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

(11) Publication number: **0 651 590 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94203064.4**

(51) Int. Cl.[6]: **H05B 6/46**, H05B 6/60

(22) Date of filing: **21.10.94**

(30) Priority: **27.10.93 IT MI932272**

(43) Date of publication of application:
03.05.95 Bulletin 95/18

(84) Designated Contracting States:
BE DE DK ES FR GB IT NL

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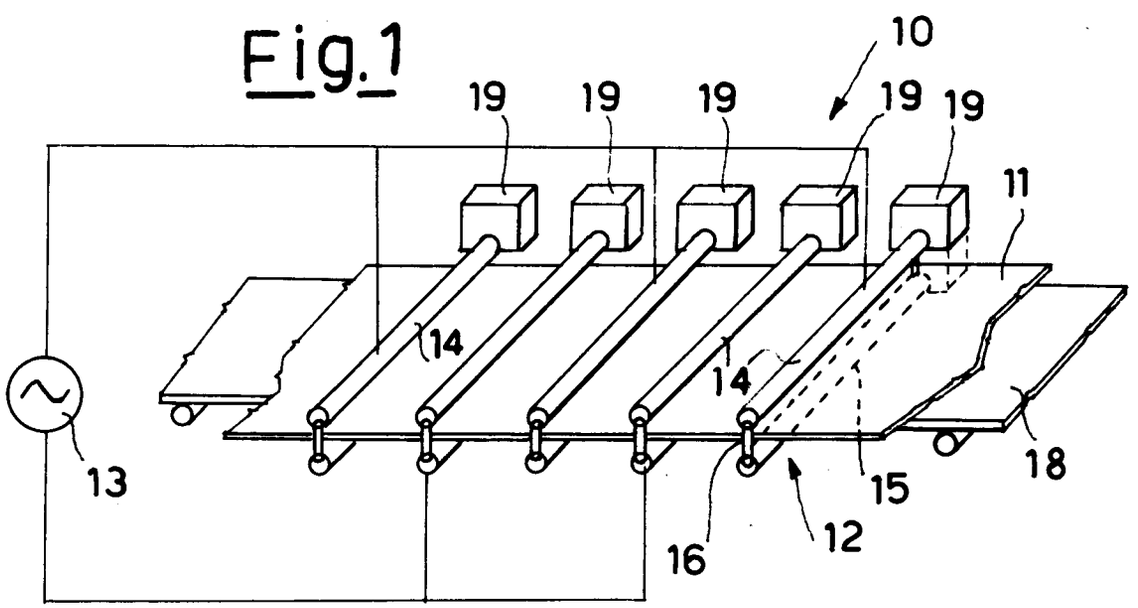
(54) Radio-frequency heating device for dielectric materials.

(57) A radio-frequency heating device (10, 110) for dielectric products (11, 111) comprising a plurality of electrodes (12, 112) disposed in side by side relation and connected to a high-frequency voltage generator (13, 113) for producing an electric field between each other. Each electrode (12, 112) comprises equipotential electrode surfaces (14, 15, 114, 115) disposed on opposite sides of the product received in the device.

Fig.1



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The present invention relates to a heating device for dielectric materials employing a radio-frequency electric field. In particular, such a device can be used for drying or heat-treating processes applied to thin dielectric materials, such as materials in the form of a plate, sheet or ribbon. The device may be advantageously used for drying or heat-treating foodstuffs too.

The advantages resulting from drying or heat-treating dielectric materials through the use of radio-frequency fields are well known in the art. The most typical applications are for example heat-treatment and/or drying of paper, paperboard, fabrics, carpets, hide, leather, rubber, plywood, wood and/or plastics laminate, textile yarn in the form of reels or skeins, plastic material, latex, loose or packaged foodstuffs, etc.

In radio-frequency heating plants, electrodes are generally present which are connected to a radio-frequency voltage generator to generate an electric field in the space occupied by the material to be treated. Obviously, the heating rate and amount depend on the power absorbed by the material and therefore the concentration of the electric field inside it.

