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DIELECTRIC HEATING APPARATUS PREFERABLY FOR HEATING GAS-POROUS MATERIAL

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Fig.1.

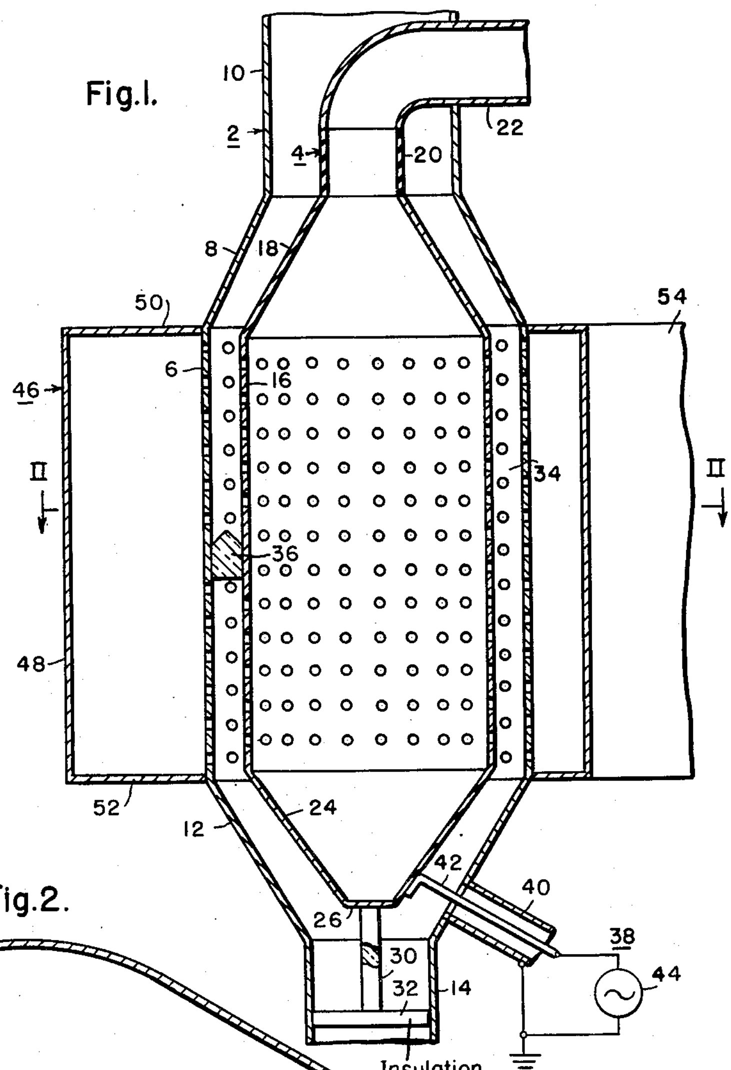
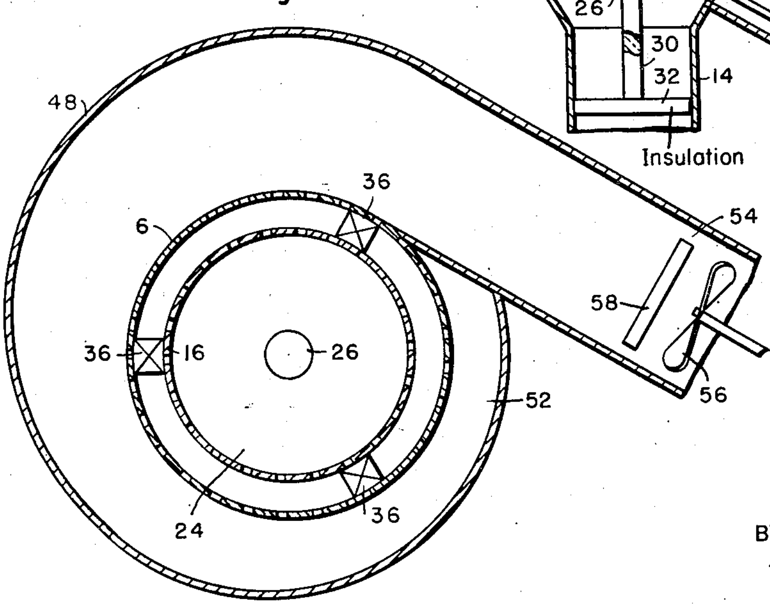


Fig.2.



