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(54) Title: VEHICLE OVEN HAVING AN OPTIMIZED WATER VAPOR INJECTOR

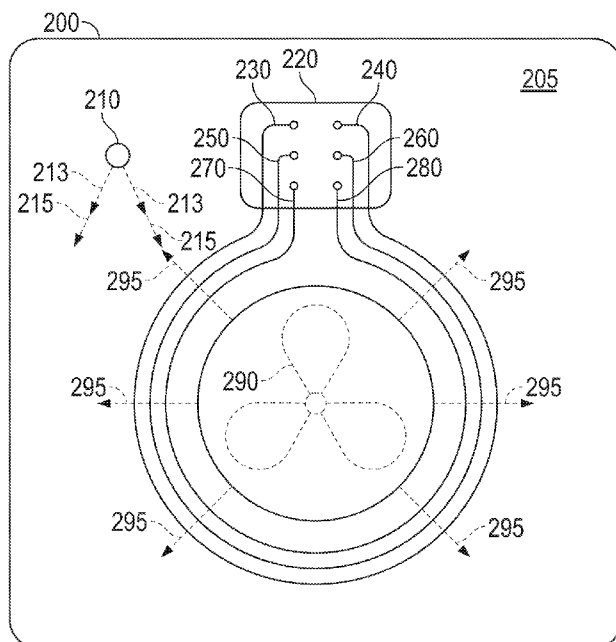


FIG. 2

(57) Abstract: An oven heating element assembly includes a heating element operable to heat air that flows across the heating element, a fan operable to cause air to flow across the heating element, and a water vapor injector. The water vapor injector is operable to inject mist into the air heated by the heating element to facilitate the mist being converted to steam by the heated air.

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VEHICLE OVEN HAVING AN OPTIMIZED WATER VAPOR INJECTOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of U.S. Provisional Patent Application No. 61/616,812 entitled “Vehicle Oven Having an Optimized Water Vapor Injector” and filed on March 28, 2012, which is hereby incorporated herein by reference in its entirety.

BACKGROUND

Field

[0002] Embodiments relate to an oven for heating food. More specifically, embodiments relate to a vehicle oven having an optimized water vapor injector.

Related Art

[0003] Conventional ovens for use in vehicles, such as aircraft, typically have water vapor injectors integrated with the heating elements. This leads to excessive water usage and chalk accumulation on the heating element, thereby reducing the lifetime of the heating element.

SUMMARY

[0004] According to an embodiment, an oven heating element assembly includes: a heating element operable to heat air that flows across the heating element, a fan operable to cause air to flow across the heating element, and a water vapor injector. The water vapor injector is operable to inject mist into the air heated by the heating element to facilitate the mist being converted to steam by the heated air.

[0005] The water vapor injector may be disposed in a location on an opposite side of the heating element from the fan whereby heated air flows proximate the water vapor injector after having flowed across the heating element.

[0006] The oven heating element assembly may further include a compartment in which the oven heating assembly is installed, wherein the heating element is operable to heat air within the compartment, and the water vapor injector is disposed in a location of the compartment proximate where heated air flows.

[0007] The compartment may further include a wall at which the heating element, the fan, and the water vapor injector are installed.

[0008] The heating element may include an electrical heating element that heats when electrical current is passed therethrough.

[0009] The heating element may include a plurality of electrical heating elements proximate one another.

[00010] The heating element may encircle a majority of the fan and the fan may blow air across a majority of the heating element that encircles the fan.

[00011] The water vapor injector may include a nebulizer.

[00012] The heating element may heat the air to a temperature above the boiling point of water.

[00013] The water vapor injector may be disposed in a location to inject water vapor into heated air that is at a temperature above the boiling point of water.

[00014] According to another embodiment, a method of injecting water vapor into an oven includes heating a heating element of the oven to a temperature above the boiling point of water, causing air to flow across the heated heating element by a fan, heating the air that flows across the heated heating element by the heating element to a temperature above the boiling point of water, injecting mist into the heated air by a water vapor injector, and converting the mist to steam by the heated air.

[00015] According to another embodiment, an oven includes a compartment; a heating element disposed in the compartment, the heating element operable to heat air that flows across the heating element; a fan disposed proximate the heating element and operable to cause air to flow across the heating element; and a water vapor injector operable to inject mist into the air heated by the heating element to facilitate the mist being converted to steam by the heated air.

[00016] While the exemplary embodiments described herein are presented in the context of an oven for an aircraft galley, these embodiments are exemplary only and are

not to be considered limiting. The embodiments of the apparatus are not limited to ovens for use in an aircraft galley. The ovens may be used for various applications including, but not limited to, cooking or heating food. Various embodiments may be used in any vehicle, including aircraft, spacecraft, ships, buses, trains, recreational vehicles, trucks, automobiles, and the like. Embodiments of the apparatus may also be used in homes, offices, hotels, factories, warehouses, garages, and other buildings where it may be desirable to have increased reliability and lower cost of heating element assemblies. In general, the embodiments may be used in any location or application in which it may be desirable to have increased reliability and lower cost of heating element assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

[00017] Exemplary embodiments will be explained in more detail with reference to the attached drawings in which the embodiments are illustrated as briefly described below.

[00018] FIG. 1 illustrates a schematic view of a conventional oven heating element assembly including a water vapor injector.

[00019] FIG. 2 illustrates a schematic view of a water vapor injector installed at a rear wall of an oven compartment separately from a heating element assembly, according to an embodiment.

[00020] FIG. 3 illustrates a method of using a water vapor injector in heating an oven, according to an embodiment.

[00021] FIG. 4 illustrates a system for heating an oven including a water vapor injector, according to an embodiment.

[00022] FIG. 5 illustrates a controller for heating an oven using a water vapor injector, according to an embodiment.

