

[54] **MICROWAVE APPLICATOR**
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3,665,141 5/1972 Schiffmann 219/10.55
3,451,014 6/1969 Brosnatan et al. 333/95 X

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[52] **U.S. Cl.** **219/10.55, 333/95 R**
[51] **Int. Cl.** **H05b 9/06**
[58] **Field of Search** **219/10.55; 333/95 R,**
333/98

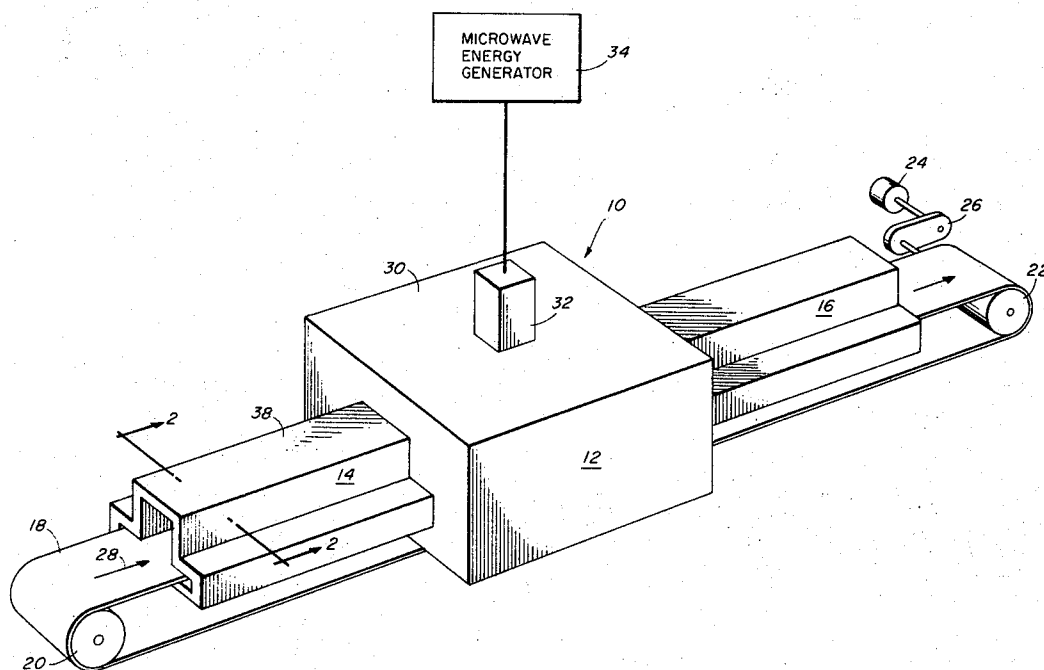
[56] **References Cited**
UNITED STATES PATENTS