INVENTOR

Marion E. Wade.

BY

B. L. Zangwill

ATTORNEY

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DIELECTRIC HEATING APPARATUS PREFERABLY FOR HEATING GAS-POROUS MATERIAL

Marion E. Wade, Kansas City, Kans., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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My invention is directed to improvements for dielectric heating materials of a type which give off a gas or vapor during such heating, although my invention may have broader uses.

An object of my invention is to provide a simple economical and rugged apparatus for dielectrically drying a mass of material while air or other gas is passed through the mass for removing vapors or gases that may be produced during the dielectric heating, or for aiding the heating of the material, or for any other purpose. An important ancillary object is dielectrically to heat the material as aforesaid so that the heating is uniform throughout the mass, within tolerable limits.

A further object of the invention is to provide apparatus for dielectrically heating granular material or the like which can be continuously fed to the apparatus for heat-treatment and continuously removed therefrom after the heat-treatment.

A further object of my invention is to provide an apparatus having a pair of heating-electrodes between which material is dielectrically heated, the apparatus having means which passes a hot air-stream between the heating-electrodes and through the material for one or more purposes such as to carry away gases and moisture given off by the material during the heating period, or to equalize the temperature gradient of the material between the heating-electrodes, or to help supply heat losses due to radiation and convection, or to safeguard against overheating.

In accordance with my invention I provide two upstanding concentric heating-electrodes each of which is formed of perforated metal or screening. The heating-electrodes are relatively insulated and a high-frequency electric field is established in the annular work-receiving space between them by any suitable means. The material to be heated is fed into the top of this annular work-receiving space and removed continuously from the bottom. A hot air-stream is caused to flow through the heating-electrodes and material; and, in accordance with an important feature of my invention, this hot air-stream moves generally radially through the material from the outside inwardly. The temperature of the air-stream is controlled so that it tends to keep the material at the desired temperature.

Objects, features and innovations of my invention, in addition to the foregoing, will be discernible from the following description of a form now preferred. The description is to be taken in

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conjunction with the accompanying drawing, in which:

Figure 1 is a vertical sectional view centrally through apparatus embodying my invention; and

Fig. 2 is a horizontal sectional view substantially on the line II—II of Fig. 1.

The preferred apparatus comprises on outer tubular member which is referred to in its entirety by the reference numeral 2, and an inner tubular member which is referred to in its entirety by the reference numeral 4.

The outer tubular member 2 comprises, in end-to-end relation, a perforated heating-electrode 6 having a circular cross-section, an upwardly tapered tube-section 8 and an upright cylindrical tube-section 10. Below the heating-electrode 6, the other tubular member 2 comprises a downwardly tapered tube-section 12 and a tubular tube-section 14 extending downwardly therefrom. All sections are metallic and all, except the heating-electrode 6, have solid walls.

The inner tubular member 4 comprises, in end-to-end relation, an inner perforated heating-electrode 16 having a circular cross-section, an upwardly tapered tube-section 18, an insulating tube-section 20, preferably of quartz or the like, and an exhaust duct-section 22 that passes out of the section 10 of the outer tubular member 2. Below the inner heating-electrode 16, the inner tubular member 4 comprises a downwardly tapered tube-section 24 terminating in a flat closing apex portion 26. All sections of the inner tubular member 4, except the heating-electrode 16, have solid walls, and all, except the insulating section 20, are metallic.

The inner tubular member 4 is supported by insulating means 30 attached to the apex portion 26. The insulating means 30 is carried on an insulator structure 32 securedly fixed to the tube-section 14 of the outer tubular member 2. Preferably, the inner tube-sections 18 and 24 taper at greater angles than their opposite facing tube-sections 8 and 12, respectively.

