms resonantly absorb the energy in well-defined excitation bands. This is mainly a vibrational energy absorption process. In the near-visible and visible regions of the spectrum, the principal absorption mechanism is excitation of the electrons that couple the atoms to form the molecules. These interactions are easily discerned in the visible band of the spectra, where we identify them as "color" absorptions. Finally, in the ultraviolet, the wavelength is short enough, and the energy of the radiation is sufficient to actually remove the electrons from their component atoms, thereby creating ionized states. This short wavelength ultraviolet, while it finds uses in sterilization techniques, probably has little use in foodstuff heating, because it promotes chemical reactions and destroys food molecules.

Using intense visible, near-visible, and infrared radiation to cook food has a number of significant advantages. First of all, the cooking process is very fast. Bakery products, like pizza crust for example, can be baked 5 to 10 times faster than ovens that rely on conventional convection and conduction processes only. Second, the quality of the cooking process is enhanced for many foodstuffs. For example, crusts become fully cooked with crispy exteriors and moist, chewy interiors. Vegetables are cooked so fast that they are virtually steamed in their own water vapor, leaving them hot, but with very little loss of any of their nutritive values. Third, the process is very energy efficient. Because the oven has reflective inner walls, most of the energy produced by the sources is used to cook the food rather than heat the oven. A pizza can be fully baked for about $.01 of electrical energy.

Ordinarily, in the preferred oven configuration, the visible, near-visible and infrared impinging means is one or more quartz-halogen tungsten lamps, or equivalent means such as quartz arc lamps. Typical quartz-halogen lamps of this type, operating at 3000 degrees Kelvin, convert electrical energy into black body radiation having a range of wavelengths from .4 μm to 4.5 μm with a peak intensity at .965 μm. Each lamp can generally provide from 1 to 2 KW of radiant energy with a significant portion of the energy in the visible light spectrum.

Typical configurations can use one to as many as ten lamps operated in unison, and larger ovens could use even more lamps. One or more of the radiation source lamps may be used in the cooking process as necessary. These radiation sources are ordinarily positioned above and below the food item. Certain applications may require that radiation sources surround the food item. The walls of the surrounding food chamber are preferably treated to be highly reflective to this radiation. The visible and infrared waves from the radiation sources impinge directly on the food item and are also reflected on this inner surface of the oven to strike the food item many times and from many angles. This reflecting action results in a greater uniformity of cooking, and since very little of the radiation is absorbed in the surrounding reflecting surface, almost all of the radiant energy is converted into heat upon and within the foodstuff. Hence, this process is a very efficient mode of transferring energy to the foodstuff for cooking, and operation is very economical.

For certain cooking applications, the food item may be placed on a radiant energy absorbing and heat conductive support platter. The platter can be selectively heated by means of the bottom set of lamps to increase its temperature to a point where it can aid the cooking process by conductive heating, if desired. The platter may be perforated in such a manner so as to facilitate the removal of internal water vapor and gases from the bottom of the foodstuff.

The intensity of the radiation from the lamps is controllable. Each lamp can be individually controlled or the lamps can be operated in unison to provide the desired cooking result. It is necessary that this control be performed quickly, because of the inherent speed of the cooking process. For certain food products, it is necessary that the intensity be varied throughout the cooking cycle. Such fast and variable intensity control is preferably managed through automatic means, such as computer or microprocessor circuits.

In general, this is a new mode of cooking. The potentialities of using this enhanced range of wavelengths for cooking and baking are just starting to be explored, and a whole new range of cooking techniques should result from the invention.

Brief Description of the Drawings

Figure 1 is a graph showing the absorption of water at various wavelengths of electromagnetic radiation.

Figure 2 is a schematic representation showing various modes of electromagnetic absorption.

Figure 3 shows a front cross section of a preferred embodiment of the present invention.

Figure 4 is a graph showing the depth of penetration of electromagnetic radiation into water versus wavelength.

Figure 5 is a graph showing cooking time versus diameter-squared of a pizza.

Figure 6 shows a side cross section of the preferred embodiment of the present invention.

Figure 7 is a graph showing the approximately inverse linear relationship between cooking power and cooking time.

Figure 8 is a graph showing the constant power-time product for baking a pizza in the oven of the preferred embodiment.

Detailed Description of the Preferred Embodiment

Fig. 3 is a front cross section of the preferred embodiment of the present invention. The oven in Fig. 3 includes an outer enclosure 10. The enclosure has an inner wall 12 coupled to the outer wall 10. Ordinarily, an insulating layer 14 is formed between the outer enclosure 10 and the inner wall 12. Because of the inherent speed of the cooking cycle, the insulating layer 14 may be a layer of air.

The present invention has been used to cook pizzas reasonably continuously for an hour in an oven with only air as an insulator. While the exterior of the oven did warm up, it never became too warm to touch comfortably. This is true because the interior walls of the oven are reflective so that most of the energy is used to cook the food, not heat the oven. Second, a fan is used to pull hot air out of the oven. Though some air is heated directly by the radiation, most of the air is heated by convection from the cooked food. In prior art convection ovens, hot air is forced onto a food product and acts to cook the food. Commercial pizzas are often cooked this way. Because the cooking times are so short with the present invention, the hot air is removed to prevent further cooking after the radiation source is turned off.

The energy for cooking is supplied by the lower radiation heating lamps 16 and the upper radiation heating lamps 18. These lamps are generally any of the quartz body, tungsten-halogen or quartz arc lamps commercially available, e.g., 1.5KW 208V quartz-halogen lamps. The oven according to the preferred embodiment utilizes ten such lamps and cooks with approximately 40% to 50% of the energy in the visible and near-visible light portion of the spectrum, which is significant. Quartz xenon-krypton arc lamps have been used as an alternate source in which 95% of the radiation is below 1 μm and good cooking results have been achieved with their shorter wavelengths.

There is no precise definition for the range of wavelengths for visible light because the perceptive ranges of each human eye is different. Scientific definitions typically encompass the range of 0.39 μm to 0.77 μm. An engineering shorthand for visible light specifies the range of 0.4 μm to 0.7 μm. The term near-visible has been coined for radiation that has wavelengths longer than the visible range, but less than the water absorption cut-off at 1.35 μm.

Figure 4 is a graph showing depth of penetration of electromagnetic radiation into water relative to the wavelength. Please note that the vertical scale is logarithmic. The depth of penetration for the visible light range is in excess of 100 cm (1 meter) which is substantially larger than any ordinary food product. Because food is mostly water, one would expect the shorter wavelength radiation of visible light to simply pass through food. In fact, it is the color absorption bands of most foods that absorb the radiation and convert the radiant energy into heat and the high penetration provides heating deep into the foodstuff. Alternately, the long infrared has a very small penetration (less than 2 mm) and this provides high surface temperatures and good browning characteristics.

The inner surface of the inner wall 12 is preferably a highly polished, poorly absorptive surface, so that it appears to be very reflective to the wide spectrum of wavelengths from the radiant lamps. Polished Aluminum and stainless steel have been successfully used for the inner wall 12. Plating the inner wall 12, such as with gold, increased the efficiency of the reflector for visible light by about 10% over the polished Aluminum or stainless steel walls.

The oven efficiently uses the generated radiant energy. Figure 5 shows a graph relating cooking time to diameter-squared of a pizza. The pizzas were all loaded with similar ingredients to approximately the same depth so that area (which is proportional to the diameter-squared) is proportional to volume. As expected, as the volume of pizza to be cooked increased, the cooking time also increased. This graph shows two surprising results. First, the graph is linear. In other words, the cooking time is directly proportional to volume (all pizzas were of the same height). This indicates that nearly all of the radiant energy goes into cooking the pizza. Second, the graph passes approximately through zero. In conventional ovens one would expect a displacement of the line up the vertical axis to account for inefficiencies in the cooking process.

