US 20160349771A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2016/0349771 A1**

KIM et al. (43) **Pub. Date: Dec. 1, 2016**

(54) **TEMPERATURE CONTROL APPARATUS AND METHOD IN MICROWAVE IMAGING SYSTEM**

(71) Applicant: **ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE**, Daejeon (KR)

(72) Inventors: **Jang Yeol KIM**, Daejeon (KR); **Hyuk Je KIM**, Daejeon (KR); **Seong Ho SON**, Daejeon (KR); **Kwang Jae LEE**, Daejeon (KR); **Jong Moon LEE**, Seoul (KR); **Soon Ik JEON**, Daejeon (KR)

(73) Assignee: **ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE**, Daejeon (KR)

(21) Appl. No.: **15/079,146**

(22) Filed: **Mar. 24, 2016**

(30) **Foreign Application Priority Data**

May 26, 2015 (KR) 10-2015-0072735

Publication Classification

(51) **Int. Cl.**

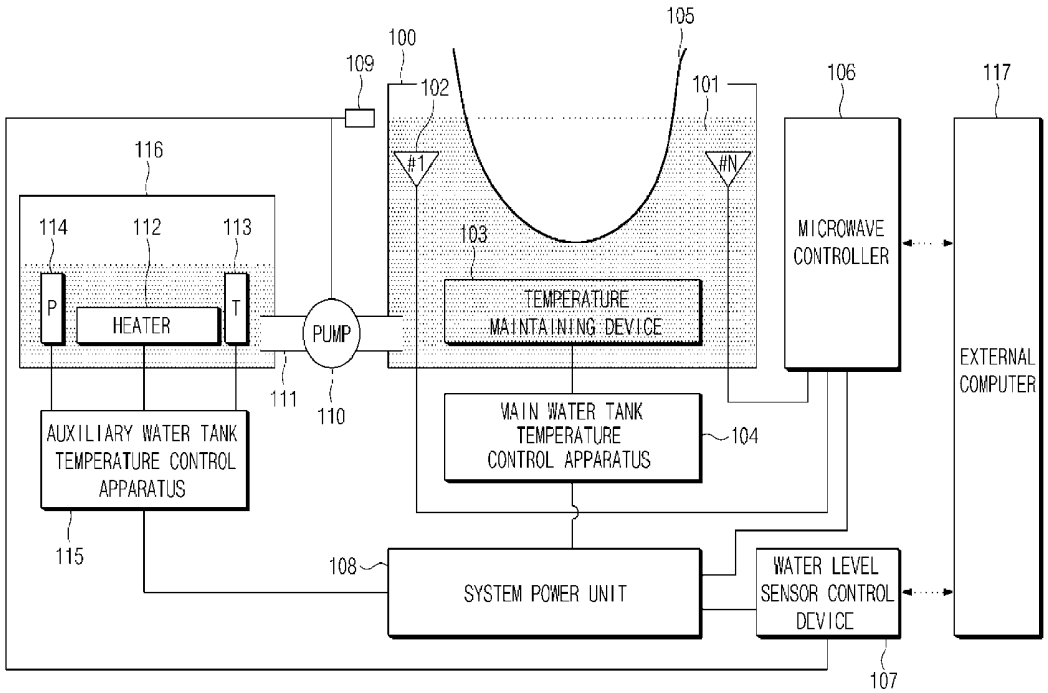
G05D 23/19	(2006.01)
A61B 5/05	(2006.01)
A61B 5/00	(2006.01)
G01N 22/00	(2006.01)

(52) **U.S. Cl.**

CPC ***G05D 23/19*** (2013.01); ***G01N 22/00*** (2013.01); ***A61B 5/0507*** (2013.01); ***A61B 5/4312*** (2013.01); ***A61B 5/708*** (2013.01)

(57) **ABSTRACT**

Disclosed is an apparatus and a method for efficiently controlling a temperature, which are capable of minimizing a temperature deviation and decreasing a temperature control time by simultaneously controlling temperatures of matching material used in a microwave imaging system in a main water tank and an auxiliary water tank, and preventing an amplitude and phase information of the microwaves obtained by the microwave imaging system from deteriorating over a lapse of time.



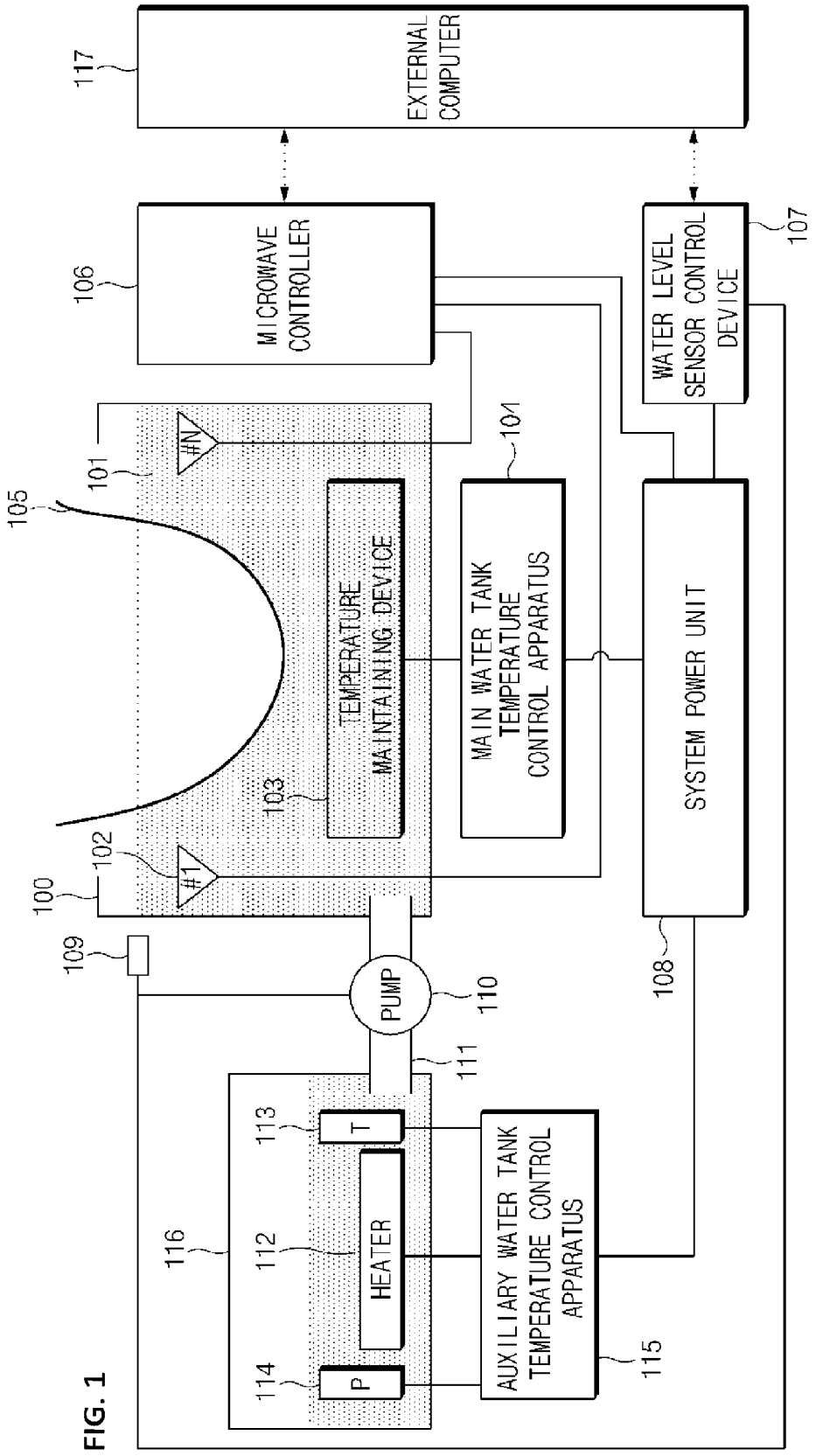

EXTERNAL COMPUTER
117
MICROWAVE CONTROLLER
106
WATER LEVEL SENSOR CONTROL DEVICE
107
#N
101
105
TEMPERATURE MAINTAINING DEVICE
103
MAIN WATER TANK TEMPERATURE CONTROL APPARATUS
101
SYSTEM POWER UNIT
#1
102
100
109
PUMP
110
108
111
T
113
HEATER
112
116
P
114
AUXILIARY WATER TANK TEMPERATURE CONTROL APPARATUS
115