DETAILED DESCRIPTION

[00023] FIG. 1 illustrates a schematic view of a conventional oven heating element assembly 100 including a water vapor injector 180. The heating element assembly 100 includes a first heating element having a first end 110 and a second end 120, the first end 110 and the second end 120 being part of a continuous loop. Likewise, the heating element assembly 100 includes a second heating element having a first end 130 and a second end 140, the first end 130 and the second end 140 being part of a continuous loop, and a third heating element having a first end 150 and a second end 160, the first end 150 and the second end 160 being part of a continuous loop. The loops of each of the three heating elements are in close proximity to one another. The first, second, and third heating elements may be electric heating elements that couple with an electric heating element control system (see FIGS. 4 and 5) of an oven. The heating element assembly 100 may be installed in an oven compartment 105, for example at a back wall of the oven compartment 105, to heat air within the oven compartment 105. The heating element assembly 100 may be installed such that the continuous loops of the first, second, and third heating elements encircle a fan 190 that causes airflow to flow over the first, second, and third heating elements in order to heat the interior of the oven compartment 105.

[00024] The water vapor injector 180 injects water 185 into the oven compartment in which the heating element assembly 170 is installed by spraying water 185 onto the fan 190 encircled by the first, second, and third heating elements. The water 185 may be sprayed at one of a variety of different locations of the fan 190 – three potential locations are shown in FIG. 1. For example, the water 185 may be sprayed onto a single location of the fan 190 to the right of the top of the fan 190. The fan 190 then creates water spray 193 from the injected water. Outward airflow from the fan 190 causes the water spray 193 and any existing liquid water droplets to hit the first, second, and third heating elements, which convert the water spray 193 and liquid water droplets into steam 195. The water spray 193 may hit a different region of the first, second, and third heating elements, depending upon where the water 185 is sprayed onto the fan 190 and which direction the fan 190 is rotating. FIG. 1 illustrates a number of alternative potential areas of the first, second, and third heating elements that the water spray 193 may hit. For example, when the water 185

is sprayed onto the single location of the fan 190 to the right of the top of the fan 190, and the fan 190 is rotating in the clockwise direction, the water spray 193 may hit the first, second, and third heating elements at the upper right portion of the heating element loop illustrated in FIG. 1.

[00025] Because the water spray 193 and liquid water droplets physically touch the first, second, and third heating elements of FIG. 1, mineral residues (e.g., chalk) are deposited on the first, second, and third heating elements. The mineral residues then accumulate on the heating elements where the liquid water droplets touch the heating elements, leading to a reduction in life for the heating elements. In addition, frequent temperature changes of the heating elements due to the spray of cold water 185 onto the heating elements negatively impacts the reliability of the heating elements. Furthermore, alignment of the water vapor injector 180 with the fan 190 is critical in order for the fan 190 to properly create and distribute the water spray 193 that the heating elements convert to steam 195.

[00026] FIG. 2 illustrates a schematic view of a water vapor injector 210 installed at a rear wall 205 of an oven compartment 200 separately from a heating element assembly 220, according to an embodiment. FIG. 2 also illustrates a fan 290 installed at the rear wall 205 within a continuous loop created by first, second, and third heating elements having first and second ends 230 and 240, 250 and 260, and 270 and 280, respectively. In various embodiments, there may be more or fewer heating elements. For example, there may be one, two, four, five, or more heating elements. Each of the heating elements may generally encircle the fan 290 generally along a plane parallel with the wall 205 of the oven compartment 200 at which the water vapor injector 220 is installed. There may be an opening between the ends of the heating elements through which air blown by the fan 290 does not flow across the heating elements, for example. In addition, the heating elements may be arranged with respect to one another along a plane perpendicular with the wall of the oven compartment 200 at which the heating element assembly 220 is installed, along a plane parallel with the wall 205 of the oven compartment 200 at which the heating element assembly 220 is installed, along a diagonal plane in between perpendicular and parallel to the wall 205 of the oven compartment 200, or other arrangement that facilitates airflow 295 from the fan 290 passing across the heating elements to be heated. The fan 290 may

be a rotary fan with a propeller style blade, an axial-flow fan, a radial fan, a centrifugal fan, a crossflow fan, or other type of fan as known in the art.

[00027] The water vapor injector 210 may be disposed in a location on an opposite side of the heating elements from the fan 290 whereby heated air flows proximate the water vapor injector 210 after having flowed across the heating element. In other embodiments, the water vapor injector 210 may be disposed in a location on a same side of the heating elements as the fan 290, such as below, on, or proximate the heating element assembly 220. The water vapor injector 210 may inject mist 213 into airflow 295 created by the fan 290 and heated by the first, second, and third heating elements. The mist 213 may be heated in the heated airflow 295 until the mist 213 changes state to the vapor phase to become steam 215 without the mist 213 physically touching the heating elements or the fan.

[00028] Although the water vapor injector 210 is illustrated as being installed to the left of the heating element assembly 220, this should not be construed as limiting. In various embodiments, the water vapor injector 210 may be placed in other or multiple locations independent of the shape or placement of the heating element assembly 220 to optimize formation and distribution of steam 215 in the oven compartment 200. In contrast to the water vapor injector 180, the placement of the water vapor injector 210 is more flexible.

[00029] The water vapor injector 210 may include a nozzle coupled with a water source such that mist 213 is controllably injected into the oven compartment 200 using a nebulizer or solenoid powered valves and the nozzle. The heated airflow 295 from the fan 290 quickly heats the mist 213 injected by the water vapor injector 210 to create steam 215. The mist 213 from the water vapor injector 210 is converted to steam 215 by the heated airflow 295 that flows across the heating elements in the heating element assembly 220, rather than by the heating elements directly as in FIG. 1.

[00030] The water vapor injector 210 reduces water usage compared to the conventional water vapor injector 180, and also prevents chalk accumulation on the heating elements because the water vapor injector 210 does not cause mist or water droplets to spray directly onto the heating elements in contrast to the conventional water vapor injector 180. Because the fineness of the mist 213 facilitates the mist 213 being

converted to steam 215 by the heated airflow 295 without touching the heating element assembly 220 first, the heating element assembly 220 does not have the problems of the heating element assembly 170 in this regard. In various embodiments, other factors that may contribute to prevention of problems in the heating element assembly 220 similar to those of the heating assembly 170 include distance between the first, second, and third heating elements of FIG. 2 and the water vapor injector 210, and the airflow 295 from the fan 290 sending the mist 213 and any existing liquid water droplets from the water vapor injector 210 in a direction away from the heating element assembly 220. As a result, the lifetime of the heating element assembly 220 of FIG. 2 is increased in comparison with the heating element assembly 170 of FIG. 1.