Two radiation transparent plates 20 and 24 are used to isolate the cooking chamber from the radiant sources making the oven easier to clean as shown in Figure 3. These plates can be formed from such materials as quartz or a glass that transmits visible, non-visible and infrared radiations. The lower transparent plate 20 is supported by brackets 22a and 22b and is positioned above the lower lamps 16. The upper transparent plate 24 is supported by brackets 26a and 26b and is positioned below upper lamps 18.

Brackets 28a and 28b support platter 30. The platter 30 is positioned above the lower transparent plate 20 and below the upper glass plate 24. A food item 32 is positioned on platter 30 to be cooked. The control circuit 34, shown as a circuit block, controls the operation of lamps 16 and 18.

The platter 30 may formed of a material similar to the transparent plates 20 and 24 to allow even cooking over the surface of the food item 32. However, in some circumstances it may be desirable to crisp the bottom of the food item 32. As a particular example, when cooking a pizza, it is desirable that the crust be light and crispy, rather soggy and doughy. In such an application, the cooking platter 30 can be formed of a radiation absorbing, heat conducting material, such as black anodized aluminum. In this way, the lower lights 16 would rapidly heat the platter 30 to a high temperature in order to crisp and brown the bottom of the pizza. It may also be desirable to perforate the platter 30 in order to allow steam to escape from the cooking pizza dough. Platter 30 should touch the support brackets 28a and 28b over very limited areas, so that the heat delivered to platter 30 is not lost by conduction.

The lamps 16 and 18 produce very high intensity visible and infrared radiation. Prior art uses of radiant energy heat sources teach cooking using radiation in the infrared portion of the electromagnetic spectrum. For example, see Malick U.S. Patent 4,481,405 and Bassett U.S. Patent 4,486,639. Burkhart, in U.S. Patent 4,516,486, discloses a radiant energy cooker for the exclusive purpose of charring the surface of foods, particularly meats.

The use of high intensity visible radiation provides a very rapid method of high quality cooking and baking both alone or in combination with infrared radiation. The radiant energy from the lamps 16 and 18 radiates from each bulb in all directions. A portion of the energy radiates directly onto the food item 32. The remainder of the energy will be reflected off the surface of the preferably metal inner wall 12 and then strike the food item 32 for more efficient cooking.

It is possible to control the lights 16 and 18 independently with the control circuit 34. The control circuit 34, shown as a circuit block in Fig. 3, may include a microprocessor or a microcontroller and associated memory to store individual cooking recipes to control proper heating of the food product.

For example, in cooking a pizza, it may be desirable to run the upper lamps 18 at a reduced power level for a time. For a pizza having fresh vegetables, this would prevent the overcooking of the vegetables making them mushy. The lower lamps 16 might be operated at a higher power level to make the pizza crust light and crispy.

Figure 6 shows a side cross section of the preferred embodiment of the present invention. In the preferred embodiment, there are 5 lower lamps 16a through 16e and 5 upper lamps 18a though 18e. By appropriately selecting the lateral spacing between the lamps relative to the food, even cooking can be achieved over the entire surface. A door 40 is also shown.

Experimental results show that cooking with one 1.5KW lamp above and one below, i.e. impinging a maximum of 3KW of radiant energy onto a pizza, does not achieve the dramatic improvement in speed that is possible according to the present invention. The oven in the preferred embodiment includes 5 lamps above and 5 lamps below. This number provides for a maximum of 15KW of cooking energy.

Pizza has been successfully cooked using a modification of the present invention with more powerful bulbs using total power in the range of 4KW to approximately 20KW. There appears to be no reason preventing the power ranges in excess of 20KW. This is a significant advantage of the present invention. Cooking times can be reduced by increasing power. The only way to increase power in a conventional oven is to increase temperature which damages the food. In a microwave, severe federal restrictions prevent increasing the power that can be delivered to food because of the potential for leakage of the dangerous waves.

While cooking a pizza using total power in excess of about 4KW an approximately inverse linear relationship develops between time and cooking power. In other words, as the power delivered to the pizza is doubled, the time to cook a pizza is cut in half. This result is totally unexpected in view of conventional oven baking where increasing oven temperature to achieve a higher energy transfer rate results in a burnt product which may have an uncooked interior.

Figure 7 is a graph showing the relationship between cooking time and cooking power for baking four pizzas at 3.8, 6, 9 and 12KW of power. The raw pizzas were essentially identical. While the quality of a pizza is subjective, the four finished pizzas from this experiment were all of similar satisfying quality.

Figure 8 is a graph showing the power-time product versus power for baking a pizza in the oven of the preferred embodiment. Note that in the preferred oven the power-time product is constant and has a value of about 470KW-sec.

This cooking in the linear range of the power-time product appears to be a function of both the wavelength of radiation and the amount of power applied. Thus, the specific mechanical configuration of the oven in the preferred embodiment is not critical to the invention. Rather, it is the combination of the lamps that provide at least a significant portion of radiation in the visible light range in excess of 4KW (total radiant power) and impinging the radiation directly onto the food item of energy which provides the dramatic speed increase of the present invention.

For example, an oven having a reflective inner surface could operate according to the present invention with a single arc lamp capable of producing sufficient power in the desired frequency ranges. In certain circumstances it may be desirable in such a single source oven to place the food product, such as a pizza, on a highly thermally conductive platter with the lamp positioned above the food item. The amount of heating to the bottom of the pizza can be regulated by heating the platter and by adjusting the ratio of the size of the pizza to the size of the pan. In other words, the amount of exposed area of the pan would control the amount of energy absorbed by the pan used to heat the bottom of the pizza.

Microwave ovens cannot be used in cooking high quality freshly prepared pizza. The commercially available frozen pizzas for microwave ovens are precooked and then frozen. The pizza is merely heated to the proper serving temperature in the microwave oven, but the result is usually unsatisfactory. A higher quality pizza can be baked in a commercial grade conduction/convection oven. There, the pizza is placed directly on the hot floor of the oven to properly crisp the bottom of the crust (up to 900°F in a brick oven). Unfortunately, the ovens have various "hot" spots and require constant operator attention to avoid over or under cooking the pizza, i.e., consistency is a major problem. Such ovens cook a pizza in 5 to 20 minutes. Conveyorized infrared and hot air convection ovens can cook a pizza in 5 to 15 minutes, but have great difficulty in properly crisping the bottom of the pizza.

A pizza can be cooked using the present invention in as little as 30 to 45 seconds. This speed is very important in the commercial pizza market because it enables pizza to be produced in a manner that would qualify it as a true fast-food.

The energy efficiency of the present invention is illustrated by the fact that the energy cost to cook such a pizza is about $0.01. The majority of the radiant energy produced by the oven is utilized in cooking the pizza and after the cooking process is completed the energy is turned off. In contrast, conventional commercial pizza ovens must be preheated to desired cooking temperatures. Ordinarily, the oven in a pizza restaurant is left on all day, whether cooking a pizza or not, making the energy consumption significant.

Another way of considering this new mode of cooking, especially for pizza, is determining the amount of radiant energy necessary to cook a pizza, per unit time and mass. By impinging approximately 20 watts/gram of radiant energy in an oven of the preferred embodiment, a minimal nine inch cheese pizza can be cooked in about 30 seconds, and a combination pizza with extra large portions of toppings can be baked in around 50 seconds. A typical twelve inch pizza takes about 70 seconds. Because of the inverse dependence of power and cooking time, a nine inch pizza could be cooked in two minutes or less by impinging about 10 watts of radiant power/gram of ingredients from the oven of the preferred embodiment. The inventors believe that improving the reflective efficiency of the oven would reduce this cooking time. The inventors know of no other pizza oven capable of baking a quality pizza of this diameter in times of less than 5 minutes.