FIG. 1

FIG. 2

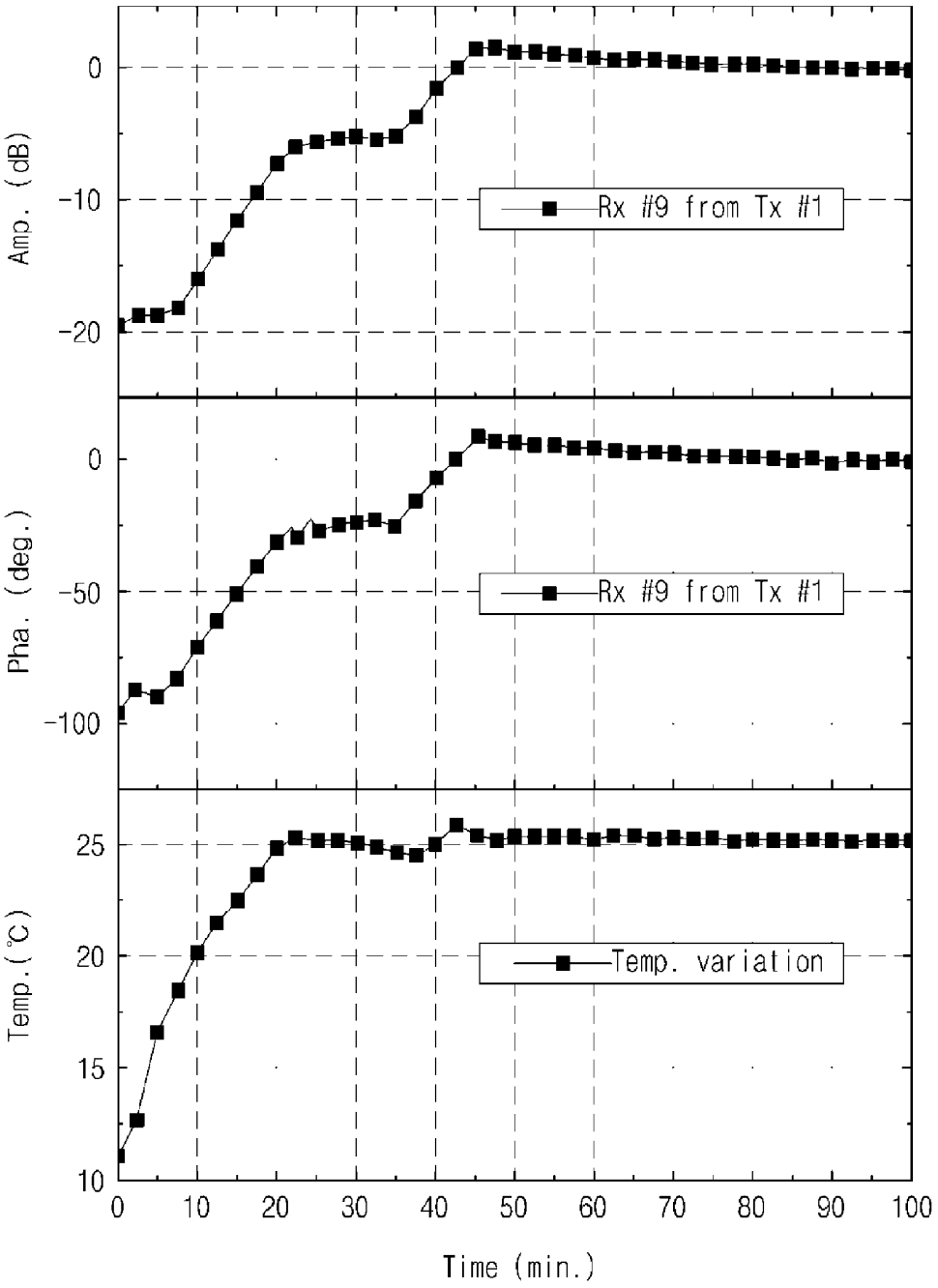

Amp. (dB)
0
-10
-20
Rx #9 from Tx #1
Pha. (deg.)
0
-50
-100
Rx #9 from Tx #1
Temp.(℃)
25
20
15
10
Temp. variation
0
10
20
30
40
50
60
70
80
90
100
Time (min.)