The heating-electrodes 6 and 16 are nested or concentric and provide an annular-like work-receiving space 34. A plurality or small distributed insulating spacers 36, of a material such as quartz, is secured to the heating-electrodes 6 and 16 so as to keep them suitably spaced, preferably at a uniform distance apart. High-frequency energy is delivered to the work-receiving space 34 between the heating-electrodes by any suitable means shown as a coaxial transmission line 38 having an outer grounded conductor 40 secured to the metallic section 12 of the outer tubular member 2, and an insulated conductor 42 that connects to the metallic section 24 of the inner tubular member 4. A tube-oscillator generator 44 feeds high-frequency energy to the transmission line 38.

Material to be heat-treated is fed at a controlled rate into the top of the upper section 10 of the outer tubular member 2 by any suitable means, such as a hopper. The material drops through this upper section 10 and passes downwardly through the space between the tapered members 8 and 18 and into the work-receiving space 34. Most of the heating of the material takes place in this space 34, although a slight preliminary heating of the material can be made to occur in the space between the tapered upper tube-sections 8 and 18. After heating, the material passes through the lower tubular section 12 in a well-understood manner, to any suitable receptacle or other work-receiving means.

In the operation of the apparatus described, the electric field provided is preferably such that by the time the material reaches the lower part of the work-receiving space 34 it is at substantially the desired temperature. The electric heating, however, is augmented by a heated air-stream which is fed to the work-receiving space 34 in an inward radial direction. For this purpose, an outer metallic duct 46 is placed around the outer heating electrode 6, the duct comprising a scroll-wall 48, a top wall 50, a bottom wall 52, and an inlet duct-section 54 connected to the largest part of the scroll. Air is fed to the inlet duct 54 by a fan 56, the air passing through heating means 58 which is suitably controlled in any desired manner so that the air passing into the scroll 48 will be at the desired temperature. This air passes through the perforations in the outer heating-electrode 6, then through the material in the work-receiving space 34, then through the perforations of the inner heating-electrode 16, then inwardly and upwardly through the tube-section 20, and leaving by the exhaust tube section 22 which may include a heat-exchanger if desired.

Because of the radial electrical field in the work-space 34, the field gradient is higher at a point radially nearer the inner heating-electrode 16 than it is at a point farther therefrom. Consequently, there will be a temperature gradient radially through the material in the work-space 34. By forcing the hot air from the outside inwardly, a balance can be made between the electrical heating so that the temperature gradient is made more uniform across the width of the material.

While the apparatus described is obviously of general application, it is recommended for heating granular material. The activation of silica gel is an example of such material. For such use, the work-receiving space can be about one inch wide, and have a voltage gradient thereacross of about 3,000 volts per inch maximum so as to avoid excessive arcing, the voltage source having the frequency of 30 megacycles per second. For such application, it is recommended that the air supplied to the scroll 48 be at about 1300° F., and the rate of air-flow controllable.

While I have described my invention in a form now preferred, it is obvious that its principles are of general application for many uses, and that the specific embodiment herein described is subject to wide modification.

I claim as my invention:

1. Dielectric heating apparatus of a type described comprising a pair of relatively insulated tubular upstanding heating-electrodes, each of said heating-electrodes being perforated across its surface, said heating-electrodes being nested with radial spacing to provide a work-heating space therebetween, means for supplying high-frequency energy to said heating-electrodes, and means for feeding work to be heated to said work-heating space, a fluid medium supply member positioned on one side of a first of said heating-electrodes, said fluid medium supply member surrounding said first heating-electrode, and a fluid medium exhaust member positioned adjacent the other of said heating-electrodes to remove said fluid medium from the side of the last-said heating-electrode which is opposite said first heating-electrode.

2. Dielectric heating apparatus of a type described comprising a pair of relatively insulated tubular heating-electrodes, each of said heating-electrodes being perforated across its surface, said heating-electrodes being nested with radial spacing to provide a work-heating space therebetween, means for supplying high-frequency energy to said heating-electrodes, means for feeding work to be heated to said work-heating space, a duct connected to the space inside the inner of said heating-electrodes, and an outer duct about the outer of said heating-electrodes, fluid medium supply means positioned on one side of said work-heating space, said fluid medium supply means surrounding said space, and fluid medium exhaust means positioned adjacent the opposite side of said work-heating space and adapted to remove said fluid medium from the last-named side of said space.

