Feb. 20, 1951 R. J. STANTON ET AL 2,542,589

ELECTRODE STRUCTURE AND METHOD FOR DIELECTRIC HEATING

Filed May 16, 1946

Fig. 1

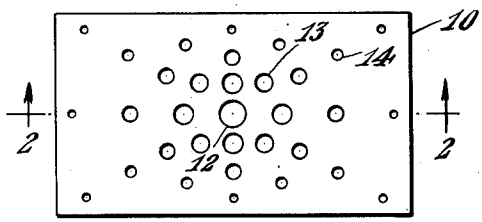


Fig. 5

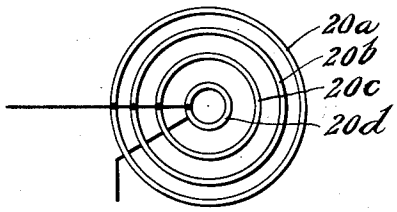


Fig. 2

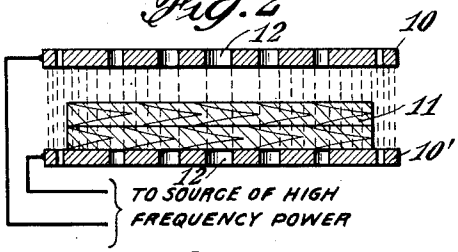


Fig. 6

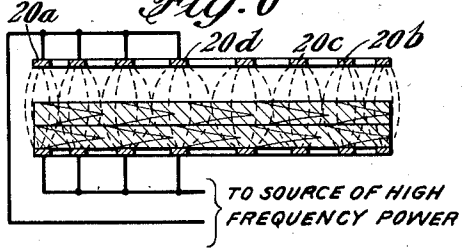


Fig. 3

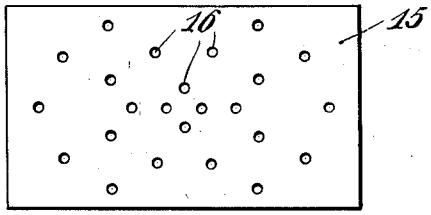


Fig. 7

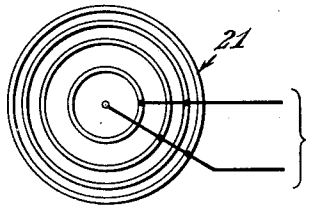


Fig. 4

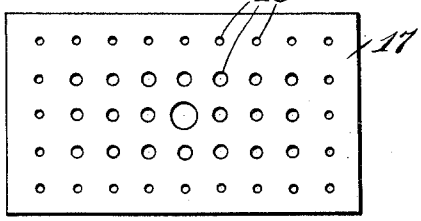
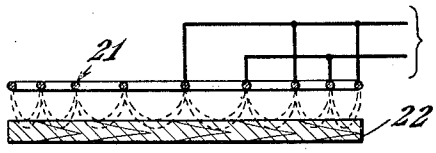


Fig. 8



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Patented Feb. 20, 1951

2,542,589

UNITED STATES PATENT OFFICE

2,542,589

ELECTRODE STRUCTURE AND METHOD FOR DIELECTRIC HEATING

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Application May 16, 1946, Serial No. 670,066

7 Claims. (Cl. 219—47)

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This invention relates to dielectric heating and to improved electrode structures therefor.

When an object is heated dielectrically as by being placed between two generally flat plate-like electrodes, the temperature of the object tends to rise substantially more rapidly at the center than at the perimeter. This is apparently principally due to the fact that substantially less heat is lost by radiation or otherwise from the central areas than at the exposed or more nearly exposed outer areas. In some cases the resulting lack of even approximate uniformity of heating throughout the work piece is a serious disadvantage.

According to the present invention, various novel and improved forms of electrodes are made available for satisfactorily overcoming the above noted difficulty, by providing in a simple way for the establishment of an electrostatic field, the middle portion of which is of a lesser intensity than the outer portions. Preferably in accordance with the invention, at successive points closer to the middle portion of the object to be heated, the field is of progressively decreasing intensity, thereby compensating for the smaller heat loss from the middle portion of the object.

