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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

[Continued on next page]

(54) Title: HIGH EFFICIENCY HEAT GENERATOR

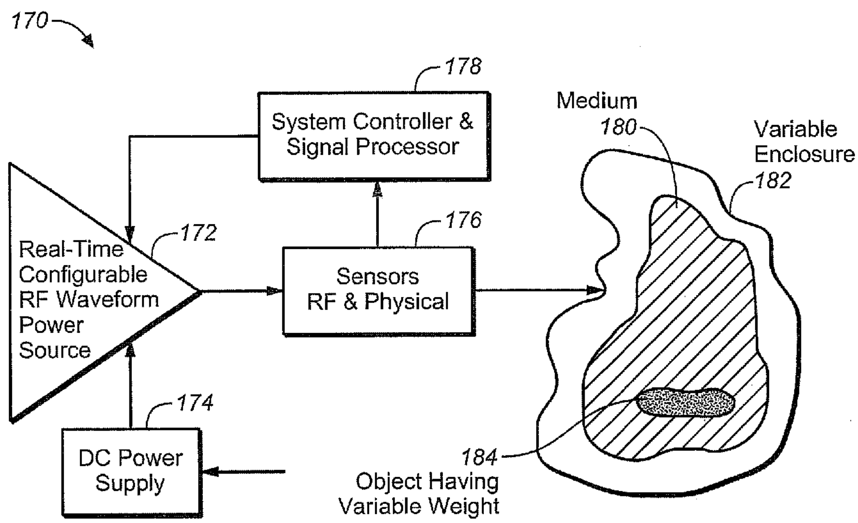

FIG. 8

(57) Abstract: A method for heating a medium that includes an object having a variable weight (184) is provided. The method comprises (A) placing medium including an object having variable weight (184) into a variable enclosure (182) having adjustable dimensions; (B) initiating a heating process by subjecting the medium including the object to a variable AC electrical field (172); (C) substantially continuously measuring (176) an impedance of medium including the object during the heating process; (D) adjusting dimensions of said variable enclosure to optimize the heating process; (E) adjusting parameters of the variable AC electrical field (174) to optimize the heating process; and (F) controlling (178) the heating process.

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Description

HIGH EFFICIENCY HEAT GENERATOR

TECHNICAL FIELD

[0001] The technology relates to the field of Radio Frequency (RF) heating systems.

BACKGROUND

[0002] Conventional clothes dryers heat a large volume of air that then passes over tumbling clothes. Water is extracted from the wet clothes by evaporation into the heated air. This conventional drying process is extremely inefficient, as at least 85 % of the energy consumed by the machine goes out the vent.

[0003] The stated above inefficiency of conventional drying process is due to the fact that air is a very poor heat conductor. Thus, for example, only very small engines can be air cooled efficiently. On the other hand, some large engines, for example, an automobile engine, or a high power motorcycle engine, use water cooling because water is much better heat conductor than air.

SUMMARY

[0004] This Summary is provided to introduce a selection of concepts that are further described below in the Detailed Description. This Summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0005] A method for heating a medium that includes an object having a variable weight is provided. The method comprises: (A) placing the medium including an object having a variable weight into a variable enclosure having adjustable dimensions; (B) initiating a heating process by subjecting the medium including the object having a variable weight to a variable AC electrical field; wherein the object substantially absorbs the medium in a first "cool" state; and wherein the object is substantially free from the medium in a second "heated" state.

[0006] The method further comprises: (C) substantially continuously measuring an impedance of the medium including the object having a variable weight during the heating process; (D) adjusting dimensions of the variable enclosure to optimize the heating process; (E) adjusting the parameters of the variable AC electrical field to optimize the heating process; and (F) controlling the heating process, wherein the heating process is completed when the object is substantially transferred into the second "heated" state.

[0007] In an embodiment of the present technology, an apparatus for drying a load of clothing uses a dryer drum having an anode plate configured to dry efficiently a load of clothing by directing the applied RF energy to water and use an air flow to remove the evaporated water.

DESCRIPTION OF THE DRAWINGS

[0008] The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the technology and, together with the description, serve to explain the principles below:

[0009] FIG. 1 illustrates an apparatus of the present technology for efficient drying a load of clothing.

[0010] FIG. 2 shows a dielectric dryer drum of the present technology.

[0011] FIG. 3 depicts a dielectric load model of the apparatus of the present technology for efficient drying a load of clothing

[0012] FIG. 4 illustrates basic dielectric heater concept of the apparatus of the present technology for efficient drying a load of clothing

[0013] FIG. 5 shows threaded rod anode plate mechanical driver of the apparatus of the present technology for efficient drying a load of clothing.

[0014] FIG. 6 depicts a complex anode plate mechanical driver including a non-rotating RF connection of the apparatus of the present technology for efficient drying a load of clothing.

[0015] FIG. 7 illustrates a complex anode plate mechanical driver with spring inductor of the apparatus of the present technology for efficient drying a load of clothing

[0016] FIG. 8 shows an apparatus of the present technology for efficient heating medium.

DETAILED DESCRIPTION

[0017] Reference now is made in detail to the embodiments of the technology, examples of which are illustrated in the accompanying drawings. While the present technology will be described in conjunction with the various embodiments, it will be understood that they are not intended to limit the present technology to these embodiments. On the contrary, the present technology is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the various embodiments as defined by the appended claims.

[0018] Furthermore, in the following detailed description, numerous specific-details are set forth in order to provide a thorough understanding of the presented embodiments. However, it will be obvious to one of ordinary skill in the art that the presented embodiments may be practiced without these specific details. In other instances, well known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the presented embodiments.

I. APPARATUS FOR EFFICIENT DRYING A LOAD OF CLOTHING.

[0019] In an embodiment of the present technology, FIG. 1 depicts the apparatus 10 for efficient drying a load of clothing comprising a DC power supply 12, a real time configurable RF Waveform power source 14, a system controller

& signal processor 16, a plurality of RF & Physical sensors 18, and a dryer drum 20. As it is disclosed below, in an embodiment of the present technology, the apparatus 10 is used to directly heat water in the laundry load by RF energy.

[0020] In one embodiment of the present technology, the level of the RF source DC supply voltage (12 of FIG. 1) is adjusted for optimum power transfer to varying real components of the load impedance. The adjustment of the level of the RF source DC supply voltage (12 of FIG. 1) optimizes the energy transfer efficiency and heating speed. Please, see discussion below.

[0021] In an embodiment of the present technology, FIG. 2 shows a dielectric dryer drum 40 of the present technology in more details. The dielectric dryer drum 40 is similar to a conventional hot air dryer in drum construction and air flow. It includes open impellers 42 used to help tumble the clothes during the drying process. The open impeller comprises a series of vanes attached to a central hub for mounting on the shaft without any form of side wall or shroud. Impellors 42, and surface contact shapes (vanes), are designed to direct wet clothing into a centered & symmetrical position for various load types and weight.

[0022] Referring still to FIG. 1, in an embodiment of the present technology, DC power supply 12 is implemented by transforming standard AC 240 Volt (or AC 120 Volt) line Voltage.

[0023] Referring still to FIG. 1, in an embodiment of the present technology, the real time configurable RF Waveform power source 14 can be implemented by using 1KW Class E Module PRF-1150 produced by IXYS.

Please, see www.IXYS.com.

[0024] Referring still to FIG. 1, in an embodiment of the present technology, the RF Waveform power source 14 is configured by adjusting the gate drive generator impedance in real time based on both measured load characteristics and RF generator output current & voltage waveforms.

[0025] In an embodiment of the present technology, the RF & Physical sensors 18 of FIG. 1 are used to implement a real time RF power source that optimizes efficiency of the power transfer into the variable load. This process requires real- time sensors for a number of dynamic parameters, including: load impedance, load RF voltage magnitude and envelope wave shape, load RF current magnitude and envelope wave shape, phase of RF voltage vs. current (dynamic load factor), and load voltage standing wave ratio (VSWR) presented to the RF power source over the range of load variation.

