(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 371 739 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **89312307.5**

(51) Int. Cl.5: **H05B 6/64**

(22) Date of filing: **28.11.89**

(30) Priority: **28.11.88 GB 8827708**

(43) Date of publication of application:
06.06.90 Bulletin 90/23

(84) Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

(71) Applicant: **BECKETT INDUSTRIES INC.**
610 South Service Road
Oakville Ontario L6K 2H4(CA)

(72) Inventor: **Beckett, Donald Gregory**
3695 Kaneff Crescent Apt.No.1104
Mississauga Ontario L5A 4B6(CA)

(74) Representative: **Laight, Martin Harvey et al**
W H Beck, Greener & Company 7 Stone
Buildings Lincoln's Inn
London WC2A 3SZ(GB)

(54) Article for and method of heating.

(57) A novel article of manufacture is described which is capable of converting incident microwave energy to thermal energy for use in the external heating of foodstuffs, for example, to achieve browning, during the microwave reconstitution of such foodstuffs for consumption. The article consists essentially of a substrate layer formed of structural fibrous stock material and a layer of metal or other electroconductive material directly engaging and supported on one face of the fibrous material layer. The metal layer, which preferably is stainless steel applied by sputtering, has a thickness such as to convert microwave energy into thermal energy.

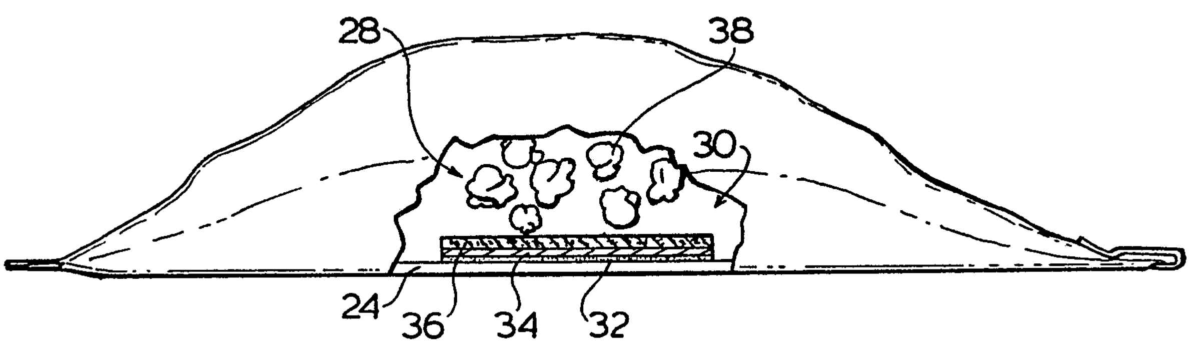

FIG. 3

EP 0 371 739 A2

ARTICLE FOR AND METHOD OF HEATING

The present invention relates to novel heat susceptor structures for use in converting microwave energy to thermal energy.

It is well known that a thin film of electroconductive metal can convert incident microwave energy to thermal energy and this effect has been used to achieve external heating of food products during microwave reconstitution or heating of food products, such as popcorn, pizzas and french fries.

For this purpose, the metal usually is supported on a polymeric substrate, such as a polyester, for example, that sold under trademark "Mylar". The thickness of the metal film required to achieve the generation of thermal energy varies depending on the electroconductive metal chosen. For aluminum, a metal commonly employed for this purpose, the thickness may vary from about 0.1 to about 0.8 optical density, particularly about 0.2 to about 0.3 optical density. Other metals which may be employed include copper and stainless steel.

In order to inhibit the polymeric substrate from distorting upon the application of microwave energy to the metal film, the polymeric substrate usually is laminated to a single sheet of relatively stiff paper or paperboard or sandwiched between two sheets of such material, using conventional laminating adhesives. One typical prior art structure is shown in U.S. Patent no. 4,641,005.

A concern has been expressed by certain regulatory authorities that the heat generated upon application of microwave energy to the metal film may cause degradation of the polymeric substrate and/or the laminating adhesive to result in gaseous by-products which may be harmful in a food environment.

A search has been conducted in the facilities of the U.S. Patent and Trademark Office with respect to background prior art with respect to the present invention. As a result of that search, the following U.S. Patents have been noted as potentially relevant prior art:

4,210,124 Husslein et al
4,267,420 Brastad
4,363,851 Mishina et al
4,514,446 Kadono et al
4,592,914 Kuchenbecker
4,641,005 Seiferth
4,703,148 Mikulski et al
4,777,053 Tobelmann et al
4,248,687 Fan
4,351,997 Mattisson et al
4,364,995 Crawford et al
4,528,234 Kaiho et al
4,599,275 Hayashi et al
4,702,963 Phillips et al
4,735,513 Watkins et al
4,785,160 Hart

With respect to this prior art:

U.S. Patent no. 4,210,124 describes a dish structure having a microwave-reflective metal foil coating and a microwave structure metal interactive metal oxide film. The substrate is formed of porcelain, fired silica or similar material of construction of dishes.