Various other objects, features and advantages of the invention will clearly appear from the detailed description given below taken in connection with the accompanying drawings forming a part of the specification and illustrating by way of example, various forms of apparatus which may be used in carrying out the invention. The invention consists in such novel features, arrangements and combinations of parts and method steps as may be shown and described herein.

In the drawings:

Figure 1 is a plan view of one form of electrode structure made in accordance with the invention;

Fig. 2 is a vertical sectional view of a cooperating pair of electrodes as of Fig. 1 and showing therebetween an object being heated dielectrically by a field, the intensity of which decreases toward the middle of the object;

Figs. 3, 4 and 5 respectively are plan views of alternative forms of electrode structures embodying features of the invention;

Fig. 6 is a sectional view similar to that of Fig. 2 except for the use of electrodes of the type shown in Fig. 5; and

Figs. 7 and 8 respectively are plan and sectional views of another alternative form of electrode structure embodying features of the invention.

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With the form of the invention shown in Figs. 1 and 2, two cooperating electrodes 10 and 10', preferably of like construction, are indicated as connected to a suitable source of high frequency power which may comprise one of the various known types of high frequency generators as now commonly used for dielectric heating purposes. Between these electrodes a work piece 11 is indicated which for example may comprise two layers of wood, plastic composition or other dielectric material, which are to be secured together by a layer of thermosetting glue.

As best shown in Fig. 1, each of the electrodes 10 and 10' is formed with numerous perforations as at 12, 13, 14 for example, the diameters or areas occupied by these perforations respectively being smaller and smaller starting with the larger openings at the middle portion of the electrode and with the smaller openings nearer the perimeter. Also if desired as indicated in Figs. 1 and 2, the spacing of the successive openings or perforations is made greater and greater, starting with the closest spacing near the middle portion of the electrode and with the widest spacing adjacent the perimeter. As a consequence of this varying size and spacing of the perforations, as indicated by the dotted lines in Fig. 2, the intensity of the dielectric heating field set up between the electrodes will be greatest at the outside portion of the field, the central region having a substantially lower field intensity, the intensity at successive intermediate points more or less gradually diminishing inwardly of the structure.

The size and spacing of the perforations may be varied to secure the desired difference of field intensity and consequent heating effect as between the middle and outer portions of the field. In the usual case where substantially uniform heating throughout the work piece is desired, the perforations should be arranged so that the field intensity will progressively decrease inwardly of the object to an extent sufficient to substantially compensate for the smaller heat losses from the middle portions during the operation of heating the object. To this end, the size, arrangement and spacing of the apertures or perforations may be readily determined by trial and may depend upon the heat conductivity of the work piece being treated, the dimensions and spacing of the electrodes, and the possibilities for heat losses from various parts of the work piece due to radiation or convection.

With the alternative form of electrode 15, as shown in Fig. 3, the perforations as at 16 are all

of the same size but those closest to the middle area are arranged with the closest spacing, the spacing progressively increasing between successive perforations nearer the perimeter.

With the form of electrode **17** shown in Fig. 4, all of the perforations **18** are shown as equally spaced, but the diameters thereof progressively decrease from the middle area outwardly.

With each of the forms of Figs. 3 and 4, it will be apparent that more and more of the electrode surface is cut away at successive points inwardly of the electrode so that such electrodes may be used to establish dielectric heating fields, the intensity of which progressively decreases toward the middle region, as contrasted with the usual dielectric heating field in which the intensity is high at the middle and diminishes rapidly around the perimeter of the field.

With the form of the invention shown in Figs. 5 and 6, each of the two electrode structures may be comprised of a plurality of generally concentric ring elements as at **20***a*—**20***d*, all of which as shown in Fig. 6 may be connected in parallel to the source of high frequency power. As shown, each of the concentric conductive rings may have a cross section like that of a strip or ribbon, and the rings collectively form generally plate-like electrode structures having a series of annular openings or spaces therebetween which are progressively wider and wider toward the middle of the structure. Consequently, the dielectric heating field established thereby will in general be of progressively decreasing intensity inwardly of the field. This form of the invention is well adapted for the heating of circular or disc-like work pieces with a high degree of uniformity of each sector as compared with other sectors of the work piece. The various ring-like portions of the electrodes may be suitably supported by the connection wires therefor or otherwise as desired.