[0026] Referring still to FIG. 1, in an embodiment of the present technology, RF & Physical sensors 18 are used to measure a number of parameters during the heating process including: (a) an impedance at at least one RF frequency; (b) temperature variations of the load of clothing placed in the dryer drum; (c) moisture variations of the load of clothing placed in the dryer drum; (d) dimension variations of the dryer drum related to the movement of the anode plate (please, see discussion below); and (e) weight variations of the load of clothing.

[0027] In an embodiment of the present technology, RF & Physical sensors 18 include a non-contact thermal imaging temperature sensor that is based on the measuring thermal emission of radiation.

[0028] In an embodiment of the present technology, RF & Physical sensors 18 includes a non-contact moisture sensor, and sensors configured to measure dimension variations of the dryer drum related to the movement of the anode plate (please, see discussion below), and weight variations of the load of clothing.

[0029] In an embodiment of the present technology, the RF & Physical sensors 18 can be implemented by using MCT 360 **NIR** Transmitter that is a multiple constituent sensor configured to monitor moisture, load weight, load thickness, etc. from the same transmitter, continuously over the dynamic drying cycle.

[0030] In an embodiment of the present technology, the RF & Physical sensors 18 includes an RF impedance sensor that can be implemented by using Agilent E4991A RF Impedance/Spectrum Analyzer that can measure RF impedance in the wide range (1 MHz - 3 GHz). The Agilent E4991A RF Impedance/Spectrum Analyzer derives the Impedance of a device under test (DUT) from measured voltage and current values.

[0031] Referring still to FIG. 1, in an embodiment of the present technology, the system controller & signal processor 16 can be implemented by using Altera® FPGAs. More specifically, Nios® II embedded processor can be used to create a microprocessor-based system that is customized to enable automation and control of the heating drying process of the present technology.

[0032] Referring still to FIG. 1, in an embodiment of the present technology, the system controller & signal processor 16 implements a dryer control system, by enabling the following functions: (a) collecting data inputs from all above described sensors; (b) providing real-time optimized DC supply voltage; (c) implementing load inductor pre-positioning; (d) adjusting output device gate voltage waveform and gate driver source impedance; and (e) implementing appropriate adjustment of the drying process depending on the load type, size, water content, user settings of cloth types, and desired level of final dryness.

[0033] Referring still to FIG. 1, in an embodiment of the present technology, the system controller & signal processor 16 provides hosting for all system data processing and provides an external data port for system diagnostics and maintenance.

[0034] Referring still to FIG. 1, in an embodiment of the present technology, the system controller & signal processor 16 utilizes user inputs for clothing type (delicate, cotton, etc.) and desired level of dryness to optimally control the drying process.

[0035] The apparatus 10 (of FIG. 1) comprises a high efficiency, solid-state, energy source/mechanical arrangement RF dielectric heating system for water (or other liquids) drying applications. The key concept is providing heat directly to the liquid in a load object that was previously (in the prior art) heated with hot air for evaporative drying. Heating the water directly is much more efficient process than heating the air used for evaporation. For example, the apparatus 10 (of FIG. 1) comprises an electric clothes dryer.

[0036] The apparatus 10 (of FIG. 1) is configured to convert electrical power into heat in a new and completely unique way. If the apparatus 10 (of FIG. 1) is applied to use in electric clothes drying, it results in drying a typical load of clothes with less than 50% energy, more than twice as fast, and at at least half of the temperature rise as compared with prior art conventional dryers. Please, see discussion below.

[0037] As opposed to high frequency microwave cavity oven that concentrates heat only on the surface of an object being heated due to very short wavelengths used, the apparatus 10 (of FIG. 1) of the present technology is configured to use RF radiation that heats the volume of the load of clothing thus removing the moisture from the load in a more efficient manner

Example I

For instance, the RF is in the range of 1-250 MHz.

[0038] In an embodiment of the present technology, the RF electrical model of the apparatus 10 (of FIG. 1) for efficient drying a load of clothing is reduced to a dielectric load model 60 as depicted in FIG. 3. The drum has a fundamental capacitance, 62 based on its physical dimensions and air dielectric permittivity. The water in the load has an RF resistance 64 related to the amount of water contained. The materials in the load add an additional capacitance 66 to the model, based on their dielectric constant > 1. Thus, the net impedance 68 of the load is:

$$Z = R + jX \qquad \text{(Eq. 1)}$$

[0039] In an embodiment of the present technology, the basic dielectric heater concept 80 of the apparatus 10 (of FIG. 1) is illustrated in FIG. 4. The push rod A 82 moves the anode plate C 84 toward the moist load 86 to optimize the RF load resistance R 88 (please, see Eq. 1) at the RF feed point D 90.

[0040] The spacing distance B 92 has the minimum width consistent with the softness compressibility of the load materials. The variable tuning inductor 94 adjusts its value to tune out the +jX (please, see Eq. 1) of the load 86, thus yielding a pure resistive load, R (please, see Eq. 1) at feed point D 90.

[0041] In an embodiment of the present technology, referring still to FIG. 4, RF power P 96 is applied, proportionate to the amount of heating required by the load. The level of RF power P 96 is adjusted by setting the level of DC voltage Vdc 98 to a proper level for the given load resistance R (please, see Eq. 1).

Example II.
1 KW of power will heat 717g of water 20 deg C in 1 minute.

[0042] In an embodiment of the present technology, referring still to FIG. 4, the drying process consists of alternating cycles, wherein each cycle comprises the following steps: (a) RF dielectric heating the load 86 in a fixed, non-rotating position where the anode plate C 84 is adjacent to the load; (b) moving the anode plate C 84 back to allow tumbled air drying of the heated load 86; (c) moving the anode plate C 84 forward towards the load 86; and (d) repeating the steps (a)-(c). In this embodiment, anode plate C 84 in the dryer drum 91 moves close to the clothes load 86 to minimize parasitic air/load capacitance jX 0 and to optimize the resistive (real) R component of the load 86.

[0043] In an embodiment of the present technology, referring still to FIG. 4, the drying process comprises RF dielectric heating of a rotating, tumbling load 86.

[0044] In an embodiment of the present technology, FIG. 5 shows threaded rod anode plate mechanical driver 100 of the apparatus 10 (of FIG. 1) of the present technology for efficient drying a load of clothing

[0045] In this embodiment of the present technology, the anode plate 102 is a single piece, slotted at C 104 to allow movement over the impellers.

[0046] In this embodiment of the present technology, a rotating RF connection A 106 is used for receiving RF energy from a fixed, externally located RF power source (not shown). Rotating threaded rods 112 (and 114), connected to the mating threaded anode plate 102 at B 116 (and C 104) move the anode plate 102 forward and backward. Thus, the anode plate 102 rotates with the drum (108 & 110).

[0047] In one embodiment of the present technology, gear drives (not shown) derived from the rotating drum could be used to turn the rods 112 and 114.

[0048] In one embodiment of the present technology, separate motor(s) (not shown) could be used to turn the rods 112 and 114.

[0049] In an embodiment of the present technology, FIG. 6 shows complex anode plate mechanical driver 120 of the apparatus 10 (of FIG. 1) of the present technology for efficient drying a load of clothing.

[0050] In this embodiment of the present technology, the RF power source (not shown) is connected to a non-rotating telescoping rod 122. The non-rotating telescoping rod 122 is attached to the back plate 124 at D 125. The non-rotating telescoping rod 122 provides a flexible RF connection from the RF power source (not shown) to point D 125.

[0051] In this embodiment of the present technology, the anode plate comprises a three piece structure. The first part of the anode plate is a metal back plate 124 which does not rotate with the drum 126. The diameter of metal back plate 124 is such that impellers can rotate at B 128 without interference.