[00031] In addition, the water vapor injector 210 may be more easily cleaned, serviced, and replaced than the water vapor injector 180 of FIG. 1, because the water vapor injector 210 is not integrated with the heating element assembly 220. However, in various embodiments, the water vapor injector 210 may be integrated with the heating element assembly 220 while still enjoying advantages of the embodiments of the combination of the heating element assembly 220 and water vapor injector 210 discussed herein. Furthermore, in embodiments such as that illustrated in which the water vapor injector 210 is further from the heating elements than the water vapor injector 180, the water vapor injector 210 is not subjected to as extreme hot temperatures as the water vapor injector 180. As a result, more materials may be chosen for constructing the water vapor injector 210 than the water vapor injector 180. For example, because of the close proximity of the water vapor injector 180 to the heating elements in the conventional heating element assembly 170, the material choice for the water vapor injector 180 is typically limited to stainless steel. In the water vapor injector 210, other materials may be chosen in order to reduce or eliminate deposition of minerals in the water vapor injector 210. As such, the lifetime of the water vapor injector 210 may also be extended and the total cost of ownership of the water vapor injector 210 and/or heating element assembly 220 reduced compared to the water vapor injector 180.

[00032] FIG. 3 illustrates a method of using a water vapor injector in heating an oven, according to an embodiment. In a step 310, a heating element is heated. The heating element may be one or more of the heating elements having first and second ends

230 and 240, 250 and 260, and 270 and 280, respectively. In the case of an electrical heating element, the heating element may be heated by passing electrical current through an electrically resistive heating element. Other heating elements that are heated by or heat air using other power sources or fuels may be used in various embodiments as known in the art, for example, gas, propane, or kerosene. The heating element may be heated to a temperature at or above the boiling point of water, which is 100 degrees centigrade at one atmosphere of pressure under standard conditions. The boiling point of water is a physical property of water that depends upon factors such as environmental conditions including atmospheric pressure. Impurities, such as salt, in the water may increase its boiling point. Also, in aircraft during flight, the atmospheric pressure is typically less than one atmosphere of pressure. As a result, the boiling temperature of water in an aircraft during flight is typically a lower temperature than it would be at one atmosphere of pressure. In various embodiments, the heating element may be heated to 100, 150, 200, 250, or 300 degrees centigrade, or more, and may heat the air within a compartment of the oven to a temperature about the same as the temperature of the heating element.

[00033] In a step 320, air is blown across the heating element heated in step 310. The air may be blown by a fan, e.g., fan 290. The air may be blown in a direction from the fan toward the heating element whereby the majority of the air blown by the fan is blown across the heating element. The fan may blow the air outwardly from the fan and across the heating element that encircles the fan. The speed and direction of airflow through the fan may be set by a variably controlled electrical power used to drive a motor of the fan.

[00034] In a step 330, the heating element heats the air that flows across the heating element. The air may be heated by an incremental amount each time the air flows across the heating element as the air circulates within the oven, raising a temperature of the air each time the air flows across the heating element. The air may decrease in temperature as the air circulates through the oven before returning to the fan. The air that flows between the fan and the heating element may be at a temperature above the boiling point of water prior to being incrementally heated by the heating element during any given air circulation cycle. The amount by which the air temperature is increased by passing over the heating element may be determined by how hot the heating element is, which in turn may be

determined by how much electrical current is passing through the heating element in the case of an electrical heating element.

[00035] In a step 340, mist is injected into the heated air. The mist may be injected by the water vapor injector 210. The mist may be injected away from the heating element, whereby the heated air contacts the mist after the heated air is heated by the heating element in step 330. The mist may be injected in the form of a mist or fine water droplets that provide a sufficiently large surface area relative to volume in order to reduce a time required to be converted into steam by the heated air to a sufficiently short duration to prevent the mist or fine water droplets from reaching the heating element. As such, the mist may be sufficiently fine such that the mist changes state to the vapor phase prior to reaching the heating element. A nebulizer or solenoid powered valves and a nozzle may be used to inject the mist into the heated air.

[00036] In a step 350, the mist injected into the heated air in step 340 is converted into steam by the heated air. The mist may be converted into steam quickly based on the fineness of the mist and the temperature of the heated air. A finer mist and hotter heated air both reduce a time required to convert the mist into steam. The mist may be converted into steam by the heated air away from the heating element, and therefore the heating element may not have any mineral deposits left behind by the mist when the mist is converted to steam.

[00037] FIG. 4 illustrates a system 400 for heating an oven including a water vapor injector 420, according to an embodiment. A control system 410 may control the water vapor injector 420 to inject mist into an oven compartment according to the methods described herein. The control system 410 may include an embodiment of the controller 500 shown in FIG. 5. The control system 410 may include sensors and actuators and control the water vapor injector 420, the heating element 430, and/or the fan 440 using the sensors and actuators. The sensors may include temperature sensors, for example, that measure temperature of air near the heating element 430, near the water vapor injector 420, near the fan 440, or in other areas within a compartment of the oven, or that measure temperature of the heating element 430 and/or the water vapor injector 420 themselves. The sensors may also include humidity sensors, for example, that measure temperature of air near the heating element 430, near the water vapor injector 420, near the fan 440, or in

other areas within a compartment of the oven. The sensors may additionally include flow sensors that measure an amount of airflow from the fan 440 or an amount of fluid or water flow through the water vapor injector 420 and/or water supply piping that provides water to the water vapor injector 420. The sensors may also include a pressure sensor that measures the air pressure within the oven. The sensors further may include a current sensor that measures how much electrical current flows through the heating element 430 or a voltage that measures the voltage across the heating element 430 in the case of an electrical heating element. The actuators may include a motor that drives the fan 440, an actuator that controls water flow through the water vapor injector 420, and an element such as a switch or driver that controls an amount of electrical current that flows through the heating element 430 in the case of an electrical heating element.