For items having a fair three-dimensional extension, for example blocks of material, reels of yarn, etc., it is relatively easy to achieve high electric fields internal to the material, by merely placing the material between two flat electrodes parallel to each other.

On the contrary, the achievement of satisfactory concentrations becomes problematic in the case of foil elements, that is substantially two-dimensional items having a thickness smaller than the other dimensions. In such cases the absorbed power can be increased for example by increasing voltage between the electrodes, but this fact involves the risk of electric discharges between the electrodes and between the latter and the material, which will damage the material.

Even in the case of "three-dimensional" items, the use of known R.F. applying devices often gives rise to problems in terms of evenness of treatment resulting in non-homogeneous heatings, or, which is worse, localized burnings.

In an attempt to improve the features of the electric field, different electrode structures have been proposed. For example, electrodes made of a plurality of parallel tubes disposed alternately on either side of the material and connected to the generator have been proposed, such that the tubes on one side of the material have a potential different from the potential of the immediately close tubes disposed on the other side of the material. In this manner, field lines are obtained that pass from the tubes on one side to the tubes on the other side, passing through the material according to directions inclined to the perpendicular of the material itself or the sliding direction thereof. Such a solution however is only capable of offering a weak increase of the electric field in the material, above all for relatively thin materials, such as paper or fabric sheets or ribbons.

Electrodes formed of a plurality of parallel tubes disposed on one side alone of the material have been also proposed, which tubes are alternately connected to either pole of the generator so that field lines extend between each tube and the two tubes immediately close thereto, thereby slightly touching the material. Such a solution however, exhibits a high unevenness in terms of concentration and field direction over the material extension, areas having a good energy exchange being alternated with areas having a weak or zero energy exchange between the electrodes and the material, which will bring about a non-homogeneous heating of the material, this drawback being more apparent in the case of relatively thick materials.

Therefore, results are unsatisfactory, above all in the case of products continuously carried through the applying device by means of conveyor belts.

The general object of the present invention is to eliminate the above mentioned drawbacks by providing a device for applying a radio-frequency electric field to a dielectric material producing a relatively high power absorption in the material in a highly uniform manner, in particular for drying or heat-treatment.

In view of the above object, in accordance with the present invention, a radio-frequency heating device for dielectric products has been devised which comprises a plurality of electrodes disposed in side by side relation in a first direction and connected to a high-frequency voltage generator for producing an electric field between them, in which field the product to be heated is located, characterized in that each electrode comprises equipotential electrode surfaces disposed on opposite sides of the product received in the device for identifying a plane substantially normal to said first direction.

For better explaining the innovatory principles of the present invention and the advantages it offers as compared to the known art, possible embodiments applying said principles will be given hereinafter by way of example, with the aid of the accompanying drawings, in which:

- Fig. 1 is a partly perspective diagrammatic view of a first embodiment of a high-frequency heating device made according to the invention;
- Fig. 2 is a partly perspective diagrammatic view of a second embodiment of a high-

frequency heating device made according to the invention.

Referring to the drawings, two embodiments of a heating device according to the invention, intended for drying for example, are diagrammatically shown in Figs. 1 and 2. Corresponding elements in the two embodiments (generally identified by 10 and 110, respectively) will be allocated the same reference numbers differentiated by a hundred, for more convenience.

The device comprises a plurality of aligned electrodes 12, 112. The material may be, for example, either a dielectric continuous or discrete foil material 11, 111, such as a ribbon or sheet of paper, wood, etc., or a relatively thick, continuous or discrete dielectric material such as foodstuffs to be dried for usual production processes well known to a person skilled in the art. Conveying of the material within the device, for example by its introduction at one end of the device and emission at the other end thereof, can be carried out by any known means consistent with the material nature, as a person of ordinary skill in the art can easily conceive.

