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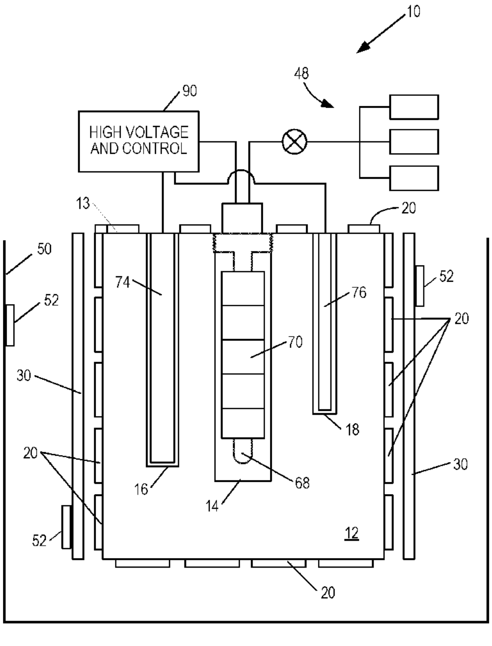

FIG. 1

(57) **Abstract:** A method of calibrating an exothermic reaction chamber calorimeter is provided. The calorimeter includes at least a core, a heating element, a thermal sensor, and a thermoelectric generator. The method includes: with no power applied to the at least one heating element, recording a voltage output by the thermoelectric generator; iteratively applying successive increased power amounts to the heating element until the power amount applied to the heating element reaches a predetermined maximum applied power, wherein applying successive increased power amounts comprises maintaining each increased power amount until the thermal sensor outputs a stable temperature for a first stabilization duration; and at least while iteratively applying successive increased power amounts to the heating element, recording, at each expiration of a predetermined measurement duration, parameters including, at the time of each recording, the power amount applied to the heating element and the voltage output by the thermoelectric generator.

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CALIBRATION METHODS FOR CALORIMETER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority of U.S. provisional patent application no. 62/627,861, titled “Calibration Procedure for HT Seebeck Calorimeter,” filed on February 8, 2018, which is incorporated herein in its entirety by this reference.

TECHNICAL FIELD

[0002] The present invention relates generally to calorimetry, and in particular to a calibration procedure for a calorimeter used to measure excess heat generated in an exothermic reaction.

BACKGROUND

[0003] The phenomenon of excess heat generation has been observed when hydrogen/deuterium reaches high loading in a variety of metals or alloys. This excess heat has been attributed to exothermic reactions between occluded nuclei. In one theory, two deuterium nuclei, when trapped in the small confinement inside the metal lattice, have a wide spread of momentum based on the Heisenberg uncertainty principle. The combined probability of two deuterium nuclei having requisite momenta to overcome the Coulomb barrier may become statistically significant, triggering fusion reactions in the trapped deuterium gas. According to a second theory, the two trapped deuterium nuclei overcome the Coulomb barrier by going through a quantum tunnel to reach the lower energy state, i.e., to form a 4He nucleus.

[0004] One type of exothermic reactions is the so-called Low Energy Nuclear Reactions. Many LENR experiments have been replicated around the world, and numerous different conditions, in which the generation of excess heat can be triggered at will and with control, have been documented. Thus, LENR based heat production is a topic of significant ongoing theoretical and practical research. A significant impediment to the systematic exploration of such triggering mechanisms is the lack of a consistent, reliable, calibrated means for both detecting and quantifying exothermic reactions.

SUMMARY

[0005] This summary is provided to introduce, in a simplified form, concepts that are further described in the following detailed descriptions. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it to be construed as limiting the scope of the claimed subject matter.

[0006] In at least one embodiment, a method of calibrating an exothermic reaction chamber calorimeter is provided. The calorimeter includes a core, at least one heating element, at least one thermal sensor, and at least one thermoelectric generator. The method includes: with no power applied to the at least one heating element, recording a voltage output by the thermoelectric generator; iteratively applying successive increased power amounts to the at least one heating element until the power amount applied to the at least one heating element reaches a predetermined maximum applied power, wherein applying successive increased power amounts includes maintaining each increased power amount until the at least one thermal sensor outputs a stable temperature for a first stabilization duration; and at least while iteratively applying successive increased power amounts to the at least one heating element, recording, at each expiration of a predetermined measurement duration, parameters including, at the time of each recording, the power amount applied to the at least one heating element and the voltage output by the at least one thermoelectric generator.

[0007] The method may include, before iteratively applying successive increased power amounts to the at least one heating element, applying a sufficient power amount to the at least one heating element to bring a temperature output by the at least one thermal sensor to a first predetermined temperature.

[0008] The method may include, after iteratively applying successive increased power amounts to the at least one heating element, iteratively applying successive decreased power amounts to the at least one heating element.

[0009] Iteratively applying successive decreased power amounts to the at least one heating element may begin after the power amount applied to the at least one heating element reaches the predetermined maximum applied power.

[00010] Iteratively applying successive decreased power amounts to the at least one heating element may continue until a temperature output by the at least one thermal sensor reaches or falls below the first predetermined temperature.

[00011] The method may include, while iteratively applying successive decreased power amounts to the at least one heating element, recording, at each expiration of the predetermined measurement duration, the parameters including, at the time of recording, the power amount applied to the at least one heating element and the voltage output by the at least one thermoelectric generator.

[00012] Iteratively applying successive decreased power amounts to the at least one heating element may include maintaining each decreased power amount until the at least one thermal sensor outputs a stable temperature for a second stabilization duration.

[00013] The at least one heating element, the at least one thermal sensor, and the at least one thermoelectric generator, may each be placed in the core in a respective receptacle space.

[00014] The calorimeter may include a reaction chamber.

[00015] The reaction chamber may be in thermal communication with the at least one heating element, the at least one thermal sensor, and the at least one thermoelectric generator via the core.

[00016] Each successive increased power amount applied to the at least one heating element may be greater than a closest preceding power amount applied to the at least one heating element by a first delta power amount.

[00017] When applying successive decreased power amounts to the at least one heating element, each successive decreased power amount applied to the at least one heating element may be lesser than a closest preceding power amount applied to the at least one heating element by a second delta power amount.

[00018] The first delta amount of power may be approximately 30 W.

[00019] The second delta amount of power may be approximately 15 W.

[00020] The predetermined maximum applied power may be approximately 320 W.

[00021] The at least one thermoelectric generator may include multiple thermoelectric generators wired in series.

[00022] The first stabilization duration may be a duration sufficient to observe a maximum variation of: +/- 0.1 degrees Celsius in temperature output by the at least one thermal sensor; or +/- 1%

in the voltage output by the at least one thermoelectric generator.

[00023] The first stabilization duration may be between approximately 6 hours and approximately 8 hours.

[00024] The calorimeter further may further include at least one heat sink at least partially covering a cold side of the at least one thermoelectric generator.

[00025] The calorimeter may further include at least one temperature measuring device affixed to the heat sink.

[00026] The calorimeter may be disposed within a refrigerated container having a temperature measuring device therein, and further including, at each expiration of the predetermined measurement duration, recording the temperature of the refrigerated container.

[00027] The method may include, upon the temperature of the refrigerated container deviating by a predetermined ambient temperature deviation limit, invalidating a calibration defined by the recorded parameters.

[00028] The predetermined ambient temperature deviation limit may be +/-0.2 degrees Celsius.