FIG. 3

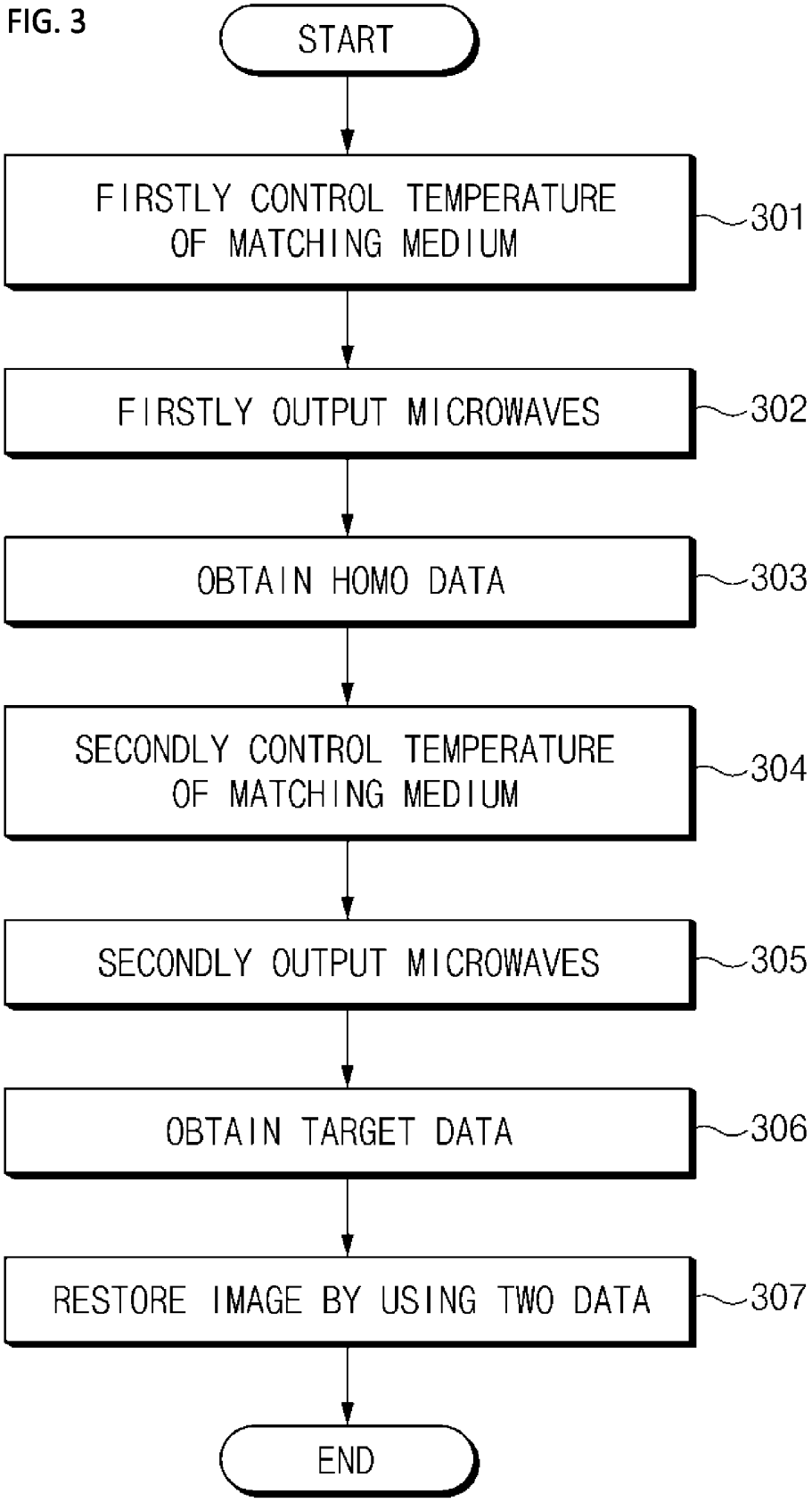
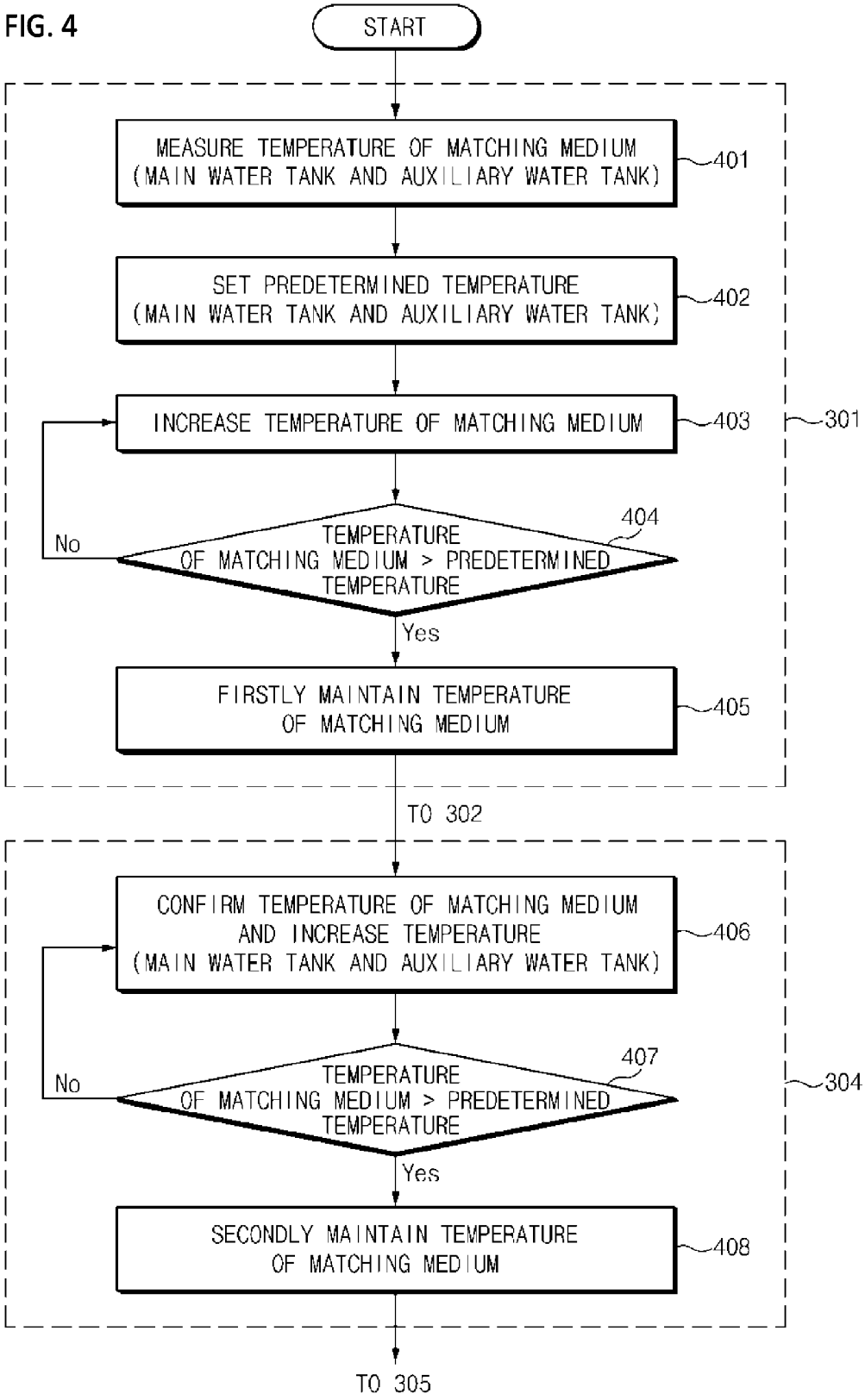

START
FIRSTLY CONTROL TEMPERATURE OF MATCHING MEDIUM
301
FIRSTLY OUTPUT MICROWAVES
302
OBTAIN HOMO DATA
303
SECONDLY CONTROL TEMPERATURE OF MATCHING MEDIUM
304
SECONDLY OUTPUT MICROWAVES
305
OBTAIN TARGET DATA
306
RESTORE IMAGE BY USING TWO DATA
307
END

FIG. 4


START
MEASURE TEMPERATURE OF MATCHING MEDIUM (MAIN WATER TANK AND AUXILIARY WATER TANK)
401
SET PREDETERMINED TEMPERATURE (MAIN WATER TANK AND AUXILIARY WATER TANK)
402
INCREASE TEMPERATURE OF MATCHING MEDIUM
403
301
404
No
TEMPERATURE OF MATCHING MEDIUM > PREDETERMINED TEMPERATURE
Yes
FIRSTLY MAINTAIN TEMPERATURE OF MATCHING MEDIUM
405
TO 302
CONFIRM TEMPERATURE OF MATCHING MEDIUM AND INCREASE TEMPERATURE (MAIN WATER TANK AND AUXILIARY WATER TANK)
406
407
No
TEMPERATURE OF MATCHING MEDIUM > PREDETERMINED TEMPERATURE
304
Yes
SECONDLY MAINTAIN TEMPERATURE OF MATCHING MEDIUM
408
TO 305

TEMPERATURE CONTROL APPARATUS AND METHOD IN MICROWAVE IMAGING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2015-0072735 filed in the Korean Intellectual Property Office on May 26, 2015, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to an apparatus and a method of controlling a temperature of a matching material used in an imaging system using microwaves, and particularly, to an apparatus and a method of efficiently controlling a temperature for maintaining a characteristic of a matching material related to a propagation loss and a dielectric constant characteristic in a microwave imaging system.

BACKGROUND ART

[0003] Recently, an imaging technology using microwaves has been researched by considering a sharp increase of breast cancer patients and urgent demands for new technology for a breast cancer diagnosis apparatus in a medical world, and reflecting potential growth possibility and market demands. Accordingly, the microwave imaging system using the technology is a system for diagnosing cancer by restoring an image of the breast from scattered data obtained by radiating microwaves to a breast immersed in a matching material. Accordingly, in order for an amplitude a and phase information of a signal which are the scattered data, to have accurate and stable values, a characteristic of the matching material needs to be maintained for a measurement time of signal information.

