

[54] **MICROWAVE APPLICATOR**

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[58] Field of Search **219/10.55**

[56] **References Cited**

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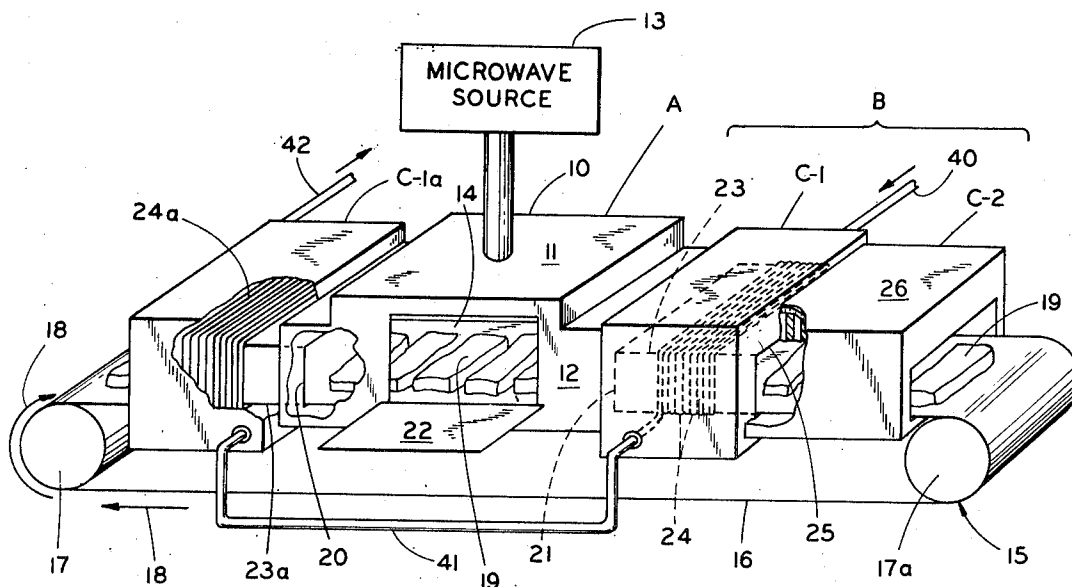
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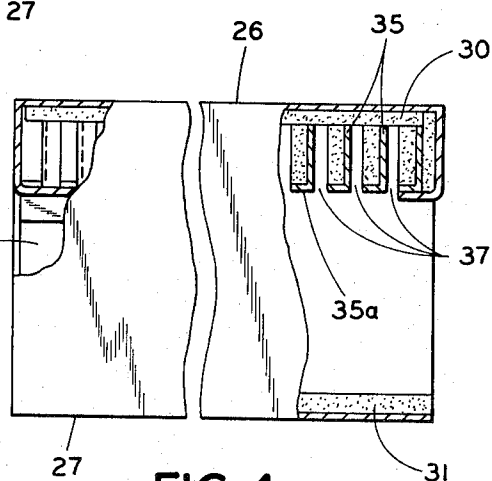
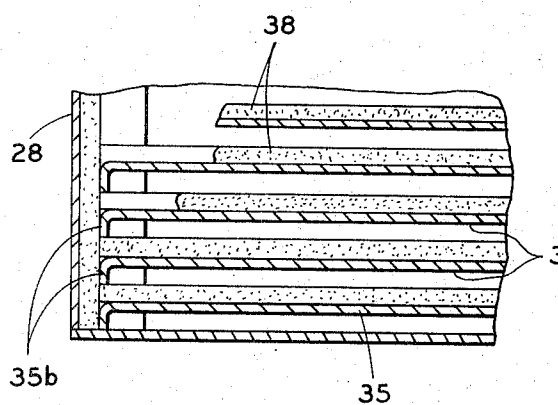
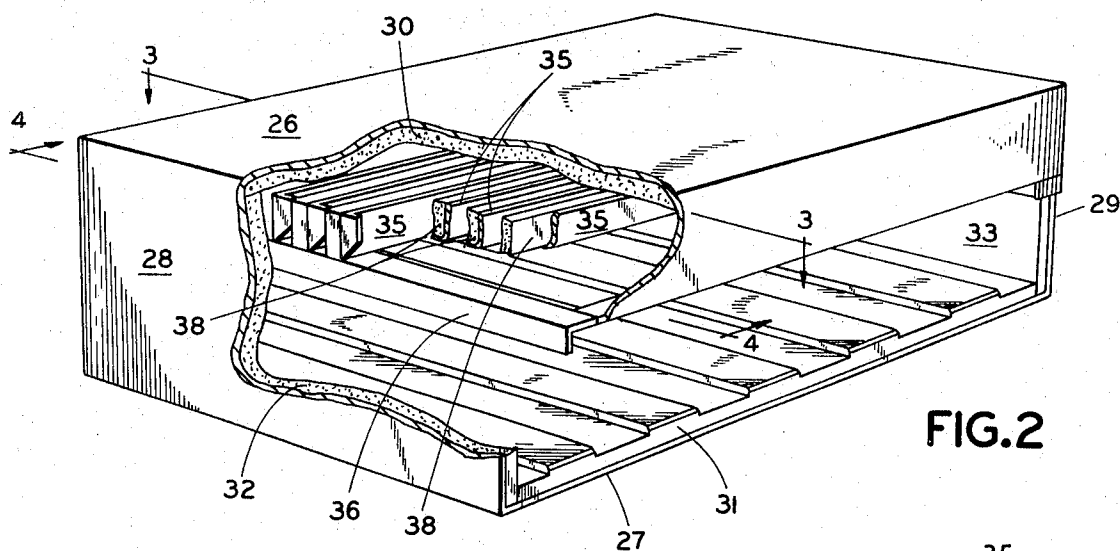
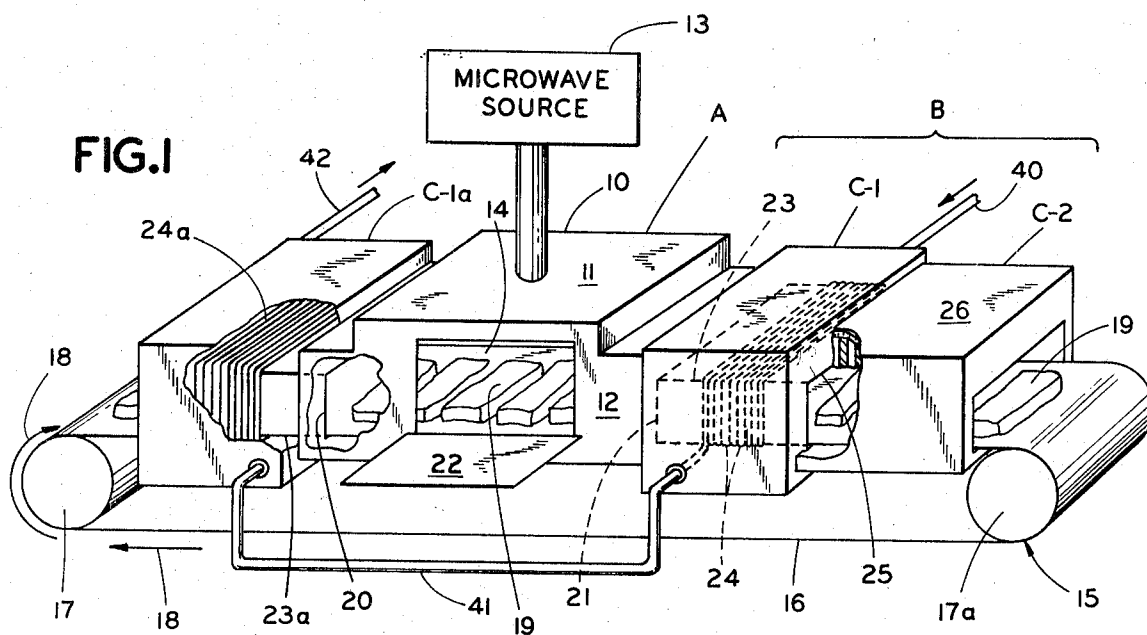
Primary Examiner—Bruce A. Reynolds
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[57] **ABSTRACT**

An applicator for microwave energy employing a heating chamber with inlet and outlet openings and an attenuation channel communicating with one of these openings. A conveyor is arranged to carry material to be treated in and out of the openings and through the channel. A feature of the applicator is the provision of an attenuation section in the channel which has spaced plates forming passages containing microwave absorbing material. Another feature is the provision of an intermediate attenuation section wherein a liquid which is lossy to microwaves is circulated into access with microwave energy within the intermediate section.