The oven of the present invention is not limited to cooking pizzas. Certain foods are cooked with more consistent and reliable results than with conventional techniques. For example, cooking vegetables, such as broccoli, so that they retain good texture is difficult using prior art techniques. Generally, such items are preferred al dente. The short cooking times of the present invention, about 20 seconds for broccoli, bring the product to serving temperature so rapidly that the vegetable maintains its crisp, firm texture.

Popcorn is another interesting food that can be prepared in the oven. If the popcorn kernels are completely surrounded with a water-filled shield, all of the long infrared can be removed leaving only the visible and near-visible wavelengths to heat the kernels. Even with all of the direct water-heating radiation removed the corn will pop in less than 20 seconds (3 or 4 times faster than hot air poppers). This is another example showing the efficacity of the visible and near-visible radiation for rapidly cooking food. It is interesting to note that when the corn pops, its very low absorbing white color automatically terminates the radiant heating, and the popcorn does not burn.

Even TV dinners can be defrosted and heated in the oven. Generally, heating times are one-half to one-third of the times required in microwave ovens, depending on the foodstuff. For example, darkly colored items like salisbury steaks heat very fast, while lightly colored items like mashed potatoes heat at a slower rate.

The oven of the present invention may also be used cooperatively with other cooking sources. For example, the oven of the present invention may include a microwave radiation source. Such an oven would be ideal for cooking a thick highly absorbing food item such as a roast beef. The microwave radiation would be used to cook the interior portions of the meat and the infrared and visible light radiation of the present invention would cook the outer portions. Further, the oven according to the present invention could be used with a convection oven or with both convection oven and microwave oven cooking sources.

The present invention was described in relation to a preferred embodiment. However, it will be apparent to one skilled in the art that one can change the parameters and still practice an invention within the spirit and scope of the present invention.

C L A I M S

What is claimed is:

1. An oven for cooking a food item in a food location comprising:

   a. means for generating at least 4KW of radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum; and

   b. means for directing the energy to impinge directly on the food location.

2. The oven according to claim 1 having an approximately inverse linear relationship between cooking time and cooking power.

3. The oven according to claim 1 wherein the portion of radiant energy in the visible light range is at least eight percent.

4. The oven according to claim 1 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

5. The oven according to claim 2 wherein the means for generating energy includes a plurality of sources of energy positioned spatially around the food.

6. The oven according to claim 5 wherein the food item has an upper surface and a lower surface, and further wherein the plurality of sources is comprised of a first group of sources positioned above the upper surface and a second group of sources positioned below the lower surface.

7. The oven according to claim 1 wherein the means for generating radiant energy is comprised of a quartz body tungsten halogen lamp.

8. The oven according to claim 6 further comprising means for differentially controlling each of the plurality of sources by time and by intensity.

9. The oven according to claim 1 wherein the means for generating radiant energy is comprised of a quartz arc lamp.

10. The oven according to claim 1 wherein at least 10 Watts of power is generated per gram of the food item.

11. An oven for cooking and baking food comprising:

a. a cooking chamber having reflective inner walls;

b. means for generating at least 4KW of radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum, the means for generating positioned inside the cooking chamber for impinging the radiant energy directly on the food; and

c. a container for holding the food while cooking which is transparent to the radiant energy.

12. The oven according to claim 11 having an approximately inverse linear relationship between cooking time and cooking power.

13. The oven according to claim 11 wherein the portion of radiant energy in the visible light range is at least eight percent.

14. The oven according to claim 11 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

15. The oven according to claim 11 wherein the means for generating radiant energy comprises a quartz body tungsten lamp.

16. The oven according to claim 11 wherein the means for generating radiant energy comprises a quartz arc lamp.

17. The oven according to claim 11 wherein at least 10 Watts of power is generated per gram of the food item.

18. A pizza oven for cooking and baking a pizza and forming a cooked pizza therefrom, the pizza having a crust formed of dough and toppings formed of any variety of foodstuffs comprising:

a. a cooking chamber having reflective inner walls;

b. a plurality of quartz body tungsten lamps for generating at least 4KW of radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum, the lamps having a first group of lamps inside the cooking chamber positioned above the pizza and a second group of lamps inside the cooking chamber positioned below the pizza for impinging the radiant energy directly onto the pizza;

c. a plurality of plates which are transparent to radiant energy positioned between the pizza and the lamps; and

d. means for controlling the first group of lamps and the second group of lamps differentially by time and intensity.

19. The oven according to claim 18 wherein the pizza is placed upon a radiation absorbing platter for absorbing radiation from the lower lamps for improved crisping of the pizza bottom.

20. The oven according to claim 18 having an approximately inverse linear relationship between cooking time and cooking power.

21. The oven according to claim 18 wherein the portion of radiant energy in the visible light range is at least eight percent.

22. The oven according to claim 18 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

23. The oven according to claim 18 wherein at least 10 Watts of power is generated per gram of the pizza.

24. A method for cooking and baking food comprising:

a. generating at least 4KW of radiant energy in the electromagnetic spectrum having a significant portion of the radiant energy in the visible light range; and

b. directing the energy to impinge directly on the food.

25. The method according to claim 24 having an approximately inverse linear relationship between cooking time and cooking temperature.

26. The method according to claim 24 wherein the portion of radiant energy in the visible light range is substantially eight percent.

27. The method according to claim 24 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

28. The method according to claim 24 wherein the step of generating further comprises spatially positioning a plurality of energy sources around the food.

29. The method according to claim 24 further comprising the step of controlling the sources differentially by time.

30. The method according to claim 24 further comprising the step of controlling the sources differentially by intensity.

31. The oven according to claim 24 wherein at least 10 Watts of power is generated per gram of the food.

32. A method for cooking and baking a pizza in a cooking chamber having reflective inner walls comprising the steps of:

a. generating at least 4KW of radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum by using a plurality of quartz body tungsten lamps, the lamps having a first group of lamps inside the cooking chamber positioned above the pizza and a second group of lamps inside the cooking chamber positioned below the pizza for impinging the radiant energy directly onto the pizza;

b. positioning a plurality of plates which are transparent to radiant energy between the pizza and the lamps; and

c. controlling the first group of lamps and the second group of lamps differentially by time and intensity.

33. The method according to claim 32 having an approximately inverse linear relationship between cooking time and cooking power.

34. The method according to claim 32 wherein the portion of radiant energy in the visible light range is at least eight percent.

35. The method according to claim 32 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

36. The method according to claim 32 wherein at least 10 Watts of power is generated per gram of the food.

37. An oven for baking a pizza, the oven having a food location for holding a pizza, the oven comprising:

a. means for generating at least 10 Watts of power per gram of pizza of radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum; and

b. means for directing the energy to impinge directly on the food location.

38. The oven according to claim 37 having an approximately inverse linear relationship between cooking time and cooking power.

39. The oven according to claim 38 wherein the portion of radiant energy in the visible light range is at least eight percent.

40. The oven according to claim 38 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

41. The oven according to claim 39 wherein the means for generating energy includes a plurality of sources of energy positioned spatially around the food.

42. The oven according to claim 41 wherein the food item has an upper surface and a lower surface, and further wherein the plurality of sources is comprised of a first group of sources positioned above the upper surface and a second group of sources positioned below the lower surface.

43. The oven according to claim 38 wherein the means for generating radiant energy is comprised of a quartz body tungsten halogen lamp.

44. The oven according to claim 43 further comprising means for differentially controlling each of the plurality of sources by time and by intensity.