[00029] In at least one embodiment, a method of sensitivity calibrating an exothermic reaction chamber calorimeter is provided. The calorimeter includes a core, at least one heating element, at least one thermal sensor, and at least one thermoelectric generator. The method includes: applying a first power amount to the at least one heating element to bring a temperature output by the at least one thermal sensor to a first sensitivity testing temperature; maintaining the first power amount applied to the at least one heating element until the at least one thermal sensor outputs a stable first temperature for a stabilization duration; recording, at expiration of the stabilization duration in which the first power amount is maintained, parameters including the first power amount and a voltage output by the at least one thermoelectric generator; applying an increased power amount to the at least one heating element; maintaining the increased power amount applied to the at least one heating element until the at least one thermal sensor outputs a stable second temperature for the stabilization duration; and recording, at expiration of the stabilization duration in which the increased power amount is maintained, the increased power amount and the voltage output by the at least one thermoelectric generator.

[00030] The sensitivity calibrating method may include, after at expiration of the stabilization duration in which the increased power amount is maintained: applying a decreased power amount to

the at least one heating element; maintaining the decreased power amount applied to the at least one heating element until the at least one thermal sensor outputs a stable third temperature for the stabilization duration; and recording, at expiration of the stabilization duration in which the decreased power amount is maintained, the decreased power amount and the voltage output by the at least one thermoelectric generator.

[00031] The first sensitivity testing temperature may be below a desired operating temperature of the calorimeter.

[00032] The increased power amount may be greater than the first power amount by an incremental power amount.

[00033] The decreased power amount may be less than the increased power amount by the incremental power amount.

[00034] The stabilization duration in at least one example is a duration sufficient to observe a maximum variation of: +/- 0.1 degrees Celsius in temperature output by the at least one thermal sensor; or +/- 1% in the voltage output by the at least one thermoelectric generator.

[00035] The incremental power amount may be approximately 1 W.

[00036] According to one or more embodiments described herein, a calorimeter designed to measure the excess heat of an exothermic reaction is carefully calibrated across a range of temperatures bracketing a desired operating temperature. The calorimeter core includes a metal block holding an exothermic reaction chamber, heating elements, and thermocouples. The block is covered with thermoelectric generators (TEG) operative to output a voltage in response to a temperature difference between a hot side facing the block and a cold side facing away from the block. In some embodiments, heat sinks may cover the TEGs and/or the calorimeter may be disposed in a refrigerated container, both to maintain the TEG cold sides at a constant temperature. The block is heated to a temperature below the operating temperature by adjusting the power applied to heating elements. Once the calorimeter stabilizes at that temperature, as measured by the thermocouple outputs, the power applied to the heating elements is adjusted to bring the block to a higher temperature. This process is repeated throughout the range of temperatures bracketing the desired operating temperature. At regular intervals throughout the calibration procedure, such as every 60 seconds, at least the power applied to the heating elements and the output voltage of the TEG's are recorded. In some embodiments, the

temperature of heat sinks and the temperature in the refrigerated container are also recorded. The data are plotted, and provide a baseline against which changes in the TEG output voltage, caused by a temperature change in the calorimeter block other than a change in the power applied to the heating elements, may be measured and attributed to an exothermic reaction in the reaction chamber.

[00037] In another form of calibration procedure, the sensitivity of the calorimeter is ascertained. For each of several target temperatures throughout the calibration range, the calorimeter block is heated to the target temperature and allowed to stabilize. The power applied to the heating elements is then increased a small incremental amount, such as 1 W, and changes in the TEG output voltage are observed. After the calorimeter stabilizes, the power is decreased by the incremental amount, and changes in the TEG output voltage are observed. This process is repeated at a plurality of target temperatures. The incremental power amount may be adjusted, to ascertain the smallest change in input power (without an exothermic reaction being triggered) that causes an observable change in TEG output voltage.

[00038] One embodiment relates to a method of calibrating an exothermic reaction chamber calorimeter. The calorimeter includes a metal block holding an exothermic reaction chamber in a first bore; a plurality of heating elements in a plurality of second bores; and a plurality of thermocouples in a plurality of third bores. Substantially the entire surface of the metal block is covered with thermoelectric generators (TEG) operative to output a voltage in response to a temperature difference between a hot side facing the metal block and a cold side facing away from the metal block. The TEGs are wired in series. With no power applied to the heating elements, a temperature output by each thermocouple and voltage output by the TEGs are recorded as zero-power data points. Power is applied to the heating elements in a sufficient amount to bring the input power to a first predetermined power level, which produces a reactor temperature below a maximum desired operating temperature. The power applied to the heating elements is maintained until the temperatures output by the thermocouples and the voltage output by the TEG's are stable for a first stabilization duration. The power applied to the heating elements is increased by a first delta power amount, and that power is maintained until the temperatures output by the thermocouples and the voltage output by the TEG's are stable for the first stabilization duration. These steps are iteratively repeated until the heating elements reach a predetermined maximum applied power, and the outputs of the thermocouples reach thermal

equilibrium. Throughout the calibration procedure, beginning with recording the zero-power data points, at each expiration of a predetermined measurement duration, the power applied to the heating elements and the voltage output by the TEG's are recorded.

BRIEF DESCRIPTION OF THE DRAWINGS

[00039] The previous summary and the following detailed descriptions are to be read in view of the drawings, which illustrate particular exemplary embodiments and features as briefly described below. The summary and detailed descriptions, however, are not limited to only those embodiments and features explicitly illustrated.

[00040] FIG. 1 is a section view of a calorimeter according to at least one embodiment.

[00041] FIG. 2 is flowchart representing a method, according to at least one embodiment, of implementing a power-response calibration of a calorimeter.

[00042] FIG. 3 is flowchart representing a method, according to at least one embodiment, of implementing a sensitivity calibration of a calorimeter.

DETAILED DESCRIPTIONS

[00043] These descriptions are presented with sufficient details to provide an understanding of one or more particular embodiments of broader inventive subject matters. These descriptions expound upon and exemplify particular features of those particular embodiments without limiting the inventive subject matters to the explicitly described embodiments and features. Considerations in view of these descriptions will likely give rise to additional and similar embodiments and features without departing from the scope of the inventive subject matters. Although steps may be expressly described or implied relating to features of processes or methods, no implication is made of any particular order or sequence among such expressed or implied steps unless an order or sequence is explicitly stated.

[00044] Any dimensions expressed or implied in the drawings and these descriptions are provided for exemplary purposes. Thus, not all embodiments within the scope of the drawings and these descriptions are made according to such exemplary dimensions. The drawings are not made necessarily to scale. Thus, not all embodiments within the scope of the drawings and these descriptions are made according to the apparent scale of the drawings with regard to relative dimensions in the

drawings. However, for each drawing, at least one embodiment is made according to the apparent relative scale of the drawing.

[00045] Like reference numbers used throughout the drawings depict like or similar elements. Unless described or implied as exclusive alternatives, features throughout the drawings and descriptions should be taken as cumulative, such that features expressly associated with some particular embodiments can be combined with other embodiments.

[00046] According to at least one embodiment, a calorimeter designed to measure the excess heat of an exothermic reaction is calibrated across a range of temperatures. In at least one embodiment, the calorimeter includes a metal block core holding a reaction chamber, heating elements, and thermocouples. The core is covered with thermoelectric generators (TEG’s) outputting a voltage in response to the block temperature. The core is heated by applying power to the heating elements. Once the calorimeter stabilizes at one temperature, as measured by the thermocouple outputs, the input power is increased to raise the block to a higher temperature. This first calibration process is repeated throughout a range of temperatures bracketing a desired operating temperature. At least the applied power and TEG output voltage are recorded at regular intervals (e.g., 1 minute.). The data provide a baseline against which deviations in the TEG output voltage, caused by an exothermic reaction in the LENR reaction chamber, may be measured. A second procedure calibrates the sensitivity of the calorimeter, by measuring the temperature change caused by an incremental change in input power, at several test temperatures or across the range of the first calibration.

