

[54] **COMPOSITE MICROWAVE ENERGY
PERTURBATING DEVICE**[75] Inventors: **Larry D. Gades; Lawrence C.
Brandberg; Roger A. Gorman**, all of
Minneapolis, Minn.[73] Assignee: **The Pillsbury Company**,
Minneapolis, Minn.[22] Filed: **Feb. 1, 1973**[21] Appl. No.: **328,585**[52] U.S. Cl. **219/10.55**[51] Int. Cl. **H05b 9/06**[58] Field of Search **219/10.55**[56] **References Cited**
UNITED STATES PATENTS

3,490,580 1/1970 Brumfield et al. 219/10.55

*Primary Examiner—J. V. Truhe**Assistant Examiner—Hugh D. Jaeger**Attorney, Agent, or Firm—James V. Hermon; Michael
D. Ellwein; Ronald E. Lund*[57] **ABSTRACT**

For the purpose of concentrating microwave energy to a central point or other desired location in a microwave oven, a composite signal perturbing device is placed in the oven. It consists of a sheet of a low loss dielectrical material together with a layer of microwave reflecting material. The device is placed on the floor of the oven and on the opposite side of the product heated from the source of microwave energy. The low loss dielectric consists, for example, of a flat sheet of dielectric material having two sheets of aluminum foil imbedded therein as concentric rings positioned in a plane parallel to the floor of the oven chamber and spaced from about $\frac{3}{4}$ of an inch to one inch below the product that is to be heated.