U.S. Patents nos. 4,248,687, 4,267,420, 4,363,851, 4,514,446, 4,528,234, 4,599,275, 4,641,005, 4,702,963, 4,735,513 and 4,785,160 all disclose structures which require a combination of a microwave-active metal layer, usually aluminum, supported on a polymeric film substrate.

U.S. Patent no. 4,351,997 discloses a tray structure in which a metal layer is described as foil and a reflector of microwave material.

U.S. Patent No. 4,364,995 is a general process for the formation of metal and metal oxide coatings on substrates.

U.S. Patent no. 4,592,914 describes the provision of a container including both a microwave absorptive layer, which is metallized plastic film, and microwave reflective layer, described as foil, coated on paper.

U.S. Patents Nos. 4,703,148 and 4,777,053 also describe a package for microwave heating including a microwave-reflective foil layer and a microwave susceptible metal film on polymeric substrate.

None of this prior art discloses or suggests that it may be possible to provide a microwave susceptor in which a thin metal layer is provided directly supported by a paper substrate, as in the present invention and as described in more detail below.

In accordance with the present invention, there is provided a novel heat susceptor structure in which an electroconductive material, such as a metal, for example, aluminum, copper or stainless steel, of heat susceptor thickness is directly supported on a paper or paperboard or other similar fibrous material substrate. It was previously not known that a heat susceptor could be provided by directly applying a metal film to a paper substrate and is contrary to the general understanding of the art. By the term "heat susceptor thickness", as used herein, is meant that the electroconductive metal is of a thickness such that it becomes semiconductive, which results in the dissipation of the electrical resistance or heat when exposed to microwave energy.

Accordingly, in one aspect of the present invention, there is provided an article of manufacture capable of conversion of a portion of microwave energy applied thereto to thermal energy consisting essentially of a substrate layer formed of structural fibrous stock material and a layer of electroconductive material directly engaging and being supported on one face of said fibrous material layer and having a thickness effective to convert a portion of incident microwave energy into thermal energy.

By positioning the layer of electroconductive material directly in contact with the fibrous material substrate, generally paper, the prior art necessity for laminating adhesives and a polymeric film layer are eliminated and hence the potential for the formation of gaseous by-products of such materials is eliminated.

It has not previously been thought possible by those involved in this art to provide a thin film metal susceptor for conversion of microwave energy to thermal energy other than supported by a polymeric substrate laminated to a paper layer.

For example, during the prosecution the patent application which lead to the aforementioned U.S. Patent No. 4,641,005, it was stated:
"Vacuum deposition of aluminum onto a paperboard substrate cannot produce an interactive layer having satisfactory microwave heating characteristics" and "Any attempt to achieve an aluminum layer of sufficient thinness to be microwave heatable by vacuum depositing directly onto a paper stock would be impossible".

Among the reasons given for this conclusion with respect to vapour deposition of aluminum were:

(a) predictable effects require that the surface upon which the aluminum is deposited must be extremely smooth,

(b) it is not possible to form a continuous layer of aluminum onto a paper surface but rather the surfaces of individual fibres only would become coated, providing a highly irregular layer of aluminum, and

(c) moisture normally present in paper tends to outgas in a vacuum thereby interfering with the predictability of the amount of material being vacuum deposited. These observations are made with respect to vacuum deposition of aluminum and nothing is said of other metals or other deposition techniques.

It is, therefore, highly surprising that the applicant is able to produce a microwave susceptor in which a thin metal layer is supported directly by a paper substrate.

As mentioned above, in its broadest aspect, the present invention provides an article of manufacture comprising two elements, namely a substrate and a layer of electroconductive material supported on the substrate. The structure is an extremely simple one and yet provides a very effective heat susceptor which can be incorporated directly into a wide variety of packaging structures for thermal heating of food products to achieve a variety of effects during microwave heating or reconstitution of such food products, for example, crisping and browning. A second coating of electroconductive material of heat susceptor thickness may be provided on the opposite side of the substrate from the first layer of such material to achieve an enhanced heating effect from the two layers.

The electroconductive material layer usually is a metal layer, although carbon and certain metal oxides also may be employed. The metal layer may comprise any electroconductive metallic material which is capable in the form of a thin film of a thickness effective to convert microwave energy to thermal energy. Stainless steel is preferred for the reasons outlined below but other metals, such as aluminum or copper may be employed. Other possibilities include lead, gold, silver and platinum.

Stainless steel, for example 316 stainless steel, is a preferred metal in the structure of the present invention for a variety of reasons. Stainless steel is inert to oxidation under normal room temperature conditions and hence maintains a stable sheet resistance over the storage and shelf life of the package. Many metals, aluminum in particular, oxidize over time and the resulting metal oxides do not heat upon the application of microwave energy thereto, which decreases its efficiency as a heat susceptor.

Stainless steel, as is well known, is an alloy containing iron, chromium and carbon as its essential components. Resistance to oxidation results from the chromium constituent migrating to the surface and being oxidized thereat to act as a barrier to oxidation of the subsurface iron.