[00038] The water vapor injector 420 may be an embodiment of the water vapor injector 210. The heating element 430 may be an embodiment of the heating elements having first and second ends 230 and 240, 250 and 260, and 270 and 280, respectively. The fan 440 may be an embodiment of the fan 290.

[00039] FIG. 5 illustrates a controller for heating an oven using a water vapor injector, according to an embodiment. The controller 500 may be coupled with a control panel 540 via an I/O interface 530. The controller 500 may be included in the oven having the oven compartment 200 and the control panel 540 may be installed on an exterior surface of the oven or near an installation location of the oven. The controller 500 may receive input commands from a user via the control panel 540 such as turning the oven on or off, selecting an operation mode, and setting a desired temperature of the oven compartment 200. The controller 500 may output information to the user regarding an operational status (e.g., operational mode, activation of a steam generation cycle, shut-off due to over-temperature conditions of the oven compartment 205 and/or components of the oven, etc.) of the oven using the control panel 540.

[00040] The controller 500 may include a processor 510 that performs computations according to program instructions, a memory 520 that stores the program instructions and other data used or generated by the processor 510, and a network interface 550 that includes data communications circuitry for interfacing to a data communications network 590 such as Ethernet, Galley Data Bus (GAN), or Controller Area Network (CAN). The

processor 510 may include a microprocessor, a Field Programmable Gate Array, an Application Specific Integrated Circuit, or a custom Very Large Scale Integrated circuit chip, or other electronic circuitry that performs a control function. The processor 510 may also include a state machine. The controller 500 may also include one or more electronic circuits and printed circuit boards. The processor 510, memory 520, and network interface 550 may be coupled with one another using one or more data buses 580. The controller 500 may communicate with and control various sensors and actuators 570 of the oven via a control interface 560. The sensors and actuators of the control system 410 may be embodiments of the sensors and actuators 570 of FIG. 5.

[00041] The controller 500 may be controlled by or communicate with a centralized computing system, such as one onboard an aircraft. The controller 500 may implement a compliant ARINC 812 logical communication interface on a compliant ARINC 810 physical interface. The controller 500 may communicate via the Galley Data Bus (e.g., galley networked GAN bus), and exchange data with a Galley Network Controller (e.g., Master GAIN Control Unit as described in the ARINC 812 specification). In accordance with the ARINC 812 specification, the controller 500 may provide network monitoring, power control, remote operation, failure monitoring, and data transfer functions. The controller 500 may implement menu definitions requests received from the Galley Network Controller (GNC) for presentation on a GNC Touchpanel display device and process associated button push events to respond appropriately. The controller 500 may provide additional communications using an RS-232 communications interface and/or an infrared data port, such as communications with a personal computer (PC) or a personal digital assistant (PDA). Such additional communications may include real-time monitoring of operations of the oven, long-term data retrieval, and control system software upgrades. In addition, the control interface 560 may include a serial peripheral interface (SPI) bus that may be used to communicate between the controller 500 and motor controllers within the oven.

[00042] A user may select a desired temperature for the oven compartment 200 using the control panel 540. The user may also select a desired humidity and/or pressure for the oven compartment 200 using the control panel 540. The controller 500 may control a temperature within the oven compartment 200 at a high level of precision

according to the desired temperature. The controller 500 may also control a humidity within the oven compartment 200 at a high level of precision according to the desired humidity, and/or according to a desired pressure. For example, when the pressure drops below a threshold, additional water vapor may be injected into the oven compartment to increase the pressure. Therefore, quality of food cooked within the oven compartment 205 may be uniformly obtained according to the user-selected operational mode of the oven.

[00043] All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[00044] For the purposes of promoting an understanding of the principles of the invention, reference has been made to the embodiments illustrated in the drawings, and specific language has been used to describe these embodiments. However, no limitation of the scope of the invention is intended by this specific language, and the invention should be construed to encompass all embodiments that would normally occur to one of ordinary skill in the art. The terminology used herein is for the purpose of describing the particular embodiments and is not intended to be limiting of exemplary embodiments of the invention. In the description of the embodiments, certain detailed explanations of related art are omitted when it is deemed that they may unnecessarily obscure the essence of the invention.

[00045] The apparatus described herein may comprise a processor, a memory for storing program data to be executed by the processor, a permanent storage such as a disk drive, a communications port for handling communications with external devices, and user interface devices, including a display, touch panel, keys, buttons, etc. When software modules are involved, these software modules may be stored as program instructions or computer readable code executable by the processor on a non-transitory computer-readable media such as magnetic storage media (e.g., magnetic tapes, hard disks, floppy disks), optical recording media (e.g., CD-ROMs, Digital Versatile Discs (DVDs), etc.), and solid state memory (e.g., random-access memory (RAM), read-only memory (ROM), static random-access memory (SRAM), electrically erasable programmable read-only memory (EEPROM), flash memory, thumb drives, etc.). The computer readable recording

media may also be distributed over network coupled computer systems so that the computer readable code is stored and executed in a distributed fashion. This computer readable recording media may be read by the computer, stored in the memory, and executed by the processor.

[00046] Also, using the disclosure herein, programmers of ordinary skill in the art to which the invention pertains may easily implement functional programs, codes, and code segments for making and using the invention.

[00047] The invention may be described in terms of functional block components and various processing steps. Such functional blocks may be realized by any number of hardware and/or software components configured to perform the specified functions. For example, the invention may employ various integrated circuit components, e.g., memory elements, processing elements, logic elements, look-up tables, and the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices. Similarly, where the elements of the invention are implemented using software programming or software elements, the invention may be implemented with any programming or scripting language such as C, C++, JAVA®, assembler, or the like, with the various algorithms being implemented with any combination of data structures, objects, processes, routines or other programming elements. Functional aspects may be implemented in algorithms that execute on one or more processors. Furthermore, the invention may employ any number of conventional techniques for electronics configuration, signal processing and/or control, data processing and the like. Finally, the steps of all methods described herein may be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context.