[00047] FIG. 1 is a functional section diagram of some parts of a calorimeter 10 operative to measure the excess heat of an exothermic reaction, according to one or more embodiments. The calorimeter 10 includes a core 12, which may be shaped, for example, as a rectangular block or other form. The core 12 serves as a structural frame, and as a bulk thermal mass that stores and distributes thermal energy and moderates against temporally rapid heat fluctuations and high-gradients in spatial temperature patterns. Thus, the core 12 regularizes heat flow and prevents excessive temperature differentials in its mass. Thus the core 12 in various embodiments is constructed of material having a high melting point, and good thermal conductivity. The core 12, for example, may be constructed of one or metals.

[00048] The core 12 may be constructed of, in whole or at least in part, copper. In at least one

embodiment, core 12 is constructed as a rectangular block of copper having receptacle spaces for use as described in the following. In other embodiments, other metals may be used, taking into account their thermal transfer properties. In one embodiment the core 12 is formed from aluminum, due to its thermal conductivity and ease of machining.

[00049] An exothermic reaction chamber 68, in some embodiments surrounded by magnets 70, is disposed in a first receptacle space 14 defined in the core 12. The core 12 is heated to a relatively high temperature, such as 150 ° - 300° C, by one or more heating element 74, each placed in a respective second receptacle space 16 defined in the core 12. The temperature of the core 12 is monitored by one or more thermal sensor 76, each placed in a respective third receptacle space 18 defined in the core.

[00050] The thermal sensors 76 may be, for example, thermocouples, and may be described herein, for convenience, as outputting a temperature. For example, each thermal sensor 76 may output a voltage level. The output voltage can be used in combination with a conversion factor or calculation to determine a temperature. For example, one or more sets of calibration data can be applied or correlated with the output voltage to indicate a temperature. Accordingly, by outputting a voltage level, each thermal sensor 76 can be considered to output a temperature or temperature indication.

[00051] A controller 90 receives, as input, the output voltages or other temperature indications from the thermal sensors 76, and controls the heating elements 74, to maintain the core 12 temperature at a selected or desired level. The heating elements 74, thermal sensors 76, and exothermic reaction chamber 68 are each in thermal communication with the core 12. Thus, the heating elements 74, thermal sensors 76, and exothermic reaction chamber 68 are in thermal communication with each other via the core 12.

[00052] In some embodiments, a gas flow manifold 48 controls the pressure and flow of gases into and out of the exothermic reaction chamber 68, facilitating implementation with various conditions and reaction triggering events. The controller 90 can provide high voltage (e.g., 5 kVDC) to an anode in the exothermic reaction chamber 68, and in some embodiments may superimpose an RF signal on the provided voltage.

[00053] When an exothermic reaction is triggered in the exothermic reaction chamber 68, the heat of the reaction is in part conducted away by the core 12, raising the temperature of the core 12.

The core 12 spreads heat evenly from the heating elements 74 around the exothermic reaction chamber 68 and magnets 70. Additionally, the core 12 quickly conducts excess heat from the exothermic reaction chamber 68 to the exterior surface of the core 12. The rise in temperature is detected by one or more TEGs 20, which partially surround the core 12. Each TEG generates a voltage proportional to the temperature difference between a “hot side,” which is pressed against the core 12, and a “cold side,” which faces away from the core 12. Due to the high temperature of the core 12, heat sinks 30 are affixed to the cold side of the TEGs 20 to help cool the cold side, to maintain a thermal differential. In some embodiments, fans direct convective cooling air over the fins of the heat sinks 30. In some embodiments, the entire calorimeter 10 may be placed in a refrigerated container.

[00054] The “hot side” and “cold side” of a typical TEG are indicated by the manufacturer so as to assure proper orientation of the generator in use. For example, the cold sides of some manufactured TEGs have part numbers or other textual or graphical indications. The actual temperature of any given TEG side of course may vary according to its placement and use. In typical use, the “hot side” faces or thermally contacts a heat source or surface and the “cold side” faces away so as to cool radiantly or by thermal contact with a cooling device, structure, or flow. Thus, in use, the “hot side” typically has a higher temperature than the “cold side.” However, when not installed upon a heat source and in use, the hot and cold sides may be temperature equilibrated according to conditions of their environment. Nonetheless, the sides of a TEG can be described for nominal purposes herein as hot and cold sides without ambiguity according to the construction and expected use of the TEG, for example according to manufacturer specifications.

[00055] The core 12 may completely or partially cover or surround the exothermic reaction chamber 68 and magnets 70, and additionally has room for the heating elements 74 and thermal sensors 76. Accordingly, the size or dimensions of the core 12 accommodates the exothermic reaction chamber 68 and magnets 70. However, the core 12 is not required to mimic the shape of the exothermic reaction chamber 68. The core 12 may have flat external sides or surfaces to which the “hot side” of each TEG 20 may be affixed. The sides of the core 12 may be rectangular. Other regular polygonal shapes may also or alternatively be used. In at least one embodiment represented in FIG. 1, the core 12 has a rectangular block shape with a square cross-sectional profile.

[00056] In the illustrated embodiment, the receptacle spaces 14, 16 and 18 that receive the

reaction chamber 68, heating element(s) 74, and thermal sensor(s) 76 are defined as parallel holes or bores drilled or otherwise formed as extending inward into the core 12 from the top side 13 of the core 12 as shown in FIG. 1. In the center of the core 12, the first receptacle space 14 has sufficient internal dimensions to accommodate an exothermic reaction chamber 68 and magnets 70. Preferably, magnets 70 arrayed around the exothermic reaction chamber 68 make solid, constant contact with the inner walls of the first receptacle space. The receptacle spaces in at least one embodiment of the core 12 are cylindrical bores. The first receptacle space 14, formed as such, may be tapped to receive a threaded portion of the exothermic reaction chamber 68.

[00057] A plurality of second receptacle spaces 16, for example four, may be evenly spaced around the first receptacle space 14. For example, the second receptacle spaces 16 may be positioned between the central first receptacle space 14 and four planar sides of the core 12. Each second receptacle space 16 has sufficient internal dimensions to receive a respective heating element 74. The heating elements 74 may include electrical resistive heating elements, which may be cylindrical in shape. Accordingly, each second receptacle space 16 may be a cylindrical bore having an internal diameter sufficient to accommodate a respective heating element 74.

[00058] In at least one embodiment, each second receptacle space 16 is formed all the way through the core 12, and two heating elements 74, each of which may be less than half the length of the core 12, may be inserted into each second receptacle space 16 from either end of the core 12. In another embodiment, a plurality of second receptacle spaces 16 are formed in the opposite end of the core 12, and may or may not be aligned with the second receptacle spaces 16 formed in the first end of the core 12. This may evenly heat the core 12.

[00059] In at least one embodiment, the heating elements 74 are operative to heat the core 12 to a temperature in a range between 150° to 300° C. A suitable heating element 74, for example, is model SWH16519-00 available from Watlow Electric Manufacturing Company, Inc. of St. Louis, Missouri.

[00060] A plurality of third receptacle spaces 18, for example four, may defined as cylindrical bores evenly spaced around the first receptacle space 14, and generally disposed between the plurality of second bores 16. For example, the third receptacle spaces 18 may be positioned between the central first receptacle space 14 and corners of the core 12 defined at the junctions of the planar sides of the core 12. The third receptacle spaces are internally dimensioned, for example in cylinder diameter and

depth, to accommodate thermal sensors 76. The thermal sensors 76 may be correspondingly cylindrical in shape. The thermal sensors 76 are operative to monitor the temperature of the core 12. The second cylindrical spaces 16 may be formed deeply enough that, when installed, the most sensitive portion of the thermal sensors 76 are even with the center of the exothermic reaction chamber 68, where an exothermic reaction may be most likely to occur. The thermal sensors 76 in at least one embodiment are precise to 0.1° C and withstand temperatures up to 1100° C. A suitable thermal sensor for use is a thermocouple model TJ72-CASS-18U-6-CC-SB available from Omega Engineering, Inc. of Stamford, Connecticut.