The stainless steel layer in the structure of the invention heats up upon the application of microwave energy thereto. Since it is a resistive metal, there is a limit to the extent of a temperature rise which results, dictated by the temperature at which oxidation spontaneously occurs, which, for stainless steel, is around 425°F, a temperature ideal for the paper package environment in which the susceptor is to be employed. For aluminum, however, the self-oxidation upper limit is around 675°F, although this temperature varies widely depending on the pre-existing state of oxidation of the aluminum, so that continued application of microwave energy to an aluminum layer results in a continued rise in the temperature, which is often undesirable, since scorching or burning of the paper substrate should be avoided.

In order to be effective as a microwave susceptor for a browning or crisping application, the metal layer should be capable of rapidly heating to a temperature of about 300° to about 400° F and of sustaining that temperature for the desired heating time for which microwave energy is to be applied to the food product, usually about 5 to 10 minutes. Depending on the resistance of the stainless steel layer, it is possible with the structure of the present invention to achieve temperatures in the range of about 200° to about 420° F and to maintain such temperatures for as long as about 30 minutes, depending on the application.

All microwave energy which is incident on a microwave susceptor structure is reflected off the surface, absorbed into the metal layer or transmitted through the structure. Only the energy absorbed into the metal layer can be converted to thermal energy.

The absorbed microwaves cause electrons in the metal to vibrate with the frequency of the oscillating microwave electric field. For a typical microwave oven, the frequency is 2.45 GH_Z. The semiconductive thickness metal resists the movement of the electrons and the resulting energy is dissipated from the metal layer as heat.

The heat output obtained from the metal layer depends on the resistance of the metal layer, which may vary from about 50 to about 5000 ohms, preferably in the range of about 100 to about 2000 ohms. The resistance is determined, to some extent, by the thickness of the metal layer, which may vary in depth across the face of the metal layer, depending on the nature of the substrate layer, as discussed in more detail below. The thickness of the metal layer generally varies from about 10 to about 150 angstroms.

As the resistance of the metal layer decreases with increasing thickness of metal, a multiple interdependent number of effects are observed, namely the absorption increases slowly from a level of about 25% to a maximum of about 50% before rapidly dropping off to around 10% at the minimum sheet resistance (thick layer), the transmittance slowly declines from over 70% to around 0% and the reflectance slowly rises from around 5% to around 25% at the point of maximum absorption before rapidly rising to around 90% at the minimum sheet resistance.

Hence, as the sheet resistance is decreased from that of the maximum absorption and heat generation, corresponding to about 50% of the incident microwave energy, the absorption decreases, the reflection increases and the transmission decreases. Similarly, as the sheet resistance is increased from that of the maximum absorption, the absorption decreases, the reflection decreases and the transmission increases.

In order to produce the maximum heat output from the metal layer, it is desirable for the resistance of the layer to be that which produces within about 5% of the peak absorption for the metal layer. A sheet resistance which produces at least 45% absorption of microwave energy, however, permits a wide range of balance of reflectance and transmission for the remainder of the microwave energy. In this regard, it is possible to provide a range of resistance for the metal layer which permits the trade off of reflectance versus transmission to range from 45% reflected and 10% transmitted to 10% reflected and 45% transmission with essentially the same heat output from the heat susceptor, providing a considerable degree of flexibility in application of the susceptor to a variety of packaging structures. The degree of transmission of microwave energy by the novel structure may be determined by providing a microwave transmitter on one side of the structure and a microwave receiver on the other and determining the proportion of the incident microwave energy from the transmitter received by the receiver.

The metal layer of desired thickness may be applied to the substrate by any convenient substrate coating technique and the actual technique employed often depends on the metal employed. As noted earlier, the preferred metal is stainless steel and it is preferred to employ a sputtering process to effect the coating of the stainless steel layer on the substrate. Sputtering is a well-known coating process and is described, for example, in "Electron Beam Evaporation and D.C. Magnetron Sputtering in Roll Coating" by J. Mattencci, Proc. 30th Tech. Conf., Society of Vacuum Coaters, April 28, 1987, p.2. The electron beam coating process also described in that same article also may be employed.

The metal layer is directly applied to the substrate layer without the necessity for any intermediate layer, thereby eliminating the need for a polymeric film layer and a laminating adhesive, such as is required in the prior art.

Since the structure provided in accordance with this invention does not employ adhesives, polymers or other heat sensitive materials, the possibility of thermal breakdown of such materials in the structure of the invention is avoided, thereby overcoming environmental objections to the structures previously available. At the same time, a greater heat output is obtained by the structure of the present invention at the same thickness of metal on the substrate in comparison to structures wherein a thin metal layer is supported on a polymeric film laminated to paper. In addition, paper or paperboard represents a much less expensive substrate material than polyester film.

A second thin metal layer may be provided on the face of the substrate opposite to that of the first layer, if desired, as noted earlier. With a paper sheet substrate, it is often possible to achieve a synergistic heating effect from the two metal layers of heat susceptor thickness, when compared to the heat output obtained from a single metal layer of a thickness corresponding to the total thickness of the two metal layers.