[00048] For the sake of brevity, conventional electronics, control systems, software development and other functional aspects of the systems (and components of the individual operating components of the systems) may not be described in detail. Furthermore, the connecting lines, or connectors shown in the various figures presented are intended to represent exemplary functional relationships and/or physical or logical couplings between the various elements. It should be noted that many alternative or additional functional relationships, physical connections or logical connections may be present in a practical device. The words “mechanism”, “element”, “unit”, “structure”,

“means”, and “construction” are used broadly and are not limited to mechanical or physical embodiments, but may include software routines in conjunction with processors, etc.

[00049] The use of any and all examples, or exemplary language (e.g., “such as”) provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. Numerous modifications and adaptations will be readily apparent to those of ordinary skill in this art without departing from the spirit and scope of the invention as defined by the following claims. Therefore, the scope of the invention is defined not by the detailed description of the invention but by the following claims, and all differences within the scope will be construed as being included in the invention.

[00050] No item or component is essential to the practice of the invention unless the element is specifically described as “essential” or “critical”. It will also be recognized that the terms “comprises,” “comprising,” “includes,” “including,” “has,” and “having,” as used herein, are specifically intended to be read as open-ended terms of art. The use of the terms “a” and “an” and “the” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless the context clearly indicates otherwise. In addition, it should be understood that although the terms “first,” “second,” etc. may be used herein to describe various elements, these elements should not be limited by these terms, which are only used to distinguish one element from another. Furthermore, recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein.

CLAIMS

What is claimed is:

1. An oven heating element assembly comprising:
 - a heating element operable to heat air that flows across the heating element;
 - a fan operable to cause air to flow across the heating element; and
 - a water vapor injector operable to inject mist into the air heated by the heating element to facilitate the mist being converted to steam by the heated air.
2. The oven heating element assembly of claim 1, wherein the water vapor injector is disposed in a location on an opposite side of the heating element from the fan whereby heated air flows proximate the water vapor injector after having flowed across the heating element.
3. The oven heating element assembly of claim 1, further comprising a compartment in which the oven heating assembly is installed, wherein:
 - the heating element is operable to heat air within the compartment; and
 - the water vapor injector is disposed in a location of the compartment proximate where heated air flows.
4. The oven heating element assembly of claim 3, the compartment further comprising a wall at which the heating element, the fan, and the water vapor injector are installed.
5. The oven heating element assembly of claim 1, wherein the heating element comprises an electrical heating element that heats when electrical current is passed therethrough.
6. The oven heating element assembly of claim 5, wherein the heating element comprises a plurality of electrical heating elements proximate one another.

7. The oven heating element assembly of claim 5, wherein the heating element encircles a majority of the fan and the fan blows air across a majority of the heating element that encircles the fan.
8. The oven heating element assembly of claim 1, wherein the water vapor injector comprises a nebulizer.
9. The oven heating element assembly of claim 1, wherein the heating element heats the air to a temperature above the boiling point of water.
10. The oven heating element assembly of claim 1, wherein the water vapor injector is disposed in a location to inject water vapor into heated air that is at a temperature above the boiling point of water.
11. A method of injecting water vapor into an oven, the method comprising:
 - heating a heating element of the oven to a temperature above the boiling point of water;
 - causing air to flow across the heated heating element by a fan;
 - heating the air that flows across the heated heating element by the heating element to a temperature above the boiling point of water;
 - injecting mist into the heated air by a water vapor injector; and
 - converting the mist to steam by the heated air.
12. The method of claim 11, wherein heating the heating element comprises passing electrical current through the heating element.
13. The method of claim 11, wherein the heating element is heated within a compartment of the oven, and the mist is injected into the heated air in a location of the compartment proximate where heated air flows.

14. The method of claim 11, wherein the heating element encircles a majority of the fan, and causing air to flow across the heated heating element comprises blowing air across a majority of the heating element that encircles the fan.

15. The method of claim 11, wherein injecting mist into the heated air comprises generating the mist using a nebulizer.

16. An oven comprising:

a compartment;

a heating element disposed in the compartment, the heating element operable to heat air that flows across the heating element;

a fan disposed proximate the heating element and operable to cause air to flow across the heating element; and

a water vapor injector operable to inject mist into the air heated by the heating element to facilitate the mist being converted to steam by the heated air.

17. The oven of claim 16, further comprising a wall at which the heating element, the fan, and the water vapor injector are installed.

18. The oven of claim 16, wherein the heating element comprises a plurality of electrical heating elements proximate one another.

19. The oven of claim 16, wherein the heating element encircles a majority of the fan and the fan blows air across a majority of the heating element that encircles the fan.

20. The oven of claim 16, wherein the water vapor injector comprises a nebulizer, and injecting mist into the heated air comprises generating the mist using the nebulizer.

