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(54) SYSTEMS AND METHODS FOR TREATING HYPOTHERMIA

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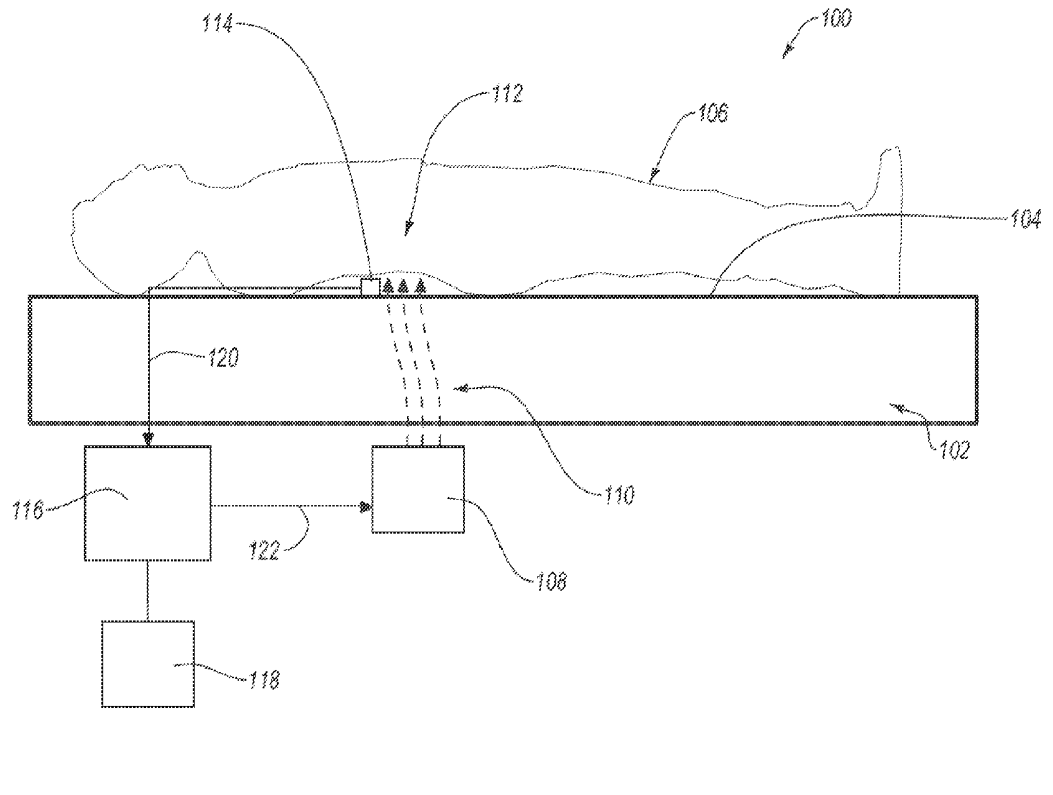
(57) **ABSTRACT**

Embodiments disclosed herein are directed to systems and methods for treating hypothermia in a subject is disclosed. In an embodiment, a method includes determining or measuring a temperature of a target region of the subject. The method also includes responsive to determining or measuring the temperature, directing electromagnetic energy at an external surface of the target region of the subject effective to heat the target region to a temperature of less than an ablation temperature of the target region.