[0004] In the matching material, a propagation loss is generated during a process of radiating microwaves, and the propagation loss is changed according to a temperature. Further, a dielectric constant characteristic of the matching material is differently exhibited according to a temperature. Since a value of signal data is changed when a temperature of the matching material is changed during a process of obtaining scattered data of the breast, it is impossible to obtain a stable value, and as a result, there is a problem in restoring an image of the breast or it is impossible to restore an image of the breast. Accordingly, in order to obtain stable scattered data, an apparatus and a method of controlling a temperature for controlling a characteristic of a matching material in a microwave imaging system have been required.

SUMMARY OF THE INVENTION

[0005] The present invention has been made in an effort to provide an apparatus and a method for efficiently controlling a temperature, which are capable of minimizing a temperature deviation and decreasing a temperature control time by simultaneously controlling temperatures of matching material used in a microwave imaging system in a main tank and an auxiliary tank, and preventing an amplitude and phase information of the microwaves, which are obtained by the microwave imaging system, from deteriorating over a lapse of time.

[0006] Technical objects of the present invention are not limited to the aforementioned technical objects and other technical objects which are not mentioned will be apparently appreciated by those skilled in the art from the following description.

[0007] An exemplary embodiment of the present invention provides an apparatus for maintaining a temperature of a water tank in a microwave imaging system, the apparatus including: a main water tank configured to contain a matching material for putting a measurement target object in the matching material; an auxiliary water tank coupled with the main water tank by a connection hose, and communicable with the matching material of the main water tank by a pump installed at a center of the connection hose; and an external computer (ex, PC) configured to perform a combined control of a first temperature control apparatus for controlling a first temperature maintaining device provided within the main water tank and a second temperature control apparatus for controlling a second temperature maintaining device provided within the auxiliary water tank(or manual control in each of the temperature control apparatus), in which the external computer obtains a microwave image by using a difference between homo microwave measurement data for the matching material of the main water tank and target microwave measurement data for the measurement target object after the measurement target object is put into the main water tank, the homo microwave measurement data and the target microwave measurement data being received from a controller for controlling sequential transception of the microwaves of a plurality of microwave transceivers installed within the main water tank by using an image restoring program.

[0008] A temperature of the matching material of each of the main water tank and the auxiliary water tank according to a control of operations of a heater and a temperature sensor included in each of the first temperature maintaining device and the second temperature maintaining device may be maintained at a predetermined temperature through the combined control of the external computer or each temperature control apparatus.

[0009] A water level sensor control device receiving the combined control of the external computer may maintain a water level of the main water tank through the communication of the matching material through the control of the pump according to sensing a water level by a water level sensor of the main water tank.

[0010] Each of the first temperature maintaining device and the second temperature maintaining device may further include a water-jet pump for circulating the corresponding matching material.

[0011] The apparatus may minimize a temperature deviation according to the communication and decrease a time taken for a temperature control, and make an amplitude and phase information of a microwave signal of the plurality of microwave transceivers be stably received by simultaneously controlling the temperatures of the matched material in the main water tank and the auxiliary water tank in the combined control of the external computer.

[0012] The measurement target object may include a phantom for a test measurement, a part of a body including a breast, or other flexible objects.

[0013] In order to obtain the homo microwave measurement data containing an amplitude and phase information of a scattered microwave signal for the matching material,

before the measurement target object is put into the matching material of the main water tank, the first temperature control apparatus and the second temperature control apparatus may control the first temperature maintaining device and the second temperature maintaining device, respectively, and perform a temperature measurement, temperature setting, and a temperature control to a predetermined temperature or higher for each matching material.

[0014] In order to obtain the target microwave measurement data containing an amplitude and phase information of a scattered microwave signal for the measurement target object, in a state where the measurement target object is put into the matching material of the main water tank, the first temperature control apparatus and the second temperature control apparatus may control the first temperature maintaining device and the second temperature maintaining device, respectively, while maintaining the water level of the main water tank through the communication of the matching material through a control of the pump according to sensing a water level by a water level sensor of the main water tank under the combined control of the external computer, and perform a temperature measurement and a temperature control to a predetermined temperature or higher for the matched material, respectively.

[0015] Each of the first temperature control apparatus and the second temperature control apparatus may use any one of a proportional control, an integral control, and a differential control for controlling a temperature of the matching material thereof.

[0016] Another exemplary embodiment of the present invention provides a method of maintaining a temperature of a water tank in a microwave imaging system, the method including: uniformly maintaining a temperature of a matching material of each of a main water tank and an auxiliary water tank by using the main water tank for containing a matching material for putting a measurement target object in the matching material, the auxiliary water tank coupled with the main water tank by a connection hose, and communicable with the matching material of the main water tank by a pump installed at a center of the connection hose, and an external computer performing a combined control of a first temperature control apparatus for controlling a first temperature maintaining device provided within the main water tank and a second temperature control apparatus for controlling a second temperature maintaining device provided within the auxiliary water tank; receiving, by the external computer performing the combined control, homo microwave measurement data for the matching material of the main water tank from a controller for controlling sequential transception of the microwaves of a plurality of microwave transceivers installed within the main water tank; receiving, by the external computer performing the combined control, target microwave measurement data for the measurement target object from the controller after the measurement target object is put into the main water tank; and obtaining, by the external computer performing the combined control, a microwave image by using a difference between the homo microwave measurement data and the target microwave measurement data.

[0017] According to the apparatus and the method of controlling a temperature in the microwave imaging system according to the present invention, it is possible to minimize a temperature deviation and decrease a time taken for controlling a temperature by simultaneously controlling temperatures of matching material used in the microwave imaging system in the main water tank and the auxiliary water tank, prevent an amplitude and phase information of microwaves received by the microwave imaging system from deteriorating over a lapse of time, and easily restore a microwave image of an object, such as the breast, by stably and accurately obtaining scattered data.

[0018] The present invention may be widely utilized in a breast cancer diagnosis apparatus using a matching material, a cancer diagnosis in a medical device field, a converged system of a biomedical field and a radio communication field, other diagnosis device fields utilizing body tissue, and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** is a configuration diagram of a microwave imaging system including a temperature control apparatus according to an exemplary embodiment of the present invention.

[0020] FIG. **2** is a diagram illustrating an example of an amplitude and phase information of received microwaves according to a change in a temperature in the microwave imaging system according to the exemplary embodiment of the present invention.

[0021] FIG. **3** is a flowchart for describing a method of restoring an image for a measurement target object according to the exemplary embodiment of the present invention.

[0022] FIG. **4** is a flowchart for describing a method of controlling a temperature of a matching material according to an exemplary embodiment of the present invention.

[0023] It should be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various features illustrative of the basic principles of the invention. The specific design features of the present invention as disclosed herein, including, for example, specific dimensions, orientations, locations, and shapes will be determined in part by the particular intended application and use environment.

[0024] In the figures, reference numbers refer to the same or equivalent parts of the present invention throughout the several figures of the drawing.

DETAILED DESCRIPTION

[0025] Hereinafter, some exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings. When reference numerals refer to elements of each drawing, it is noted that although the same elements are illustrated in different drawings, the same elements are referred to by the same reference numerals as much as possible. Further, in describing the exemplary embodiments of the present invention, when it is determined that the detailed description of publicly known configurations or functions related to the present invention may obscure the understanding of the exemplary embodiment of the present invention, the detailed description thereof will be omitted.