[0052] In this embodiment of the present technology, the second part of the anode plate is a metal front plate 130 bonded with an insulator plate 132 (the third part of the anode plate), which rotates with the drum 126. Both the metal front plate 130 and the insulator plate 132 are slotted to allow movement over the impellers.

[0053] An air gap 134 between the rotating front plate 130 and fixed back plate 124 is provided. The air gap 134 should be sufficiently wide to ensure, with manufacturing tolerances, that no frictional contact exists between the rotating front plate 130 and the fixed back plate 124.

[0054] In one embodiment of the present technology, referring still to FIG. 6, a shaft bolt 136 is attached at A 138 to hold the anode plate assembly at a fixed overall thickness during front-back movement of the anode plate.

[0055] In one embodiment of the present technology, referring still to FIG. 6, a geared-periphery clutch ring 140 at C142 can be engaged to mesh with gear- edged impellers to move the anode plate.

[0056] In one embodiment of the present technology, FIG. 7 illustrates a complex anode plate mechanical driver with spring inductor 150 of the apparatus 10 (of FIG. 1) of the present technology for efficient drying a load of clothing.

[0057] A complex anode plate mechanical driver with spring inductor 150 of the apparatus 10 (of FIG. 1) of the present technology for efficient drying a load of clothing is substantially the same device as depicted on FIG. 6 complex anode plate mechanical driver 120 plus an additional element- a spring inductor 152 that connects the non-rotating telescoping rod 154 to a non-rotating RF connection 154.

[0058] In this embodiment of the present technology, the power transfer of the RF source to the drying load is optimized by using a spring-like RF variable tuning inductor 150 configured to minimize the reactive effect of the load of both the variable positions of the anode plate and the load dielectric effects.

[0059] In an embodiment of the present technology, referring still to FIG. 7, the reactance of the spring-like RF variable tuning inductor 150 is adjusted (minimized) by varying its length by using an electric motor or by gearing from the rotating drum 156.

[0060] In an embodiment of the present technology, referring still to FIG. 7, the position of the anode plate 156 is adjusted to optimize the real component R of the complex impedance load (please, see Eq. 1).

[0061] In an embodiment of the present technology, (not shown) electrical connections of RF power with all RF source electronics located outside the drum, in a fixed position to the rotating drum are implemented by a mechanically connected "rotating RF commutator".

[0062] In an embodiment of the present technology, electrical connections to the rotating drum are implemented by a capacitive rotating RF commutator, using concentric metal cylinders, separated by cylindrical spacers of dielectric insulating material (not shown).

[0063] In an embodiment of the present technology, a rotating mechanical DC commutator (slip ring) with RF source electronics is located as a module on the rotating drum (not shown).

[0064] In an embodiment of the present technology, data connection, for the sensors and control functions of the rotating module, is implemented by using a wireless modem such as IR.

[0065] In an embodiment of the present technology, the apparatus 10 of FIG.1 provides an efficient RF dielectric heating system for drying applications by applying the RF heating energy directly to liquids for drying "wet" materials instead of the prior art drying process when the heating energy was applied to heat the air.

[0066] In an embodiment of the present technology, the apparatus 10 of FIG.1 is further optimized by using an RF power source whose optimum load line is real time adaptable to the dielectrically heated load.

[0067] In an embodiment of the present technology, the apparatus 10 of FIG.1 is further optimized by using a moving capacitive coupling plate for optimized RF power transfer.

0068] In an embodiment of the present technology, the apparatus 10 of FIG.1 is further optimized by using a tuning process, wherein a spring-like tunable inductor (no RF switching or sliding contacts) is used to tune out the capacitive reactance of the load. In addition, a variable DC voltage source is configured to implement the RF power transfer for the real (resistive) part of the load impedance.

[0069] In operation, the apparatus 10 of FIG. 1 implements the method for heating a medium (water) that includes an object having a variable weight (load of clothing) placed into a variable enclosure (a dryer drum having an anode plate).The load of clothing substantially absorbs water in a first "cool" state, and is substantially free from water in a second "heated" state.

[0070] In an embodiment of the present technology, the method for drying a load of clothing (not shown) comprises the following steps: adjusting dimensions of anode plate to optimize the heating process; adjusting the parameters of variable AC electrical field to optimize the heating process; and controlling the heating process, wherein the heating process is completed when the load of clothing is substantially dry (transferred into a "heated" state).

0071] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of using at least one electromechanically driven push rod (82 of FIG. 4) to both move and support the anode plate (84 of FIG. 4).

[0072] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of using at least one push rod (82 of FIG. 4) to move the anode plate (84 of FIG. 4) toward the moisture load (86 of FIG. 4) to maximize an RF load resistance (88 of FIG. 4) at an RF feed point (90 of FIG. 4).

[0073] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of using at least one push rod (82 of FIG. 4) to move the anode plate (84 of FIG. 4) toward the moisture load (86 of FIG. 4) wherein a variable tuning inductor (94 of FIG. 4) is configured to tune out reactance of the load (92 of FIG. 4) resulting in the load having a substantially real value resistance R.

[0074] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of rotating the drum (91 of FIG. 4) in two directions, wherein the first rotation of the drum (91 of FIG. 4) is configured to move the anode plate (84 of FIG. 4) into the load (86 of FIG. 4) for dielectric heating, and wherein the second rotation of the drum (91 of FIG. 4) is configured to allow space for air flow to remove moisture from the heated clothes load (86 of FIG. 4).

[0075] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of optimally configuring the shape and capacity of the dryer drum (91 of FIG. 4) internal dimensions (92 of FIG. 4) in both fixed and variable ways to accommodate for different kind of fabrics and different kind of load (86 of FIG. 4).

[0076] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of pre-heating the air inside the dryer drum (91 of FIG. 4) for better water evaporation from the load of clothing (86 of FIG. 4).

[0077] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of optimizing the heating process by using a tuning inductor (94 of FIG. 4).

[0078] In an embodiment of the present technology, tuning inductor (94 of FIG. 4) is selected from the group consisting of: a variable spring-like RF tuning inductor; a variable ferrite core tuning inductor; and a roller coil tuning inductor.

[0079] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of optimizing the heating process by adjusting the input drive generator impedance, voltage waveform and duty cycles to the RF output devices in real-time, based on both measured load characteristics and RF generator output current & voltage waveforms.

[0080] In an embodiment of the present technology, the method for drying a load of clothing (not shown) further comprises the step of using a dryer control system (16 of FIG. 1) to control the heating process.

[0081] In an embodiment of the present technology, the step of using a dryer control system (16 of FIG. 1) to control the heating process further comprises the step of measuring temperature and power load to calculate the moisture context.

[0082] In an embodiment of the present technology, the step of using a dryer control system (16 of FIG. 1) to control the heating process further comprises the step of calculating the drying time.

[0083] In an embodiment of the present technology, if the apparatus 10 is used in a drying facility for commercial operations, the step of using a dryer control system (16 of FIG. 1) to control the heating process further comprises the step of scheduling the completion of the drying process to optimize commercial operations.

[0084] In an embodiment of the present technology, wherein the system controller and signal processor 16 of FIG. 1 further includes the Internet access via a wireless access (for example, via Wi-Fi), the step of using a dryer control system (16 of FIG. 1) to control the heating process further comprises the step of sending (or posting) a message on the Internet when the drying process is over.

Table I.

Caldo Prototype Test Results for Cotton Towels

Dryer Type	kWh per lb Water Removed	% Energy Reduction	Time to Dry	Maximum temperature
Standard Hot Air	1.263 kWh/lb	0	80 min	112 deg F
Caldo RF Heater	0.567 kWh/lb	55%	40 min	72 deg F

H. APPARATUS FOR EFFICIENT HEATING MEDIUM THAT INCLUDES OBJECT HAVING A VARIABLE WEIGHT.

[0085] FIG. 8 shows an apparatus 170 of the present technology for efficient heating medium 180 including an object 184 having a variable weight. The apparatus 170 comprises: a DC power supply 174, a real time configurable RF Waveform power source 172, a system controller & signal processor 178, a plurality of RF & Physical sensors 176, and a variable enclosure 182 including medium 180 and an object having a variable weight.