45. The oven according to claim 37 wherein the means for generating radiant energy is comprised of a quartz arc lamp.

AMENDED CLAIMS

[received by the International Bureau on 3 November 1992 (03.11.92); original claims 1,11,18,24,31,32 and 37 amended; remaining claims unchanged (8 pages)]

What is claimed is:

1. An oven for cooking a food item in a food location comprising:

a. a food cooking chamber having reflective inner walls;

b. means for generating in excess of 4KW of radiant energy within said walls and having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum; and

c. means for directing the energy to impinge directly on the food location.

2. The oven according to claim 1 having an approximately inverse linear relationship between cooking time and cooking power.

3. The oven according to claim 1 wherein the portion of radiant energy in the visible light range is at least eight percent.

4. The oven according to claim 1 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

5. The oven according to claim 2 wherein the means for generating energy includes a plurality of sources of energy positioned spatially around the food.

6. The oven according to claim 5 wherein the food item has an upper surface and a lower surface, and further wherein the plurality of sources is comprised of a first group of sources positioned above the upper

surface and a second group of sources positioned below the lower surface.

7. The oven according to claim 1 wherein the means for generating radiant energy is comprised of a quartz body tungsten halogen lamp.

8. The oven according to claim 6 further comprising means for differentially controlling each of the plurality of sources by time and by intensity.

9. The oven according to claim 1 wherein the means for generating radiant energy is comprised of a quartz arc lamp.

10. The oven according to claim 1 wherein at least 10 Watts of power is generated per gram of the food item.

11. An oven for cooking and baking food comprising:

a. a food cooking chamber having reflective inner walls;

b. means for generating in excess of 4KW of radiant energy within said walls and having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum, the means for generating positioned inside the cooking chamber for impinging the radiant energy directly on the food; and

c. a container for holding the food while cooking which is transparent to the radiant energy.

12. The oven according to claim 11 having an approximately inverse linear relationship between cooking time and cooking power.

13. The oven according to claim 11 wherein the portion of radiant energy in the visible light range is at least eight percent.

14. The oven according to claim 11 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

15. The oven according to claim 11 wherein the means for generating radiant energy comprises a quartz body tungsten lamp.

16. The oven according to claim 11 wherein the means for generating radiant energy comprises a quartz arc lamp.

17. The oven according to claim 11 wherein at least 10 Watts of power is generated per gram of the food item.

18. A pizza oven for cooking and baking a pizza and forming a cooked pizza therefrom, the pizza having a crust formed of dough and toppings formed of any variety of foodstuffs comprising:

a. a pizza cooking chamber having reflective inner walls;

b. a plurality of quartz body tungsten lamps for generating in excess of 4KW of radiant energy within said walls having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum, the lamps having a first group of lamps inside the cooking chamber positioned above the pizza and a second group of lamps inside the cooking chamber positioned below the pizza for impinging the radiant energy directly onto the pizza;

c. a plurality of plates which are transparent to radiant energy positioned between the pizza and the lamps; and

d. means for controlling the first group of lamps and the second group of lamps differentially by time and intensity.

19. The oven according to claim 18 wherein the pizza is placed upon a radiation absorbing platter for absorbing radiation from the lower lamps for improved crisping of the pizza bottom.

20. The oven according to claim 18 having an approximately inverse linear relationship between cooking time and cooking power.

21. The oven according to claim 18 wherein the portion of radiant energy in the visible light range is at least eight percent.

22. The oven according to claim 18 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

23. The oven according to claim 18 wherein at least 10 Watts of power is generated per gram of the pizza.

24. A method for cooking and baking food comprising:

a. generating in excess of 4KW of radiant energy in the electromagnetic spectrum having a significant portion of the radiant energy in the visible light range; and

b. directing the energy to impinge directly on the food.

25. The method according to claim 24 having an approximately inverse linear relationship between cooking time and cooking temperature.

26. The method according to claim 24 wherein the portion of radiant energy in the visible light range is substantially eight percent.

27. The method according to claim 24 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

28. The method according to claim 24 wherein the step of generating further comprises spatially positioning a plurality of energy sources around the food.

29. The method according to claim 24 further comprising the step of controlling the sources differentially by time.

30. The method according to claim 24 further comprising the step of controlling the sources differentially by intensity.

31. The method according to claim 24 wherein at least 10 Watts of power is generated per gram of the food.

32. A method for cooking and baking a pizza in a cooking chamber having reflective inner walls comprising the steps of:

a. generating in excess of 4KW of radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum by using a plurality of quartz body tungsten lamps, the lamps having a first group of lamps inside the cooking chamber positioned above the pizza and a second group of lamps inside the cooking chamber positioned below the pizza for impinging the radiant energy directly onto the pizza;

b. positioning a plurality of plates which are transparent to radiant energy between the pizza and the lamps; and

c. controlling the first group of lamps and the second group of lamps differentially by time and intensity.

33. The method according to claim 32 having an approximately inverse linear relationship between cooking time and cooking power.

34. The method according to claim 32 wherein the portion of radiant energy in the visible light range is at least eight percent.

35. The method according to claim 32 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

36. The method according to claim 32 wherein at least 10 Watts of power is generated per gram of the food.

37. An oven for baking a pizza, the oven having a food location for holding a pizza, the oven comprising:

a. a pizza cooking chamber having reflective inner walls;

b. means for generating at least 10 Watts of power per gram of pizza of radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum; and

c. means for directing the energy to impinge directly on the food location.

38. The oven according to claim 37 having an approximately inverse linear relationship between cooking time and cooking power.

39. The oven according to claim 38 wherein the portion of radiant energy in the visible light range is at least eight percent.

40. The oven according to claim 38 wherein the portion of radiant energy in the visible and near visible light range is at least forty percent.

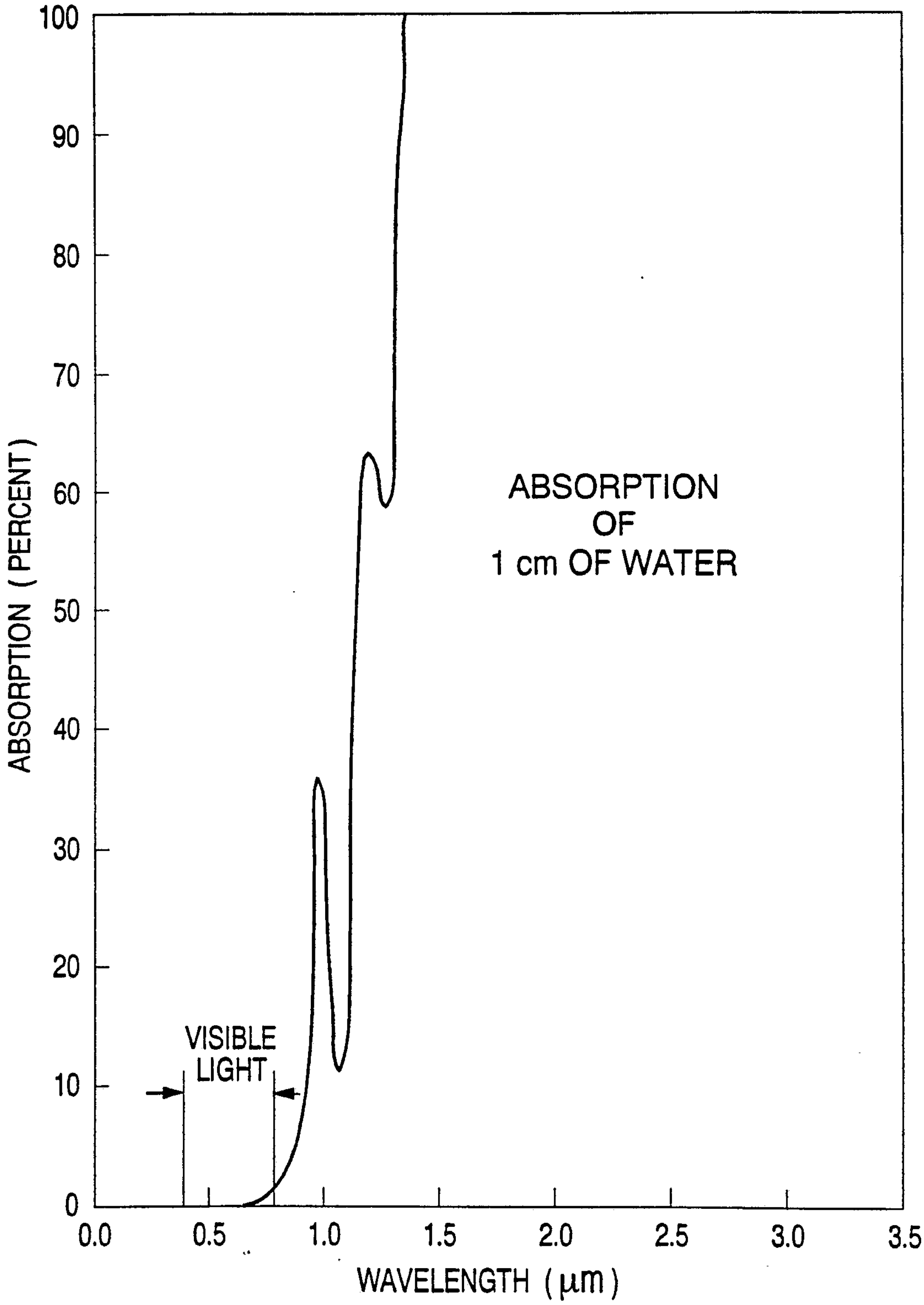
41. The oven according to claim 39 wherein the means for generating energy includes a plurality of sources of energy positioned spatially around the food.