[0026] In describing constituent elements of the exemplary embodiment of the present invention, terms such as first, second, A, B, (a), (b), and the like may be used. Such a term is only for discriminating the constituent element from another constituent element, and does not limit the essential feature, order, or sequence of the constituent element, or the like. Further, otherwise contrarily defined, all

terms used herein including technological or scientific terms have the same meaning as those generally understood by those skilled in the art. Terms which are defined in a generally used dictionary should be interpreted to have the same meaning as the meaning in the context of the related art but are not interpreted as ideal or excessively formal meaning otherwise clearly defined in the present invention.

[0027] FIG. **1** is a configuration diagram of a microwave imaging system including a temperature control apparatus according to an exemplary embodiment of the present invention.

[0028] Referring to FIG. **1**, the microwave imaging system according to the exemplary embodiment of the present invention includes a main water tank **100** and an auxiliary water tank **116** for putting a matching material **101**, and the main water tank **100** includes a temperature maintaining device **103** and N microwave transceivers **102** (N is a natural number) therein, and the auxiliary water tank **116** also includes a temperature maintaining device (including a heater **112**, a temperature sensor **113**, a water-jet (or circulation) pump **114**, and the like) therein. The main water tank **100** and the auxiliary water tank **116** are connected by a connection hose **111**, and a pump **110** for supplying and discharging the matching material **101** is provided at a center of the connection hose **111**.

[0029] The microwave imaging system according to the exemplary embodiment of the present invention includes a main water tank temperature control apparatus **104** controlling the temperature maintaining device **103** of the main water tank **100**, and an auxiliary water tank temperature control apparatus **115** controlling the temperature maintaining devices **112**, **113**, and **114** of the auxiliary water tank **116**. The main water tank temperature control apparatus **104** and the auxiliary water tank temperature control apparatus **115** may be manually controlled by control devices thereof, respectively, and are controlled under a combined control of an external computer (for example, a personal computer) **117** and receives power from a system power unit **108**. A microwave transception controller **106** may transmit microwaves to the N microwave transceivers **102** or receive microwaves from the N microwave transceivers **102** under the combined control of the external computer **117**. The combined control of the external computer **117** may control a general operation of the microwave imaging system. In addition, the combined control of the external computer **117** may control a water level sensor control device **107**, and the water level sensor control device **107** may be connected with the pump **110** and a water level sensor **109** and transceive a control signal necessary for the operations. The matching material **101** communicates (the material is movable from one side to the other side) between the main water tank **100** and the auxiliary water tank **116** according to an operation of the pump **110**, and the external computer **117** may control the matching material **101** to be moved by operating the pump **110** so that a water level of the matching material **101** of the main water tank **100** is maintained at a predetermined height through the water level sensor control device **107** in the combined control of the external computer **117** according to a detection signal of the water level sensor **109**.

[0030] The N microwave transceivers **102** may have a form including a microwave radiating unit having a structure of a waveguide form and a predetermined aperture for inputting/outputting electromagnetic waves, such as microwaves. A measurement target object **105** is put in the matching material **101**, and the N microwave transceivers **102** may be disposed around the measurement target object **105** at an appropriate interval. The matching material **101** may be a predetermined liquid through which microwaves pass through well, and the measurement target object **105** may be a flexible object, such as a phantom for a test measurement or a part of a body, such as a breast, or other objects, of which images are measurable.

[0031] In order to obtain a microwave image for the measurement target object **105**, under the combined control (a combined control program, which is software, is available) of the external computer **117**, the microwave transception controller **106** controls the N microwave transceivers **102** to sequentially transmit microwaves once from any one predetermined microwave transceiver, and collects information about the microwaves, which the remaining transceivers, other than the corresponding microwave transceiver transmitting the microwaves, simultaneously receive. The information (microwave measurement data) about the microwaves received by the transceivers contains an amplitude and phase information of a microwave signal, which passes through the measurement target object **105** and is scattered, and the N microwave transceivers **102** may sequentially transmit microwaves once, and the information about the microwaves received by the remaining transceivers may be collected by the microwave transception controller **106**. An image restoring program (software) of the external computer **117** may analyze the information about the microwaves collected by the microwave transception controller **106**, obtain a microwave image for the measurement target object **105**, and utilize the obtained microwave image for diagnosing a cancer and the like.

[0032] In this case, a propagation loss of the microwave passing through the measurement target object **105** may be generated in a corresponding frequency region by a characteristic of the matching material **101**, and the propagation loss is generated by a characteristic of a unique dielectric constant and conductivity of the matching material **101** and the characteristics of the dielectric constant and the conductivity are changed by a change in a temperature of the matching material **101**, so that a propagation loss characteristic may be varied. Accordingly, a signal analysis of the received microwave may be inaccurate due to a change in a temperature, and there is difficulty in restoring a microwave image of the measurement target object **105**.

[0033] Accordingly, in the present invention, it is possible to minimize a temperature deviation and decrease a time taken for controlling a temperature by simultaneously controlling temperatures of the matching material **101** in the main water tank **100** and the auxiliary water tank **116**, prevent an amplitude and phase information of the received microwave from deteriorating over a lapse of time, and easily restore a microwave image of the measurement target object **105**, such as the breast, by stably and accurately obtaining scattered data.

[0034] FIG. **2** is a diagram illustrating an example of an amplitude and phase information of microwaves received by the N microwave transceivers **102** according to a change in a temperature in the microwave imaging system according to the exemplary embodiment of the present invention. Here, 16 microwave transceivers **102** are used, which includes a first transmission channel Tx#**1** and the remaining 15 reception channels including a reception channel Rx#**9**, which is farthest from the first transmission channel Tx#**1**, and it is

assumed that a temperature of the matching material **101** is 11.6 to 25° C., and a time is 100 minutes.

[0035] As illustrated in FIG. **2**, it can be seen that when a temperature (Temp.) of the matching material **101** is changed over a lapse of time (around 40 mins), an amplitude (Amp.) and phase (Pha.) information of the received microwaves are irregularly changed, so that it is difficult to accurately generate a microwave image. Accordingly, in the present invention, it is possible to uniformly maintain a temperature (Temp.) of the matching material **101** over a lapse of time (after around 40 mins) according to the operations of the main water tank temperature control apparatus **104**, the temperature maintaining device **103**, the auxiliary water tank temperature control apparatus **115**, and the temperature maintaining devices **112**, **113**, and **114**, and thus it is possible to stably and accurately obtain an amplitude (Amp.) and phase (Pha.) information about the received microwave by uniformly maintaining a dielectric constant and conductivity of the matching material **101** without degrading the amplitude (Amp.) and the phase (Pha.) information about the received microwave, thereby generating a reliable microwave image for the measurement target object **105**.

[0036] For example, during the measurement of the measurement target object **105**, the auxiliary water tank temperature control apparatus **115** may heat a solution of the matching material **101** within the auxiliary water tank **116** by supplying power of the system power unit **108** to the heater **112**, such as a ring type sheath heater operable in water, by using a thermostat and the like, and generating heat, and maintain a temperature of the matching material **101** at a predetermined temperature by controlling a supply of the power to the heater **112** to be on/off according to a sensed temperature (or signal) obtained through the temperature sensor **113** (the number of temperature sensors **113** may be two or more, and a height of a connection part of an end of the sensor is variable so that a height of the end of the sensor is adjustable according to a water level) installed within the auxiliary water tank **116**. Further, the auxiliary water tank temperature control apparatus **115** may control the matching material **101** to generally and evenly have a predetermined temperature by making the matching material **101** within the auxiliary water tank **116** be forcibly circulated by controlling an operation of the water-jet pump **114** during the measurement.