15 Claims, 4 Drawing Figures





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MICROWAVE APPLICATOR

This invention relates to applicator apparatus for applying microwave energy to the material to be treated and relates particularly to such apparatus which operates continuously with the material being continuously introduced to and removed from the apparatus.

BACKGROUND

Microwave ovens wherein microwave energy is applied to foodstuffs and other materials to be heated are now well-known. Some of the ovens are of the batch type where materials are put in the oven, the door closed, and the microwave energy turned on. Other ovens now in commercial use are designed for continuous operation and in which the material to be treated is passed on a conveyor through an inlet opening through a heating chamber or cavity and then out through an outlet opening. Such a continuous applicator is shown in the U.S. Pat. No. 3,365,562 to Jeppson.

Because it is necessary in the microwave applicators of the continuous type to have openings through which material can be passed into and out of the heating cavity there has been a problem of keeping the microwave energy from leaking out through these openings. This leakage represents a loss of energy but the more important consideration is that the energy which leaks out in this way passes into the atmosphere and presents a hazard to persons who may be in the vicinity. As the use of continuous microwave applicators has become greater more notice is taking of the radiation hazard and there is needed in this art apparatus which will avoid the emission of even any small amounts of microwave radiation into the atmosphere.

Apparatus is described in U.S. Pat. No. 3,365,562 which includes an end section into which water or other lossy liquid is circulated so that energy which tends to leak out of the treatment chamber comes into access with the water and the energy so absorbed in the water is carried away. Although this attenuation substantially reduces the leakage there remains a small but still objectionable amount of energy which is passed into the atmosphere, and what is desired is an improved structure which will stop the passing of even small amounts of energy into the atmosphere while at the same time avoiding any objectionable reflections back to the system. What is needed is some simple structure easily fabricated which will accomplish the desired purpose.

SUMMARY OF THE INVENTION

I have discovered that by the inclusion in the applicator of an attenuation section having a special lining and internal passages the purposes above described can be accomplished. The special lining may take the form of a coating of a material which is lossy to microwave energy. The passages may be formed by spaced plates extending across the section adjacent to one wall of the section. Preferably also such plates have a lining of this same kind of material which is lossy to microwave energy. A more detailed disclosure of my applicator including the improved attenuating section is given in the following drawings and detailed description:

THE DRAWINGS

One embodiment of my invention is shown in the accompanying drawings in which:

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FIG. 1 is a perspective view of my improved applicator apparatus;

FIG. 2 is an enlarged perspective view of the improved attenuation section of the applicator with one corner broken away to shown the interior structure;

FIG. 3 is an enlarged broken sectional view taken along the plane of lines 3—3 of FIG. 2; and

FIG. 4 is an enlarged broken sectional view taken along the plane of line 4—4 of FIG. 2.

DETAILED DESCRIPTION

As illustrated, the improved applicator includes the central heating section A, an end attenuating channel B having an intermediate attenuation section C-1 and a second attenuation section C-2.

The heating section A is formed by a metal casing 10 which is rectangular in cross section having spaced broad walls 11 at the top and bottom and sidewalls 12 at the front and rear. A source of microwave energy 13 communicates with the interior cavity 14 and microwave energy permeates this cavity. The walls 11 and 12 of the cavity are of metal and are good electrical conductors which means they reflect the microwave energy back and forth across the cavity and so contain the energy within the cavity until it is absorbed by the product being treated or leaks out through the openings which necessarily are provided.