[00061] FIG. 1 represents the core 12 with TEGs 20 covering substantially the entirety of its external surface. The TEGs 20 in the illustrated embodiment may be Seebeck effect devices, which output a DC voltage dependent on the difference in temperature between "hot" and "cold" sides of the device 20. Each TEG 20 has a positive and negative terminal. The TEGs may be all wired in series for additive voltage output – that is, the positive terminal of each TEG 20 is connected to the negative terminal of the next TEG 20, and the positive terminal of the last TEG 20 and the negative terminal of the first TEG 20 are connected to a calibrated multimeter or other data recording device. In other embodiments, the TEGs may be wired in parallel relation for additive current output. In yet other embodiments, the TEGs may be wired independently.

[00062] Suitable models for use as TEGs 20 are model TEG1-PB-12611-6.0, and model TEG1-PB-07110-25, both available from Thermal Electronics, Inc. of Lake Elsinore, California. In at least one embodiment of the calorimeter 10, the afore-mentioned model TEG1-PB-12611-6.0 is used for the side-mounted and bottom-mounted TEGs 20, and the latter-mentioned model TEG1-PB-07110-25 is used for the top-mounted TEGs 20 along the top side 13 of the core 12, referring to the placements of the TEGs 20 in FIG. 1.

[00063] The TEGs 20 are shown in FIG. 1 to cover substantially much or all of the exterior surfaces of the core 12, including the top side 13, and bottom (lowest and opposite the top side 13) and side walls between the top side and bottom. The TEGs 20 may be held firmly against the walls of the core 12 to obtain a consistent, optimal thermal conduction for thermal communication with the core 12. The heat sinks 30 in thermal communication with the cold sides of the TEGs 20 help to maintain a constant, uniform temperature substantially cooler than that of the core 12 before, during, and after any

exothermic reaction.

[00064] The calorimeter 10 can be calibrated to ascertain the relationship between power applied to the heating elements 74 and the output voltage of the TEGs 20, with reference for example to the sum voltage output of TEGs 20 wired in series. By use of this baseline-calibrated relationship, the excess power of a reaction in the reaction chamber 68 can be ascertained, and positively attributed to an exothermic reaction.

[00065] At least one calibration protocol comprises two stages of calibration. In the first stage of calibration, the relationship of input power, as applied to the heating elements 74, to output voltage, as provided by TEGs 20, is measured throughout a range of temperatures. This range, herein described as the calibrated temperature range, is selected to bracket a desired or targeted operating temperature or range of operating temperatures. This first stage of calibration is described herein for nominal purposes as a power-response calibration.

[00066] In the second stage of calibration, the sensitivity of the calorimeter 10 is ascertained by, once stabilized at any particular operating temperature, changing the power applied to the heating elements 74 by an incremental amount, such as 1 W, and measuring the change in output voltage of the TEGs 20. The second stage calibration may be repeated at a plurality of operating temperatures throughout the calibrated temperature range. This second calibration stage is described herein for nominal purposes as a sensitivity calibration.

[00067] To further compare the first and second stages of calibration, in the power-response calibration, the power applied is: successively increased by a selected amount, below described as a first delta power amount; and maintained at each increased amount until a temperature output is stable for a period of time, below described as a first stabilization period. In the sensitivity calibration, power is applied: to bring a temperature to a particular testing temperature, below described as a first sensitivity testing temperature; and, increased by a relatively smaller selected amount, below described as a predetermined incremental amount.

[00068] While these descriptions refer to embodiments in which the TEGs 20 are wired in series for additive voltage output, parallel wiring for additive current output, and independent wiring for each TEG are also within these descriptions. Accordingly, output voltage in the below descriptions of FIGS. 2 and 3 refers to the sum (for series wiring) of the individual voltages generated by TEGs 20 or their

individual outputs (for parallel and independent wiring) according the embodiment being implemented.

[00069] FIG. 2 is flowchart detailing a method 100 by which the above-described power-response calibration is implemented according to at least one embodiment. A calorimeter, for example, calorimeter 10 according to FIG. 1 and herein descriptions thereof, may benefit from power-relationship calibration by the method 100 of FIG. 2. Accordingly, herein descriptions of the method 100 refer to features of the calorimeter 10 for illustrative purposes without limiting the method 100 to the example of FIG. 1, and without limiting the calorimeter 10 of FIG. 1 to the example of FIG. 2.

[00070] In preparation, an exothermic reaction chamber 68 is placed in the calorimeter 10, about which TEGs 20 and heat sinks 30 cover substantially the entire core 12, including the optional lid. The calorimeter 10 may be placed in a refrigerated container 50 and its temperature allowed to stabilize at zero power input to the heating elements 74, at which the output voltage should be at or near 0 V. The method 100 begins by recording zero-power data points – that is, the thermocouple 76 temperature outputs and the output voltage are recorded with no power being applied to the heating elements 74 (block 102).

[00071] Throughout the method 100, (as represented at block 104) relevant parameters are recorded at regular intervals – that is, at each expiration of a recurring predetermined measurement interval. In one embodiment, the predetermined measurement interval is one minute. The primary parameters to be recorded are the power applied to the heating elements 74, and the output voltage of the TEGs 20, which are related to the temperature difference of the metal block 12 and the heat sinks 30. However, in at least one embodiment, all measurable parameters are recorded for later analysis. These include, in the relevant implementation configurations: the output of each thermocouple 76; the output of each of one or more temperature measuring devices 52 (FIG. 1) affixed to heat sinks 30 placed over the cold sides of the TEGs 20; and the ambient temperature inside the refrigerated container 50 according to the output of one or more other temperature measuring devices 52 within the container, for example mounted upon an interior wall of the container.

[00072] Sufficient power is then applied (block 106) to the heating elements 74 to achieve a predetermined input power and to bring the temperature of the core 12, according to an output of at least one of the thermocouples 76, to a first predetermined temperature below a desired operating temperature range.

[00073] The power applied to the heating elements 78 is maintained (block 108) at a constant level until the outputs of the thermocouples 76 are stable for a first stabilization duration. In one embodiment, the first stabilization duration is the time required for the thermocouple 76 outputs to produce a flat plot with a maximum variation within the intrinsic error of the thermocouples, which is typically +/- 0.1C. In another embodiment, the first stabilization duration may be a predetermined duration, such as 6-8 hours. Note that the ongoing recording of relevant parameters at regular intervals (block 104) proceeds throughout the proceeding method 100.

[00074] The preceding initializes the calorimeter 10 and first-stage calibration according to method 100 for increases into and through the desired calibrated temperature range, for which the relationship of input power to output voltage is sought via the power-response calibration. Once initialized, a power and temperature ascending phase of the power-response calibration method 200 is implemented to increase the temperature of the core 12 as the ongoing recording of relevant parameters at regular intervals (block 104) proceeds.

[00075] The power applied to the heating elements 74 is increased by a first delta power amount (block 110). In one embodiment, the first delta power amount is 30 W. The first delta power amount increase in power is split evenly among the heating elements 74 – i.e., if four heating elements 74 are utilized, each would receive an increase of 7.5 W. This new power level is maintained for the first stabilization duration (block 110).