42. The oven according to claim 41 wherein the food item has an upper surface and a lower surface, and further wherein the plurality of sources is comprised of a first group of sources positioned above the upper surface and a second group of sources positioned below the lower surface.

43. The oven according to claim 38 wherein the means for generating radiant energy is comprised of a quartz body tungsten halogen lamp.

44. The oven according to claim 43 further comprising means for differentially controlling each of the plurality of sources by time and by intensity.

45. The oven according to claim 37 wherein the means for generating radiant energy is comprised of a quartz arc lamp.



100
90
80
70
60
50
40
30
20
10
0
ABSORPTION (PERCENT)
ABSORPTION
OF
1 cm OF WATER
VISIBLE
LIGHT
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
WAVELENGTH (μm)

FIG. 1

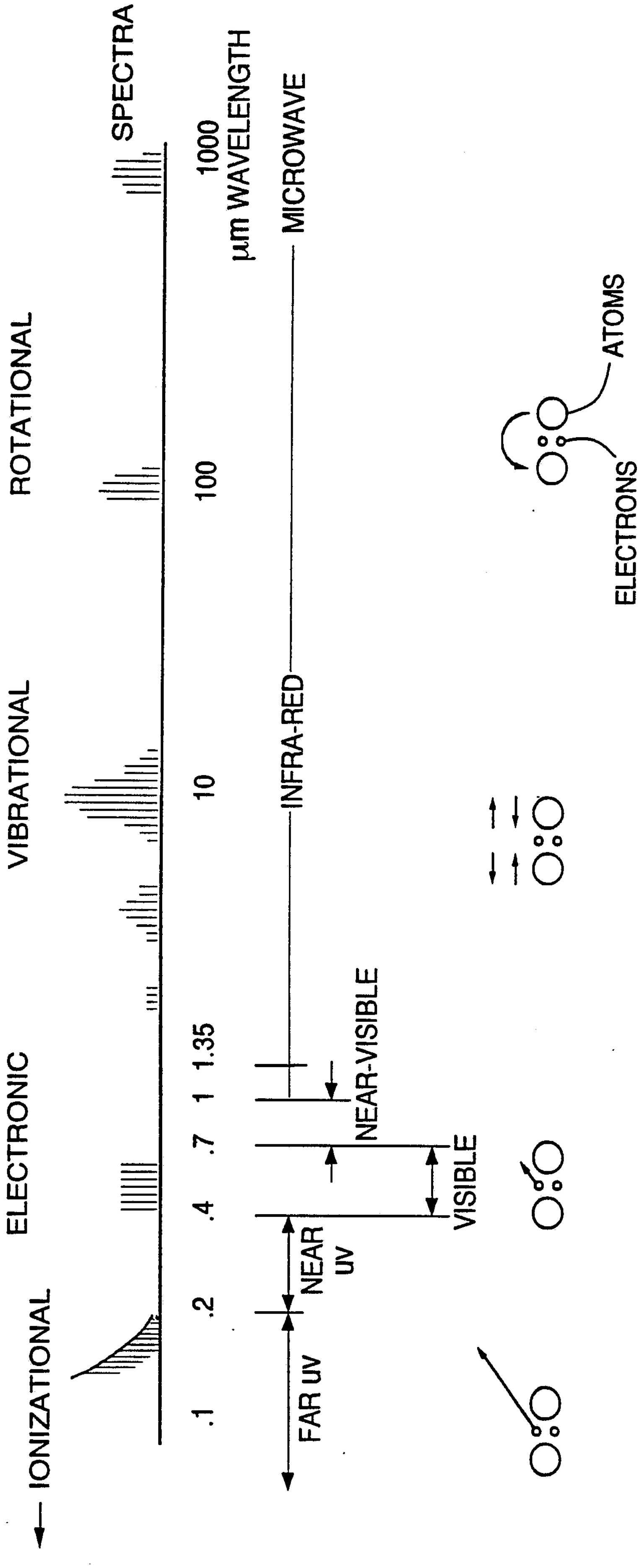

IONIZATIONAL
ELECTRONIC
VIBRATIONAL
ROTATIONAL
SPECTRA
.1
.2
.4
.7
1
1.35
10
100
1000
μm WAVELENGTH
FAR UV
NEAR UV
VISIBLE
NEAR-VISIBLE
INFRA-RED
MICROWAVE
ELECTRONS
ATOMS