[0086] Referring still to FIG. 8, in an embodiment of the present technology,medium 180 is selected from the group consisting of: water; and liquid having a dielectric permittivity above a first predetermined threshold, and having a dissipation factor above a second predetermined threshold.

Example III.

Medium 180 comprises petroleum.

Example IV.

Medium 180 comprises synthetic oil.

[0087] Referring still to FIG. 8, in an embodiment of the present technology, an object 184 is selected from the group consisting of: a food substance; a wood substance; a plastic substance; and a chemical substance.

Example V.

If object 184 comprises a food substance, the apparatus 180 of FIG. 8 can be used for preparation of dry food, like dry milk, etc.

[0088] Referring still to FIG. 8, in an embodiment of the present technology, the variable enclosure 182 is selected from the group consisting of: an enclosure having a variable thickness; an enclosure having a variable surface; and an enclosure having variable volume.

HI. APPARATUS FOR HEATING A MEDIUM CONTAINED IN A VARIABLE ENCLOSURE HAVING ADJUSTABLE DIMENSIONS.

[0089] The apparatus 170 of FIG. 8 can be also used for efficient heating medium contained in a variable enclosure having adjustable dimensions.

[0090]Oil sands, also known as tar sands, or extra heavy oil, are a type of bitumen deposit. The sands are naturally occurring mixtures of sand or clay, water and an extremely dense and viscous form of petroleum called bitumen. They are found in large amounts in many countries throughout the world, but are found in extremely large quantities in Canada and Venezuela.

[0091] Oil sands reserves have only recently been considered to be part of the world's oil reserves, as higher oil prices and new technology enable them to be profitably extracted and upgraded to usable products. Oil sands are often referred to as unconventional oil or crude bitumen, in order to distinguish the bitumen extracted from oil sands from the free-flowing hydrocarbon mixtures known as crude oil traditionally produced from oil wells.

[0092] Making liquid fuels from oil sands require energy for steam injection and refining. This process generates two to four times the amount of greenhouse gases per barrel of final product as the production of conventional oil. If combustion of the final products is included, the so-called "Well to Wheels" approach, oil sands extraction, upgrade and use emits 10 to 45 % more greenhouse gases than conventional crude.

Example VI.

If medium includes tar sands, the apparatus 170 can be used for energy efficient extraction oil from tar sands with far less production of green house gasses effect due to less energy consumption required for this process as compared to the prior art methods.

[0093] The above discussion has set forth the operation of various exemplary systems and devices, as well as various embodiments pertaining to exemplary methods of operating such systems and devices. In various embodiments, one or more steps of a method of implementation are carried out by a processor under the control of computer-readable and computer-executable instructions. Thus, in some embodiments, these methods are implemented via a computer.

[0094] In an embodiment, the computer-readable and computer-executable instructions may reside on computer useable/readable media.

[0095] Therefore, one or more operations of various embodiments may be controlled or implemented using computer-executable instructions, such as program modules, being executed by a computer. Generally, program modules include routines, programs, objects, components, data structures, etc., that perform particular tasks or implement particular abstract data types. In addition, the present technology may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote computer-storage media including memory-storage devices.

[0096] Although specific steps of exemplary methods of implementation are disclosed herein, these steps are examples of steps that may be performed in accordance with various exemplary embodiments. That is, embodiments disclosed herein are well suited to performing various other steps or variations of the steps recited. Moreover, the steps disclosed herein may be performed in an order different than presented, and not all of the steps are necessarily performed in a particular embodiment.

[0097] Although various electronic and software based systems are discussed herein, these systems are merely examples of environments that might be utilized, and are not intended to suggest any limitation as to the scope of use or functionality of the present technology. Neither should such systems be interpreted as having any dependency or relation to any one or combination of components or functions illustrated in the disclosed examples.

[0098] Although the subject matter has been described in a language specific to structural features and/or methodological acts, the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as exemplary forms of implementing the claims.

CLAIMS

1. A method for heating a medium that includes an object having a variable weight; said method comprising:

(A) placing said medium including said object having said variable weight into a variable enclosure having adjustable dimensions;

(B) initiating a heating process by subjecting said medium including said object having said variable weight to a variable AC electrical field; wherein said object substantially absorbs said medium in a first "cool" state; and wherein said object is substantially free from said medium in a second "heated" state;

(C) substantially continuously measuring an impedance of said medium including said object having said variable weight during said heating process;

(D) adjusting dimensions of said variable enclosure to optimize said heating process;

(E) adjusting the parameters of said variable AC electrical field to optimize said heating process;

and

(F) controlling said heating process, wherein said heating process is completed when said object is substantially transferred into said second "heated" state.

2. The method of claim 1, wherein said step (A) further comprises: (Al) selecting said medium from the group consisting of: water; and liquid having a dielectric permittivity above a first predetermined threshold, and having a dissipation factor above a second predetermined threshold.

3. The method of claim 1, wherein said step (A) further comprises: (A2) selecting said object from the group consisting of: a cloth substance; a food substance; a wood substance; a plastic substance; and a chemical substance.

4. The method of claim 1, wherein said step (A) further comprises: (A3) selecting said variable enclosure from the group consisting of: a drum having a variable thickness; a drum having a variable surface; a drum having a variable volume; an enclosure having a variable thickness; an enclosure having a variable surface; and an enclosure having variable volume.

5. The method of claim 1, wherein said step (B) further comprises: (B1) selecting parameters of said variable AC electrical field from the group consisting of: an applied RF voltage magnitude and envelope wave shape; an applied RF current magnitude and envelope wave shape; phase of RF voltage vs. current; voltage standing wave ratio (VSWR); and RF frequency.

6. The method of claim 1, wherein said step (C) further comprises: (C1) measuring a set of parameters of said medium including said object having said variable weight during said heating process; said set of parameters selected from the group consisting of: an impedance at at least one RF frequency; temperature variations of said object within said variable enclosure; moisture variations of said object within said variable enclosure;

dimension variations of said enclosure; and weight variations of said object.

7. The method of claim 6; wherein said step (C1) further comprises:

(C1, 1) rotating said variable enclosure to optimize said set of parameters; wherein said optimized set of parameters results in optimization of said heating process.

8. The method of claim 7; wherein said variable enclosure comprises a dryer drum having an anode plate; and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (C1, 1) further comprises:

(Cl, 1, 1) using at least one side mounted rotating threaded rod to both move and support said anode plate.

9. The method of claim 7, wherein said variable enclosure comprises a dryer drum having an anode plate; and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (C1, 1) further comprises:

(Cl, 1, 2) using at least one push rod to both move and support said anode plate.

10. The method of claim 7, wherein said variable enclosure comprises a dryer drum having an anode plate; and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (C1, 1) further comprises:

(C1, 1, 3) using at least one electromechanically driven push rod to both move and support said anode plate.

11. The method of claim 7, wherein said variable enclosure comprises a dryer drum having an anode plate; and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (C1, 1) further comprises:

(Cl, 1, 4) using at least one push rod to move said anode plate toward said load to maximize an RF load resistance at an RF feed point; wherein a spacing distance between said anode plate and a fixed ground plate comprises a minimum width consistent with size and softness of said load materials.

12. The method of claim 7, wherein said variable enclosure comprises a dryer drum having an anode plate; and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (C1, 1) further comprises:

(C1, 1, 5) using at least one push rod to move said anode plate toward said load, wherein a variable tuning inductor is configured to tune out a reactance of said load resulting in said load having a substantially real value resistance.