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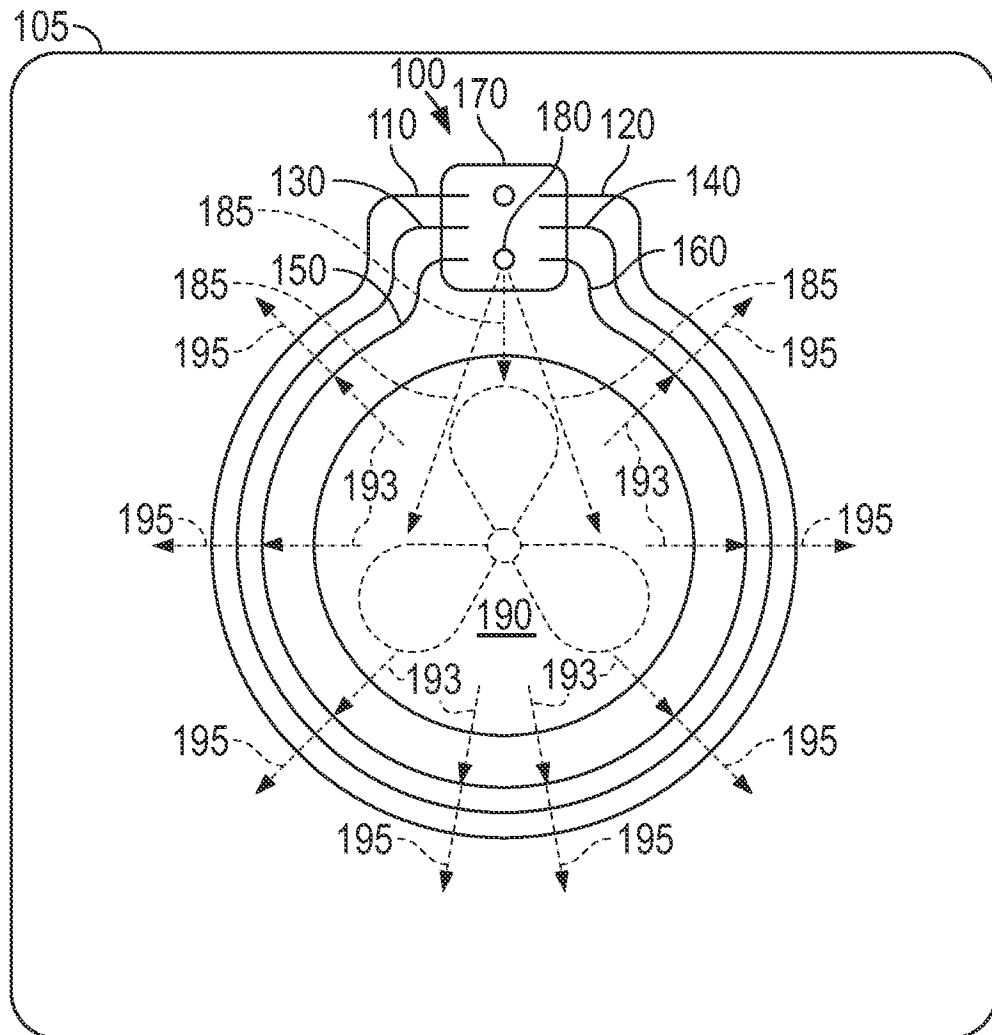


FIG. 1

(CONVENTIONAL ART)

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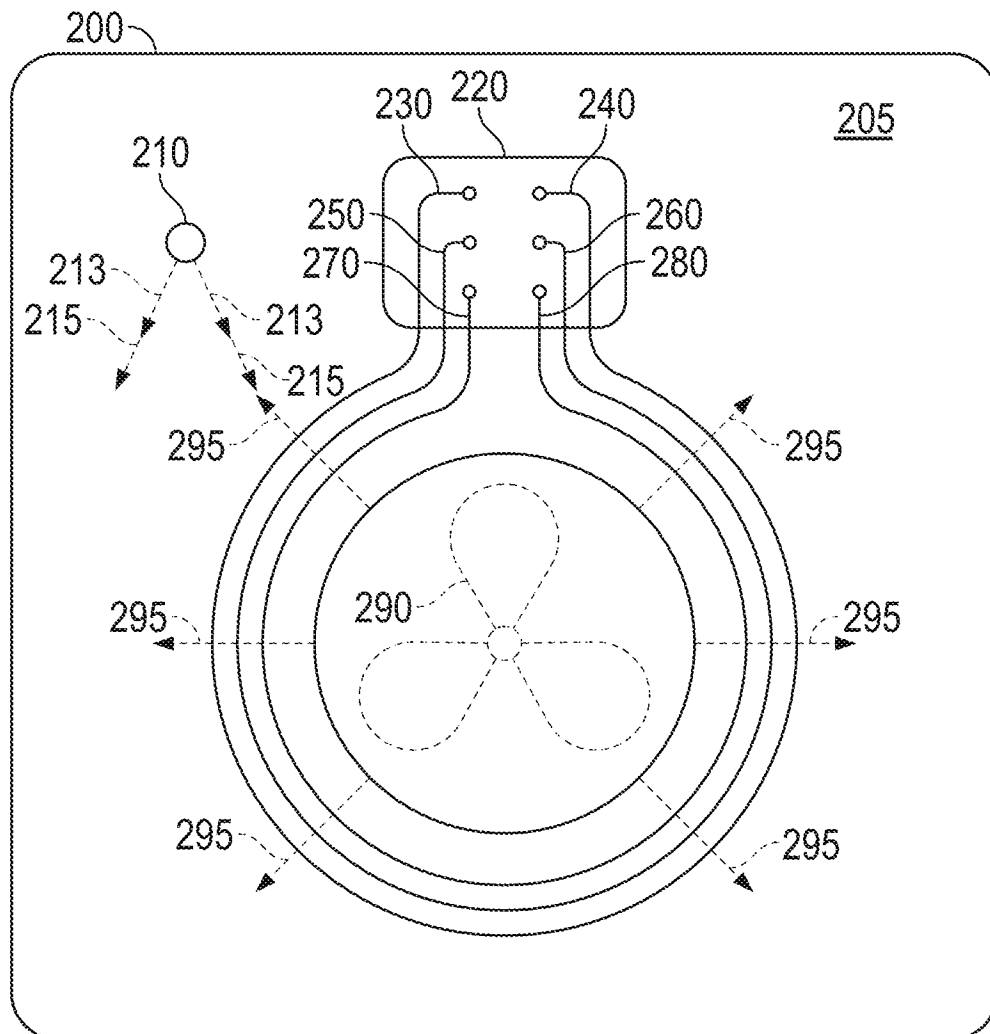
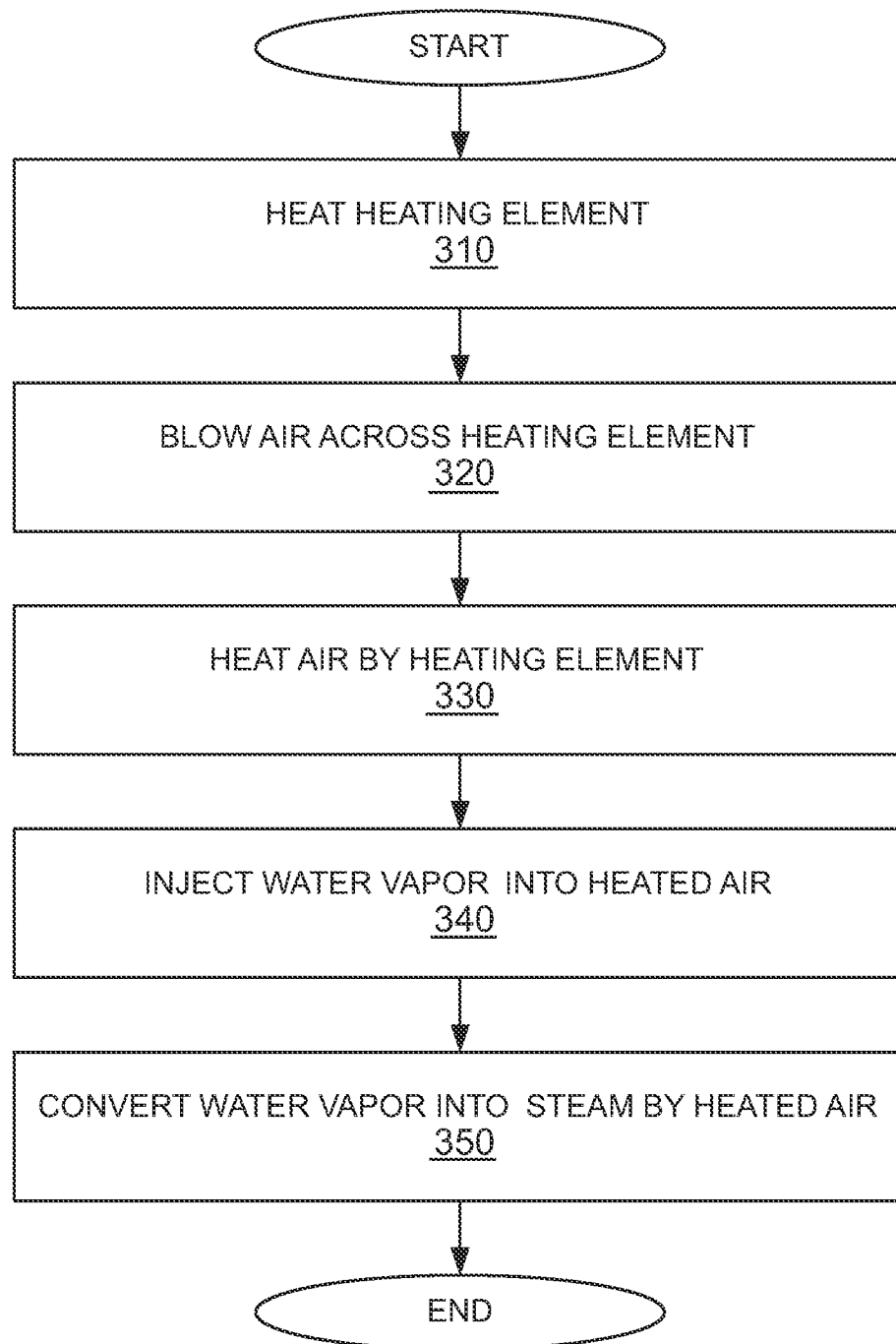