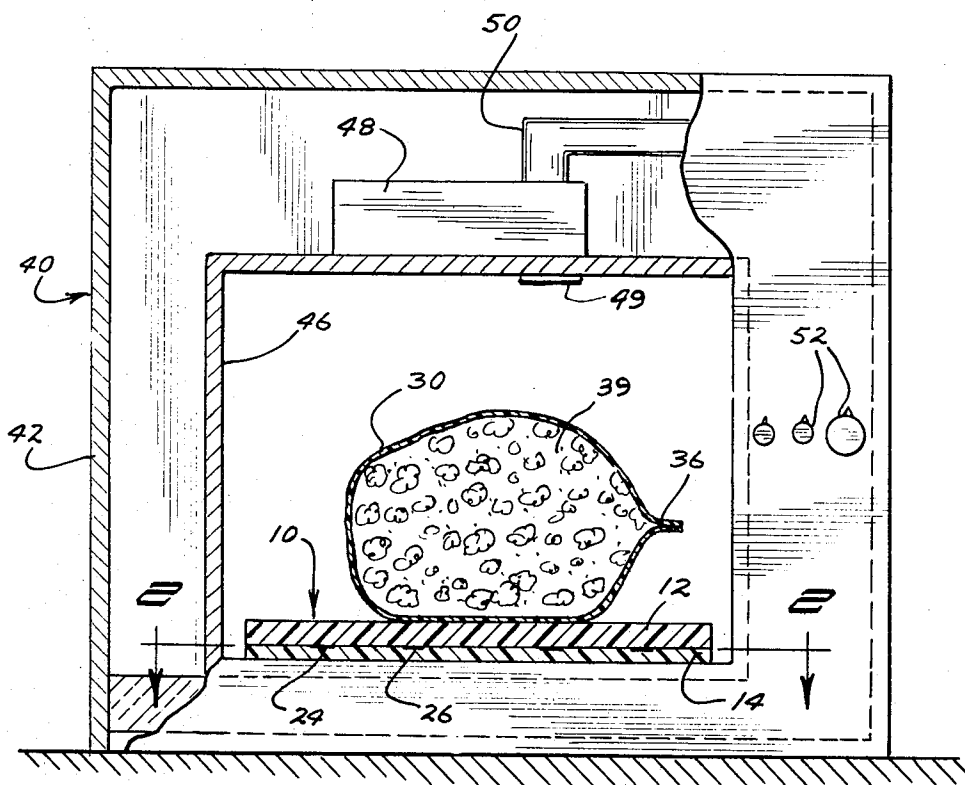
5 Claims, 4 Drawing Figures

FIG. 1

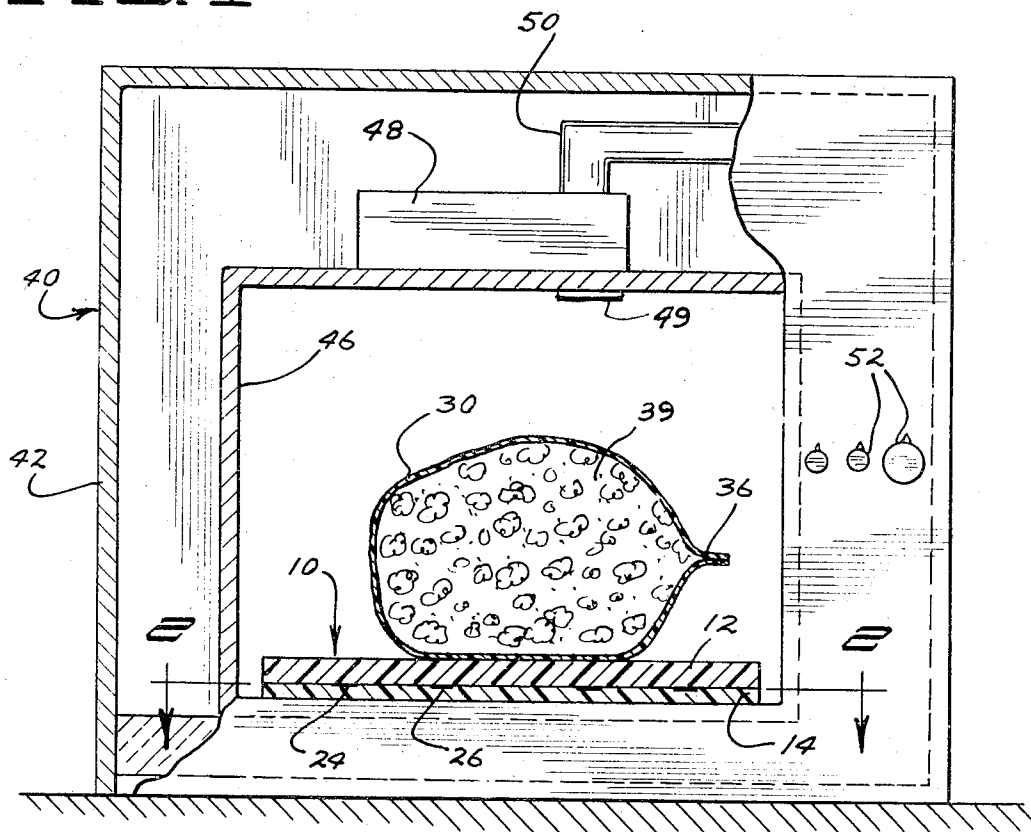


FIG. 2

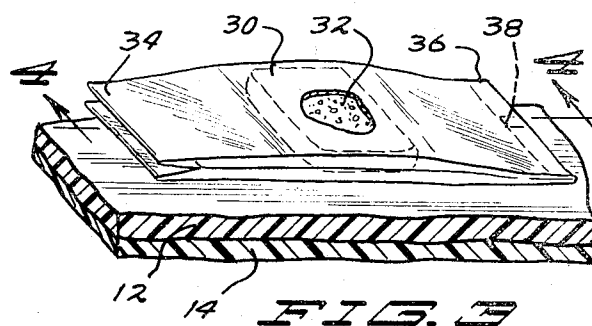
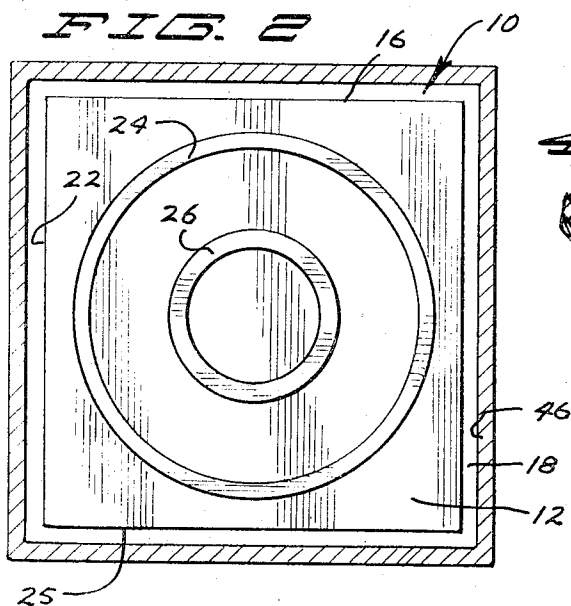
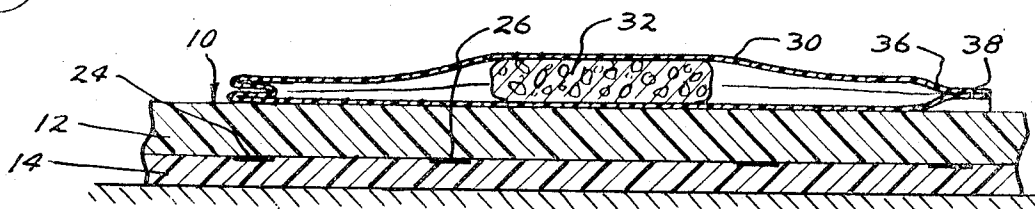