13. The method of claim 7, wherein said variable enclosure comprises a dryer drum having an anode plate; and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (C1, 1) further comprises:

Cl, 1, 6) using at least one push rod to move said anode plate toward said load, wherein variable RF power is applied to optimize said heating process.

14. The method of claim 7, wherein said variable enclosure comprises a dryer drum having an anode plate; and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (C1, 1) further comprises:

(Cl, 1, 7) using at least one push rod to move said anode plate toward said load, wherein the level of variable applied RF power is adjusted based on said load resistance.

15. The method of claim 7, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (C1, 1) further comprises:

(Cl, 1, 8) rotating said drum in two directions, wherein said first rotation of said drum is configured to move said anode plate into said load for dielectric heating, and wherein said second rotation of said drum is configured to allow space for air flow to remove moisture from said heated clothes load.

16. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (D) of adjusting dimensions of said variable enclosure during said heating process further comprises:

(D1) optimally configuring the shape and capacity of said dryer drum internal dimensions in both fixed and variable ways to accommodate for different kind of fabrics and different kind of load.

17. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (E) further comprises:

(El) pre-heating the air inside said dryer drum for better water evaporation from said load of clothing.

18. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (E) further comprises:

(E2) optimizing said heating process to said load of clothing by using a tuning inductor; wherein said tuning inductor is selected from the group consisting of: a variable spring-like RF tuning inductor; a variable ferrite core tuning inductor; and a roller coil tuning inductor.

19. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (E) further comprises:

(E3) optimizing said heating process by adjusting the input drive generator impedance and voltage waveform and duty cycles to the RF output devices in real-time, based on both measured load characteristics and RF generator output current & voltage waveforms.

20. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (F) further comprises:

(F1) using a dryer control system to control said heating process.

21. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (F) further comprises:

(F2) measuring temperature and power load to calculate the moisture context.

22. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (F) further comprises:

(F3) calculating drying time

23. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (F) further comprises:

(F4) organizing the working load for a drying facility for commercial operations.

24. The method of claim 1, wherein said variable enclosure comprises a dryer drum having an anode plate, and wherein said object comprises a load of clothing; and wherein said medium comprises water; and wherein said step (F) further comprises:

(F5) sending a message when said drying process is over.

25. An apparatus for heating a medium that includes an object having a variable weight; wherein said medium including said object having said variable weight is placed into a variable enclosure having adjustable dimensions; said apparatus comprising:

a means for subjecting said medium including said object having said variable weight to a heating process; wherein said object substantially absorbs said medium in a first "cool" state; and wherein said object is substantially free from said medium in a second "heated" state;

a means for measuring an impedance of said medium including said object having said variable weight during said heating process;

a means for adjusting dimensions of said variable enclosure to optimize said heating process;

and

a means for controlling said heating process, wherein said heating process is completed when said object is substantially transferred into said second "heated" state.

26. A method for heating a medium, said medium being contained in a variable enclosure having adjustable dimensions; said method comprising:

(A) initiating a heating process by subjecting said medium to a variable AC electrical field;

(B) substantially continuously measuring an impedance of said medium during said heating process;

(C) adjusting dimensions of said variable enclosure during said heating process based on said measured impedance to optimize the transfer of power from said AC electrical field to said medium;

(D) adjusting the parameters of said variable AC electrical field during said heating process based on said measured impedance to optimize the transfer of power from said AC electrical field to said medium;

and

(E) controlling said heating process.

27. The method of claim 26 further comprising:

(F) using said steps (A-E) of said heating process forcooking food.

28. The method of claim 26 further comprising:

(G) using said steps (A-E) of said heating process for curing chemicals such as dyes and coatings.

29. The method of claim 26 further comprising:

(H) using said steps (A-E) of said heating process for extracting liquids from solid mixtures such as tar sands and oil shale.

30. An apparatus for heating a medium, said medium being contained in a variable enclosure having adjustable dimensions; said apparatus comprising:

a means for subjecting said medium to a heating process by applying a variable AC electrical field;

a means for substantially continuously measuring an impedance of said medium during said heating process;

a means for adjusting dimensions of said variable enclosure during said heating process based on said measured impedance to optimize the transfer of power from said AC electrical field to said medium;

a means for adjusting the parameters of said variable AC electrical field during said heating process based on said measured impedance to optimize the transfer of power from said AC electrical field to said medium;

and

a means for controlling said heating process.

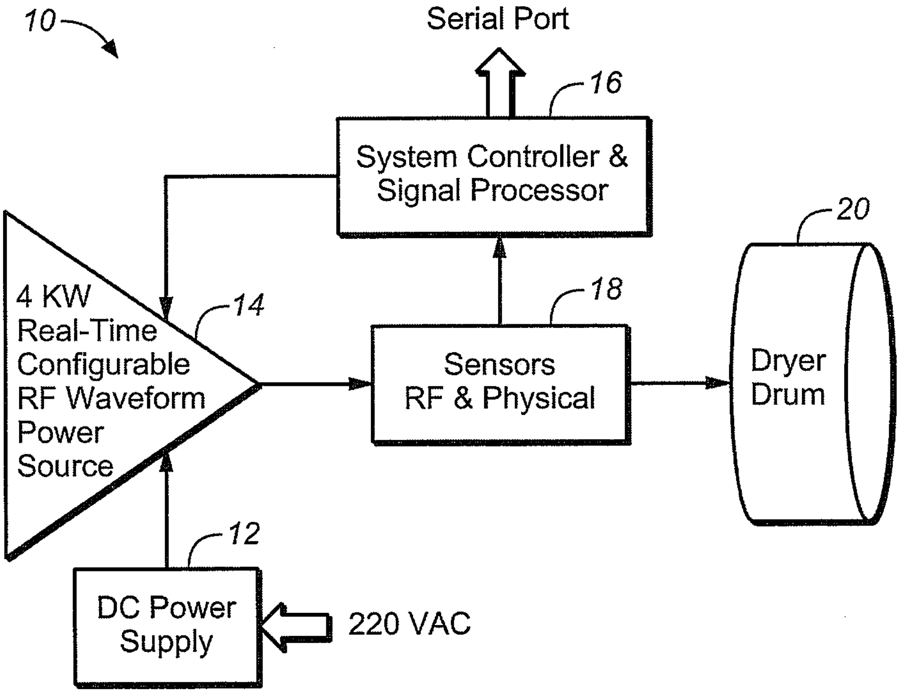
10
Serial Port
16
System Controller & Signal Processor
20
4 KW Real-Time Configurable RF Waveform Power Source
14
18
Sensors RF & Physical
Dryer Drum
12
DC Power Supply
220 VAC

FIG. 1

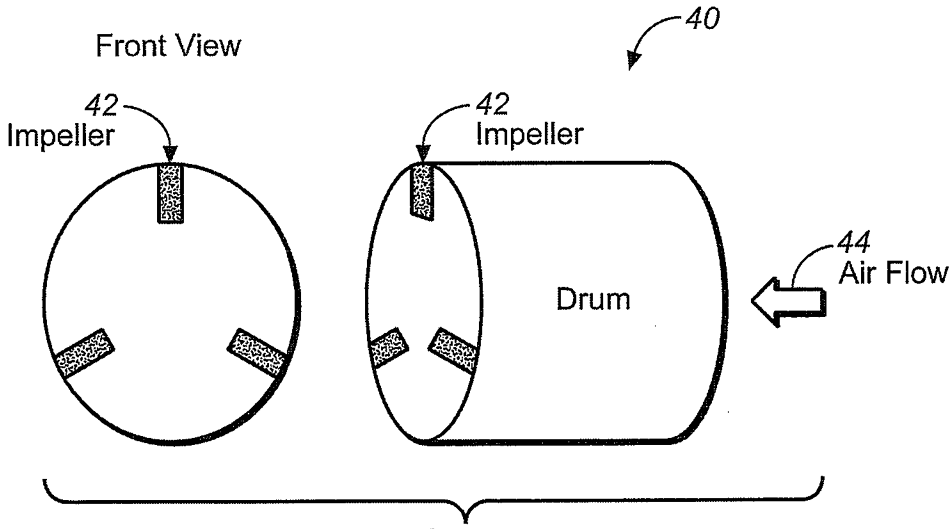
40
Front View
42 Impeller
42 Impeller
Drum
44 Air Flow