For example the material may be caused to slide and pass through the heating device from an inlet to an outlet end thereof, which is advantageous for a continuous production.

This conveyor means (identified by 18, by way of example, in Fig. 1), such as conveyor belts, roller conveyors or the like, can be at all events easily envisaged and therefore will not be further described herein. Advantageously, the electrodes are in alignment with each other in the sliding direction of the material to be treated so as to be disposed according to a plane parallel to the plane identified by the movement.

The electrodes are connected to a known high-frequency voltage generator 13, 113 in order to generate a radio-frequency electric field in the material treating space.

According to the innovatory principles of the present invention, each electrode comprises electrode surfaces equipotential with respect to each other and advantageously disposed symmetrically on the opposite sides of the travel path of the product for identifying a plane disposed transverse and normal to the travel path itself.

In particular, one embodiment is shown in Fig. 1 in which the electrode surfaces of each electrode are formed of two tubular conductive elements 14, 15 disposed parallel to each other on the two sides of the material and electrically interconnected with each other, for example by means of conductive end elements 16, so as to be kept substantially to the same electric potential. The tubular elements of each pair may also be supported by a means 19 for adjusting the mutual distance of same in order to enable adjustment of the space for passage of the products depending on the thickness of said products, for example in order to have the minimum possibile air distance left between the elements. The adjusting means 19 (optionally duplicated on both ends of the electrodes) can be worm screw means, running means or any other manual or motor-driven known means, as can be easily envisaged by a person skilled in the art and therefore they will not be shown in detail or further described.

An alternative embodiment is shown in Fig. 2 wherein the device 110 comprises electrode surfaces of each electrode 112 consisting of a conductive plate of small thickness, disposed in a plane transverse to the material 111 to be treated and provided with a central opening 117 forming a passage for the material. The upper and lower plate branches, 114 and 115, thus define the equipotential electrode surfaces disposed on the two sides of the material 111. Obviously, each plate can be of one piece construction or consist of conductive crosspieces 114 and 115 and conductive portions 116 interconnecting said crosspieces.

Electrodes 12 or 112 disposed close to each other are connected to different potentials so that electric field lines are established therebetween. For example, there is the possibility, as shown in Fig. 1, of connecting an electrode to a terminal and an electrode to the other terminal of the generator, in an alternate manner along the device extension or, as shown in Fig. 2, of sequentially connecting the electrodes, along the device extension, to a terminal of the generator, an earth potential and the other terminal of the generator.

In both cases electrodes of different potential are facing each other by pairs in a direction parallel to the travel path of the material to be treated. By virtue of the substantial symmetry of the equipotential surfaces of each electrode, electric field lines are obtained that run, at least close to the material, substantially parallel to the travel path thereof. The equipotential lines between two faced electrodes are therefore disposed substantially normal to the material surface. This produces the highest possibile power transferring between the field and the material, the voltage between the electrodes being equal. As a result, the material heating is much quicker and much more homogeneous than heating with machines having traditional electrodes, voltage between the electrodes being equal.

Thus, voltages sufficiently low to completely avoid a risk of electric discharges in the treated material can be maintained, even if at the same time heating or drying processes at a much higher speed than in known plants are achieved. This is particularly advantageous in the case of materials running through the machine for continuous work-

ings, because it is possible to keep high running speeds and consequently high production rates.

Obviously, the above description of embodiments applying the innovatory principles of the present invention is given by way of example only and must not be considered as a limitation of the scope of the invention as hereinafter claimed.

For example, the connections shown in Fig. 1 may be employed for the embodiment shown in Fig. 2 and vice-versa.

In addition, the plate electrodes of Fig. 2 may be also U-shaped instead of being of annular configuration, and the tubes of each electrode in Fig. 1 may be connected to one end alone or both of them.

Several elements may be disposed side by side in order to define several passages for products disposed in side by side relation. In this case, the electrodes in Fig. 2 can be provided with several side by side openings 117. The equipotential elements forming the electrodes can also be broken off along their extension, for example for enabling passage of conveyor elements for the products to be treated.