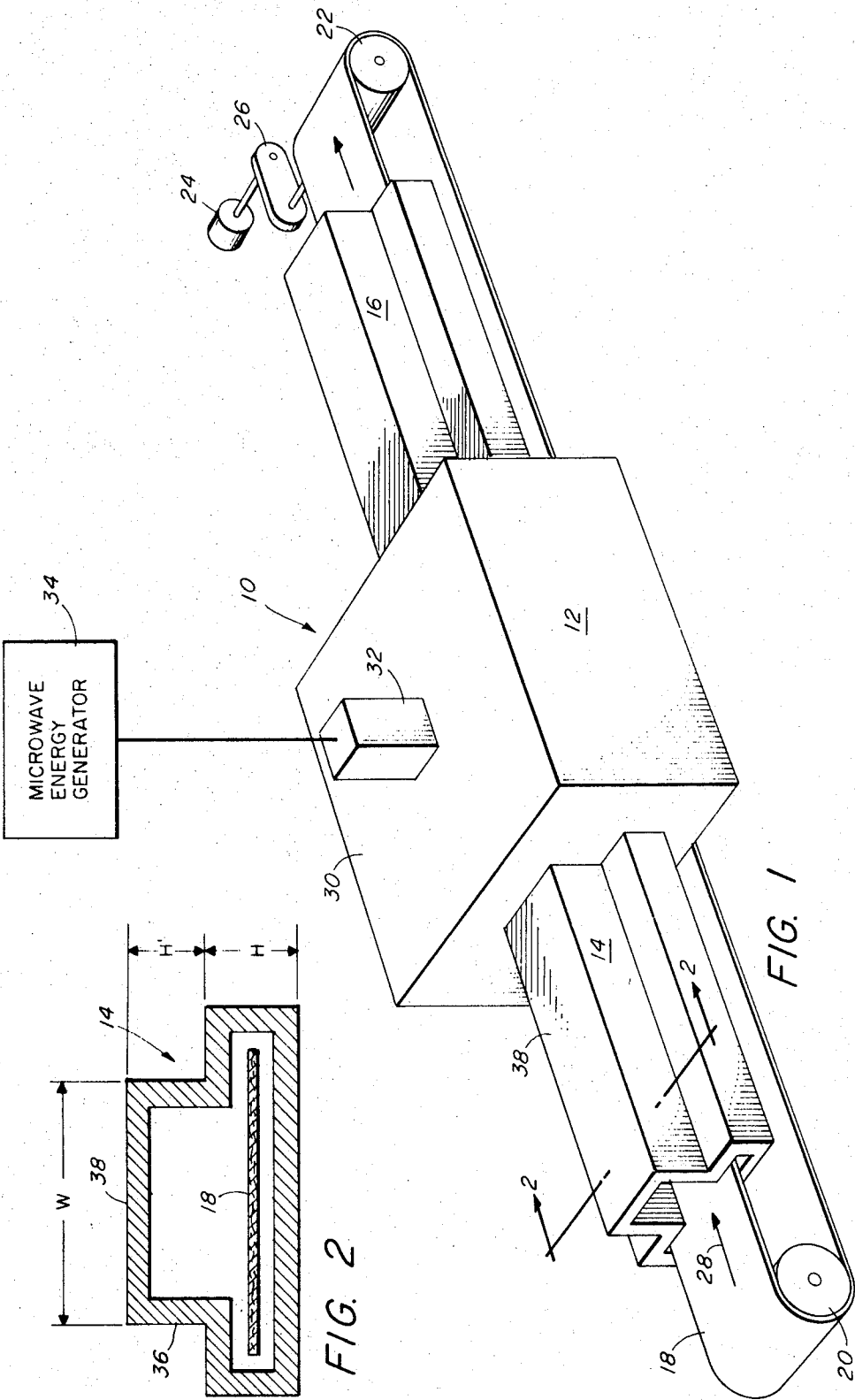
3,551,199	12/1970	Forster.....	219/10.55
3,624,335	11/1971	Dench.....	219/10.55
3,365,562	1/1968	Jeppson	219/10.55
3,597,565	8/1971	Johnson	219/10.55

[57] **ABSTRACT**

The entrance and exit waveguide access tunnel means of a conveyORIZED microwave applicator are structured to accommodate the width of the conveyor belt and at the same time substantially prevent excess leakage of energy from the open ports. The cutoff frequency characteristics of the waveguide sections are controlled to reduce energy leakage and still permit the transverse of a wide belt. The reduction of energy leakage is further enhanced by the provision of energy absorbing media in the access means.

3 Claims, 5 Drawing Figures





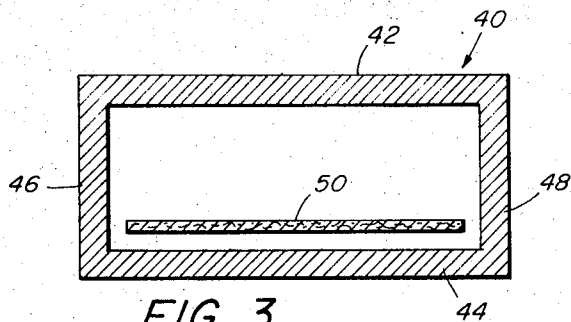


FIG. 3
PRIOR ART

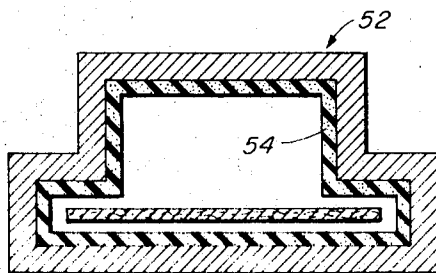


FIG. 4

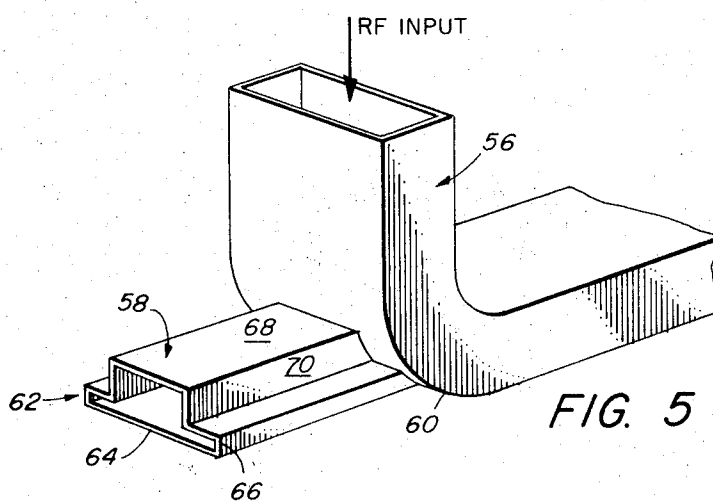


FIG. 5

MICROWAVE APPLICATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to microwave heating apparatus and, more particularly, to open ended access means for such apparatus.