A conveyor 15 having a belt 16 made of a material such as Teflon, which is a plastic having the characteristic of being transparent to microwave energy. This belt may be made of any flexible material which has this characteristic. The belt is shown as running between the rollers 17 and 17a, and for purpose of explanation is taken as moving in the direction shown by arrows 18.

Pieces of food or other material to be treated, 19, may be placed on the conveyor belt and through operation of the conveyor pass through the inlet opening 20 into the heating cavity and then out of the heating cavity through opening 21. In FIG. 1 a door 22 is shown in open position exposing the material 19 being conveyed longitudinally of the heating cavity. The door is for purposes of illustration only and is unnecessary for the proper operation of the applicator. The length of the heating cavity should be sufficient to allow for the desired heat treatment of the material 19 as may be required, taking into consideration the speed of the conveyor, etc.

The attenuation channel B communicates with the interior of the heating cavity at opening 21 and has its section C-1 adjacent this cavity. On the interior of section C-1 is a structure 23 of rectangular cross section made suitably of a plastic material which is transparent to microwave energy and about this is a tube 24 also made of a plastic or other material transparent to microwave energy and wound about this structure 23. Water or other lossy material may be circulated through the tube 24.

The structure 23 communicates on its interior with the opening 21 and the conveyor belt 16, with the material 19 thereon, passes longitudinally through structure 23.

Microwave energy which leaks out of opening 21 from the interior of cavity 14 may pass through the walls of structure 23 through the walls of tube 24 and be absorbed in the water or other lossy liquid circulated through this tube. The outer walls of section C-1, being

metallic, reflect any energy which may reach them back into the lossy liquid. Thus there is substantial attenuation of the energy which leaks through opening 21.

The attenuation channel B has its second attenuation section C-2 adjacent to section C-1 with its interior communicating through outlet opening 25 of section C-1, and the opening 21, with the heating cavity. This section has a metal outer casing which is rectangular in cross section having top and bottom broad walls 26 and 27 and sidewalls 28 and 29 (see particularly FIGS. 2 to 4). These walls are metallic and, therefore, reflect microwave energy. Lining the top wall 26 is a sheet 30 which may be a composition of materials including powdered iron and inert materials bound together with a binding material such as an epoxy resin. Such a material is manufactured by the Microdry Corporation of San Ramon, Calif. and sold under the trademark CRYOCOTE. This composite material is a good absorber of microwave energy and has a dielectric constant of between 1 and 10. The sheet 30 of this material is secured to the top wall 26 by an adhesive such as an epoxy adhesive. Likewise sheet 31, of similar material is secured to the bottom broad wall 27 and sheets 32 and 33 are secured to the left and right sidewalls respectively. Each of these sheets of absorbing material may be of the order of about ¼ inch thick, for example. Skid strips 31a extend over the lining layer 31 and the conveyor belt 16 may slide over these skids.

Inside the section C-2 are the spaced metal plates 35 which extend horizontally between the sides of the casing transversely of the end channel and transverse to the general direction of the flow of any energy tending to pass through the channel. These plates are supported at their ends by the support members 36 which are secured to the casing.

As seen more clearly in FIG. 4 the spaced plates 35 provide between them the passages 37 which lead from the interior of section C-2 and extend upwardly to the top wall. The ends of these passages are closed by the layer of lossy material 30 carried by the top wall. I prefer that the plates 35 be mounted in parallel arrangement with even and uniform spacing between them so that the vertical passages 37 will be rectangular in cross section from their open bottom ends to their top ends.

Secured on one side of each of plates 35 and within each of passages 37 is a layer or strip of lossy material 38. This strip 38 extends along substantially the whole side of plate 35 and its top edge meets the top layer 30. It may have a thickness such as about a ¼ inch, for example. The lower edges 35a of the plates are turned rearwardly so as to come under the edges of strips 38 and serve to hold these strips. Further, it is an improved feature that the end portions of plates 35 be turned forwardly as indicated at 35b of FIG. 3 so that the intumed edge portions form at least a part of the sides of the passageways 37, and the edges of these portions 35b abut against the strips 38 attached to plates 35 so as to determine the spacing between the plates and keep the plates in their uniform, parallel, evenly spaced relation. This structure also helps in manufacture since the plates may be placed simply one against the other without the need for measurement.