In addition, the electrodes can be coated or not with insulating material, as known in the art.

The proportions of the electrodes may be different from those shown in the figures. For example, the electrodes can be more extended in the movement direction of the material to be treated. The electrodes of Fig. 2, in addition, may be in the form of bored blocks instead of being embodied by cut plates.

The heating system herein described can be supplemented with auxiliary heating means, means for removing moisture, controlling drying, etc, as known in the art.

While in the figures a continuous foil material is shown, a device according to the invention may be advantageously employed for thicker materials too and also for a plurality of discrete materials, such as foodstuff packages.

Claims

1. A radio-frequency heating device (10, 110) for dielectric products (11, 111) comprising a plurality of electrodes (12, 112) disposed side by side in a first direction and connected to a high-frequency voltage generator (13, 113) for producing an electric field between them, in which field the product (11, 111) to be heated is located, characterized in that each electrode (12, 112) comprises equipotential electrode surfaces (14, 15, 114, 115) disposed on opposite sides of the product (11, 111) received in the device for identifying a plane substantially normal to said first direction.

2. A heating device according to claim 1, characterized in that each electrode (12) consists of a pair of tubular elements (14, 15) parallel to each other on opposite sides of the product (11, 111) to form one of said electrode surfaces.

3. A heating device according to claim 2, characterized in that the tubular elements (14, 15) of each pair are interconnected with each other at least at one of their ends.

4. A heating device according to claim 1, characterized in that each electrode (112) is formed of plate-like elements (114, 115, 116) disposed in said substantially normal plane.

5. A heating device according to claim 4, characterized in that the plate-like elements define an opening (117) for enabling passage of the product therethrough.

6. A heating device according to claim 5, characterized in that the plate-like elements are closed around the product passing therethrough.

7. A heating device according to claim 1, characterized in that the electrodes (12, 112) forming said plurality are alternately connected to a terminal and another terminal of the generator (13).

8. A heating device according to claim 1, characterized in that the electrodes (12, 112) are sequentially connected to a terminal of the generator (113), an earth potential and another terminal of the generator (113).

9. A heating device according to claim 1, characterized in that it comprises means (19) for adjusting the mutual distance of the equipotential surfaces of the electrodes.

10. A heating device according to claim 1, characterized in that it comprises conveyor means (18) for conveying the products along said first direction from an inlet end to an outlet end, at opposite ends of said plurality of side by side electrodes (12, 112).

11. A heating device according to claim 10, characterized in that the conveyor means comprises a continuous conveyor, the conveying plane of which is parallel to said first direction.

12. A heating device according to claim 11, characterized in that the equipotential surfaces of

each electrode are substantially symmetrical to the conveying plane of the product.

13. A heating device according to claim 1, characterized in that said first direction substantially coincides with an extension direction of the product.