[0037] Similarly, although not illustrated in the drawing, the temperature maintaining device **103** of the main water tank **100** may include a heater, a temperature sensor (the number of temperature sensors may be two or more, and a height of a connection part of an end of the sensor is variable so that a height of the end of the sensor is adjustable according to a water level), a water-jet pump, and the like having the aforementioned forms. Accordingly, the main water tank temperature control apparatus **104** may heat the solution of the matching material **101** of the main water tank **100** by supplying the power of the system power unit **108** to the heater of the temperature maintaining device **103** and generating heat, and control the supply of the power to the corresponding heater to be on/off according to the sensed temperature (or signal) obtained through the temperature sensor (the number of temperature sensors may be two or more) of the temperature maintaining device **103** installed in the main water tank **100** to maintain the matching material **101** at a predetermined temperature. Further, the main water tank temperature control apparatus **104** may control the matching material **101** to generally and evenly have a predetermined temperature by making the matching material **101** within the main water tank **100** be forcibly circulated by controlling the operation of the water-jet pump of the temperature maintaining device **103** during the measurement.

[0038] FIG. **3** is a flowchart for describing a method of restoring an image for the measurement target object **105** according to the exemplary embodiment of the present invention.

[0039] In order to obtain a microwave image for the measurement target object **105**, first, in a state where the measurement target object **105** is not put in the matching material **101**, the main water tank temperature control apparatus **104** controls the temperature maintaining device **103** so that the matching material **101** of the main water tank **100** is maintained at a predetermined temperature (**301**). A method of controlling a temperature of the matching material **101** (first control of a temperature of the matching material) will be described in more detail with reference to FIG. **4** (**401** to **405**).

[0040] When the matching material **101** is maintained at the predetermined temperature in the state where the measurement target object **105** is not put in the matching material **101** as described above, the microwave transception controller **106** controls the N microwave transceivers **102** to sequentially transmit microwaves once from any one predetermined microwave transceiver (first microwave output) under the combined control of the external computer **117** (**302**), and collects information (an amplitude and phase information about a microwave signal, which passes only the matching material and is scattered) about the microwaves, which the remaining transceivers, other than the corresponding microwave transceiver transmitting the microwaves, simultaneously receive (**303**). The information about the received microwaves in this case corresponds to homo data (microwave measurement data) for the matching material **101** in the state where the measurement target object **105** is not put in the matching material **101**.

[0041] When the aforementioned homo data is obtained, the matching material **101** of the main water tank **100** is moved to the auxiliary water tank **116** by controlling an operation of the pump **110** through the water level sensor control device **107** in the combined control of the external computer **117** according to a sensed signal of the water level sensor **109** before or after the measurement target object **105** is put in the matching material **101**, so that a water level of the main water tank **100** is controlled to be maintained at a predetermined height (see the description of operation **406** of FIG. **4**). The main water tank temperature control apparatus **104** controls the temperature maintaining device **103** so that the matching material **101** of the main water tank **100** is maintained at the predetermined corresponding temperature with the adjustment of the water level at the same time or after the adjustment of the water level, and the auxiliary water tank temperature control apparatus **115** controls the temperature maintaining devices **112**, **113**, and **114** so that the matching material **101** of the auxiliary water tank **116** is maintained at the predetermined corresponding temperature (the same temperature as that of the matching material **101** of the main water tank **100**) (**304**). The method of controlling a temperature of the matching material **101** (second control

of a temperature of the matching material) will be described in more detail with reference to FIG. **4** (operations **406** to **408**).

[0042] When the matching material **101** is maintained at the predetermined temperature in the state where the measurement target object **105** is put in the matching material **101** as described above, the microwave transception controller **106** controls the N microwave transceivers **102** to sequentially transmit microwaves once from any one predetermined microwave transceiver (second microwave output) under the combined control of the external computer **117** (**305**), and collects information (an amplitude and phase information about a microwave signal, which passes the measurement target object **105** and is scattered) about the microwaves, which the remaining transceivers, other than the corresponding microwave transceiver transmitting the microwaves, simultaneously receive (**306**). The information about the received microwaves in this case corresponds to target data (microwave measurement data) for the matching material **101** in the state where the measurement target object **105** is put in the matching material **101**.

[0043] The image restoring program of the external computer **117** may analyze information, that is, the homo data and the target data, about the microwaves collected by the microwave transception controller **106**, and obtain a microwave image for the measurement target object **105** (**307**). That is, the image restoring program of the external computer **117** may generate a microwave image for the measurement target object **105** by calculating a difference (subtraction) value between the target data and the homo data.

[0044] FIG. **4** is a flowchart for describing a method of controlling a temperature of a matching material according to an exemplary embodiment of the present invention. Operations **401** to **405** of FIG. **4** may be included in operation **301** of FIG. **3**. Further, operations **406** to **408** of FIG. **4** may be included in operation **304** of FIG. **3**, and in this case, in the setting of a predetermined temperature for controlling a temperature of the matching material **101**, setting temperatures of the main water tank **100** and the auxiliary water tank **116** are equally set.

[0045] First, in a state where the measurement target object **105** is not put in the matching material **101**, water levels of the matching material **101** in the main water tank **100** and the auxiliary water tank **116** are not changed and are set under an optimum condition. In this case, it is possible to measure temperatures of an upper part and a lower part of the main water tank **100** by using the temperature sensor of the temperature maintaining device **103** of the main water tank **100** under the control of the main water tank temperature control apparatus **104** (**401**). Particularly, in the measurement of the temperature, it is possible to measure a temperature of an upper part of the matching material **101** adjacent to the plurality of transceivers **102** and a temperature of a lower part of the matching material **101** adjacent to the heater positioned at a lower part of the main water tank **100**. Further, it is possible to measure a temperature of the matching material **101** around the heater **112** of the auxiliary water tank **116** by using the temperature sensor **113** under the control of the auxiliary water tank temperature control apparatus **115**. Further, the temperatures measured from the main water tank **100** and the auxiliary water tank **116** may be displayed on the temperature control apparatuses **104** and **115**, respectively, and may also be displayed in real time on a combined control window of a display device of the external computer **117** depending on a case.

[0046] In order to obtain accurate signal data based on the temperature of the matching material **101** measured as described above, a user may set setting temperatures of the main water tank **100** and the auxiliary water tank **116** by using the temperature control apparatuses **104** and **115**, respectively, or the combined control window of the external computer **117** (**402**). Further, the user may set an operation of the water-jet pump of the temperature maintaining device **103** of the main water tank **100** by using the temperature control apparatus **104** or the combined control window of the external computer **117**. Particularly, a temperature deviation of the matching material **101** at the upper part and the lower part of the main water tank **100** exists, and in order to minimize the temperature deviation during the temperature control process, the user may set the operation of the water-jet pump. Further, in the setting of the operation of the water-jet pump **114** of the auxiliary water tank **116**, the water-jet pump **114** may be operated by setting a predetermined operation setting value according to a water level of the matching material **101** put in the auxiliary water tank **116** in the auxiliary water tank temperature control apparatus **115** or on the combined control window of the external computer **117**. That is, when a water level of the matching material **101** of the auxiliary water tank **116** is high, the user may input a setting value so that the water-jet pump **114** is operable for circulating the matching material **101** and maintaining the predetermined temperature, and when a water level of the matching material **101** of the auxiliary water tank **116** is low, the user may input a setting value so that the water-jet pump **114** is not operated. Further, at least one control method among proportional integral differential temperature control methods including a proportional control, an integral control, and a differential control for controlling the temperatures of the matched material **101** of the main water tank **100** and the auxiliary water tank **116** may be set in the respective temperature control apparatuses **104** and **115** or the combined control window of the external computer **117**.