With the form of the invention shown in Figs. 7 and 8, a single electrode structure **21** is provided and this is made up of a series of generally concentrically arranged elements which may take the form of circular wires, the annular spaces therebetween being wider and wider toward the middle of the structure. As here shown, alternate circular wire elements are connected to one terminal of the high frequency source of power, the intermediate elements being connected to the other terminal whereby at any moment alternate elements will be of opposite polarity. As a consequence annular fields will be set up between each adjacent pair of the elements, these fields bulging outwardly of the elements and substantially merging together, as indicated in Fig. 8 so that a work piece as at **22** placed along adjacent the structure will be heated within its surface. And due to the greater spacing of the innermost electrode elements, the field intensity within the surface of the middle portion of the work piece will be less than at its peripheral areas.

While the invention has been described in detail with respect to particular preferred examples, it will be understood by those skilled in the art after understanding the invention that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended therefore in the appended claims to cover all such changes and modifications.

What is claimed as new and desired to be secured by Letters Patent is:

1. In apparatus for dielectric heating, a pair of plate-like electrodes adapted to be connected to a source of high potential high frequency current and between which dielectric objects may be placed to be heated, said electrodes being formed with perforations of such size and spacing as to occupy a substantial percentage of the middle areas of the electrodes, and successively lesser percentages of areas closer to the perimeters thereof, whereby the electrostatic field between the electrodes when charged, will be of greater intensity at successive points between the mid portions and the perimeters of the electrodes.

2. In apparatus for dielectric heating, a pair of plate-like electrodes adapted to be connected to a source of high potential high frequency current and between which dielectric objects may be placed to be heated, at least one of said electrodes being formed with numerous perforations which are closely spaced adjacent the middle portion of the electrode and successively more widely spaced at areas closer to the perimeter thereof, whereby the field between the electrodes when charged will have a substantially lesser intensity adjacent said middle portion than adjacent the perimeter.

3. In apparatus for dielectric heating, a pair of plate-like electrodes adapted to be connected to a source of high potential high frequency current and between which dielectric objects may be placed to be heated, at least one of said electrodes being formed with numerous perforations of varying sizes, successive perforations closer to the middle portion being larger whereby the field between the electrodes when charged will have a substantially lesser intensity adjacent said middle portion than adjacent the perimeter.

4. In apparatus for dielectric heating, a pair of electrode structures adapted to be connected to a source of high potential high frequency current and between which dielectric objects may be placed to be heated, said electrode structures each being formed with openings of such size and spacing that the openings occupy a substantial percentage of the middle electrode areas, and substantially lesser percentages of areas closer to the perimeters of the electrode structures, whereby the electrostatic field between the electrode structures when charged, will be of increasing intensity at successive points between the middle portions and the perimeters thereof.

5. In apparatus for dielectric heating, a pair of electrode structures adapted to be connected to a source of high potential high frequency power and between which dielectric objects may be placed to be heated, at least one of said electrode structures comprising a series of generally concentric rings with generally annular spaces therebetween, the spacing of the innermost rings being wider than the spacing of the outermost rings, whereby the middle portion of the field established by the electrodes will have a substantially lesser intensity than portions of the field surrounding such middle portion.

6. In apparatus for dielectric heating, a pair of electrode structures adapted to be connected respectively to the terminals of a source of high potential high frequency power and adjacent which dielectric objects may be placed to be heated, at least one of said electrode structures comprising a plurality of generally concentric ring-like portions, there being generally annular spaces between the electrode portions, which spaces at the mid-portion are wider than the outermost spaces, whereby the middle portion of

the field established by the electrode structures will have a substantially lesser intensity than portions of the field surrounding such middle portion.

7. An electrode structure for use in high-frequency heating apparatus, comprising a pair of electrodes, at least one of said electrodes having a plurality of holes therethrough, adjacent the center thereof, to render non-uniform the distribution of the dielectric field existing between said electrodes when a voltage is placed therebetween, the holes which are located farther from the center of said electrode being spaced farther from each other than are those which are located nearer the center of said electrode.

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