The substrate layer on which the metal layer(s) is provided may be formed of any suitable fibrous material, such as wood fibres or glass fibres, provided in sheet form. The fibrous stock material functions to provide structural rigidity to the novel article of manufacture and to provide support for the metal layer when incorporated into a package structure. The fibrous stock material is a low density material having a relatively high thermal insulating capacity and heat stability sufficient to withstand cooking temperatures generated by the metal layer.

For incorporation into packaging structures, the substrate layer most conveniently is formed from paper stock, although in other applications, paperboard or even wood sheet may be employed. Essential to the invention is that the substrate layer be capable of supporting a metal layer of an electrical resistance such that thermal energy is generated therefrom on the application of microwave energy thereto.

The substrate may be of any desired thickness consistent with the end use to which the structure may be put and the paperstock may vary from a thickness of about 12 lb/ream to about 20 points board, preferably from about 10 to about 40 mils.

The substrate sheet may comprise cellulosic material fibres, usually wood fibres, or glass fibres. In the latter case, the substrate sheet resists the burning which may occur in the case of substrates made from cellulosic fibrous material if excess heating occurs.

It is preferred to employ a substrate with a smooth surface, since it is possible thereby to obtain a more uniform degree of heating from all portions of the surface of the metal layer. Preferred forms of such smooth-surfaced paper are high-gloss calendered paper and grease-resistant paper.

Generally, it is necessary for there to be a macroscopically-continuous metal film on the substrate layer for the generation of heat from incident microwave energy. Accordingly, with rougher surfaces, it is necessary to apply heavier weight coatings of metal to the substrate to ensure the presence of the continuous film, since it is necessary to fill the "valleys" before the continuous film forms over the "peaks", than in the case of a smoother surface, since, in the latter case, the valleys are much shallower or are non-existent.

As mentioned above, the proportion of the incident microwave energy absorbed and hence the degree of heating obtained is dependent on the electrical resistance of the coating, which, in turn, is dependent, to some extent, on the thickness. As described above, as the electrical resistance of the metal layer decreases and the metal layer becomes thicker, absorption tends to decrease, so that less heat is generated. For this reason, providing the metal layer on a smooth substrate surface produces a more even heat generation from the metal layer and greater levels of such heat generation.

In the article of manufacture of the present invention, the metal layer is coextensive with the substrate layer as a result of the method of formation of the same. For certain applications of the structure, it is desirable to provide regions of the surface which do not produce thermal energy when microwave energy is applied thereto while thermal energy still is produced from the remainder of the surface. Such an arrangement, for example, permits the article to be adhered to another surface by adhesive provided in the non thermal energy producing regions, with no danger of thermal breakdown of the adhesive.

A variety of techniques is available to achieve this result. One such procedure involves employing masks during the coating process to prevent deposition of a metal layer on the portions of the substrate where no metal is required to be present. However, masking often is impractical in continuous production procedures.

It has been found that mechanical rubbing of the metal layer or scratching the metal layer is sufficient to prevent heat generation from those regions of the surface so mechanically treated.

Another procedure which may be employed is to print the substrate in a pattern of regions where heating is not desired with a suitable release material to which the metal does not adhere, such as a silicone release material, prior to metallizing the substrate surface. Following metallization of the so-treated sheet, metal may be removed from the patterned regions by any suitable technique, such as by brushing away the metal or by removing the metal with an electromagnet.

The structure of the invention may be used for a variety of purposes where it is desired to convert a portion of incident microwave energy into thermal energy.

The major application of the novel structure is in the microwave heating and reconstitution of foodstuffs of a wide variety. As set forth above, by varying the parameters of the metal layer, notably the electrical resistance, differing properties of energy absorbance, reflection and transmission of incident microwave energy and differing sustainable levels of heat generation can be achieved. The particular choice of such properties depends on the application to which the structure of the present invention is put.

The novel structure is incorporated into the desired packaging structure by positioning the structure at the desired location or locations of the packaging material, usually a paper sheet, where the thermal heating is desired, generally by employing a convenient fastening means. Generally, a suitable adhesive is employed, although mechanical bonding through interacting elements may be employed.

To minimize the possibility of thermal breakdown of such adhesive when microwave energy is applied thereto with the possibility of the formation of undesired decomposition products, a minimum of such adhesive to ensure a secure attachment preferably is employed, usually at the peripheral regions only of the structure. To further minimize the possibility of such decomposition, peripheral regions of the structure may be provided devoid of metal, by using one of the demetallization techniques described above, with the structure being adhesively bonded to the packaging material at such peripheral regions only. Since, in this arrangement there is no metal in the regions of location of the adhesive, no heating occurs in these regions and they remain cool, so that there is no possibility for thermal breakdown of the adhesive.