FIG. 2

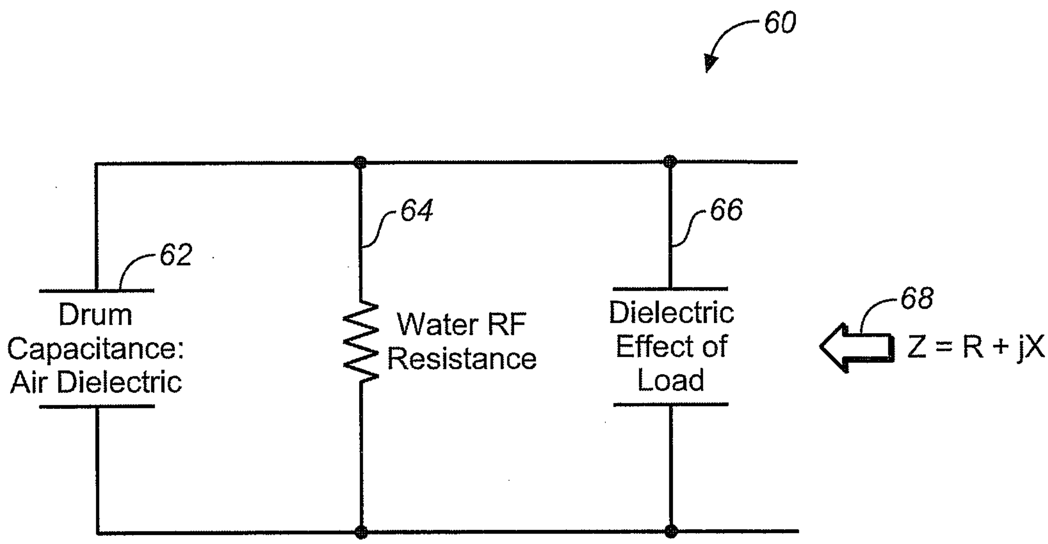
60
62
Drum
Capacitance:
Air Dielectric
64
Water RF
Resistance
66
Dielectric
Effect of
Load
68
Z = R + jX

FIG. 3

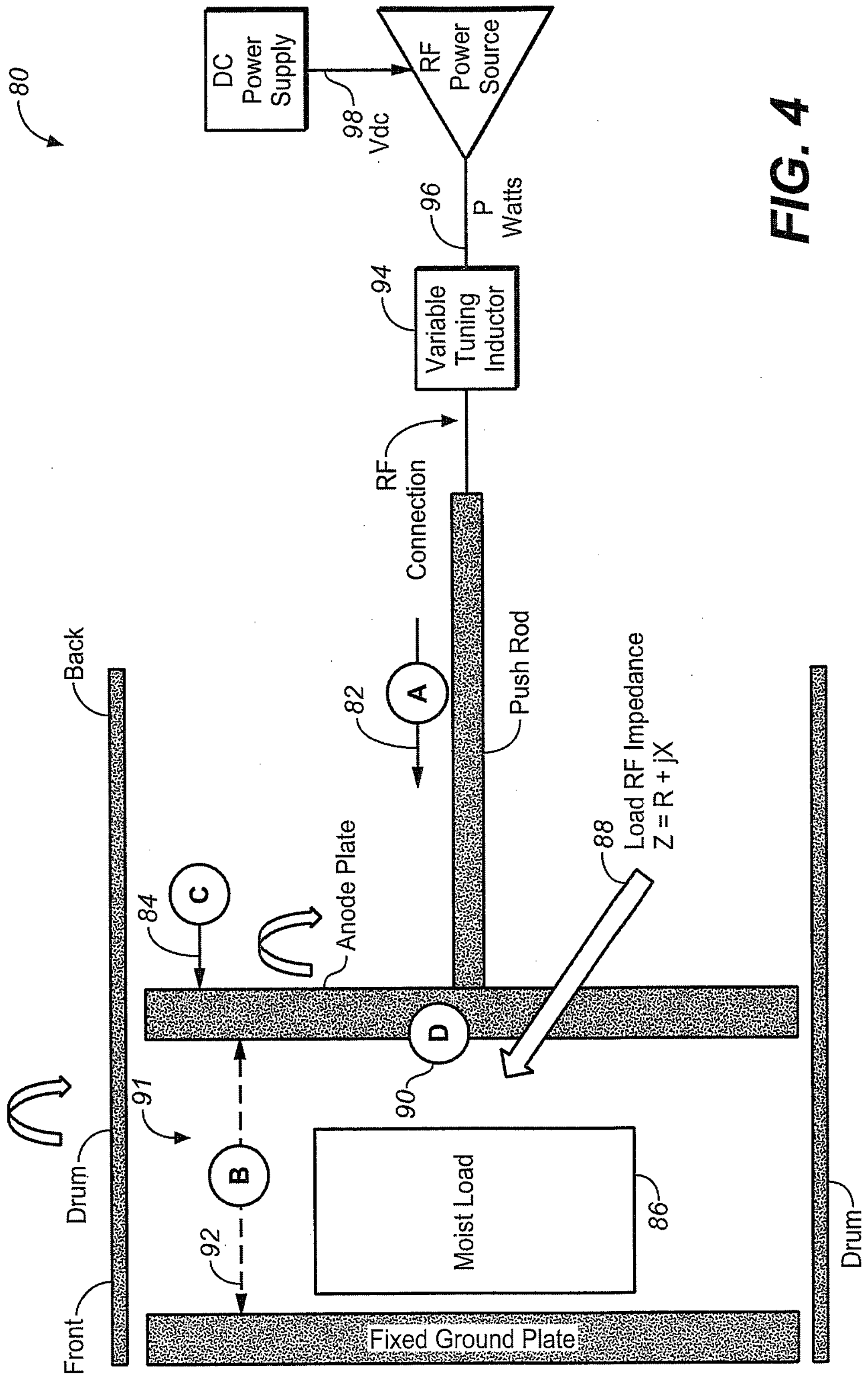
80
DC Power Supply
98 Vdc
RF Power Source
96 P Watts
94 Variable Tuning Inductor
RF Connection
Back
82
A
Push Rod
88 Load RF Impedance Z = R + jX
84
C
Anode Plate
D
90
91
B
92
Drum
Front
Moist Load
86
Fixed Ground Plate
Drum