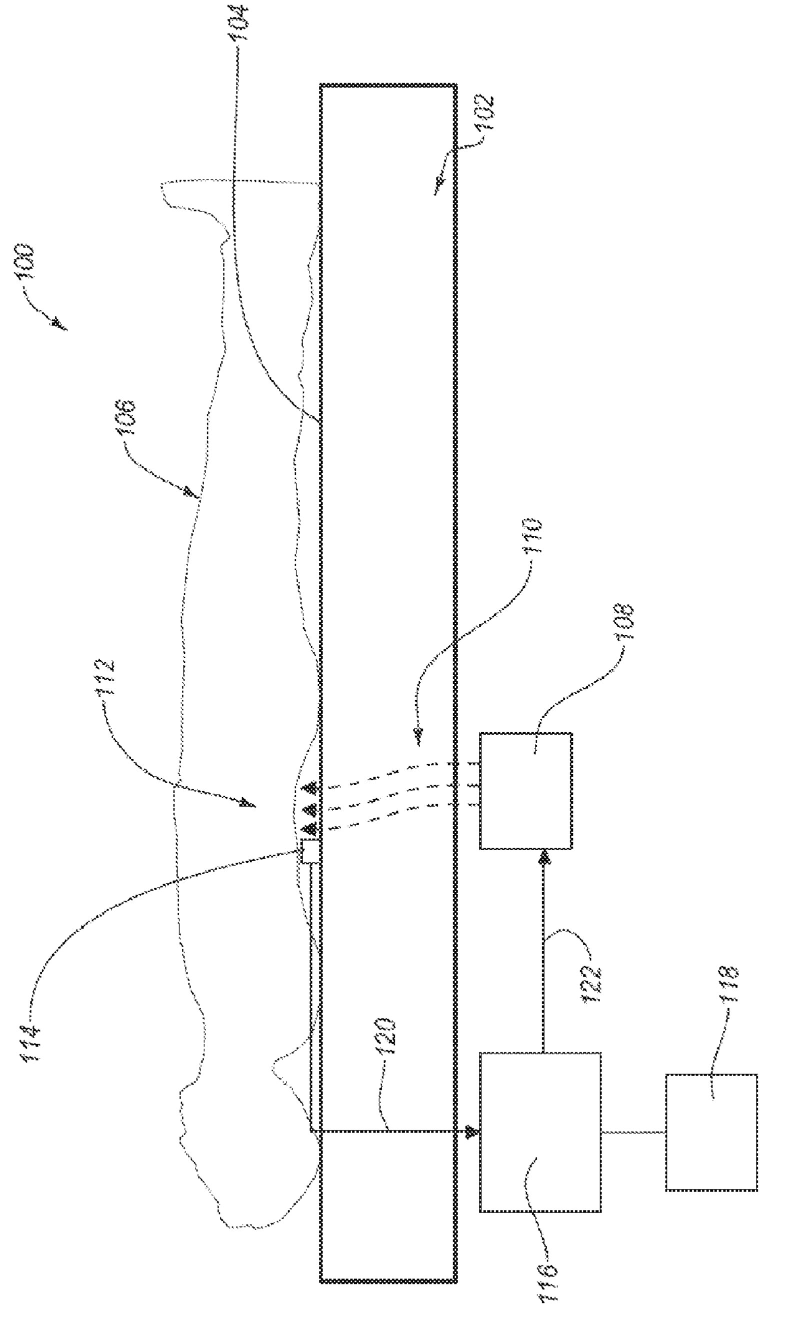


FIG. 1A

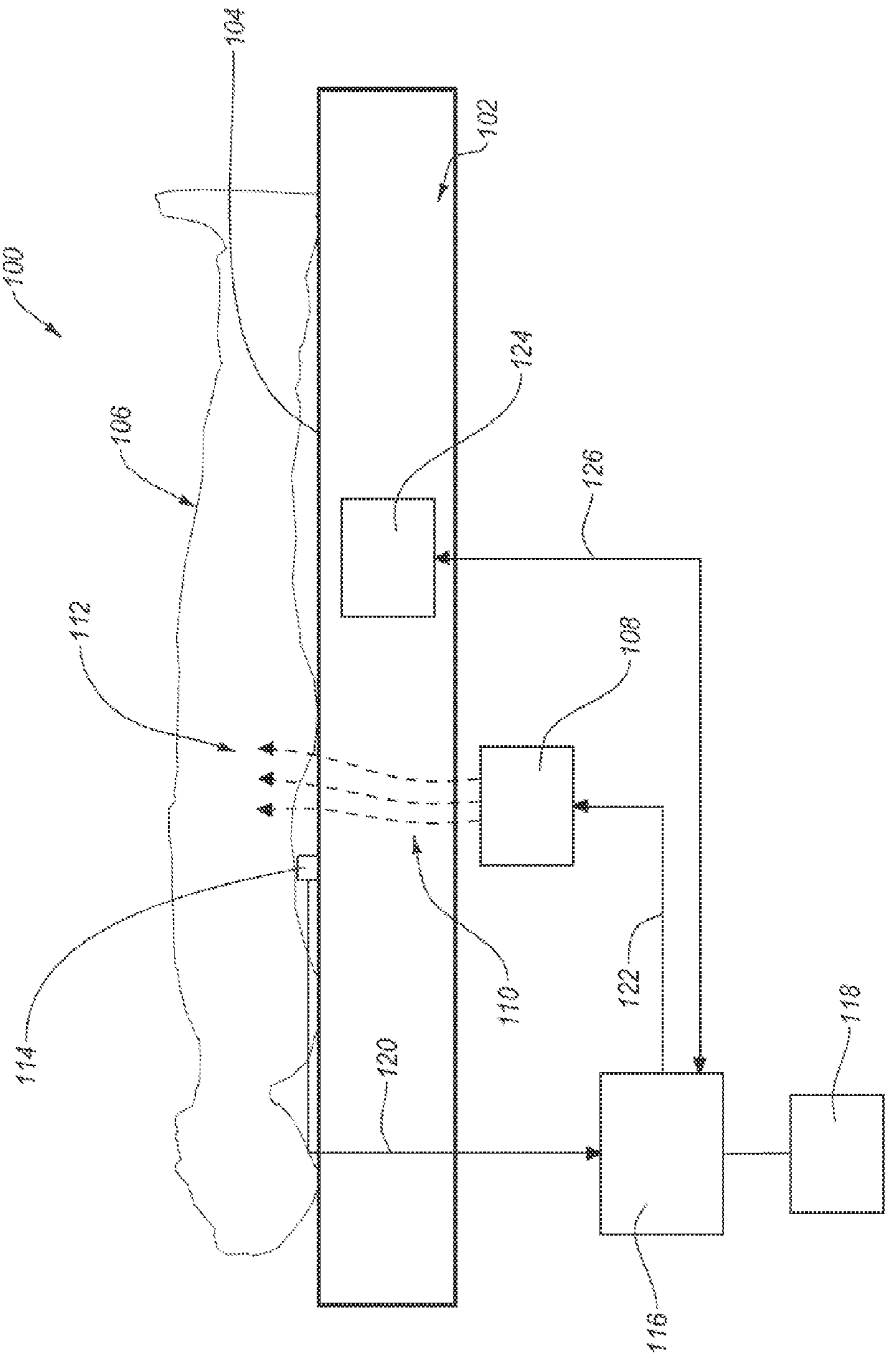