FIG. 2

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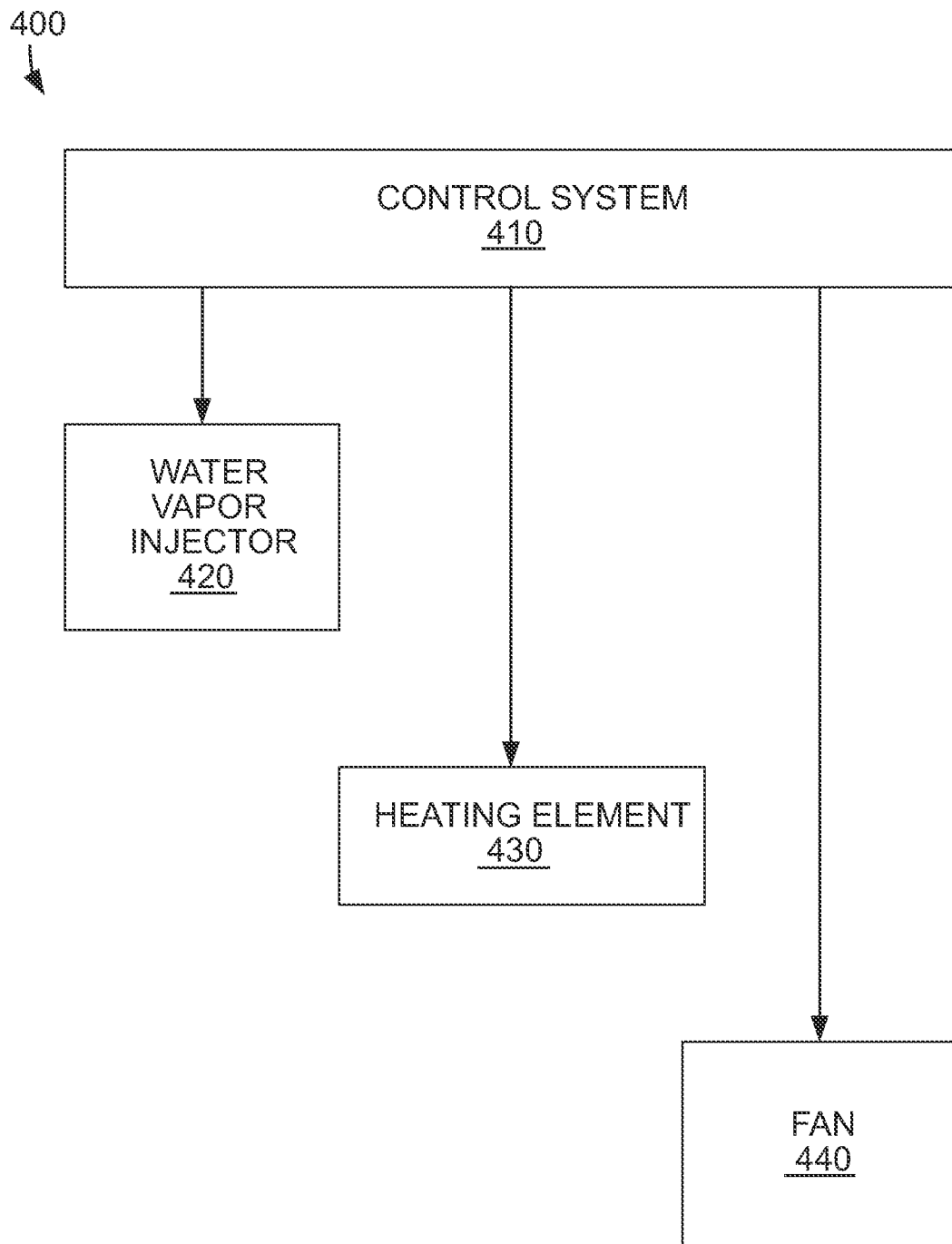