Since the novel structure is not adhered to the packaging material, such as a paper sheet, in the region where the metal layer heats up when microwave energy is applied to the packaging structure, the air trapped between the novel structure and the adjacent face of the paper sheet expands as heat is generated by the metal layer, providing a degree of thermal insulation against heat passing from the heat susceptor to the exterior of the bag. In this way, a greater proportion of the heat generated by the metal layer as it is exposed to microwave energy is used to heat the food product.

The invention is described further, by way of illustration, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an article of manufacture provided in accordance with one embodiment of the invention;

Figure 2 is a perspective view of a microwave popcorn heating bag incorporating a novel structure provided in accordance with the invention;

Figure 3 is a part sectional view of the popcorn heating bag of Figure 2 after popping of the corn;

Figure 4 is a perspective view of a pot pie dish incorporating a novel structure provided in accordance with the invention;

Figure 5 is an exploded view of the pot pie dish of Figure 4 showing the consistent layers of the laminate; and

Figure 6 is a graphical representation of heat generation by stainless steel supported on paperstock during experiments reported below.

Referring to the drawings, Figure 1 shows a perspective view of an article of manufacture 10 provided in accordance with one embodiment of the invention and consisting of a substrate layer 12 of paper supporting a metal layer 14 thereon. The metal layer 14 is coextensive with the substrate layer 12.

In Figures 2 and 3, there is illustrated the application of the present invention to a microwave popcorn heating bag 20, which comprises overlying paper sheets 22,24 which are joined by gussets 26 to allow for expansion of the popcorn within the bag enclosure 28 during microwave popping.

A structure 30 in accordance with the present invention is provided adhered to the bottom paper sheet 24 internally of the bag by adhesive 32, preferably provided at the periphery only of the structure 30. As shown, the metal layer 34 is the opposite side of the paper layer 36 from and hence out of contact with the popcorn 38. The paper layer 36 usually is provided with a layer of some form of high heat resistant release material, such as a silicone, between the popcorn 38 and the paper 36. However, the locations of the metal layer 34 and the paper layer 36 may be reversed. When such arrangement is employed, an overlying layer of a release material can be provided over the metal layer. Alternatively, the structure 30 may be adhered external to the bag 20 at the location of the popcorn 38.

In this embodiment, a peripheral region of the structure 30 where the adhesive 32 is provided is either free from metal or the metal has been deactivated by mechanically scuffing it, for example, with a pencil type eraser, so that no heating results in this region as a result of conversion of microwave energy into thermal energy, so that thermal breakdown of the adhesive does not occur.

As the bag 20 is exposed to microwave energy radiation, the popcorn 38 along with associated oil, heats up as a result both of the microwave energy to which it is exposed and the thermal energy generated by the metal layer 34, and is popped to fill the interior cavity 28 of the bag 20, as seen in Figure 3. When the popping is complete, the bag is opened to permit the popped corn to be consumed.

Another application of the principles of the invention is in a pot pie dish 50, as illustrated in Figures 4 and 5.

The pot pie dish 50 comprises a plurality of layers laminated together into the final structure. An inner layer 52 adjacent the pot pie crust comprises a polymeric film to which is adhered a thin metallic layer 54 coextensive in dimension with the polymeric film layer and of a thickness effective to convert incident microwave energy to thermal energy.

Next to the metal layer 54 is a heat susceptor according to the invention, comprising a paper substrate layer 56 supporting a further thin metal layer 58 of thickness correspondingly sufficient to convert a portion of microwave energy incident thereon to thermal energy. The combination of substrate layer 56 and thin metal layer 58 extends only for the region of base of the dish 50. An outer layer 60 of cardboard completes the structure of the laminate.

As described in my copending United States patent application Serial No. 374,655 filed June 30, 1989 ("Multi-Met"), the disclosure of which is incorporated herein by reference, the provision of two metal layers in the base portion of the dish enables higher heat generation to be obtained than in the wall region where a single metal layer is present.

The arrangement permits heat from the thin metal layer to be generated during microwave cooking of the pot pie contained in the dish. Maximum heat is generated in the region at the bottom of the dish and a lesser amount of heat is generated in the region of the side walls. The differential is chosen so that an even cooking of the pot pie occurs throughout the pie filling by a combination of the microwave energy and the heat generated from the metal film and an even browning effect to the crust is obtained.

The invention is illustrated by the following Example:

30 lb paper sheets ("Corguard") and 30 lb grease resistant sheets ("Lamopaque") were coated with stainless steel in a sputter vacuum chamber to a metal thickness ranging from an electrical resistance of about 500 ohms to about 5,000 ohms.

Each of the sheets produced heat when exposed to microwave energy, with greater degrees of heat being generated with the heavier coatings.

Specific details of the heat generation with respect to the various samples and the time frame involved are illustrated graphically in Figure 6.

In summary of this disclosure, the present invention provides a novel heat susceptor structure of a thin layer of metal or other electroconductive material of heat susceptor thickness directly engaging and supported on a paper or paperboard substrate which is useful in a variety of applications where it is desired to convert microwave energy to thermal energy and which does not produce decomposition vapors during microwave energy application. Improved heat production is achieved when compared with the conventional polyester substrate, as well as providing a much cheaper structure and an emission-decreased arrangement. Modifications are possible within the scope of this invention.