[0047] After the temperature is set as described above, it is possible to increase the temperatures of the matched material **101** of the main water tank **100** and the auxiliary water tank **116** up to the predetermined corresponding temperatures by operating the heaters within the respective water tanks under the control of the respective temperature control apparatuses **104** and **115** through the combined control of the external computer **117** (**403**).

[0048] The temperature control apparatuses **104** and **115** increase the temperatures of the matched material **101** by operating the heaters until the temperatures of the matched material **101** become the predetermined corresponding temperatures while confirming whether the temperatures of the matched material **101** of the main water tank **100** and the auxiliary water tank **116** are equal to or higher than the predetermined corresponding temperatures based on the sensing of the temperature by the temperature sensors thereof through the combined control of the external computer **117** (**404**).

[0049] Through the repetition of the aforementioned process, the temperatures of the matched material **101** of the main water tank **100** and the auxiliary water tank **116** may be maintained at the predetermined corresponding temperatures or higher (**405**). The aforementioned process may be performed by operating each water-jet pump by the respec-

tive temperature control apparatuses **104** and **15** or under the combined control of the external computer **117**.

[0050] In this case, since the matching material **101** of the auxiliary water tank **116** does not need the adjustment of a water level with the matching material **101** of the main water tank **100**, so that a process of adjusting a water level for supplying or discharging the matching material **101** is not required. Accordingly, in a situation where the matching material **101** of the main water tank **100** is maintained at the predetermined temperature, regardless of the situation where the matching material **101** of the auxiliary water tank **116** is maintained at the predetermined temperature, the microwave imaging system performs operation **302** of FIG. **3** of outputting microwaves by using the plurality of transceivers **102** in order to obtain the homo data containing the amplitude and the phase information of the signal for the matching material **101** in the situation where the measurement target object **105** is not present in the main water tank **100**.

[0051] In the meantime, after the homo data is obtained in operations **302** and **303** of FIG. **3**, in order to obtain the target data for the measurement target object **105**, the matching material temperature control, which is operation **304** of FIG. **3**, is performed again. Further, operations **406** to **408** of FIG. **4** may be included in operation **304** of FIG. **3**, and in this case, in the setting of a predetermined temperature for controlling a temperature of the matching material **101**, setting temperatures of the main water tank **100** and the auxiliary water tank **116** are equally set.

[0052] In order to put the measurement target object **105** in the matching material **101** of the main water tank **100**, an optimized water level of the matching material **101** positioned at a higher water level sensor **109** of the main water tank **100** needs to be decreased. Accordingly, a process of discharging the matching material **101** to the auxiliary water tank **116** by using a discharge pump **110** and the connection hose **111** is performed up to a point, at which the water level sensor **109** is positioned. The matching material **101** of the main water tank **100** may be discharged to the auxiliary water tank **116** partially or up to a predetermined position of the water level sensor **109** before the measurement target object **105** is put in the matching material **101**, or the matching material **101** may also be supplied to the main water tank **100** up to a predetermined position of the water level sensor **109** after the measurement target object **105** is put in the matching material **101**. The appropriate predetermined positions of the water level sensor **109** before and after the measurement target object **105** is put in the matching material **101** may be manually controlled or be controlled under the combined control of the external computer **117**. In order to meet the water level of the matching material **101** up to the position of the water level sensor **109** through the control of the pump **110** by the water level sensor control device **107** under the combined control of the external computer **117**, the matching material **101** may be moved to the auxiliary water tank **116**, as well as the main water tank **100**, and the temperatures of the matching material **101** for both the main water tank **100** and the auxiliary water tank **116** are simultaneously controlled as described above, so that it is possible to minimize a temperature deviation according to the communication of the matching material **101** between the main water tank **100** and the auxiliary water tank **116** and decrease a time taken for the temperature control.

[0053] When the measurement target object **105** is put in the main water tank **100**, and it is confirmed that the matched material of the main water tank **100** and the auxiliary water tank **116** are mixed by performing a process of supplying the matching material **101** of the auxiliary water tank **116** to the main water tank **100** up to the position of the water level sensor **109** of the main water tank **100** by using the pump **110** and the connection hose **11**, each temperature control apparatus **104** or **105** measures a temperature of each water tank, and the main water tank temperature control apparatus **104** controls the temperature maintaining device **103** so that the matching material **101** of the main water tank **100** is maintained at a predetermined corresponding temperature, and the auxiliary water tank temperature control apparatus **115** controls the temperature maintaining devices **112**, **113**, and **114** so that the matching material **101** of the auxiliary water tank **116** is maintained at a predetermined corresponding temperature (the same temperature as that of the matching material **101** of the main water tank **100**) (**406**). After the matched material are mixed, it is possible to increase the temperatures of the matched material **101** of the main water tank **100** and the auxiliary water tank **116** up to the predetermined corresponding temperatures by operating the heaters within the respective water tanks under the control of the respective temperature control apparatuses **104** and **115**.

[0054] The temperature control apparatuses **104** and **115** increase the temperatures of the matched material **101** by operating the heaters until the temperatures of the matched material **101** become the predetermined corresponding temperatures while confirming whether the temperatures of the matched material **101** of the main water tank **100** and the auxiliary water tank **116** are equal to or higher than the corresponding predetermined temperatures based on the sensing of the temperature by the temperature sensors thereof (**407**). Through the repetition of the aforementioned process, the temperatures of the matched material **101** of the main water tank **100** and the auxiliary water tank **116** may be maintained at the predetermined corresponding temperatures or higher (**408**). The aforementioned process may be performed by operating the water-jet pumps by the temperature control apparatuses **104** and **115**, respectively.

[0055] When the temperatures are maintained as described above, the microwave imaging system performs operation **305** of FIG. **3** of outputting microwaves by using the plurality of transceivers **102** in order to obtain the target data containing the amplitude and phase information of the signal for the matching material **101** in the situation where the measurement target object **105** is present in the main water tank **100**.

[0056] According to the microwave imaging system including the temperature control apparatus according to the present invention, it is possible to minimize a temperature deviation and decrease a time taken for controlling a temperature by simultaneously controlling temperatures of matching material in the main water tank and the auxiliary water tank, prevent an amplitude and phase information of microwaves received by the microwave imaging system from deteriorating over a lapse of time, and easily restore a microwave image of an object, such as the breast, by stably and accurately obtaining scattered data. The present invention may be widely utilized in a breast cancer diagnosis apparatus using a matching material, a cancer diagnosis in a medical device field, a converged system of a biomedical

field and a radio communication field, other diagnosis device fields utilizing body tissue, and the like.

[0057] The foregoing has been described for purposes of illustrating the technical spirit of the present invention, and those skilled in the art may change and modify the present invention in various ways without departing from the essential characteristic of the present invention.

[0058] Accordingly, the various exemplary embodiments disclosed herein are not intended to limit the technical spirit but describe with the true scope and spirit being indicated by the following claims. The scope of the present invention should be construed based on the following appended claims and it should be construed that the technical spirit included within the scope equivalent to the claims belongs to the present invention.

