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APPARATUS FOR DIELECTRIC HEATING

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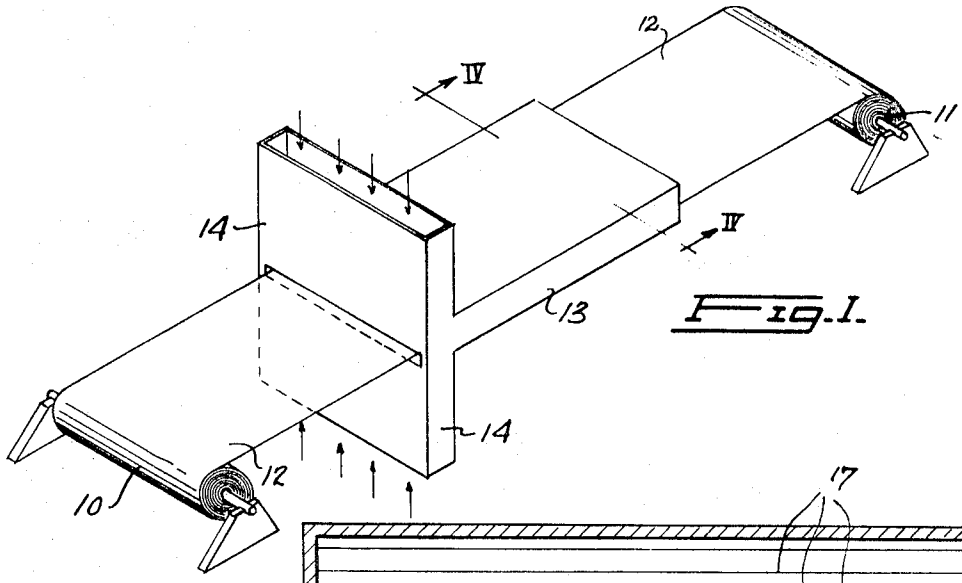

Fig. 1.

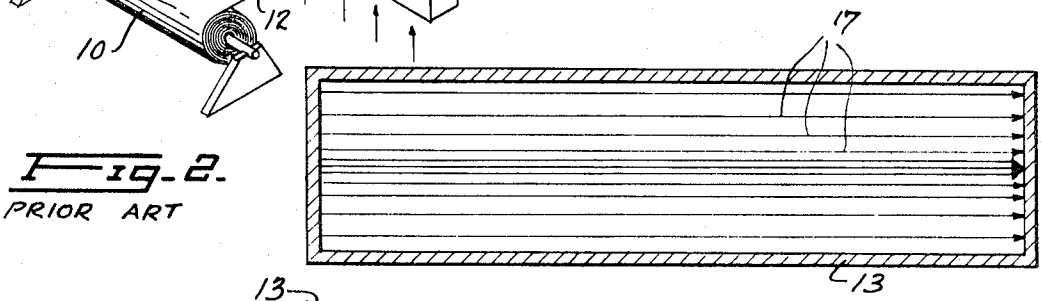

Fig. 2.
PRIOR ART

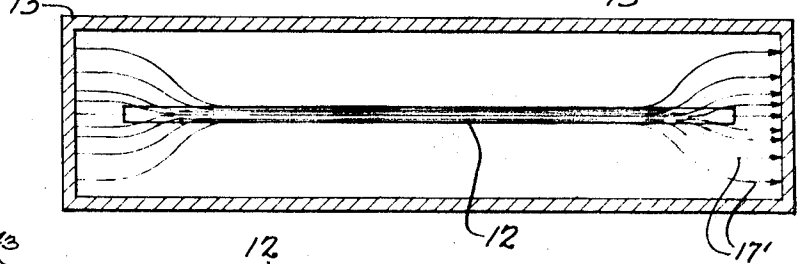

Fig. 3.
PRIOR ART

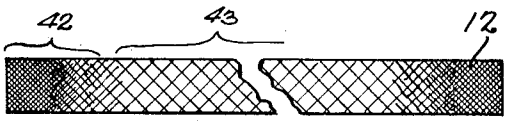

Fig. 3a.
PRIOR ART

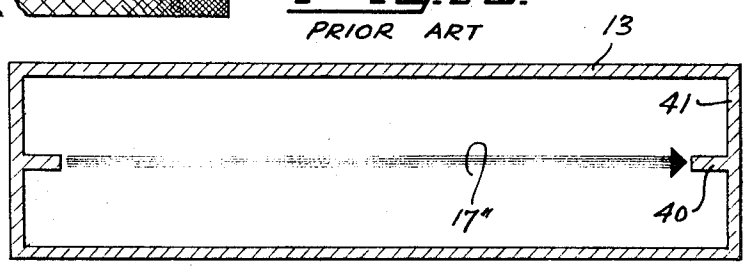

Fig. 4.