2. Description of the Prior Art

Numerous food and industrial materials are now processed with conveyORIZED microwave energy applicators which radiate such energy within an enclosure having entrance and exit access waveguide means. The fast processing times, cleanliness, relatively low cost and an absence of radiated heat during operation make microwave heating more attractive in home and industry. Most of the materials have certain dielectric loss properties and essentially all of the microwave energy is absorbed by the product during the application of energy. For the purposes of the present specification, the term "microwave" is construed to refer to electromagnetic wave energy having wavelengths in the order of one meter to one millimeter and frequencies in excess of 300 MHz. The generators most frequently employed in such applicators are the magnetron, and high power vacuum triodes. The assigned frequencies of operation allocated by Federal and State regulatory bodies are 915 and 2,450 MHz. The access means communicating with the microwave oven enclosure handle TE modes of propagation where the cutoff frequency wavelength is equivalent to $\lambda_c = 2a$ where a represents the width of a rectangular waveguide.

ConveyORIZED microwave applicator devices generally provide for conveyor belts which must be wide enough to prevent the articles from falling off during the traverse through the tunnel means and microwave heating enclosure during operation. The width of the conveyor belt, therefore, imposes a mechanical limitation on the use of such equipment that the electrical cutoff frequencies of the entrance and exit means cannot be as carefully controlled as possible to prevent the escape of energy through the open ports. Numerous solutions and structures are utilized in the art to reduce the energy leakage. One example may be found in U.S. Pat. No. 2,868,939, issued Jan. 13, 1959, to R.V. Pound which provides for the placement of lossy energy absorbing panels in a vestibule or tunnel adjacent to the main oven enclosure. Numerous lossy materials are bonded to the panels to provide for energy absorption.

Other alternative prior art structures include the use of plural quarter-wave blocking filters with adjusting members in each of the entrance and exit tunnel waveguide means as disclosed in U.S. Pat. No. 3,048,686, issued Aug. 7, 1962, to W. Schmidt. The use of slots in the waveguide tunnel means have also been proposed with the slots having predetermined wavelength orientations to reflect any microwave energy attempting to escape through the tunnel means. In U.S. Pat. No. 3,624,335, issued Nov. 30, 1971, to E.C. Dench and assigned to the assignee of the present invention, slotted entrance and exit tunnel means are disclosed with lossy energy absorbing materials mounted in such a manner as to cover all of the slot discontinuities.

A still further example of prior art ingenuity may be found in U.S. Pat. No. 3,365,562, issued Jan. 23, 1968, to M.R. Jeppson, which provides for the circulation of a dielectric medium within chambers or compartments

adjacent to the entrance and exit ports to absorb the escaping energy.

All the foregoing prior art teachings reflect the need in past structures for widening the entrance and exit tunnel means to accommodate the wider conveyor belts to prevent the material from falling off. This results in electrical propagating conditions differing from the desired electrical characteristics of the rectangular waveguide means to attenuate any escaping energy.

SUMMARY OF THE PRESENT INVENTION

The present invention provides for entrance and exit waveguide tunnel means abutting an oven enclosure in which a first portion dimension accommodates the width of the transporting means. This width, however, is maintained over a height dimension which is minimal to prevent any microwave energy leakage and still allow for clearance of the conveyor belt. The second portion waveguide means structure is now reduced in width to a dimension to provide another energy propagating characteristic as near as possible to the ideal cutoff frequency characteristic for preventing escape of radiated energy in the oven enclosure. The access means ports may also be provided with high lossy microwave energy absorbing material such as colloidal graphite suspension or other materials bonded to the walls or provided in separate panels. A substantial portion of the access means cross-sectional area is, therefore, structured not on the basis of the transporting means as is true of all the prior art embodiments, but is rather principally dimensioned for the desired electrical parameters to prevent the escape of the microwave energy from the conductive heating enclosure as well as to accommodate the transported material.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention as well as details for the provision of preferred embodiments will be readily understood after consideration of the following description and reference to the accompanying drawings, wherein:

FIG. 1 is an isometric view of the illustrative embodiment of a conveyORIZED microwave applicator;

FIG. 2 is a detailed cross-sectional view of the illustrative embodiment taken along the line 2—2 in FIG. 1;

FIG. 3 is a detailed cross-sectional view of a prior art waveguide access tunnel means;

FIG. 4 is a detailed cross-sectional view of an alternative embodiment of the invention; and