In addition to the aspects of the invention set out in the introductory paragraphs of the specification, it is to be noted that in another broad. aspect of the invention there is provided a heating element for microwave heating comprising a substrate layer of fibrous material, and a layer of electroconductive material directly engaging and supported on a face of the substrate layer and having a thickness effective to convert microwave energy into thermal energy.

The various preferred forms of layers, and dimensions of layers which have been set out hereinbefore or hereinafter in the claims, may also be provided in combination with the above aspect of the invention.

In general, features of the invention which have been set out with regard to an article, and to a heating element, are also provided in accordance with a method of heating according to the invention.

In particular, there is also provided in accordance with the invention a method of heating an item comprising placing the item in contact with or in proximity to a structure comprising a substrate layer of fibrous material, and a layer of electroconductive material directly engaging and supported on a face of the substrate layer and applying microwave energy to the structure to convert at least a portion of the incident microwave energy into thermal energy for heating the item.

Claims

1. An article of manufacture capable of conversion of a portion of microwave energy applied thereto to thermal energy, comprising a substrate layer formed of structural fibrous stock material, and a layer of electroconductive material directly engaging and supported on one face of the substrate layer and having a thickness effective to convert microwave energy into thermal energy.

2. The article of claim 1, wherein said substrate layer is paper stock.

3. The article of claim 2, wherein said paper stock is formed of cellulosic fibrous material.

4. The article of claim 2, wherein said paper stock is formed of glass fibrous material.

5. The article of claim 1 having a second metal layer having a thickness such as to convert microwave energy into thermal energy directly engaging and supported on the face of said fibrous material opposite to said one face.

6. The article of claim 5, wherein said substrate is a paper stock of thickness which permits a synergistic generation of heat from said metal layers.

7. The article of claim 1 wherein said metal

layer is stainless steel of a continuous film thickness producting an electrical resistance of about 50 to about 5,000 ohms.

8. The article of claim 7 wherein said electrical resistance is from about 100 to about 2,000 ohms.

9. The article of claims 2 wherein said metal layer is stainless steel applied to said substrate layer by a sputtering process.

10. The article of claim 1, wherein said metal layer has a continuous thickness of about 10 to about 150 angstroms.

11. The article of any preceding claim wherein said structural fibrous stock material is paperstock having a thickness of about 8 mils to about 60 mils.

12. The article of claim 11 wherein said paperstock has a thickness of about 10 to about 40 mils.

13. An article of manufacture capable of conversion of a portion of microwave energy applied thereto, consisting essentially of:
a substrate layer of paperstock, and
a metal layer of stainless steel applied to one face of said substrate layer by a sputtering process and directly engaging and supported on said face of said substrate layer,
said stainless steel layer being capable of absorbing a portion of incident microwave energy and to converting said absorbed microwave energy to thermal energy, of reflecting a portion of incident microwave energy and of transmitting the balance of said incident microwave energy not absorbed and reflected by said stainless steel layer,
said stainless steel layer having an electrical resistance such that the absorbed portion of the incident microwave energy is converted to thermal energy which rapidly produces a surface temperature of about 200° to about 420° F which is sustainable for up to about 30 minutes.

14. The article of claim 13, wherein said stainless steel layer has an electrical resistance such that the absorbed portion of the incident microwave energy is converted to thermal energy which rapidly produces a surface temperature of about 300° to about 400° F which is sustainable for about 5 to about 10 minutes, whereby browning and crisping of food products can be effected.

15. The article of claim 13 wherein said electrical resistance of said stainless steel layer is about 50 to about 5,000 ohms.

16. The article of claim 13, 14 or 15 wherein said electrical resistance of said stainless steel layer is about 100 to about 2,000 ohms.

17. The article of any of claims 13 to 16, wherein said stainless steel layer absorbs at least about 45% of the incident microwave energy.

18. The article of any preceding claim wherein said substrate is smooth surfaced paper.

19. The article of claim 18 wherein said smooth-surfaced paper is high-gloss calendered paper.

20. The article of any preceding claim sized to provide thermal energy from a selected region of a packaging structure and having peripheral regions thereof devoid of said metal to permit such article to be adhesively joined at such peripheral regions to a material of construction from which said packaging structure is to be formed.

21. A heating element for microwave heating comprising a substrate layer (12,56) of fibrous material, and a layer (14,58) of electroconductive material directly engaging and supported on a face of the substrate layer (12,56) and having a thickness effective to convert microwave energy into thermal energy.

22. A method of heating an item comprising placing the item in contact with or in proximity to a structure comprising a substrate layer (12,56) of fibrous material, and a layer (14,58) of electroconductive material directly engaging and supported on a face of the substrate layer (12,56) and applying microwave energy to the structure to convert at least a portion of the incident microwave energy into thermal energy for heating the item.