FIG. 2

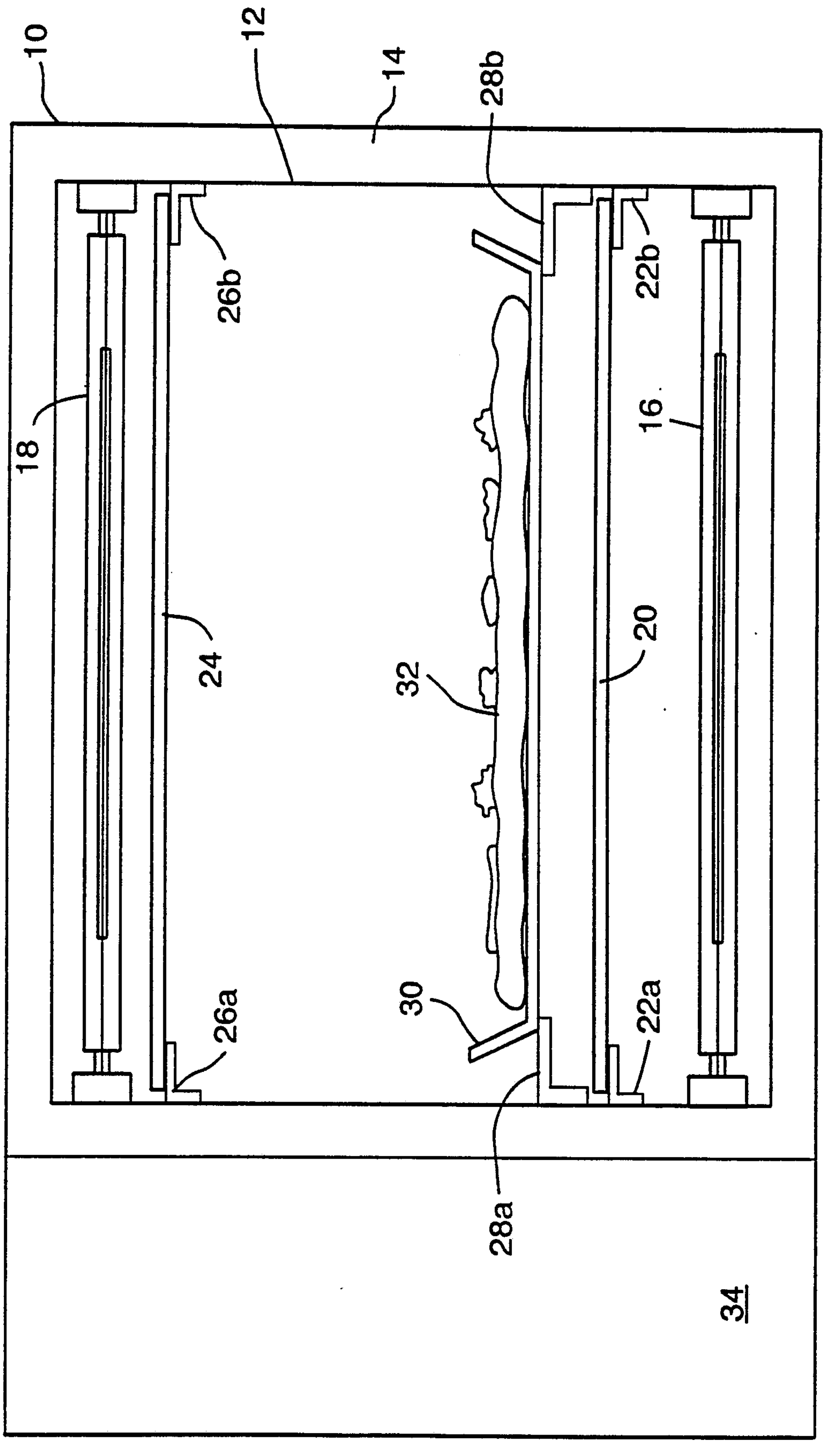


FIG. 3

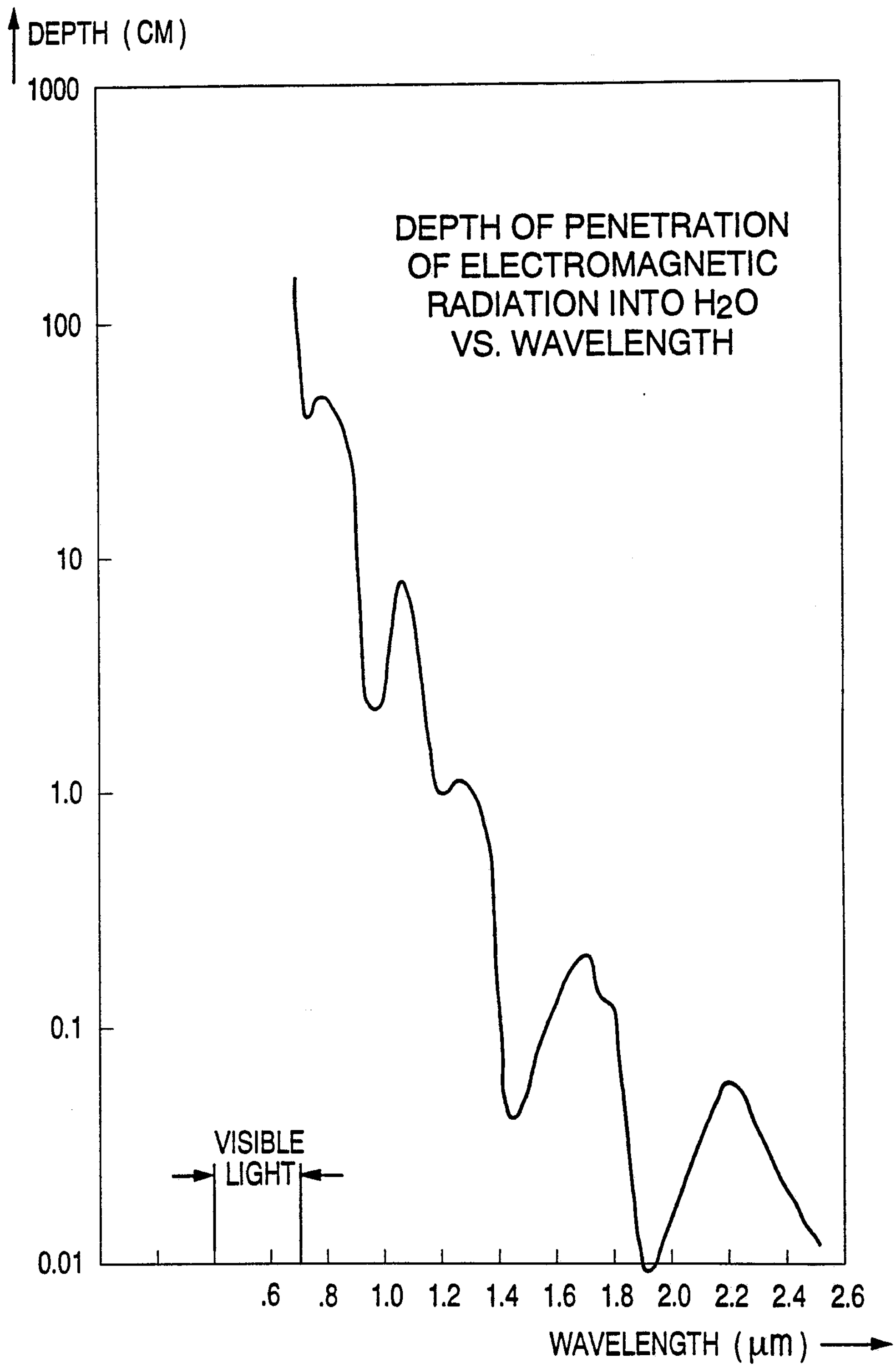
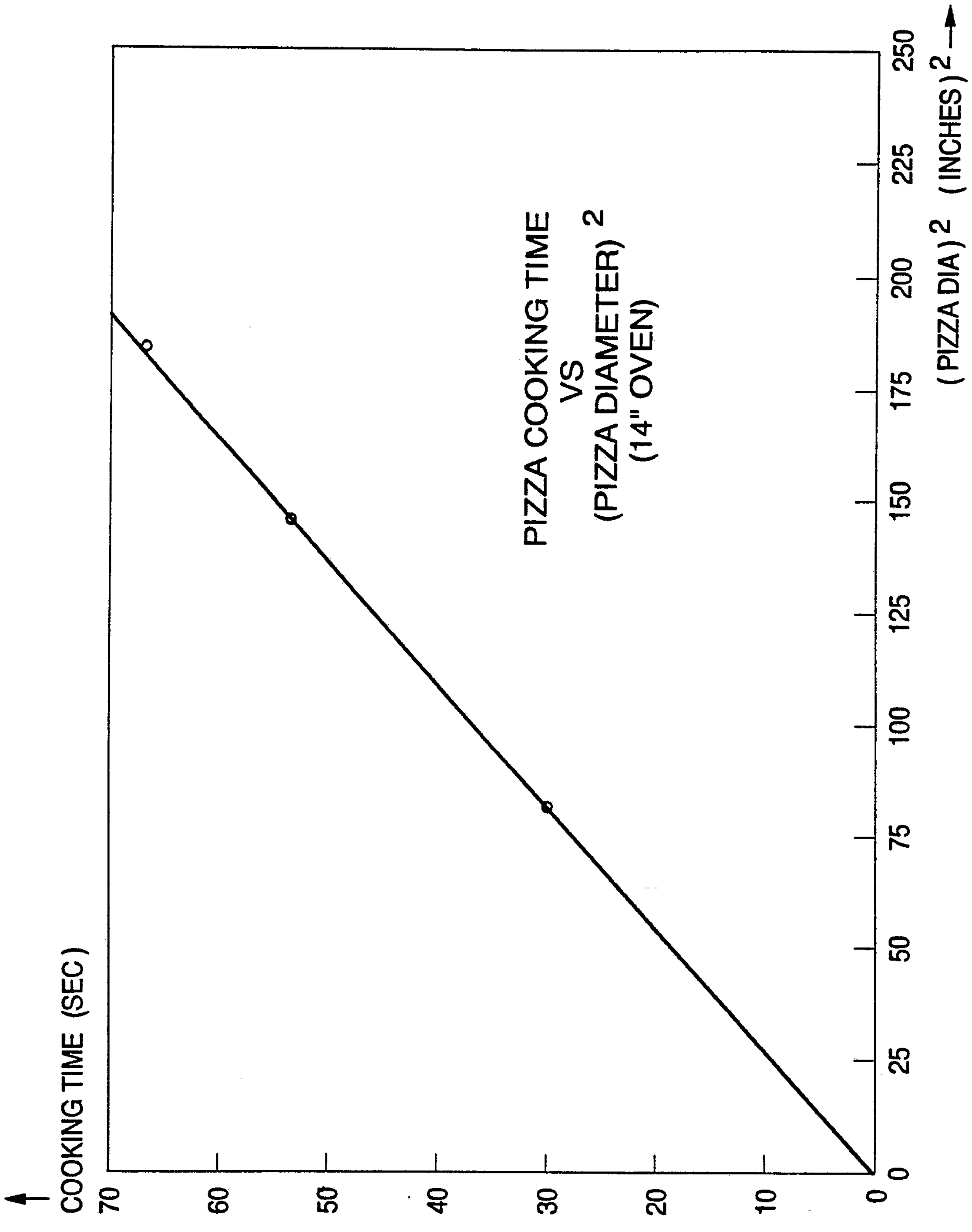