[00076] This process – increasing, over the closest preceding applied power amount, the applied power by the first delta power amount and maintaining the new power for the first stabilization duration (block 110) – is repeated iteratively. Accordingly, electrical power applied to the core 12 will increase in a step-wise fashion as the process is continued until the power applied to the heating elements 74 reaches a predetermined maximum applied power level (block 112). In one embodiment, the predetermined maximum applied power level is 320 W. The range of temperatures recorded during the calibration should include the minimum and maximum desired operating temperatures.

[00077] Note again that the ongoing recording of relevant parameters at regular intervals (block 104) proceeds throughout the procedure. The first calibration procedure 100 thus produces a quantified relationship between power input to the heating elements 74, and the voltage output of the TEGs 20, as the input power is increased in step-wise fashion by a known amount (the first delta power amount)

across the calibrated temperature range.

[00078] In one embodiment, the power-response calibration stage of the above-described two stage calibration continues as power input to the heating elements 74 is decreased. The blocks 110-112 expressly shown in FIG. 2 represent a power and temperature ascending phase of the power-response calibration stage, which can include as well a power and temperature descending phase. In at least one such embodiment of the method 100, after reaching the predetermined maximum applied power (block 112), the power is decreased at each step by a second delta power amount, which may be the same or different from the first delta power amount. In one embodiment, the second delta power amount is 15 W. After each decrease in applied power, the new power input level is maintained for a second stabilization duration, which may the same as or different than the first stabilization duration. The second stabilization duration may be the time required for the thermocouple 76 to produce a flat plot with a maximum variation within the intrinsic error of the thermocouples, which is typically +/- 0.1C, or it may be a predetermined duration, such as 6-8 hours. The step-wise decrease in applied power is iteratively repeated until the temperature output by least one of the thermocouples is at or below the first predetermined temperature. All relevant parameters continue to be recorded at each expiration of a predetermined measurement interval, such as one minute.

[00079] As already described, the relevant parameters include at least the power applied to the heating elements 74 and the output voltage of the TEGs 20. In some embodiments, relevant parameters to be recorded may additionally include the temperature output by each thermocouple 76, the temperature of the heat sinks 30, and the ambient temperature inside the refrigerated container.

[00080] In at least one embodiment, throughout the first calibration procedure 100, if the ambient temperature inside the refrigerated container deviates by more than a predetermined ambient temperature deviation limit, the entire first calibration procedure 100 is invalidated. In one embodiment, the predetermined ambient temperature deviation limit is +/-0.2C. This prevents a power-relationship calibration from being established using parameter data adversely affected by fluctuations in temperature of the environment around the calorimeter.

[00081] In order to establish and certify the response of the calorimeter to exothermic reactions, for example LENR exothermic reactions in the reaction chamber 68, the sensitivity of the calorimeter 10 is ascertained by the second stage of calibration, that is, the afore-mentioned sensitivity calibration.

In order to detect and characterize exothermic reactions and to discern and quantify the energy released by such reactions, the sensitivity of the calorimeter 10 can be established across the calibrated temperature range. At any particular operating temperature, an output voltage of the TEGs in excess of that determined in the power-response calibration can be attributed to exothermic activity in reaction chamber 68.

[00082] Thus, against the first-stage calibration data, a small increase in power input can be added to the system, producing discernible increases in the temperature of the core 12 and in the voltage output of the TEGs 20. This triggering mechanism can be less than 1 watt, representing less than 1% of total input power. This triggering input power is also added to the total electrical input power but is of such a low power level that any significant increase in reactor power output can confidently be attributed to exothermic LENR activity in the reaction chamber 68.

[00083] FIG. 3 is flowchart representing a method 200, by which the above-described sensitivity calibration is implemented according to at least one embodiment. A calorimeter, for example, calorimeter 10 according to FIG. 1 and herein descriptions thereof, may benefit from sensitivity calibration by the method 200 of FIG. 3. Accordingly, herein descriptions of the method 200 refer to features of the calorimeter 10 for illustrative purposes without limiting the method 200 to the example of FIG. 1, and without limiting the calorimeter 10 of FIG. 1 to the example of FIG. 3.

[00084] The method 200 quantifies the sensitivity of a calorimeter 10 to small changes in power applied to the heating elements 74 at a selected sensitivity testing temperature – for example, below, near or at, a desired operating temperature within the calibrated range. Sensitivity calibration according to method 200 can be implemented at any desired sensitivity testing temperature, and at multiple sensitivity testing temperatures distributed or selected across any desired temperature range, such as the calibrated range.

[00085] Before determining the sensitivity of the calorimeter 10 at any target temperature at which sensitivity testing is desired, the core 12 and other components should be stabilized at that target temperature. Thus, to initialize the calorimeter 10 and sensitivity calibration, power is applied to the heating elements 74 to bring a temperature output by at least one of the thermocouples 76 to a first sensitivity testing temperature (block 202). The applied power is maintained for a stabilization duration (block 204). In one embodiment, the stabilization duration is the time required for the

thermocouple 76 outputs to produce a flat plot with a maximum variation within the intrinsic error of the thermocouples, which is typically +/- 0.1C. In another embodiment, the stabilization duration may be a predetermined duration, such as 6-8 hours. At least the power applied to the heating elements 74 and the output voltage of the TEGs 20 are recorded (block 206). In some embodiments, the temperature output by each thermocouple 76, the temperature of the heat sinks 30, and the ambient temperature inside the refrigerated container are additionally recorded.

[00086] The preceding initializes the calorimeter 10 and second-stage calibration according to the method 200 at the first sensitivity testing temperature. Once initialized, a power and temperature incrementing phase of the sensitivity calibration method 200 is implemented to increment the power applied by one or small amounts and determine the response via the thermocouples 76, TEGs 20, and optionally other measurable parameters.

[00087] Accordingly, the power applied to the heating elements 74 is increased by a predetermined incremental power amount (block 208). In one embodiment, the predetermined incremental power amount is 1 W. The increment increased power is maintained until the temperatures output by the thermocouples 76 are stable for the first stabilization duration (block 210). The relevant parameters – including at least the power applied to the heating elements 76 and the output voltage of the TEGs 20 – are then recorded (block 212).

[00088] This will determine and quantify whether the calorimeter 10 is sensitive enough to detect a change in the temperature of the calorimeter core 12 caused by an incremental increase in the power applied to the heating elements 74 at any particular first sensitivity testing temperature. The method 200 can be iteratively repeated at any second sensitivity testing temperature, third temperature, and across any range of temperatures, for example across the calibrated temperature range established by the method 100. This establishes and quantifies the ability of the calorimeter 10 to detect and characterize exothermic reactions and to discern and quantify the energy released by such reactions over the power provided to the core 12 by other sources, for example by the heating elements 74. Sensitivity testing temperatures can be selected below, at or near, and above one or various desired operating temperatures, to validate the sensitivity of the calorimeter 10 at any desired temperatures over the entire range of operational use of the calorimeter, including for example the calibrated temperature range.

[00089] The sensitivity calibration, for example as implemented by the method 200 of FIG. 3, can be described as a relatively fine calibration of the relationship between power applied to the heating elements and the output voltage, with relative respect to the power-response calibration, for example as implemented by the method 100 of FIG. 2, which can be described as a relatively coarse calibration of that relationship.

[00090] In one embodiment, the second stage of calibration as implemented by the method 200 continues by decreasing the power applied to the heating elements 74 by the predetermined incremental power amount. In one embodiment, the predetermined incremental power amount is 1 W. This new power level is maintained until the temperatures output by the thermocouples 76 are stable for the stabilization duration. The relevant parameters – including at least the power applied to the heating elements 76 and the output voltage of the TEGs 20 – are then recorded.

[00091] Without limiting the calorimeter and calibrations described herein to such use, embodiments described herein are contemplated for use at least to calibrate the calorimeter 10 for use in detecting and quantifying LENR activity in the reaction chamber 68, as well as quantify its sensitivity to incremental changes in power input. Both the calibration procedure 100 and the sensitivity testing 200 provide data against which data acquired during LENR experiments may be compared, to verify the presence of exothermic reactions in the LENR reaction chamber.