Fig.1

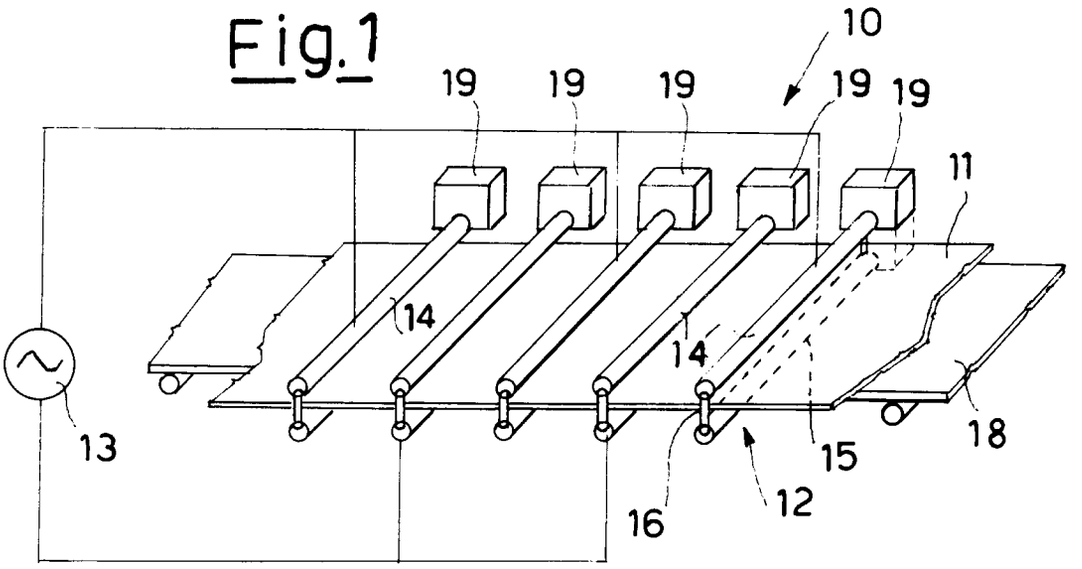
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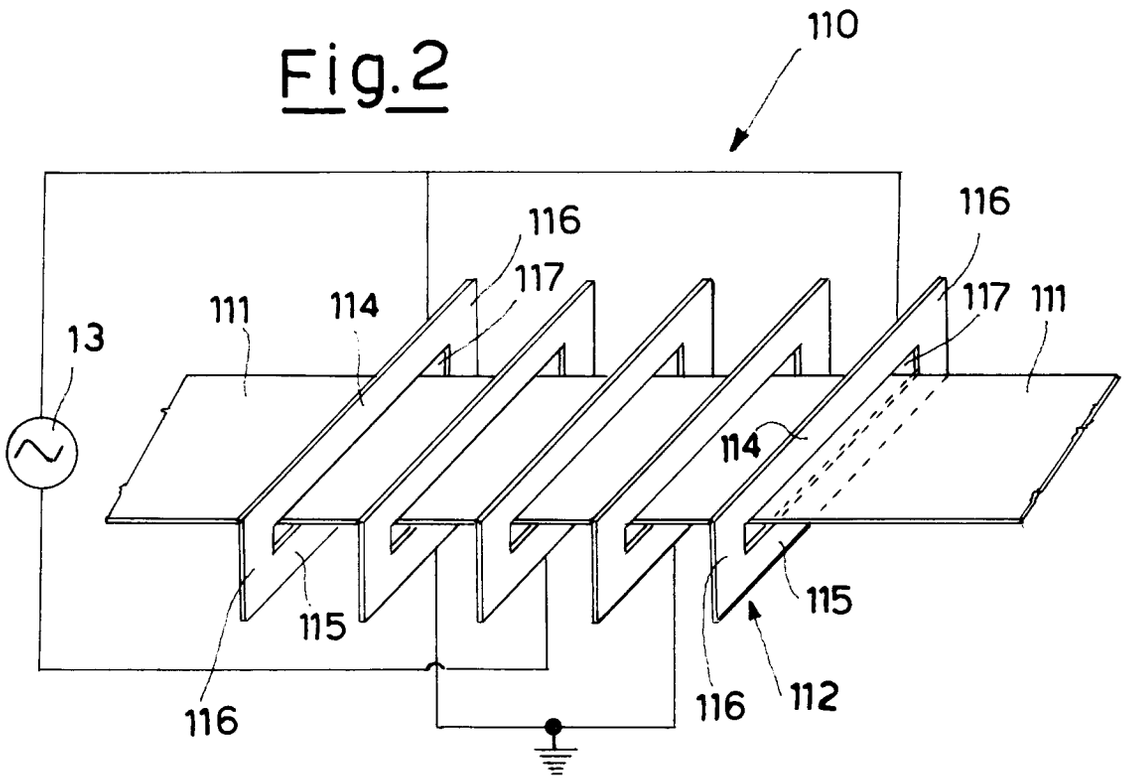
Fig.2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