FIG. 4



COMPOSITE MICROWAVE ENERGY PERTURBATING DEVICE

FIELD OF THE INVENTION

The present invention relates to microwave cooking and more particularly to an improved energy concentrator for facilitating the cooking of foods in microwave ovens.

THE PRIOR ART

In spite of the demand for a popcorn product which can be freshly popped in a microwave oven and served while it is piping hot, some of the commercially available ovens have been unsuited for this purpose. For example, numerous attempts have been made by us to satisfactorily pop packages of unpopped popcorn in the Model 500 oven manufactured by the Litton Industries, 360 North Crescent Drive, Beverly Hills, Calif., 90210. It was found by us that only about 25 percent of the kernels would pop on the average while the other 75 percent remained unpopped. This kind of performance is, of course, totally unsatisfactory for commercial acceptance.

It has been proposed to package food products such as TV dinners and frozen foods and the like in boxes formed in part of a microwave reflective material such as aluminum foil having holes in selected areas. The microwave energy appears to enter the holes and is reflected about within the package by the aluminum foil thereby facilitating the heating of the food product. In addition to increasing the cost of the package, the use of perforated aluminum foil layers or strips as a part of the package itself was evaluated by us and found to be unsatisfactory for the purposes of the present invention. U.S. Pat. No. 3,271,552 describes a heating apparatus for concentrating microwave energy at desired points in a microwave oven and includes spaced parallel strips of conductive material formed into the side walls of the package containing the food product to be heated. These strips are one half wavelength in length to obtain maximum re-radiating characteristics. In another form of the invention, an insulating block of a low dielectric constant material is as mounted in the oven. Vertical re-radiating elements such as metal rods are placed on each side of the block. We found that the re-radiation of energy is unsatisfactory in some instances because of localized heating and the possibility for arcing to occur. In addition, it is expensive to provide conductive material as a part of the package containing the food product.

OBJECTS OF THE INVENTION

The primary objects of the invention are to provide (a) a simple and reliable method of concentrating microwave energy in a microwave oven such as the Litton Industries Inc. 500 oven whereby products which are difficult to properly prepare because they are relatively sensitive to the distribution microwave energy can be cooked satisfactorily e.g., so that when popcorn is popped 80 percent of the kernels pop when the invention is used in a Litton Model 500 oven, (b) to provide a durable and unitary article which functions both as an energy concentrator and as a support for the popcorn or other material being heated, (c) a device which is capable of functioning by two different methods of operation to concentrate the microwave energy at the

point where it is most needed, (d) a compact, unitary microwave energy concentrator and combination shelf which is capable of operating successfully over extended periods of time without reflecting excessive amounts of microwave energy back to the magnetron and (e) to provide an energy concentrator of the type described which can be left in the oven at all times—even during the heating of foods which are less critical than popcorn concerning the concentration of microwave energy.

THE FIGURES

FIG. 1 is a side elevational view partly in section of a microwave oven and concentrator in accordance with the invention showing a popcorn product in the oven as it appears after being popped.

FIG. 2 is a partial horizontal sectional view taken on Line 2—2 of FIG. 1 on a slightly reduced scale.

FIG. 3 is a partial perspective view of the concentrator and food product before heating.

FIG. 4 is a partial vertical sectional view taken on Line 4—4 of FIG. 3 on a slightly enlarged scale.