[00092] Particular embodiments and features have been described with reference to the drawings. It is to be understood that these descriptions are not limited to any single embodiment or any particular set of features, and that similar embodiments and features may arise or modifications and additions may be made without departing from the scope of these descriptions and the spirit of the appended claims.

CLAIMS

What is claimed is:

1. A method of calibrating an exothermic reaction chamber calorimeter, the calorimeter comprising a core, at least one heating element, at least one thermal sensor, and at least one thermoelectric generator, the method comprising:

   with no power applied to the at least one heating element, recording a voltage output by the thermoelectric generator;

   iteratively applying successive increased power amounts to the at least one heating element until the power amount applied to the at least one heating element reaches a predetermined maximum applied power, wherein applying successive increased power amounts comprises maintaining each increased power amount until the at least one thermal sensor outputs a stable temperature for a first stabilization duration; and

   at least while iteratively applying successive increased power amounts to the at least one heating element, recording, at each expiration of a predetermined measurement duration, parameters comprising, at the time of each recording, the power amount applied to the at least one heating element and the voltage output by the at least one thermoelectric generator.

2. The method of claim 1, further comprising, before iteratively applying successive increased power amounts to the at least one heating element, applying a sufficient power amount to the at least one heating element to bring a temperature output by the at least one thermal sensor to a first predetermined temperature.

3. The method of any preceding claim, further comprising, after iteratively applying successive increased power amounts to the at least one heating element, iteratively applying successive decreased power amounts to the at least one heating element.

4. The method of claim 3, wherein said iteratively applying successive decreased power amounts to the at least one heating element begins after the power amount applied to the at least one heating element reaches the predetermined maximum applied power.

5. The method of any one of claims 3-4, wherein said iteratively applying successive decreased power amounts to the at least one heating element continues until a temperature output by the at least one thermal sensor reaches or falls below the first predetermined temperature.

6. The method of any one of claims 3-5, further comprising, while iteratively applying successive decreased power amounts to the at least one heating element, recording, at each expiration of the predetermined measurement duration, the parameters comprising, at the time of recording, the power amount applied to the at least one heating element and the voltage output by the at least one thermoelectric generator.

7. The method of any one of claims 3-6, wherein iteratively applying successive decreased power amounts to the at least one heating element comprises maintaining each decreased power amount until the at least one thermal sensor outputs a stable temperature for a second stabilization duration.

8. The method of any preceding claim, wherein the at least one heating element, the at least one thermal sensor, and the at least one thermoelectric generator, are each placed in the core in a respective receptacle space.

9. The method of any preceding claim, wherein the calorimeter further comprises a reaction chamber.

10. The method of claim 9, wherein the reaction chamber is in thermal communication with the at least one heating element, the at least one thermal sensor, and the at least one thermoelectric generator via the core.

11. The method of any preceding claim, wherein each successive increased power amount applied to the at least one heating element is greater than a closest preceding power amount applied to the at least one heating element by a first delta power amount.

12. The method of claim 11, wherein, when applying successive decreased power amounts to the at least one heating element, each successive decreased power amount applied to the at least one heating element is lesser than a closest preceding power amount applied to the at least one heating element by a second delta power amount.

13. The method of any one of claims 11 and 12, wherein the first delta amount of power is approximately 30 W.

14. The method of claim 13 wherein the second delta amount of power is approximately 15 W.

15. The method of any preceding claim, wherein the predetermined maximum applied power is approximately 320 W.

16. The method of any preceding claim, wherein the at least one thermoelectric generator comprises multiple thermoelectric generators wired in series.

17. The method of any preceding claim, wherein the first stabilization duration is a duration sufficient to observe a maximum variation of: +/- 0.1 degrees Celsius in temperature output by the at least one thermal sensor; or +/- 1% in the voltage output by the at least one thermoelectric generator.

18. The method of any preceding claim, wherein the first stabilization duration is between approximately 6 hours and approximately 8 hours.

19. The method of any preceding claim, wherein the calorimeter further comprises at least one heat sink at least partially covering a cold side of the at least one thermoelectric generator.

20. The method of claim 19, wherein the calorimeter further comprises at least one temperature measuring device affixed to the heat sink.

21. The method of any preceding claim, wherein the calorimeter is disposed within a refrigerated container having a temperature measuring device therein, and further comprising, at each expiration of the predetermined measurement duration, recording the temperature of the refrigerated container.

22. The method of claim 21, further comprising, upon the temperature of the refrigerated container deviating by a predetermined ambient temperature deviation limit, invalidating a calibration defined by the recorded parameters.

23. The method of claim 22, wherein the predetermined ambient temperature deviation limit is +/- 0.2 degrees Celsius.

24. A method of sensitivity calibrating an exothermic reaction chamber calorimeter, the calorimeter comprising a core, at least one heating element, at least one thermal sensor, and at least one thermoelectric generator, the method comprising:
applying a first power amount to the at least one heating element to bring a temperature output by the at least one thermal sensor to a first sensitivity testing temperature;
maintaining the first power amount applied to the at least one heating element until the at least one thermal sensor outputs a stable first temperature for a stabilization duration;
recording, at expiration of the stabilization duration in which the first power amount is maintained, parameters comprising the first power amount and a voltage output by the at least one thermoelectric generator;
applying an increased power amount to the at least one heating element;

maintaining the increased power amount applied to the at least one heating element until the at least one thermal sensor outputs a stable second temperature for the stabilization duration; and

recording, at expiration of the stabilization duration in which the increased power amount is maintained, the increased power amount and the voltage output by the at least one thermoelectric generator.

25. The method of claim 24, further comprising, after at expiration of the stabilization duration in which the increased power amount is maintained:

applying a decreased power amount to the at least one heating element;

maintaining the decreased power amount applied to the at least one heating element until the at least one thermal sensor outputs a stable third temperature for the stabilization duration; and

recording, at expiration of the stabilization duration in which the decreased power amount is maintained, the decreased power amount and the voltage output by the at least one thermoelectric generator.

26. The method of any one of claims 24 and 25, wherein the first sensitivity testing temperature is below a desired operating temperature of the calorimeter.

27. The method of any one of claims 24 to 26, wherein the increased power amount is greater than the first power amount by an incremental power amount.

28. The method of any one of claims 24 to 27, wherein the decreased power amount is less than the increased power amount by the incremental power amount.

29. The method of any one of claims 24 to 28, wherein the stabilization duration is a duration sufficient to observe a maximum variation of: +/- 0.1 degrees Celsius in temperature output by the at least one thermal sensor; or +/- 1% in the voltage output by the at least one thermoelectric

generator.

30. The method of any one of claims 24 to 28, wherein the first stabilization duration is between approximately 6 hours and approximately 8 hours.

31. The method of any one of claims 27 to 30, wherein the incremental power amount is approximately 1 W.

32. The method of any one of claims 24 to 31, wherein the calorimeter further comprises at least one heat sink at least partially covering a cold side of the at least one thermoelectric generator.

33. The method of any one of claims 24 to 32, wherein the calorimeter further comprises at least one temperature measuring device affixed to the heat sink.

34. The method of any one of claims 24 to 33, wherein the calorimeter is disposed within a refrigerated container having a temperature measuring device therein, the method further comprising, at each expiration of the stabilization duration, recording the temperature of the refrigerated container.

35. The method of any preceding claim, wherein the calorimeter further comprises a reaction chamber for conducting exothermic reactions.

36. The method of any preceding claim, wherein the calorimeter further comprises a reaction chamber for conducting exothermic LENR activity.