FIG. 5 is an isometric view of a portion of a microwave applicator having a 90° E-plane band for the input of the microwave energy.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1 and 2 of the drawings, a conveyORIZED microwave energy applicator 10 is illustrated. The oven enclosure 12 is formed by substantially parallel conductive wall members. Access means with open ports at the ends comprise entrance and exit waveguide tunnel means 14 and 16. The materials to be heated are transported through the oven enclosure by means of a conveyor belt 18 of a low dielectric loss material carried by drums 20 and 22. Generally the conveyor belt is formed of a nonconductive material such as a plastic or leather composition and does not absorb microwave energy. Drum 22 is actuated by motor means 24 which

drives a reducing gear mechanism 26 with the direction of travel of the belt indicated by the arrows 28.

Electromagnetic energy at the assigned frequencies of either 915 or 2450 MHz is illustrated as radiating the enclosure 12 through a suitable aperture in top wall 30 by means of a rectangular waveguide section 32. The microwave energy source includes a generator, such as a magnetron, together with all the electrical and safety controls indicated generally by box 34. No specific details of the energy source has been referred in view of the belief that such means are now considered to be well known in the art.

The entrance and exit waveguide tunnel means 14 and 16 will now be described with attention being directed to FIG. 2. Conveyor belt 18 has a predetermined width to accommodate the articles to be transported through enclosure 12. The first portion of the rectangular waveguide tunnel 14 is, therefore, dimensioned to accommodate the width of the belt 18. As a result, this region of the access means has a first energy propagating characteristic. The height of this portion designated by the letter H is maintained as small as possible in order to prevent the escape of microwave energy as well as to accommodate the transporting means. The remainder of the waveguide means 14 has a reduced width designated by the letter W and a height H' to result in a second electrical propagation characteristic for any escaping energy and to accommodate the transported articles. Desirably the dimensions of the second or upper waveguide portion provided by walls 36 and 38 has a cutoff frequency wavelength as near to escaping radiated energy or $\lambda_c/2$. Exit waveguide tunnel means 16 is similarly dimensioned.

Referring now to FIG. 3 the advantages of the present invention over prior art embodiments will be evident. Rectangular waveguide section 40 comprises broad upper and lower waveguide walls 42 and 44 and narrow sidewalls 46 and 48. The dimensions of the rectangular waveguide are uniform throughout and are determined by the width of the conveyor belt 50. The invention, therefore, provides for plural cross-sectional areas of the waveguide access means of varying dimensions with the prevention of the escape of radiated energy as the primary consideration rather than the transporting means. The articles to be heated in the microwave applicator of the invention are still prevented from falling off the conveyor belt during traversal and the escape of radiated energy is substantially reduced.

Referring to FIG. 4 a means for the further attenuation of any escaping energy will be described. Waveguide section 52 constructed in accordance with the teaching of the invention is provided on all of the inside walls with an energy absorbing medium such as any of the carbonaceous products coated on such walls or im-

pregnated in panels of insulating materials to form a layer 54. The absorbing medium may be cemented to the metallic walls of the waveguide 52 by such means as a thermally conductive cement to insure the conduction of thermal energy resulting from the absorption of the microwave energy.

In FIG. 5 the application of the invention to other waveguide microwave energy applicator structures is shown. An input section 56 of rectangular waveguide having a substantially 90° E-plane bend is adapted in accordance with the invention with waveguide access tunnel means 58 introduced through an opening in bend portion 60 of the waveguide. The conveyor-belt-accommodating portion is provided by the lower portion 62 and defined by walls 64 and 66. The upper portion of the waveguide has the narrower upper wall 68 and sidewalls 70.

The access tunnel waveguide means disclosed herein will be equally applicable to any microwave energy applicators having open ports for the introduction of the material to be heated, particularly those of the conveyorized type. Such other variations, modifications and alterations will be evident to those skilled in the art. It is intended, therefore, that the foregoing detailed description of the invention and preferred embodiments be considered in the broadest aspects and not in a limiting sense.

I claim:

1. Conveyorized microwave heating apparatus comprising:

a source of electromagnetic energy;
a conductive enclosure with energy coupling means;
access tunnel means coupled to opposing ends of said enclosure;

means for transporting articles through said enclosure and access means enclosure;

said access means having superimposed portions of different cross-sectional dimensions throughout their length;

a first of said portions being dimensioned to accommodate said transporting means; and

the second portion is dimensioned to provide a cutoff frequency wavelength characteristic to substantially prevent escape of energy and accommodate said transported articles.

2. The applicator according to claim 1 wherein the inner walls of said access means are lined with an energy absorbing material.

3. The apparatus according to claim 1 wherein said energy coupling means comprise a rectangular waveguide having a substantially right angular bend and said access means are disposed at said bend.

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