FIG. 1B

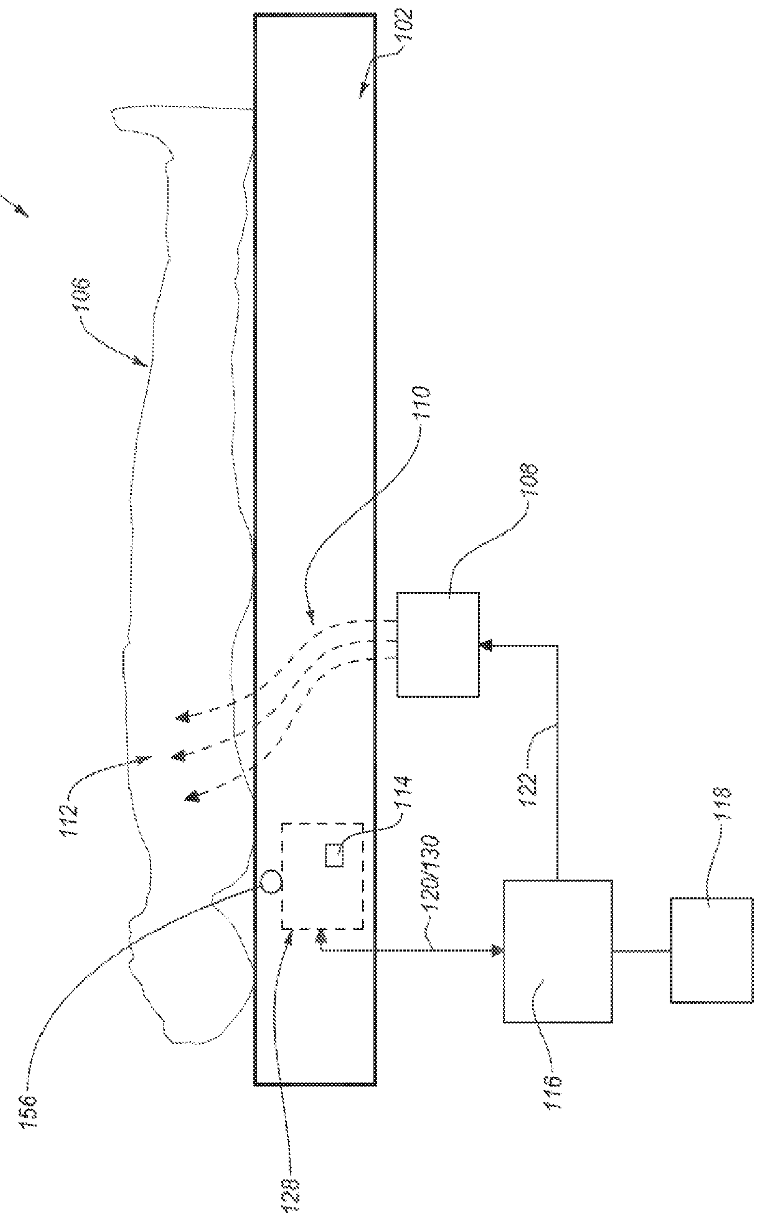


FIG. 1C