DEPTH (CM)
1000
100
10
1.0
0.1
0.01
DEPTH OF PENETRATION OF ELECTROMAGNETIC RADIATION INTO H2O VS. WAVELENGTH
VISIBLE LIGHT
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
WAVELENGTH (μm)

FIG. 4



PIZZA COOKING TIME
VS
(PIZZA DIAMETER) 2
(14" OVEN)
COOKING TIME (SEC)
70
60
50
40
30
20
10
0
0
25
50
75
100
125
150
175
200
225
250
(PIZZA DIA) 2 (INCHES) 2

FIG. 5

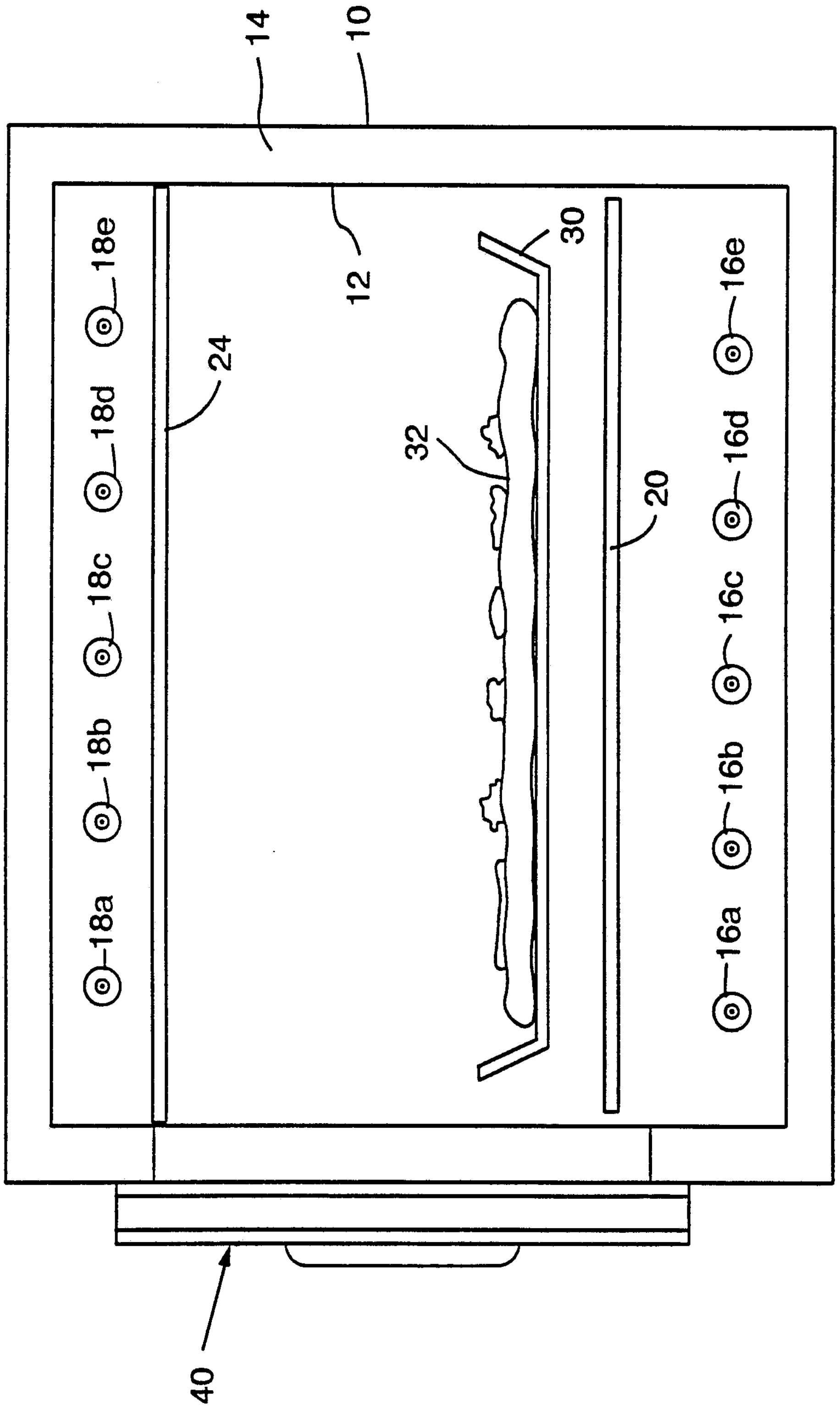


FIG. 6

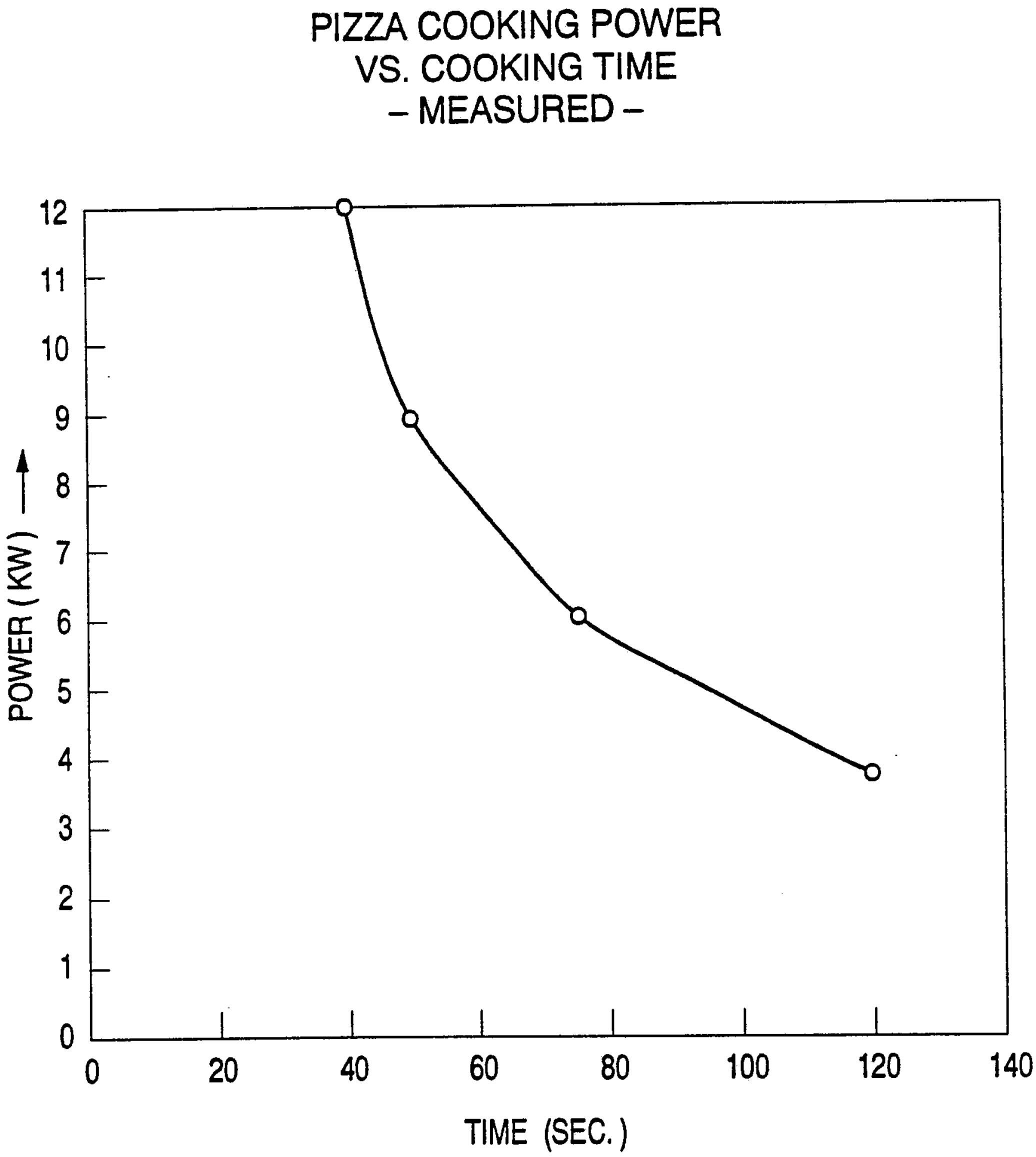

PIZZA COOKING POWER
VS. COOKING TIME
– MEASURED –
POWER (KW)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
20
40
60
80
100
120
140
TIME (SEC.)

FIG. 7

POWER TIME PRODUCT
VS
POWER
FOR PIZZA BAKING

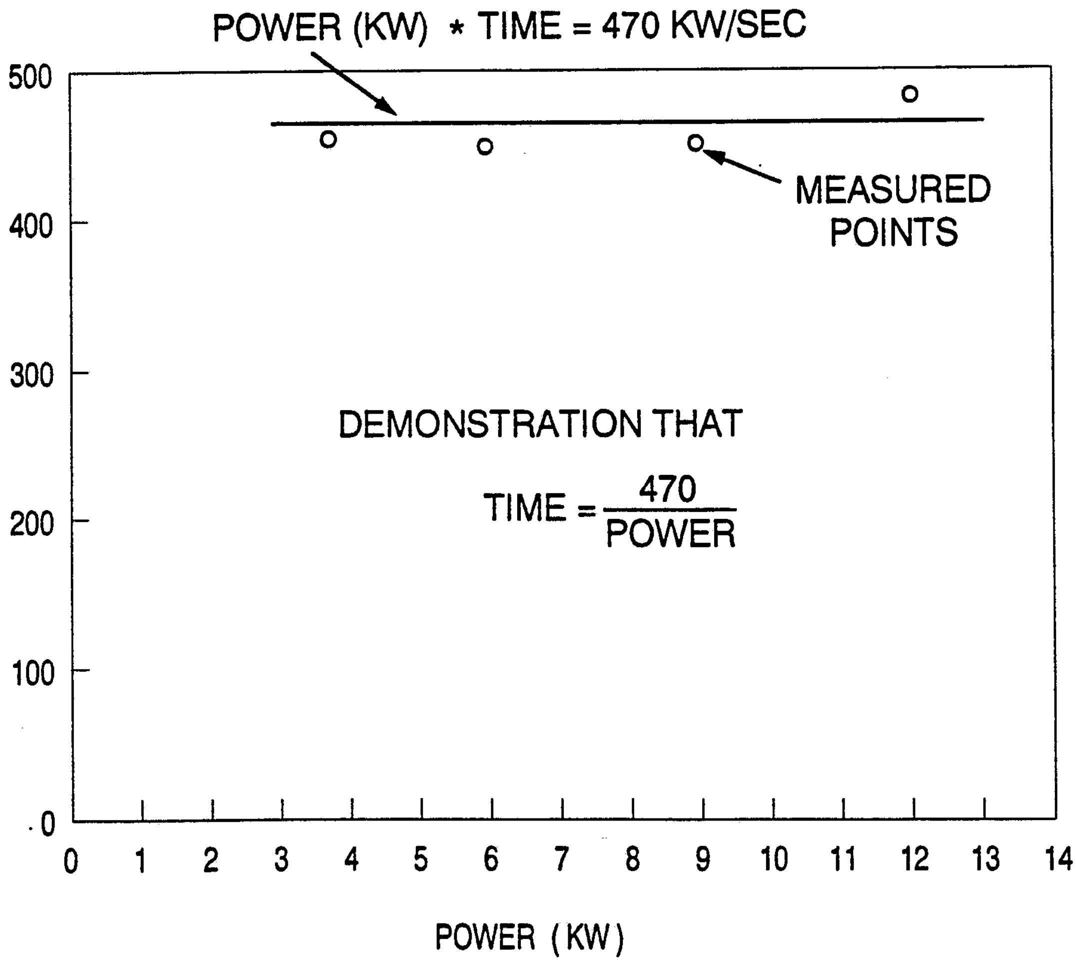


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/06266

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :F24C 7/04, F27D 11/02
US CL :219/411,405,392/416,424
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 219/388,392, 392/411

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US,A, 4,468,260 (HIRAMOTO) 28 AUGUST 1984 See column 3, lines 13-23.	1-7,9-17,37-43,45 8,18-23,24-36,44
Y	US,A, 4,101,759 (ANTHONY ET AL.) 18 JULY 1978 See column 8, lines 53-59	8,18-23,29,30,32-36,44
Y	US,A, 4,276,465 (FLAVIO) 30 JUNE 1981 See column 2, lines 38-49	18-36
A	US,A, 4,960,977 (ALDEN) 02 OCTOBER 1990 See entire document	1-45
A	US,A, 4,164,643 (PERRT ET AL) 14 AUGUST 1979 See entire document	1-45
A	US,A, 3,836,751 (ANDERSON) 17 SEPTEMBER 1974 See figures	1-45

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 AUGUST 1992	08 OCT 1992
Name and mailing address of the ISA/ Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer TERESA J. WALBERG Telephone No. (703) 308-1327