FIG. 4

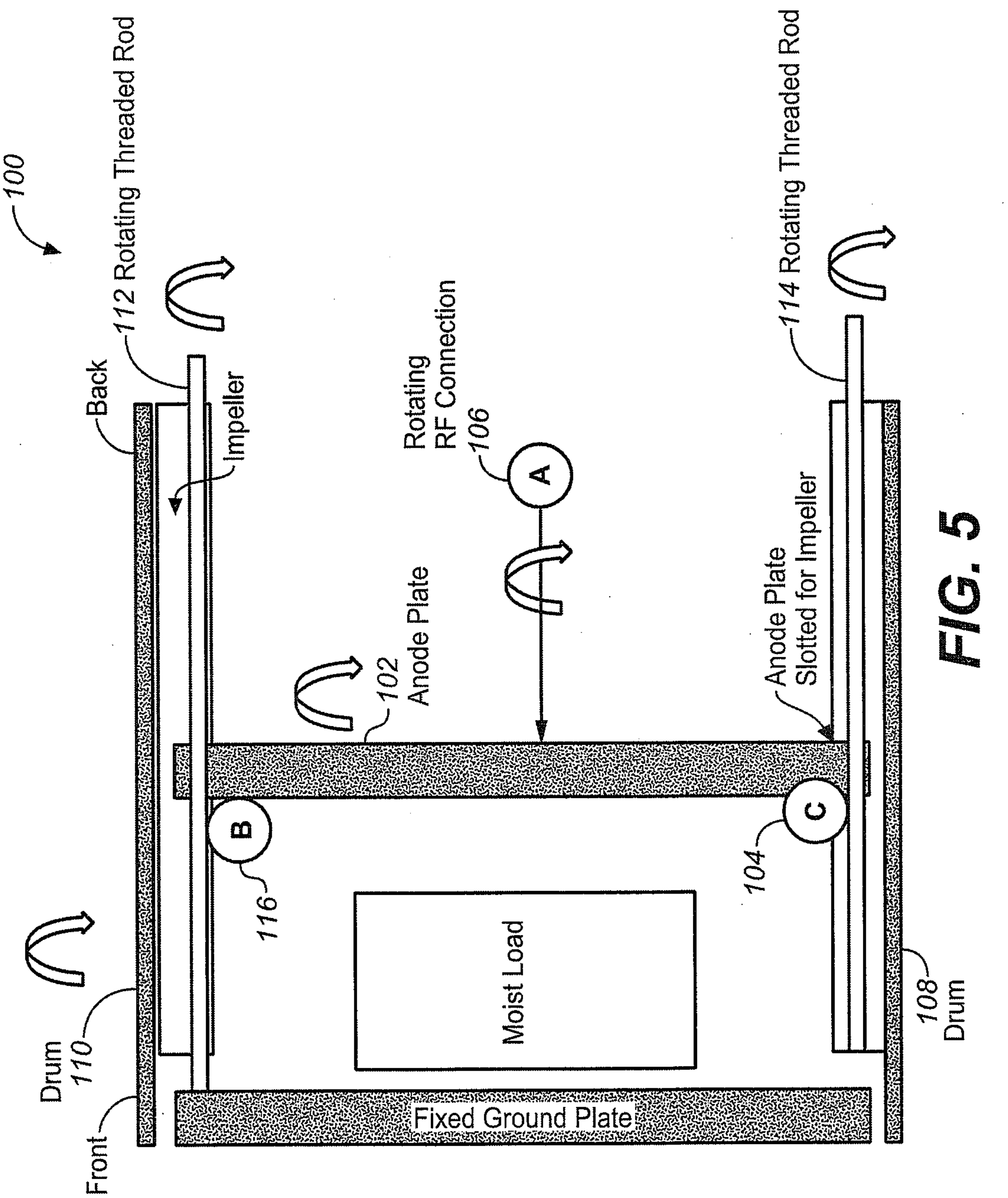
100
112 Rotating Threaded Rod
Back
Impeller
Rotating
RF Connection
106
A
114 Rotating Threaded Rod
102
Anode Plate
Anode Plate
Slotted for Impeller
B
116
C
104
Moist Load
Drum
110
Front
Fixed Ground Plate
108
Drum

FIG. 5

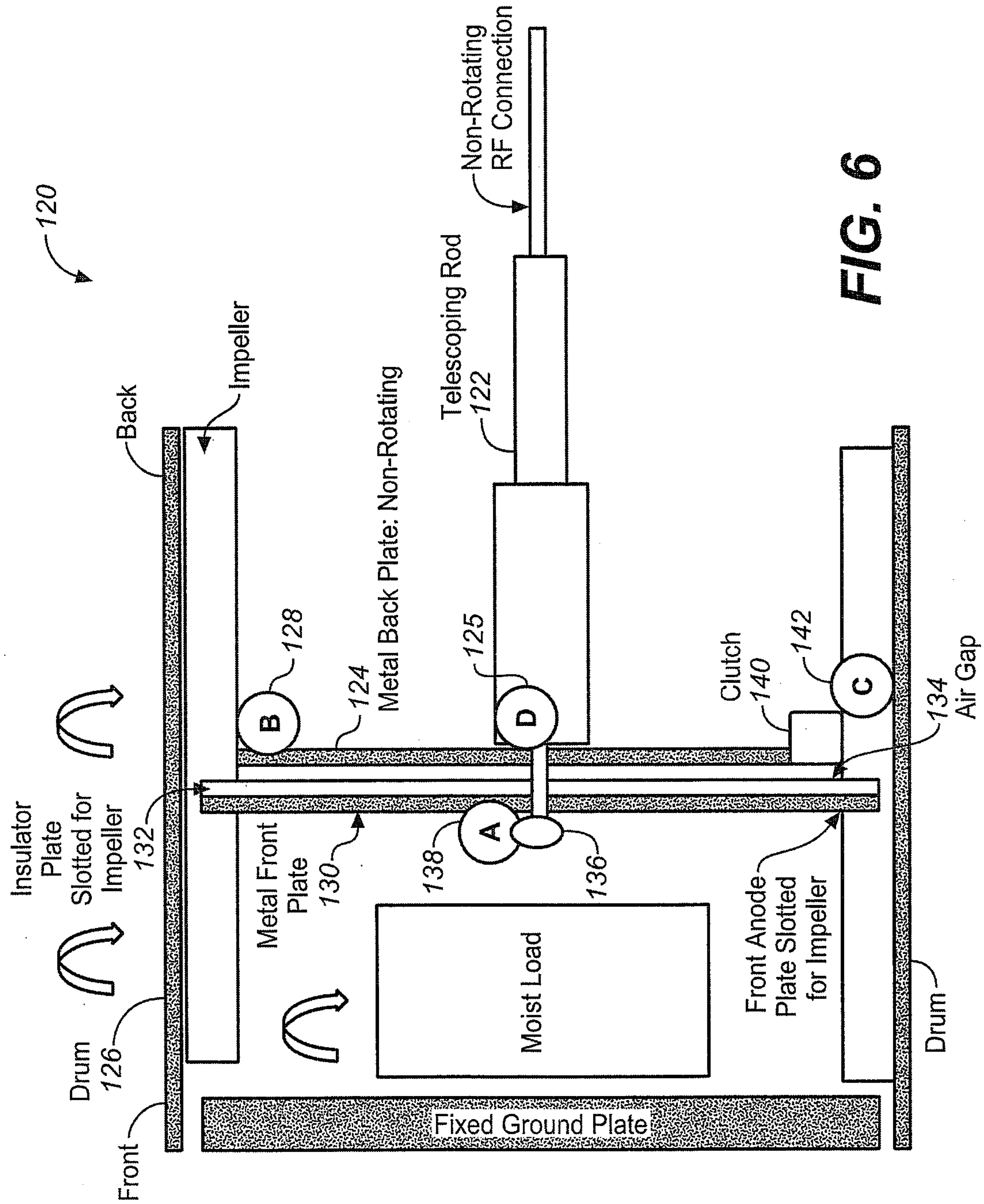
120
Non-Rotating
RF Connection
Telescoping Rod
122
Impeller
Back
Metal Back Plate: Non-Rotating
124
128
B
125
D
Clutch
140
142
C
134
Air Gap
Insulator
Plate
Slotted for
Impeller
132
Metal Front
Plate
130
A
138
136
Moist Load
Front Anode
Plate Slotted
for Impeller
Drum
126
Drum
Front
Fixed Ground Plate