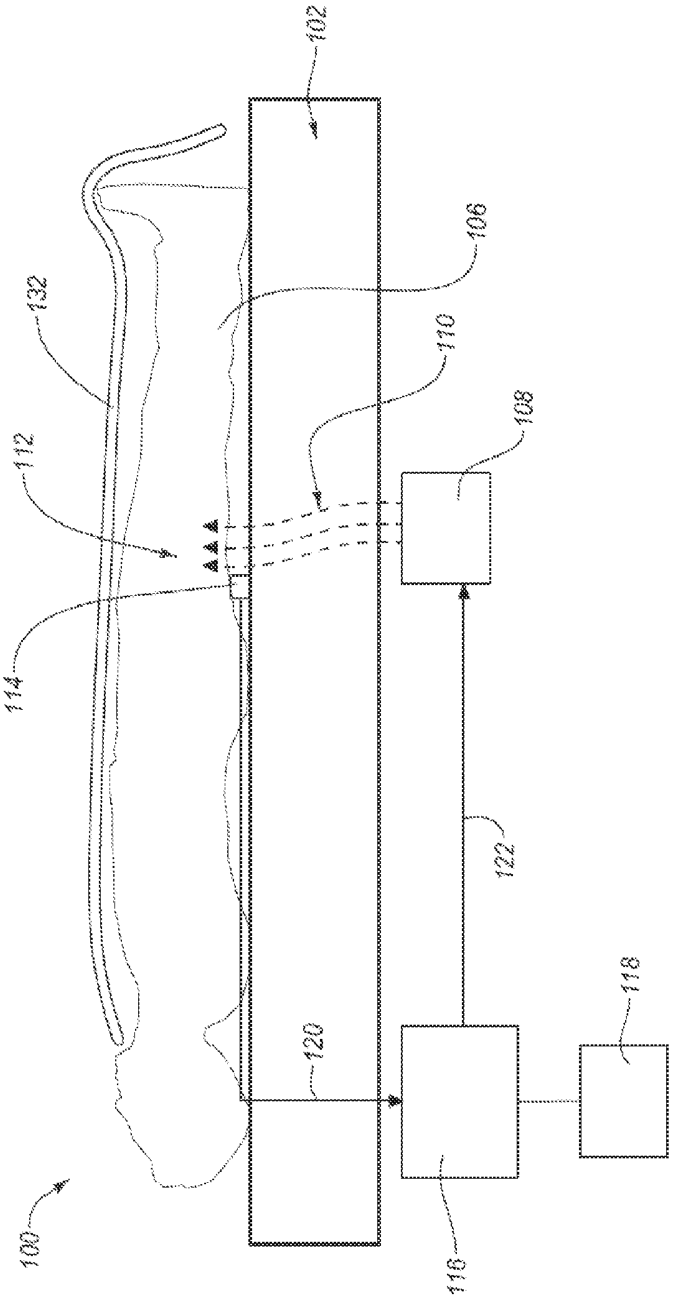


FIG. 1D

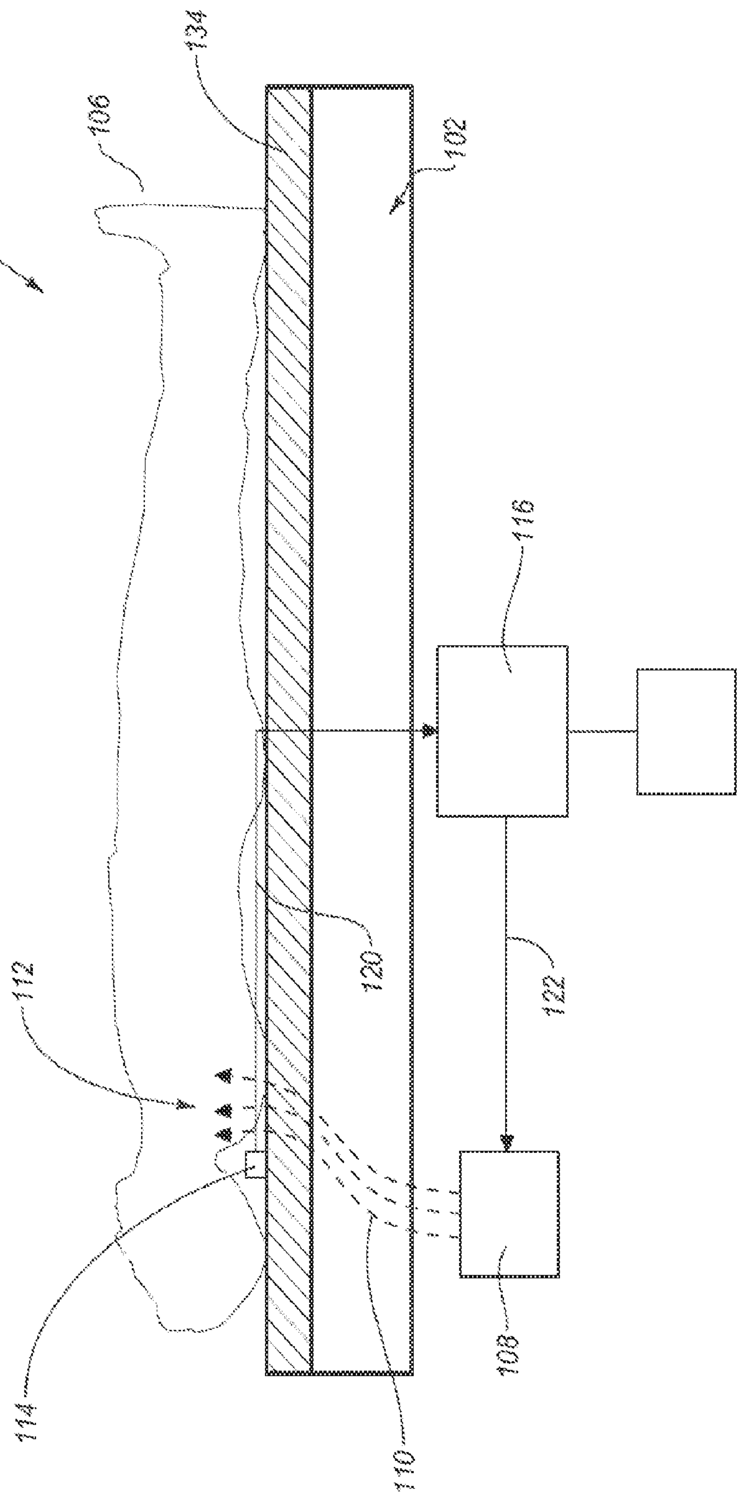


FIG. 1E