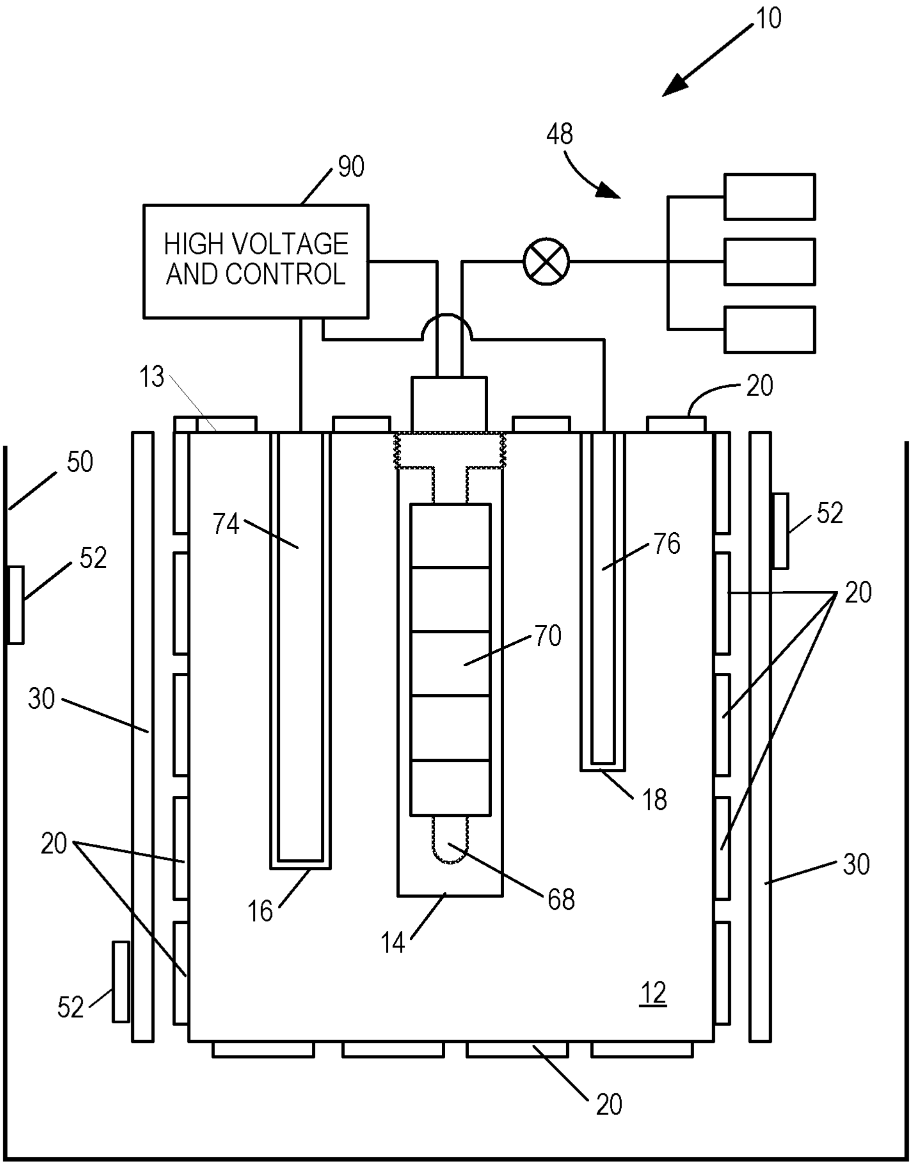
10
48
90
HIGH VOLTAGE AND CONTROL
13
20
50
74
76
52
52
70
20
30
18
20
30
16
68
14
52
12
20

FIG. 1

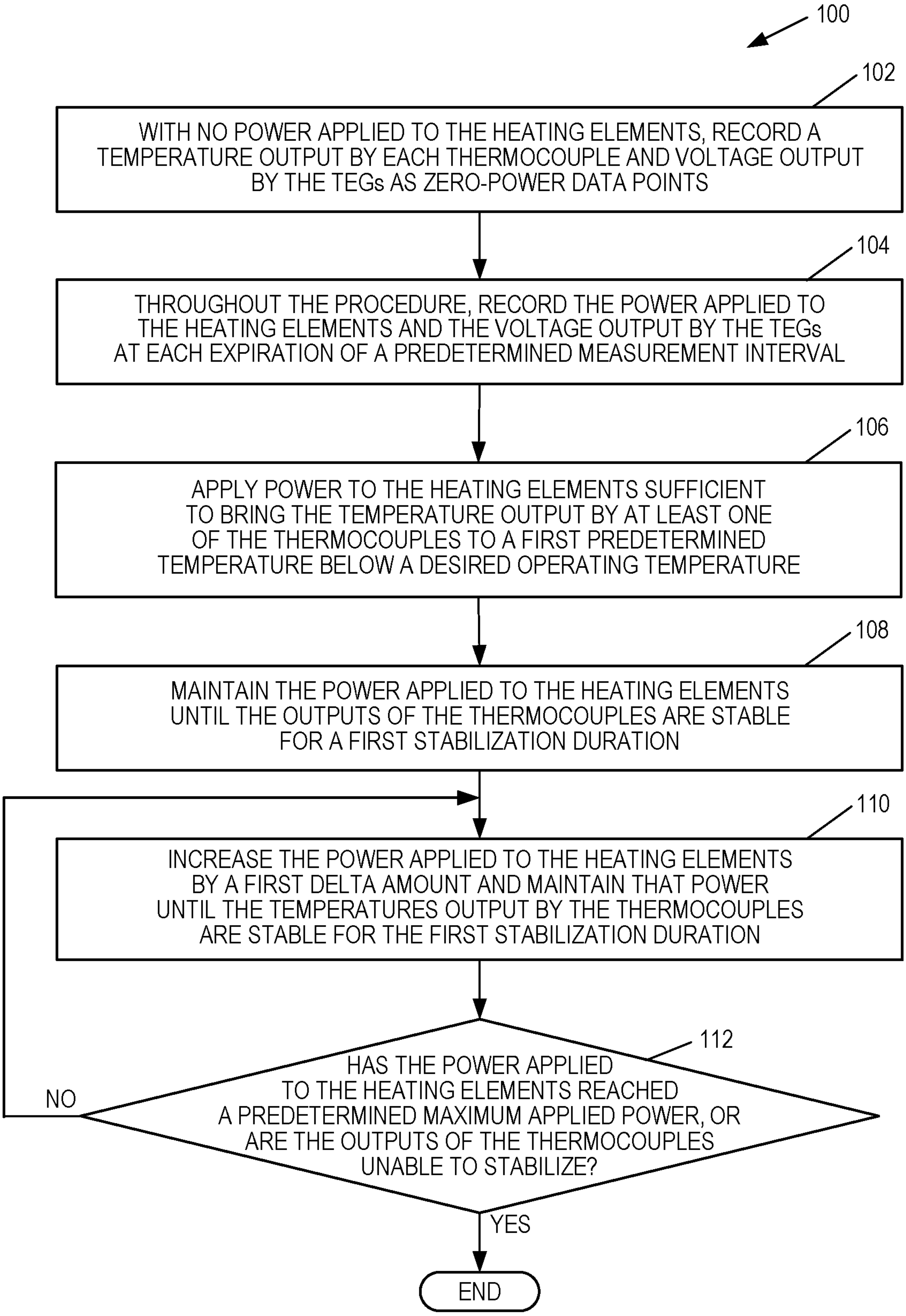
100
102
WITH NO POWER APPLIED TO THE HEATING ELEMENTS, RECORD A TEMPERATURE OUTPUT BY EACH THERMOCOUPLE AND VOLTAGE OUTPUT BY THE TEGs AS ZERO-POWER DATA POINTS
104
THROUGHOUT THE PROCEDURE, RECORD THE POWER APPLIED TO THE HEATING ELEMENTS AND THE VOLTAGE OUTPUT BY THE TEGs AT EACH EXPIRATION OF A PREDETERMINED MEASUREMENT INTERVAL
106
APPLY POWER TO THE HEATING ELEMENTS SUFFICIENT TO BRING THE TEMPERATURE OUTPUT BY AT LEAST ONE OF THE THERMOCOUPLES TO A FIRST PREDETERMINED TEMPERATURE BELOW A DESIRED OPERATING TEMPERATURE
108
MAINTAIN THE POWER APPLIED TO THE HEATING ELEMENTS UNTIL THE OUTPUTS OF THE THERMOCOUPLES ARE STABLE FOR A FIRST STABILIZATION DURATION
110
INCREASE THE POWER APPLIED TO THE HEATING ELEMENTS BY A FIRST DELTA AMOUNT AND MAINTAIN THAT POWER UNTIL THE TEMPERATURES OUTPUT BY THE THERMOCOUPLES ARE STABLE FOR THE FIRST STABILIZATION DURATION
112
HAS THE POWER APPLIED TO THE HEATING ELEMENTS REACHED A PREDETERMINED MAXIMUM APPLIED POWER, OR ARE THE OUTPUTS OF THE THERMOCOUPLES UNABLE TO STABILIZE?
NO
YES
END