The height of plates 35 and strips 38, and consequently the depths of the passages 37, should be determined to a substantial extent by the frequency used in exciting the heating chamber. Frequencies in common

use for industrial heating purposes may be either 2450 HMz or 915 HMz, these frequencies being approved for such purposes by government agencies; but my invention may, of course, be used with other frequencies.

These passages are dead-end passages, having their upper ends blocked by lining 30 and top plate 26. I prefer that the width of the metallic plates 35 and therefore the depth of the passages 37, be of the order of ¼ the wave length of the selected frequency. This depth may be within the range of ⅓ to ¾ wave length, preferably not greater than ½ wave length of the predetermined frequency.

To demonstrate the preferred size of my improved attenuation section I take, for example, an excitation frequency of 2450 HMz. For this frequency I provide a section about 8 inches long with a breadth of about 10 inches and a height of about 4½ inches. This accommodates an end opening of about 3 inches in height with space in the upper part of the casing for the special internal structures. The sheets which provide the internal linings along the walls may be about one-fourth inch thick. The plates 35 may be about one-half inch apart and extend in height about 1 inch (the wave length for 2450 HMz is about four inches). The lossy strips which are secured to the plates 35 may also be about one-quarter inch in thickness.

OPERATION

In operation, the microwave energy which passes through the first attenuation section C-1 enters the interior of section C-2 where it meets the lossy dry material of sheets 31, 32 and 33 lining the interior of the metal casing, and also passes into the mouths of passages 37 between plates 35 and proceeds by reflection between the plates 35 until it is absorbed by the material 38 or by the material 30 at the end of the passages. Substantially all of the microwave energy which enters section C-2 is absorbed therein, with practically none being permitted to be discharged to the atmosphere. We have found that the attenuation applicable to the reduced amounts of the energy passed into section C-2 is very efficient, reducing by a factor of more than 5 to 1 the energy which is permitted to be passed on.

We find that while the provision of the water load in section C-1 is efficient to remove most of the microwave energy tending to leak from the heating chamber it is not practical to attempt to remove enough of the energy by this method to satisfy all requirements. Further, it is not practicable to have in addition to the water load attenuation any device such as a reject filter. A reject filter is necessarily limited in size to a wave guide propagating energy in a single mode at the frequency which has been selected. What is desired is a device such as I have described which will handle multi-mode transmission of energy, and which can be constructed in a practical size to accommodate the approved frequency ranges.

In the foregoing description I have described an attenuation channel structure B which is in communication with the outlet opening from the heating cavity. It may be observed that if the conveyor belt 16 were run in the opposite direction the opening 21 would, in such case become the inlet opening and the attenuator section C-1 and C-2 would be guarding against leakage of energy issuing from the inlet opening to the heating cavity.

I prefer to provide an attenuation section C-1a similar to section C-1 but guarding against energy passing through the opening 20 and another attenuation section similar to section C-2 which can be adjacent section C-1a to attenuate energy which may pass through section C-1a.

Conveniently, water may be circulated into the coil 24 through pipe 40 and then into the coil 24a of section C-1a by means of pipe 41 and discharged through pipe 42.

Further, and particularly if the amount of energy leaking through opening 21 is not great, the attenuator section C-2 may be used exclusively for absorbing the energy leaking through the opening of the heating cavity. This may be done by not circulating the lossy liquid through section C-1 or by omitting this section altogether so that all energy passing through the outlet opening in the heating cavity enters the heating section C-2 and is attenuated therein.