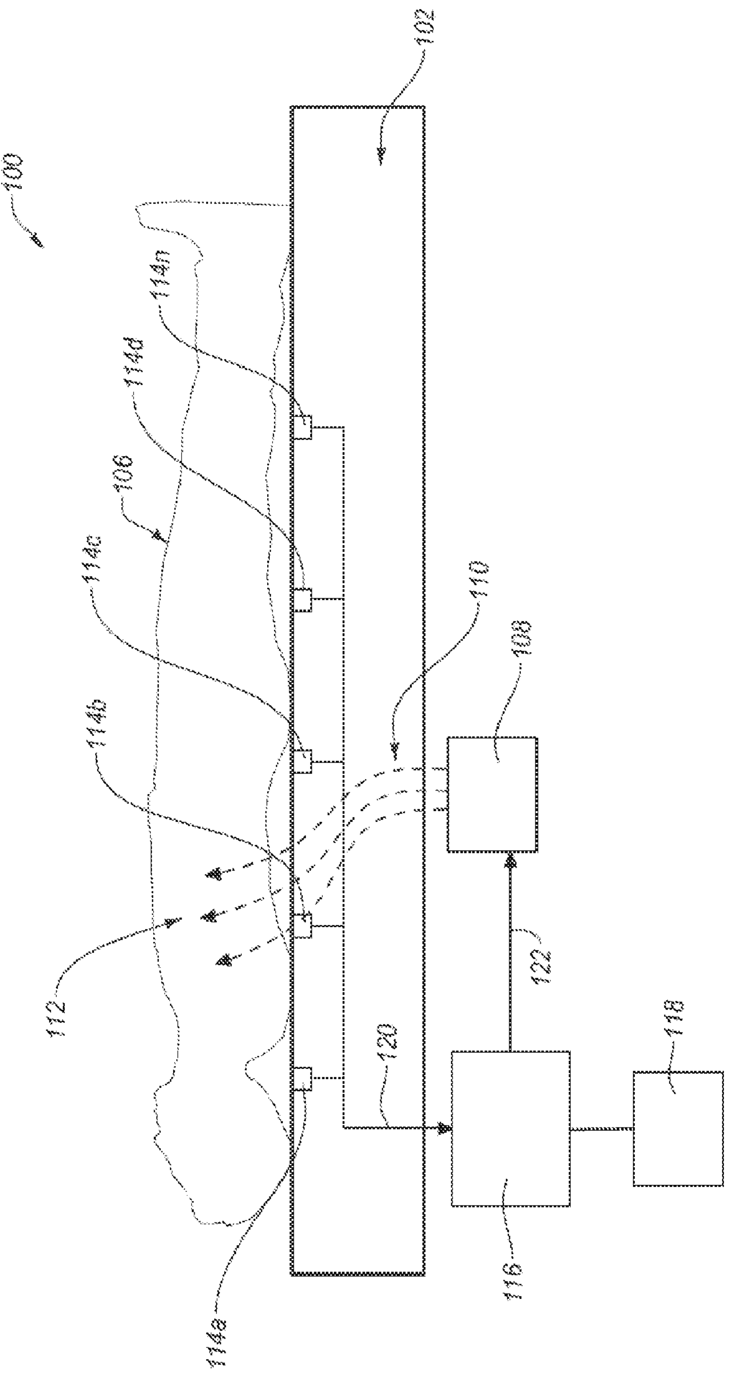

100
102
106
108
110
112
114a
114b
114c
114d