3. Dielectric heating apparatus of a type described comprising a pair of relatively insulated tubular heating-electrodes, each of said heating-electrodes being perforated across its surface, said heating-electrodes being nested with radial spacing to provide a work-heating space therebetween, means for supplying high-frequency energy to said heating-electrodes, means for feeding work to be heated to said work-heating space, and an exhaust duct connected to the space inside the inner of said heating-electrodes, and fluid medium supply means positioned adjacent the work-heating space to force the fluid medium through said space in a direction perpendicular to the direction of movement of the work through said space.

4. Dielectric heating apparatus of a type described comprising a pair of relatively insulated tubular heating-electrodes, each of said heating-electrodes being perforated across its surface, said heating-electrodes being nested with radial spacing to provide a work-heating space therebetween, means for supplying high-frequency energy to said heating-electrodes, means for feeding work to be heated to said work-heating space, an exhaust duct connected to the space inside the inner of said heating-electrodes, an outer supply duct about the outer of said heating-electrodes, and means for forcing hot gas through said outer supply duct for passage through said work-heating space and then to said exhaust duct.

5. Dielectric heating apparatus of a type described comprising a pair of tubular heating-electrodes, support means carrying said heating-electrodes so that they are upstanding and nested with radial spacing to provide a work-heating

space therebetween, said support means comprising insulation insulating the inner of said heating-electrodes from the outer of said heating-electrodes, said outer heating-electrode being grounded, said heating-electrodes having perforated surfaces, a gas-duct extending from an end of said inner heating-electrode, said duct comprising an insulating section, and means for feeding work to be heated to said work-heating space.

6. Dielectric heating apparatus of a type described comprising a pair of tubular members comprising heating-electrodes, support means carrying said heating-electrodes so that they are upstanding and nested with radial spacing to provide a work-heating space therebetween, said support means comprising insulating means insulating the inner of said heating-electrodes from the outer of said heating-electrodes, said outer heating-electrode being grounded, said heating-electrodes having perforated surfaces, a solid wall duct extending from an upper end of said inner heating-electrodes, said duct comprising an insulating section, and an insulated power supply conductor electrically connected to the other end of said inner heating-electrode.

7. Dielectric heating apparatus of a type described comprising a pair of tubular members comprising heating-electrodes, support means carrying said heating-electrodes so that they are upstanding and nested with radial spacing to provide a work-heating space therebetween, said support means comprising insulating means insulating the inner of said heating-electrodes from the outer of said heating-electrodes, said outer heating-electrode being grounded, said heating-electrodes having perforated surfaces, a solid wall duct extending from the upper end of said inner heating-electrodes, said duct comprising an insulating section, means for feeding work to the upper end of said work-heating space, and means for removing work from the lower end of said work-heating space.

8. Dielectric heating apparatus of a type described comprising a pair of tubular members comprising heating-electrodes, support means carrying said heating-electrodes so that they are upstanding and nested with radial spacing to provide a work-heating space therebetween, said support means comprising insulating means insulating the inner of said heating-electrodes from the outer of said heating-electrodes, said outer heating-electrode being grounded, said heating-electrodes having perforated surfaces, an exhaust duct extending from an upper end of said inner heating-electrode, said duct comprising an insulating section, an outer supply duct about said outer heating-electrode, means for forcing hot gas through said outer supply duct for passage through said work-heating space to said exhaust duct, and means for applying high-frequency power across said heating-electrodes.

9. Dielectric heating apparatus of a type described comprising a pair of tubular members comprising heating-electrodes, support means carrying said heating-electrodes so that they are upstanding and nested with radial spacing to provide a work-heating space therebetween, said support means comprising insulating means insulating the inner of said heating-electrodes from the outer of said heating-electrodes, said heating-electrodes having perforated surfaces, and a solid wall duct extending from the upper end of said inner heating-electrode, said duct comprising an insulating section, an insulated power supply conductor connected to said inner heating-electrode, an outer supply duct about said outer heating-electrode, and means for forcing hot gas through said outer supply duct for passage through said work-heating space and then to said exhaust duct, said tubular members having a work-receiving upper end leading to said work-heating space, and a work-leaving lower end.

MARION E. WADE.

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