What is claimed is:

1. An apparatus for maintaining a temperature of a water tank in a microwave imaging system, the apparatus comprising:

a main water tank configured to contain a matching material for putting a measurement target object in the matching material;

an auxiliary water tank coupled with the main water tank by a connection hose, and communicable with the matching material of the main water tank by a pump installed at a center of the connection hose; and

an external computer configured to perform a combined control of a first temperature control apparatus for controlling a first temperature maintaining device provided within the main water tank and a second temperature control apparatus for controlling a second temperature maintaining device provided within the auxiliary water tank,

wherein the external computer performing the combined control obtains a microwave image by using a difference between homo microwave measurement data for the matching material of the main water tank and target microwave measurement data for the measurement target object after the measurement target object is put into the main water tank, the homo microwave measurement data and the target microwave measurement data being received from a controller for controlling sequential transception of the microwaves of a plurality of microwave transceivers installed within the main water tank.

2. The apparatus of claim **1**, wherein the external computer performing the combined control maintains a water level of the main water tank through the communication of the matching material through the control of the pump according to sensing a water level by a water level sensor of the main water tank through a water level sensor control device, and maintains a temperature of the matching material of each of the main water tank and the auxiliary water tank according to a control of an operation of a heater and a temperature sensor included in each of the first temperature maintaining device and the second temperature maintaining device at a predetermined temperature.

3. The apparatus of claim **2**, wherein each of the first temperature maintaining device and the second temperature maintaining device further includes a water-jet pump for circulating the corresponding matching material.

4. The apparatus of claim **1**, wherein the external computer performing the combined control minimizes a temperature deviation according to the communication and decreases a time taken for a temperature control, and makes an amplitude and phase information of a microwave signal of the plurality of microwave transceivers be stably received by simultaneously controlling the temperatures of the matched material in the main water tank and the auxiliary water tank.

5. The apparatus of claim **1**, wherein the measurement target object includes a phantom for a test measurement, a part of a body including a breast, or other flexible objects.

6. The apparatus of claim **1**, wherein in order to obtain the homo microwave measurement data containing an amplitude and phase information of a scattered microwave signal for the matching material, before the measurement target object is put into the matching material of the main water tank, the first temperature control apparatus and the second temperature control apparatus control the first temperature maintaining device and the second temperature maintaining device, respectively, and perform a temperature measurement, temperature setting, and a temperature control to a predetermined temperature or higher for each matching material.

7. The apparatus of claim **1**, wherein in order to obtain the target microwave measurement data containing an amplitude and phase information of a scattered microwave signal for the measurement target object, in a state where the measurement target object is put into the matching material of the main water tank, the first temperature control apparatus and the second temperature control apparatus control the first temperature maintaining device and the second temperature maintaining device, respectively, while maintaining the water level of the main water tank through the communication of the matching material through a control of the pump according to sensing a water level by a water level sensor of the main water tank through a water level sensor control device under the combined control of the external computer, and perform a temperature measurement and a temperature control to a predetermined temperature or higher for the matched material, respectively.

8. The apparatus of claim **1**, wherein each of the first temperature control apparatus and the second temperature control apparatus uses one or more of a proportional control, an integral control, and a differential control for controlling a temperature of the matching material thereof.

9. A method of maintaining a temperature of a water tank in a microwave imaging system, the method comprising:

uniformly maintaining a temperature of a matching material of each of a main water tank and an auxiliary water tank by using the main water tank for containing a matching material for putting a measurement target object in the matching material, the auxiliary water tank coupled with the main water tank by a connection hose, and communicable with the matching material of the main water tank by a pump installed at a center of the connection hose, and an external computer performing a combined control of a first temperature control apparatus for controlling a first temperature maintaining device provided within the main water tank and a second temperature control apparatus for controlling a second temperature maintaining device provided within the auxiliary water tank;

receiving, by the external computer performing the combined control, homo microwave measurement data for the matching material of the main water tank from a controller for controlling sequential transception of the

microwaves of a plurality of microwave transceivers installed within the main water tank;

receiving, by the external computer performing the combined control, target microwave measurement data for the measurement target object from the controller after the measurement target object is put into the main water tank; and

obtaining, by the external computer performing the combined control, a microwave image by using a difference between the homo microwave measurement data and the target microwave measurement data.

10. The method of claim **9**, wherein the combined control of the external computer includes maintaining a water level of the main water tank through the communication of the matching material through the control of the pump according to sensing a water level by a water level sensor of the main water tank through a water level sensor control device, and maintaining a temperature of the matching material of each of the main water tank and the auxiliary water tank according to a control of an operation of a heater and a temperature sensor included in each of the first temperature maintaining device and the second temperature maintaining device at a predetermined temperature.

11. The method of claim **10**, wherein each of the first temperature maintaining device and the second temperature maintaining device further includes a water-jet pump for circulating the corresponding matching material.

12. The method of claim **9**, wherein the external computer performing the combined control minimizes a temperature deviation according to the communication and decreases a time taken for a temperature control by simultaneously controlling the temperatures of the matched material in the main water tank and the auxiliary water tank.

13. The method of claim **9**, wherein the measurement target object includes a phantom for a test measurement, a part of a body including a breast, or other flexible objects.

14. The method of claim **9**, wherein in order to obtain the homo microwave measurement data containing an amplitude and phase information of a scattered microwave signal for the matching material, before the measurement target object is put into the matching material of the main water tank, the first temperature control apparatus and the second temperature control apparatus control the first temperature maintaining device and the second temperature maintaining device, respectively, and perform a temperature measurement, temperature setting, and a temperature control to a predetermined temperature or higher for each matching material.

15. The method of claim **9**, wherein in order to obtain the target microwave measurement data containing an amplitude and phase information of a scattered microwave signal for the measurement target object, in a state where the measurement target object is put into the matching material of the main water tank, the first temperature control apparatus and the second temperature control apparatus control the first temperature maintaining device and the second temperature maintaining device, respectively, while maintaining the water level of the main water tank through the communication of the matching material through a control of the pump according to sensing a water level by a water level sensor of the main water tank through a water level sensor control device under the combined control of the external computer, and perform a temperature measurement and a temperature control to a predetermined temperature or higher for the matched material, respectively.

16. The method of claim **9**, wherein each of the first temperature control apparatus and the second temperature control apparatus uses one or more of a proportional control, an integral control, and a differential control for controlling a temperature of the matching material thereof.

* * * * *

专利名称(译)	微波成像系统中的温度控制装置和方法		
公开(公告)号	US20160349771A1	公开(公告)日	2016-12-01
申请号	US15/079146	申请日	2016-03-24
[标]申请(专利权)人(译)	韩国电子通信研究院		
申请(专利权)人(译)	电子通信研究院		
当前申请(专利权)人(译)	电子通信研究院		
[标]发明人	KIM JANG YEOL KIM HYUK JE SON SEONG HO LEE KWANG JAE LEE JONG MOON JEON SOON IK		
发明人	KIM, JANG YEOL KIM, HYUK JE SON, SEONG HO LEE, KWANG JAE LEE, JONG MOON JEON, SOON IK		
IPC分类号	G05D23/19 A61B5/05 A61B5/00 G01N22/00		
CPC分类号	G05D23/19 G01N22/00 A61B5/708 A61B5/4312 A61B5/0507 A61B5/004 A61B2562/143 A61B2576/02 G05D23/1919 G16H30/40		
优先权	1020150072735 2015-05-26 KR		
外部链接	Espacenet USPTO		

摘要(译)

公开了一种用于有效控制温度的装置和方法，其能够通过同时控制主水箱和辅助水箱中的微波成像系统中使用的匹配材料的温度来最小化温度偏差并减小温度控制时间。并且防止由微波成像系统获得的微波的幅度和相位信息随着时间流逝而恶化。