FIG. 4

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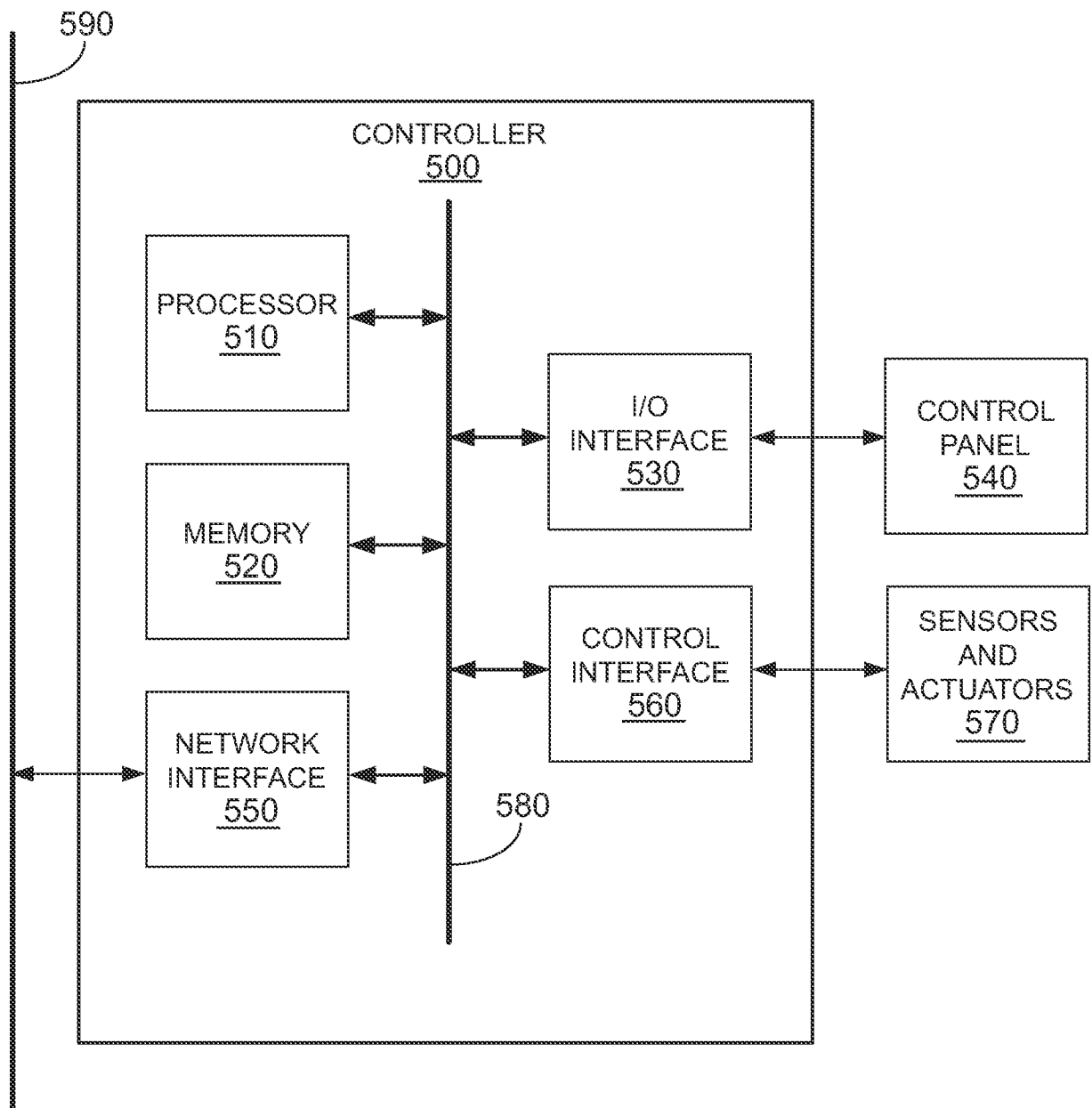


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/034502

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A21B 3/04 (2013.01)

USPC - 219/399

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) - A21B 1/08, 3/00, 3/04 (2013.01)

USPC - 126/19R, 20, 24; 219/399, 401

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - A21B 1/08, 3/00, 3/04 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Google Patents, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,700,685 A (MILLER) 20 October 1987 (20.10.1987) entire document	1-20
Y	US 2010/0230396 A1 (BOUBEDDI et al) 16 September 2010 (16.09.2010) entire document	1-20
Y	US 5,176,856 A (TAKAHASHI et al) 05 January 1993 (05.01.1993) entire document	8, 15, 20
A	US 7,867,534 B2 (SELLS et al) 11 January 2011 (11.01.2011) entire document	1-20
A	US 5,069,273 A (O'HEARNE) 03 December 1991 (03.12.1991) entire document	1-20
A	US 2006/0237182 A1 (GODECKER et al) 26 October 2006 (26.10.2006) entire document	1-20

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

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"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

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Date of the actual completion of the international search

19 June 2013

Date of mailing of the international search report

26 JUN 2013

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