FIG. 2

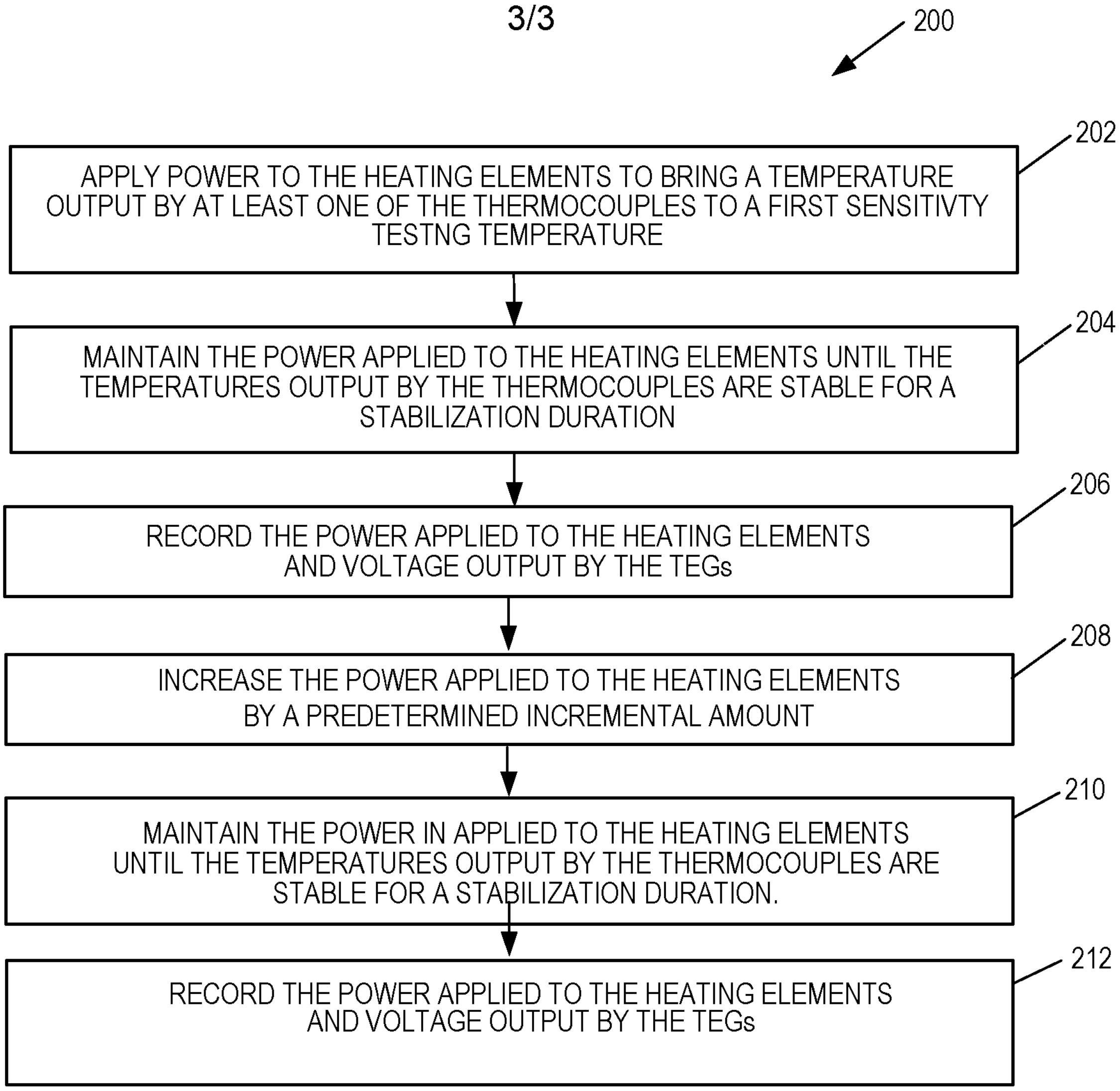
200
202
APPLY POWER TO THE HEATING ELEMENTS TO BRING A TEMPERATURE OUTPUT BY AT LEAST ONE OF THE THERMOCOUPLES TO A FIRST SENSITIVTY TESTNG TEMPERATURE
204
MAINTAIN THE POWER APPLIED TO THE HEATING ELEMENTS UNTIL THE TEMPERATURES OUTPUT BY THE THERMOCOUPLES ARE STABLE FOR A STABILIZATION DURATION
206
RECORD THE POWER APPLIED TO THE HEATING ELEMENTS AND VOLTAGE OUTPUT BY THE TEGs
208
INCREASE THE POWER APPLIED TO THE HEATING ELEMENTS BY A PREDETERMINED INCREMENTAL AMOUNT
210
MAINTAIN THE POWER IN APPLIED TO THE HEATING ELEMENTS UNTIL THE TEMPERATURES OUTPUT BY THE THERMOCOUPLES ARE STABLE FOR A STABILIZATION DURATION.
212
RECORD THE POWER APPLIED TO THE HEATING ELEMENTS AND VOLTAGE OUTPUT BY THE TEGs

FIG. 3

INTERNATIONAL SEARCH REPORT	International application No. PCT/US 2019/017156

A. CLASSIFICATION OF SUBJECT MATTER

G01K 17/10 *(2006.01)*
G01K 19/00 *(2006.01)*

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)

G01K 17//0, 17/06-17/20, G01N 25/00, 25/20-25/48, G21C 17/00, 17/10, 17/112, 17/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2968448 A1 (COMMISSARIAT A L'ENERGIE ATOMIQUEET AUX ENERGIES ALTERNATIVES) 08.06.2012	1-36
A	FR 3034867 A1 (COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES et al.) 14.10.2016	1-36
A	CN 105913886 A (CHINA NUCLEAR POWER DESIGN INST) 31.08.2016	1-36
A	KR 1630848 B1 (KOREA RESEARCH INSTITUTE OF STANDARDS AND SCIENCE) 16.06.2016	1-36
A	FR 2393286 A (VAILLANT SA) 02.02.1979	1-36

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"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 14 May 2019 (14.05.2019)	Date of mailing of the international search report 23 May 2019 (23.05.2019)
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer A. Grigoryan Telephone No. (499) 240-25-91