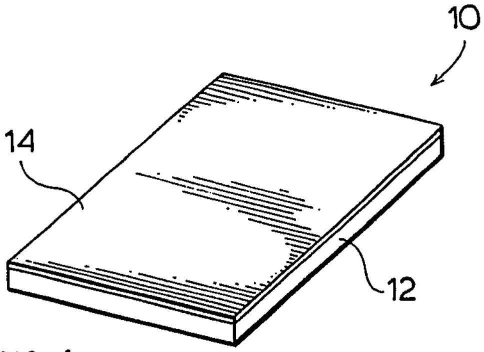

FIG. 1

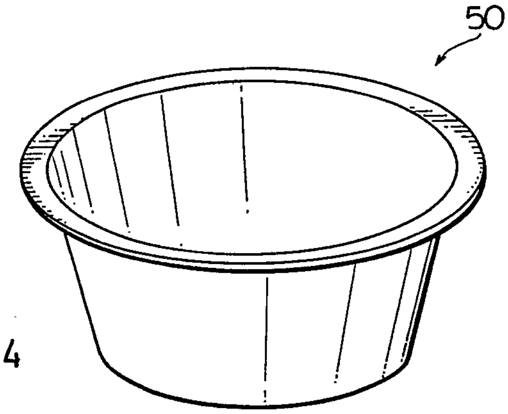

FIG. 4

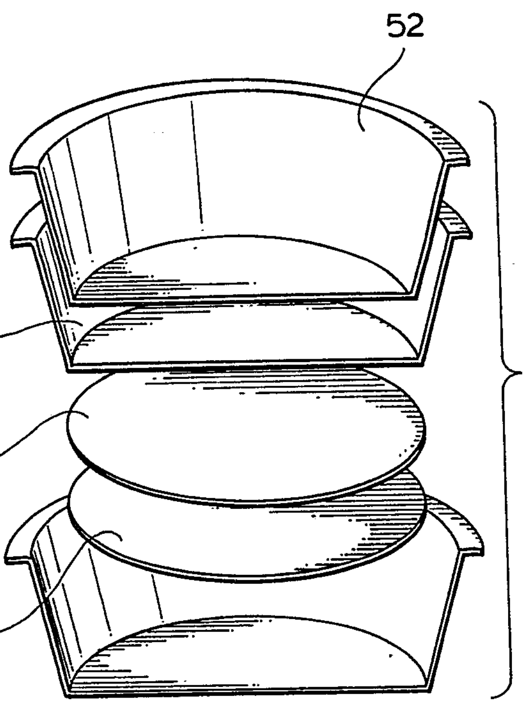

FIG. 5

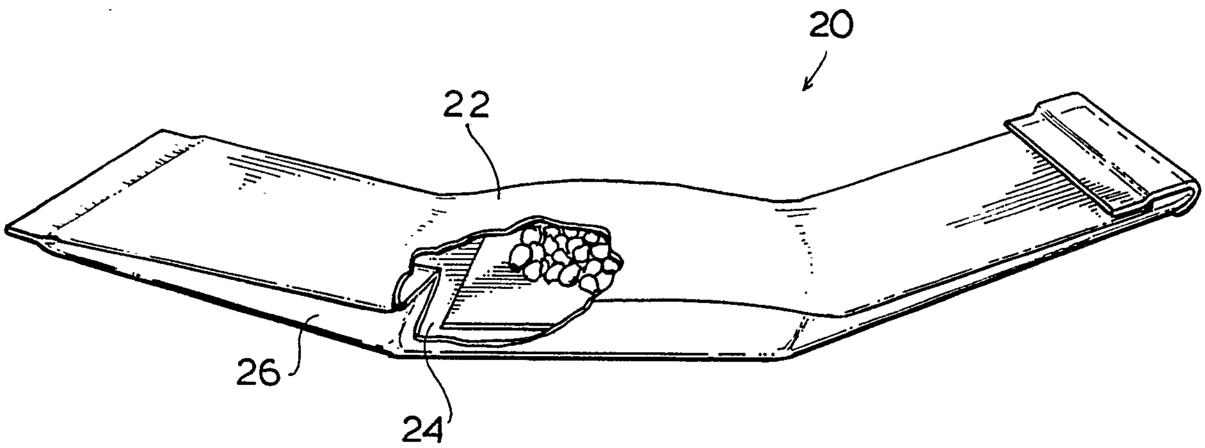

FIG. 2

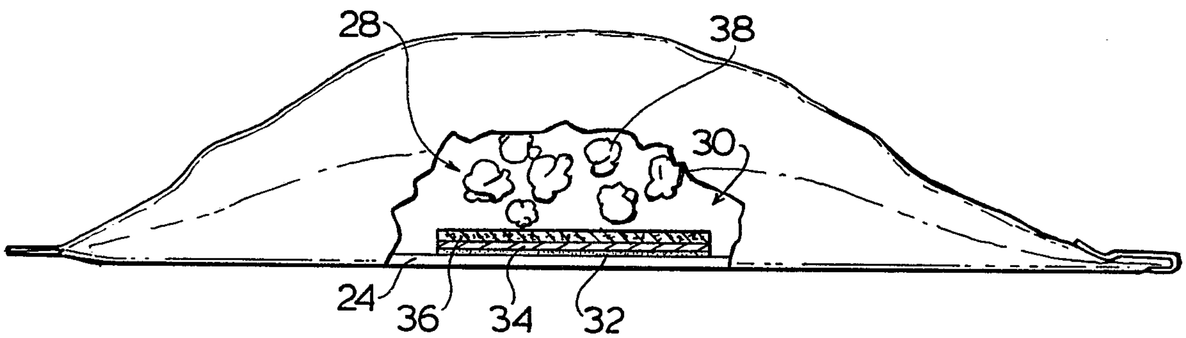