SUMMARY OF THE INVENTION

A composite microwave signal perturbing device is provided which consists of a low loss dielectrical element p.g., a plane or sheet together with microwave reflecting body bonded thereto. The device is placed in the oven and on the opposite side of the produce being heated from the source of microwave energy. The device is preferably composed of a sheet of low loss dielectric material having the layer of microwave reflecting material imbedded therein e.g., as a series of concentric rings positioned in a plane parallel to the floor of the oven chamber and spaced preferably from about $\frac{3}{4}$ of an inch to 1 inch below the product which rests on the upper surface of the dielectric material.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As seen in FIGS. 1 and 2 the composite energy concentrator 10 is generally rectangular as seen in plan view and consists of two sheets of a low loss dielectric material such as a plastic resin which can be subjected to microwave energy without damage such as melting, warpage, or carbonization. Polypropylene is an example of such a material. For convenience the low loss dielectric material will be referred to as a ballast. The ballast is composed of an upper rectangular plate 12 and a lower rectangular plate 14. The ballast is preferably slightly smaller than the door of the oven so that it can be introduced and removed as needed. A sheet eleven inches square is typical. When polypropylene is used, the upper sheet is $\frac{3}{4}$ of inch thick and the lower sheet is $\frac{3}{8}$ of an inch. Thus, the package 30 resting on the ballast 10 is held at an elevation of about 1 $\frac{1}{2}$ inches above the floor of the oven. We have found that during a typical heating period of 2 minutes the temperature of the composite sheet is raised from about 70° to about 80° F.

While the reason for the effectiveness of the ballast for improving the concentration of microwave energy is not known with certainty, it is believed to improve the matching of the impedance of the cavity with the impedance of the magnetron thereby assuring maximum energy absorption within the chamber. The dielectric constant of the ballast should be that of low

loss dielectric. While a variety of substances can be used, some of the most suitable are dimensionally stable polymeric resinous materials such as polypropylene and teflon. The dielectric constants of these materials range from about 2 to about 3.2. Polyethylene has also been found suitable but does not have quite as good dimensional stability under typical conditions of use. Polystyrene appears to be effective electrically but does not have the desired temperature stability. The same is true of acrylic resins such as polymethylmethacrylate. Glass has too high a dielectric constant and will not function for the purposes of the invention. Other suitable materials will be apparent to those skilled in the art. When polypropylene is used, the entire ballast 10 should weigh about 5 pounds when used in a Litton 500 oven.

As best seen in FIGS. 2 and 4, there is laminated between the sheets 12 and 14 a pair of rings 24 and 26 of microwave reflective material formed from 10 mil. aluminum foil sheets each 1 inch wide and having outside diameters of 6 and 10 inches respectively. Sheets 12 and 14 can be bonded together in any suitable manner as for example by a resinous adhesive having a dielectric constant about the same as the material from which the sheets 12 and 14 are constructed. One example is an epoxy adhesive.

Refer now to FIGS. 1 and 2 for a description of the oven itself. The oven indicated generally by the numeral 40 includes an outside housing 42, a microwave generator including a magnatron (not shown) connected by means of a waveguide 50 to a distributing device for uniformly supplying the microwave energy to the interior of the oven, in this case a mode stirrer 48 which communicates with the interior oven chamber through an inlet 49. The operation of the oven is regulated by a means of exterior control 52 of a suitable known construction. As mentioned above, the oven itself is entirely conventional and is best exemplified by oven model 500 manufactured by the Litton Industries Inc. of Calif.

The concentrator 10 has general application but is especially useful for popping frozen packages of popcorn in ovens as low as 500 watts measured output. In this application the popcorn package usually includes a flexible and expandable container body such as a gusseted bag formed from two plies of paper. The charge of popcorn in the package is uniformly mixed with about 1 to 5 parts by weight of shortening for each eight parts of corn. The shortening can include any edible cooking oil or plastic fat, whether solid or liquid and includes both hydrogenated and non-hydrogenated shortenings. Any of a variety of edible animal or vegetable oils or plastic fats can be used with those of vegetable origin being preferred because of their lower melting points. The package also contains salt for flavoring.

The flexible popcorn package which is designated 39 consists of paper walls with longitudinally extending gussets on each side to provide a sizeable expansion volume. The bottom and top is sealed tightly by transverse seals 34 and 36. The package preferably consists of two layers of flexible sheet material. One preferred outer sheet material is bleached kraft paper. A suitable liner (not shown) consists of glassine paper.

After the package has been filled with a charge of popcorn, the top is sealed at 36. The charge of unpopped corn and shortening 32 at the center portion of

the package 30 can be best seen in FIGS. 3 and 4. The block of popcorn and shortening 32 is made of about one to five parts of a shortening for each eight parts of corn.

After the package is filled and sealed as shown in FIG. 3, it is preferably placed in refrigerator or frozen storage until it is ready to be used. When the popcorn is to be popped, the package is placed on the center of the concentrator 10 within the cooking chamber 41 of the microwave oven 40. As microwave energy is supplied to the chamber, the package 30 is expanded by steam and then becomes filled with the popped corn 39 as shown in FIG. 1.