FIG. 6

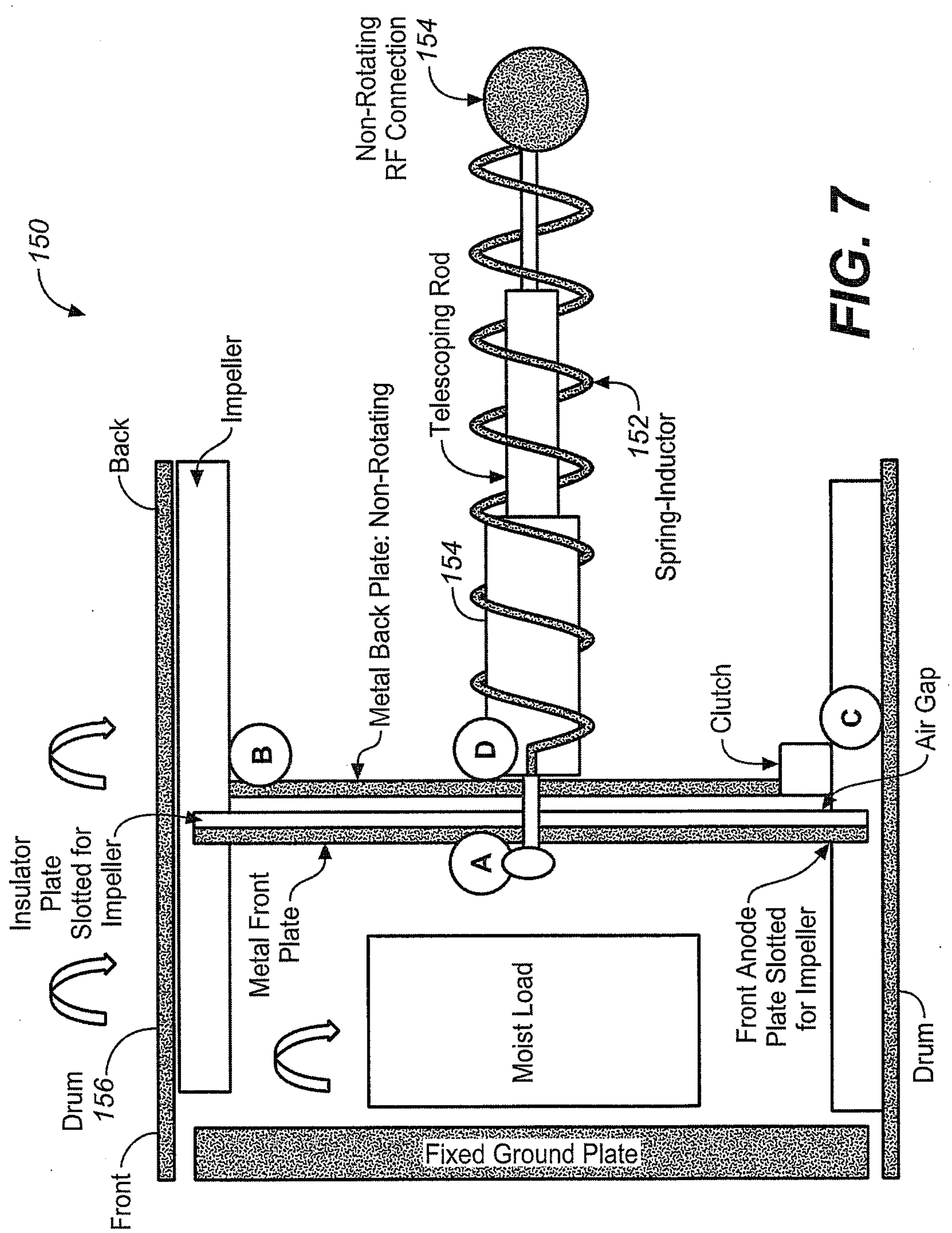
150
Non-Rotating
RF Connection
154
Telescoping Rod
152
Spring-Inductor
154
Impeller
Back
Metal Back Plate: Non-Rotating
B
D
Clutch
C
Air Gap
Insulator
Plate
Slotted for
Impeller
A
Metal Front
Plate
Moist Load
Front Anode
Plate Slotted
for Impeller
Drum
156
Drum
Front
Fixed Ground Plate

FIG. 7

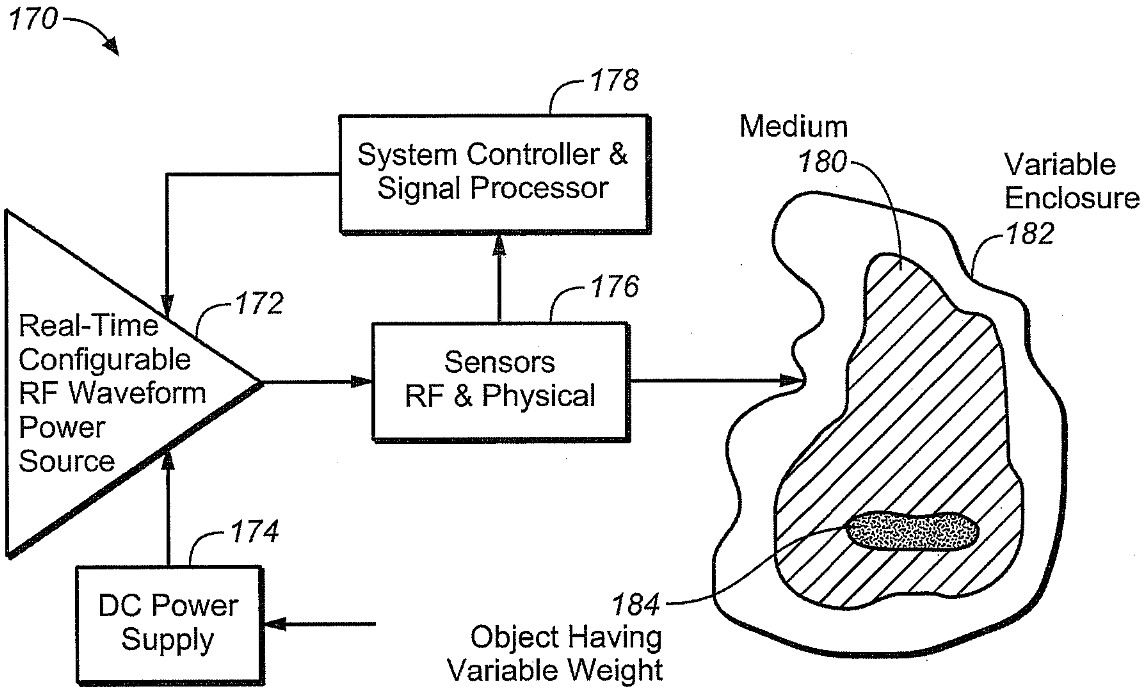
170
178
System Controller & Signal Processor
Medium
180
Variable Enclosure
182
176
172
Real-Time Configurable RF Waveform Power Source
Sensors RF & Physical
174
DC Power Supply
184
Object Having Variable Weight

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 11/38594

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F26B 19/00 (2011.01)
USPC - 34/553
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): F26B 19/00 (2011.01)
USPC: 34/553

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8): F26B 19/00 (2011.01)
USPC: 34/524, 526, 531, 549, 553, 554

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST; PGPB, USPT, EPAB, JPAB; Google Scholar; Google Patent; Search Terms: RF radio frequency microwave inductive clothing cloth garment heating dry dryer antenna coil feedback sensor drum roller agitator cylinder appliance temperature relative humidity moisture content water limit threshold permittivity density range controller micro-controlle

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,971,189 B1 (Anibas) 06 December 2005 (06.12.2005) col. 1 ln 21 to col. 5 ln. 62, Fig. 1-8	1-30
Y	US 2010/0115785 A1 (Ben-Shmuel et al.) 13 May 2010 (13.05.2010) para. [0025] through [0976], Fig. 1-34	1-30
A	US 5,463,821 A (Gauer) 07 November 1995 (07.11.1995) entire document	1-30
A	US 2007/0271814 A1 (Bae et al.) 29 November 2007 (29.11.2007) entire document	1-30
A	US 7,380,423 B1 (Musone) 03 June 2008 (03.06.2008) entire document	1-30

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 September 2011 (02.09.2011)	15 SEP 2011

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774