FIG. 3

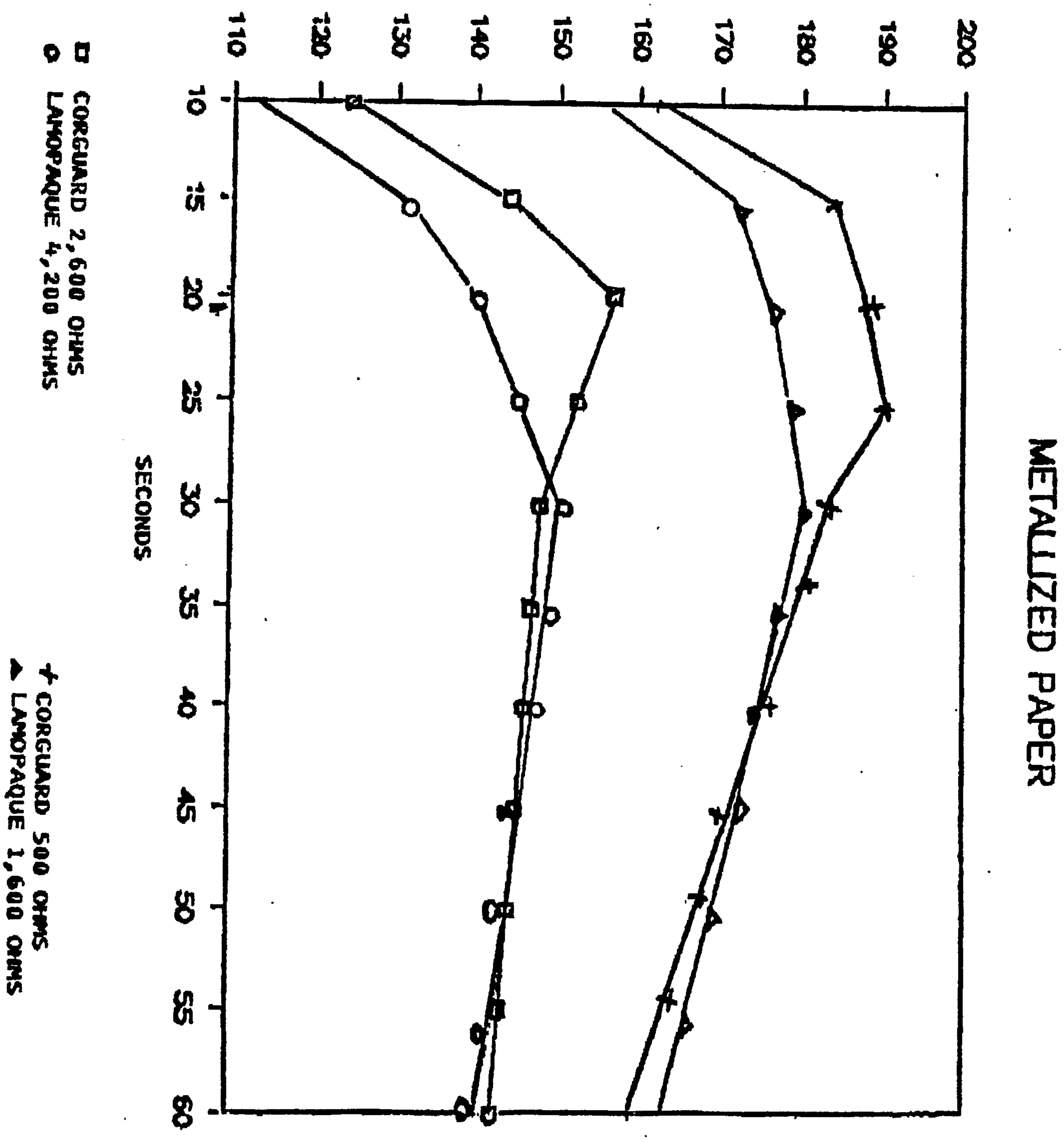
METALLIZED PAPER
TEMPS.
200
190
180
170
160
150
140
130
120
110
10
15
20
25
30
35
40
45
50
55
60
SECONDS
CORGUARD 2,600 OHMS
LAMOPAQUE 4,200 OHMS
CORGUARD 500 OHMS
LAMOPAQUE 1,600 OHMS

Fig 6