It is believed that the outstanding performance results made possible through the invention are due in large part to the concentration of microwave energy in the vicinity of the popcorn. During heating, the shortening provides a heat transfer medium for conducting heat evenly between the individual kernels in spite of the presence of hot or cool spots in the package. The package, in addition to being flexible and expandable is relatively leak proof at least during the period of time the product is being cooked.

While the invention has been described in connection with popping popcorn, it is applicable to a variety of other foods. The invention will be better understood by reference to the following example:

Example 1

A concentrator was made of about 5 pounds of polypropylene having the dimensions given above and was placed in a Litton 500 oven. A gusseted paper bag as depicted in the figures is formed from Kraft paper and includes a glassine paper lining having the dimensions 7 × 10 inches with 2 inch deep gussets. The bag is filled with 120 grams of a uniform mixture of popcorn, coconut oil and salt. Forty grams of the shortening and salt mixture consisting of 30 grams coconut oil, 10 grams of super fine granulated salt and 80 grams of yellow hybrid popcorn. After the corn and shortening is placed in the pouch it is sealed transversely at the top. The package is then frozen. Later upon being placed in a microwave oven of a capacity of 1,200 watts running at about 950 watts for one minute and 45 seconds using the concentrator described above, about 22 percent or less of the popcorn will remain unpopped. The resulting popcorn will be crisp and will have a very appealing flavor and texture. The amount of burned kernels will be less than 5 percent and the corn will not be appreciably scorched. The bag can be handled immediately and the volume of popped corn will be about 2,800 cc. or more with a volume ratio of popped to unpopped kernels of about 35 or above.

In a comparative test, otherwise identical except without the concentrator 10, the volume of popped corn was 400 cc. and the percent of unpopped kernels was 80 percent.

The mechanism by which the energy density is concentrated above the center of the unit 10 is not known with certainty but it appears to result in part from the mass of low loss dielectric material and in part from the reflective material. As a result of tests run in the development of the invention, the best results were obtained in most Litton model 500 ovens when the concentrator had an inner foil ring with an outside diameter of about 6 inches and about 60 percent of the center is cut out. Optimum results were also obtained with the top of the

polypropylene about 1 and 1/8 inches above the floor of the oven and reflective rings about three-fourths of an inch below the upper surface of the plate 10.

It has been found that when operating below 700 – 750 measured Watts of power output, the conductive strips 24 and 26 become more important. Above that level of power the plastic ballast alone is effective to enhance the heating effect so that the corn will pop to the 80 percent popped level. It has also been found that when the concentrator shown in the figures is used, the ratio of transmitted power to reflected power is improved, i.e., raised which is desirable not only from the standpoint of heating the product but also because it would appear to reduce damage to the magnatron which results from reflected energy.

We claim:

1. A composite microwave energy perturbing device useful in concentrating microwave energy in a zone located in approximately the center thereof comprising a sheet of a low loss dielectric material of an appropriate size to fit within the oven and to rest on the bottom thereof during operation, said sheet including upper and lower substantially parallel surfaces and vertical side edges which are substantially less than the width and breadth of the sheet and a plurality of concentric rings of electrically conductive microwave reflective sheet material mounted upon the perturbing device and positioned in a plane substantially parallel to the upper surface thereof thereby concentrating the microwave energy at a point near the center of the concentric rings.

2. The apparatus of claim 1 wherein the concentric rings of said sheet material are embedded within the dielectric material in spaced relationship from both of the upper and lower surfaces thereof.

3. A microwave concentrator for facilitating the

heating of food products placed within a microwave oven containing a source of microwave energy, an oven chamber and a means for supplying microwave energy from the source to the chamber, said concentrator comprising:

a. a body of low loss dielectric material having a mass on the order of more than one pound and being resistant to damage by microwave energy when subjected thereto,

b. said dielectric material comprising a sheet of a dielectric substance having flat upper and lower surfaces of substantial width, the height of the sheet between the upper and lower surfaces being substantially less than the width thereof,

c. a sheet of conductive microwave reflective material bonded to said dielectric material,

d. said sheet of conductive microwave reflective material comprising a ring-shaped endless strip of reflective material located in a plane parallel to the bottom of the oven and to the upper and lower surfaces of the dielectric sheet material,

e. said microwave reflective material being bonded to the dielectric sheet and having its center located approximately in the center of the dielectric sheet material.

4. The concentrator of claim 3 wherein there are a plurality of said ring-shaped strips of reflective material positioned concentric with one another and each is bonded to the dielectric material.

5. The apparatus according to claim 3 wherein the microwave reflective material comprises a sheet of relatively thin metal foil lying in a plane substantially parallel to the upper and lower surfaces of the dielectric sheet.

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