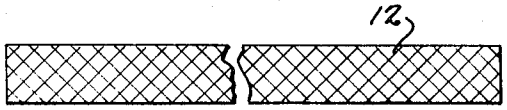

Fig. 4a.

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APPARATUS FOR DIELECTRIC HEATING

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U.S. Cl. 219—10.61 2 Claims

ABSTRACT OF THE DISCLOSURE

A web of material is longitudinally moved through a rectangular waveguide thereby being heated by microwave energy propagated along the waveguide. An electrically conductive vane is disposed in the plane that is occupied by the web, along each or both of the edges thereof, and is electrically connected to the waveguide such that the electric field yielding the energy transfer is prevented from losing intensity at said edges.

This invention relates to improvements in apparatus for dielectric heating, that is to say the heating of materials by microwave energy. The invention is particularly concerned with the drying of web-shaped articles, such as films, webs of paper or other material.

For this purpose it has already been proposed (United States patent application No. 563,606 of W. A. Cumming filed July 7, 1966) to use a waveguide of rectangular cross-section in which the web of material can be moved along its own longitudinal axis. The heating effect has been achieved by microwave energy preferably of the transverse electric mode known as the TE_{01} mode (employing the usual United States nomenclature). A wave of this operating mode has its electric field intensity concentrated in the centre plane of the waveguide, i.e. the plane extending across the greater dimension of the waveguide, equidistant from the upper and lower plates. The web has been arranged to move generally in this centre plane in order to obtain the result that the maximum intensity of the electric field lies within the web.

It was found that prior art apparatus as mentioned above worked well for drying the web over most of its width, but that there was a tendency for its edges to retain a considerable amount of moisture. If, however, an attempt were made to increase the energy input so as to heat the web to such an extent that the edges were dried adequately, the middle portion of the web would then be subjected to the danger of excessive heating.

It is, therefore, the principal object of the present invention to provide improved apparatus for dielectric heating of webs of material, comprising means for modifying the distribution of the microwave energy. Especially it is an object of the present invention to achieve said distribution of energy such that the drying process is carried out uniformly over the width of the longitudinally travelling web.

To this end, the invention consists of an apparatus for subjecting an elongated web-shaped workpiece to dielectric heating, comprising:

(a) A substantially electrically continuous waveguide of rectangular cross-section,

(b) Means for moving said web along its own longitudinal plane along a selected plane in the waveguide, said selected plane extending along the waveguide and across the greater cross-sectional dimension thereof at a location substantially central of the shorter cross-sectional dimension thereof,

(c) Means for propagating microwave energy in either

direction along said waveguide principally in the TE_{01} mode to yield an electric field having a concentration of lines of electric force in said selected plane occupied by the workpiece and having a wavelength at which at least a part of said workpiece will absorb said energy to generate heat,

(d) And electrically conductive vane means for modifying the intensity of the electric field at at least one of a pair of selected locations disposed each adjacent a respective one of the walls of the waveguide of said shorter dimension, said vane means being electrically connected to an adjacent part of said respective shorter dimension wall and extending towards an edge of said web.

Preferably, the field modifying means will be located at both side walls of the waveguide in order to take advantage at both edges of the web of the improved uniformity of heating obtained by the use of such field modifying means, which means in practice may take the form of vanes extending along the waveguide side walls and projecting inwardly towards the web edges.

While the principal utilization envisaged for the present invention is the drying of films or elongated webs of material, such as paper, the invention may also be used for other applications where it is desired to heat one substance selectively, provided that the article is of a shape suitable for being fed along a waveguide. For example, the apparatus can be applied for curing adhesives, or for setting plastics, always provided that the substance to be heated has a sufficiently high loss tangent at the frequency used to ensure that it absorbs an appreciable amount of energy. The apparatus can also be used for drying pulpwoods.

A specific embodiment of the invention is diagrammatically illustrated in the drawings by way of example only and not by way of limitation of the invention, the broad scope of which is defined in the appended claims.