I believe that the efficiency of my improved attenuating section C-2 may be due in part to the fact that the microwave energy absorbing material contained therein has a dielectric constant of from 1 to 10, usually between 2 to 5, which contrasts with the dielectric constant of water which is 80 or more, so that at the interface between air and water the dielectric ratio is about 80 to 1 whereas at the interface between air and absorbing material the dielectric ratio is usually not more than 5 to 1. This condition is believed to permit less reflection of energy when directed against our absorbing material (and consequently more efficient absorption) than would be the case where the energy moves against water. Further, the passages within my section C-2 between the plates 35 must receive the energy which moves toward the top broad wall, and this energy is not reflected back but it is absorbed therein. My improved attenuation section C-2 may, therefore, be used as the sole means of attenuation whenever the energy to be dissipated is not so great as to develop a large amount of heat. When the energy to be dissipated is so large as to require special radiation and carrying away of heat I prefer to use the C-1 section in front of the C-1 attenuator section.

In the foregoing detailed description I have set forth preferred embodiments of my invention and have given specific examples of structure and modes of practicing the invention, but it is understood that many changes and variations may be made, all within the spirit of the invention and scope of the appended claims.

What I claim is:

1. Microwave Applicator Apparatus comprising a casing providing a heating cavity and having openings through which material to be treated may be passed into and out of said cavity, means for exciting said cavity with microwave energy, an attenuating channel having its one end in communication with one of said openings and having at its other end an opening through which said material may be passed, said channel having conducting outer walls and having at one section thereof between said ends a lining adjacent to said outer walls formed of a sheet material which is lossy to microwave energy, a flat side of said sheet material being in contact with said walls, said section containing a plurality of passageways leading from the interior thereof to one of said outer walls, said passageways being formed by spaced plates of conducting material extending across said section.

2. Microwave Applicator Apparatus comprising a casing providing a heating cavity and having openings through which material to be treated may be passed into and out of said cavity, means for exciting said cavity with microwave energy, and an attenuating channel having its one end in communication with one of said openings and having at its other end an opening through which said material can be passed, said channel having conducting outer walls and containing at one section thereof a plurality of passageways leading from the interior of the channel to one of the outer walls, said passageways being formed by spaced plates of conducting material extending across said section.

3. Apparatus as set forth in claim 2 wherein each of said passageways contains a material which is lossy to microwave energy.

4. Apparatus as set forth in claim 2 wherein said passageways have closed ends and have a layer of said material across their ends and along at least one sidewall thereof.

5. Apparatus as set forth in claim 2 wherein said section is rectangular in cross section with broad top and bottom walls and wherein said passageways are vertical and extend upwardly from the interior of said section to their ends at said top broad wall.

6. Apparatus as set forth in claim 2 wherein said means is for exciting said cavity at a predetermined frequency and wherein said passageways have a depth of from one-eighth to three-eighths of the wave length of said predetermined frequency.

7. Apparatus as set forth in claim 6 wherein said passageways have a depth of about one-fourth wave length of said predetermined frequency.

8. Apparatus as set forth in claim 2 wherein said plates have a lining on one side thereof formed of a lossy material and wherein said plates are uniformly spaced and in planes parallel with each other whereby said passages are of uniform width throughout their depth.

9. Apparatus as set forth in claim 2 wherein said channel has an intermediate section between said heating cavity and said one section, means for circulating a lossy liquid through said intermediate section whereby microwave energy passing from said cavity into said one section may be at least partially absorbed in said lossy liquid.

10. Apparatus as set forth in claim 9 wherein said plates are lined on one side with a layer of lossy material.

11. In a microwave applicator an attenuator section having an open passage from one end to the other through which materials to be treated by the applicator may be passed, an outer metal casing, a plurality of spaced metal plates in said casing providing passages leading from the interior to one wall of said casing, said plates having a lining on one side thereof of a material lossy to microwave energy, whereby microwave energy entering said passages is absorbed in said lining.

12. Apparatus as set forth in claim 11 wherein said plates have their end portions turned forwardly with the end edges abutting the adjacent plates whereby the spacing between said plates is determined by the length of said forwardly turned end portions.

13. Apparatus as set forth in claim 11 wherein said frequency is about 2450 HMz and the depth of said passages is about 1 inch.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,858,022 Dated December 31, 1974

Inventor(s) Franklin J. Smith

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title page, line [73] "Canada" should read --California--.

Signed and sealed this 4th day of March 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

UNITED STATES PATENT OFFICE
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