In the drawings:

FIGURE 1 shows a perspective view of a waveguide used for drying a web of material;

FIGURE 2 is a cross-sectional view of a waveguide used in the prior art, showing the electric field of a TE_{01} wave;

FIGURE 3 is a view similar to FIGURE 2 with the web of material inserted;

FIGURE 3*a* is an enlarged cross-section of the material after processing in the waveguide shown in FIGURES 2 and 3;

FIGURE 4 is a cross-sectional view taken along the line IV—IV in FIGURE 1 and illustrating the present invention; and

FIGURE 4*a* is an enlarged cross-section of the material after processing in the waveguide shown in FIGURE 4.

FIGURE 1 shows a workpiece in the form of a web **12** of material, for example paper, that can be fed in either direction between one roll **10** and a second roll **11** by suitable driving means (not shown). The web **12** travels in the centre plane of a rectangular waveguide that consists of a main portion **13** and a pair of perpendicular side arms **14** from which microwave energy is fed into the main waveguide portion **13**. This general structure of the apparatus corresponds completely to that described in the above-mentioned prior application.

The microwave energy supplying the heat is of the TE_{01} mode, under which condition the highest intensity of the electric field exists theoretically in the centre plane of the waveguide which is occupied by the web **12**. In FIGURE 2 the electric field is indicated by the arrows **17** and may, in the specific cross-sectional plane and at the instant under consideration, be directed from left to right, with the spacing of the arrows **17** being repre-

sentative of the field intensity. As shown in FIGURE 2, the concentration of the electric field in the centre plane of an ordinary waveguide having plain inner surfaces is theoretically substantially uniform over the width of the waveguide, as long as the electric field is not disturbed.

If, however, a web **12** of dielectric material is placed in the waveguide, as shown in FIGURE 3, the electric field **17'** tends to be concentrated within the middle portion of the web **12** and to fan out at the edges thereof. As a result, the energy transfer is not uniform over the width of the web, leaving a greater amount of moisture in the edges **42** of the web than in its middle portion **43**, as diagrammatically indicated in FIGURE 3*a*.

To avoid this disadvantage, the specific form of the present invention disclosed in FIGURE 4 provides two electrically conductive vanes **40** disposed in the same centre plane as the web **12**, one vane being electrically connected, e.g. by soldering or welding, to each sidewall **41** along its centre line and extending therefrom towards the adjacent edge of the web **12**. As can be seen from the distribution of the arrows **17''**, the effect of the vanes **40** is thought to be to concentrate the lines of electric force, thereby equalizing the field intensity across the width of the web **12**.

It is to be understod that the shape and the distribution of the lines of electric force, as shown in FIGURES 2, 3 and 4, are diagrammatically represented for the purpose of explanation, and that the effect of the vanes **40** in an actual embodiment of the apparatus may be at least in part to produce a convergence of said lines rather than a concentration thereof over the entire width of the waveguide.

Instead of fixedly connecting vanes **40** to the sidewalls **41** of the waveguide, separate plates can be provided having means for adjusting their position in a direction perpendicular to the sidewalls **41**. A flexible electric connection between such plates, or to use a more general expression "vane means," and the sidewalls would then be required. With this construction the apparatus is rendered adaptable to different widths of webs, and the extent of heat concentration in the edges of the web can be selected as desired.

I claim:

1. Apparatus for subjecting a workpiece in the form of an elongated web to dielectric heating, comprising

(a) a substantially electrically continuous waveguide of rectangular cross-section,

(b) means for moving said web along its own longitudinal plane along a selected plane in the waveguide, said selected plane extending along the waveguide and across the greater cross-sectional dimension thereof at a location substantially central of the shorter cross-sectional dimension thereof,

(c) means for propagating microwave energy in either direction along said waveguide principally in the TE_{01} mode to yield an electric field having a concentration of lines of electric force in said selected plane occupied by the workpiece and having a wavelength at which at least a part of said workpiece will absorb said energy to generate heat,

(d) and electrically conductive vane means for modifying the intensity of the electric field at at least one of a pair of selected locations disposed each adjacent a respective one of the walls of the waveguide of said shorter dimension, said vane means being electrically connected to an adjacent part of said respective shorter dimension wall and extending towards an edge of said web.

2. Apparatus according to claim **1**, wherein a pair of said vane means is provided, each vane being fixedly connected to a respective shorter dimension wall of the waveguide and lying in said selected plane to project into the vicinity of a respective adjacent edge of said web.

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U.S. Cl. X.R.

219—10.55