114n
116
118
120
122

FIG. 2A

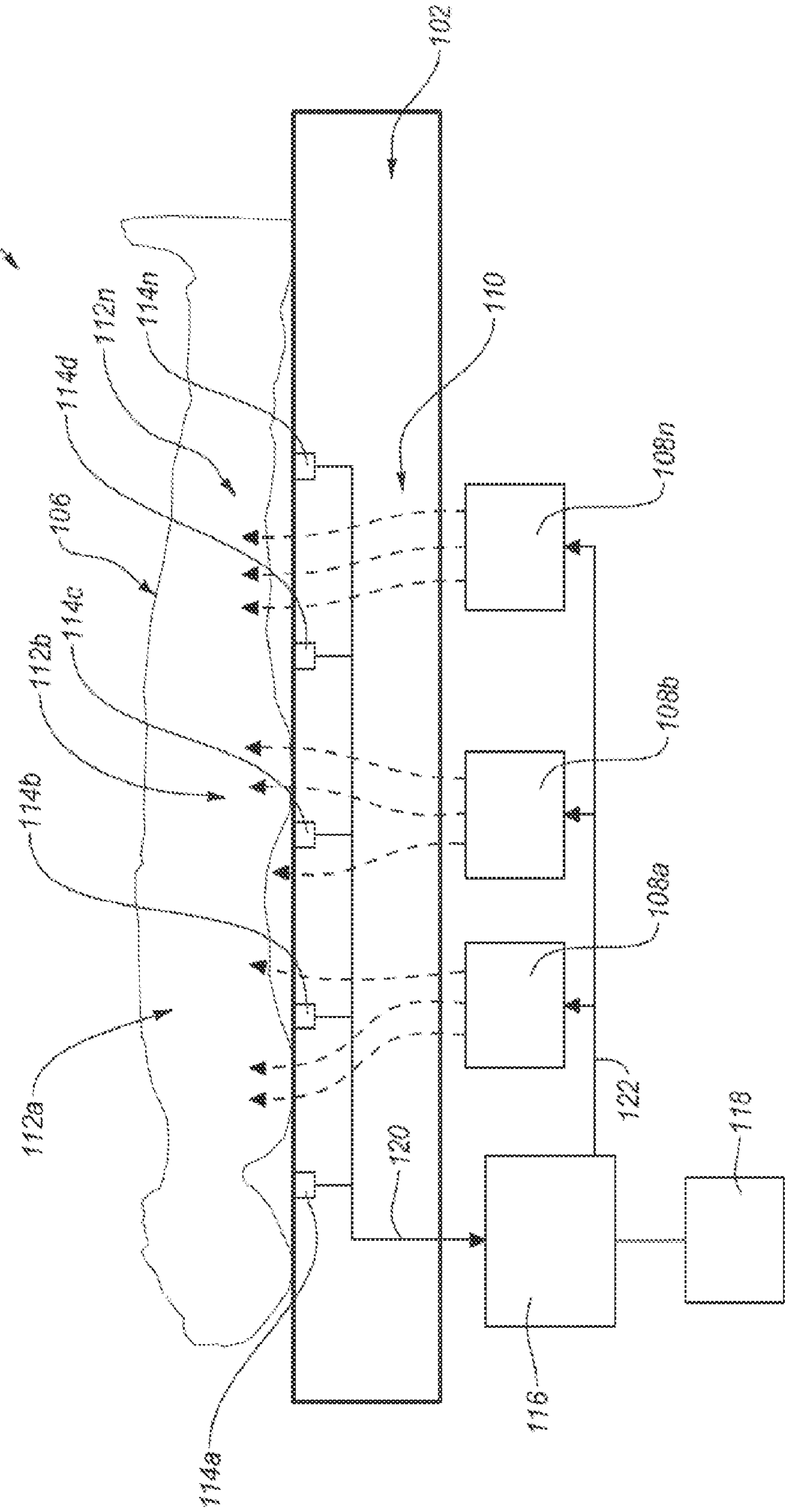

100
102
110
112n
114n
114d
106
114c
112b
114b
112a
108n
108b
108a
122
120
118
116
114a

FIG. 2B

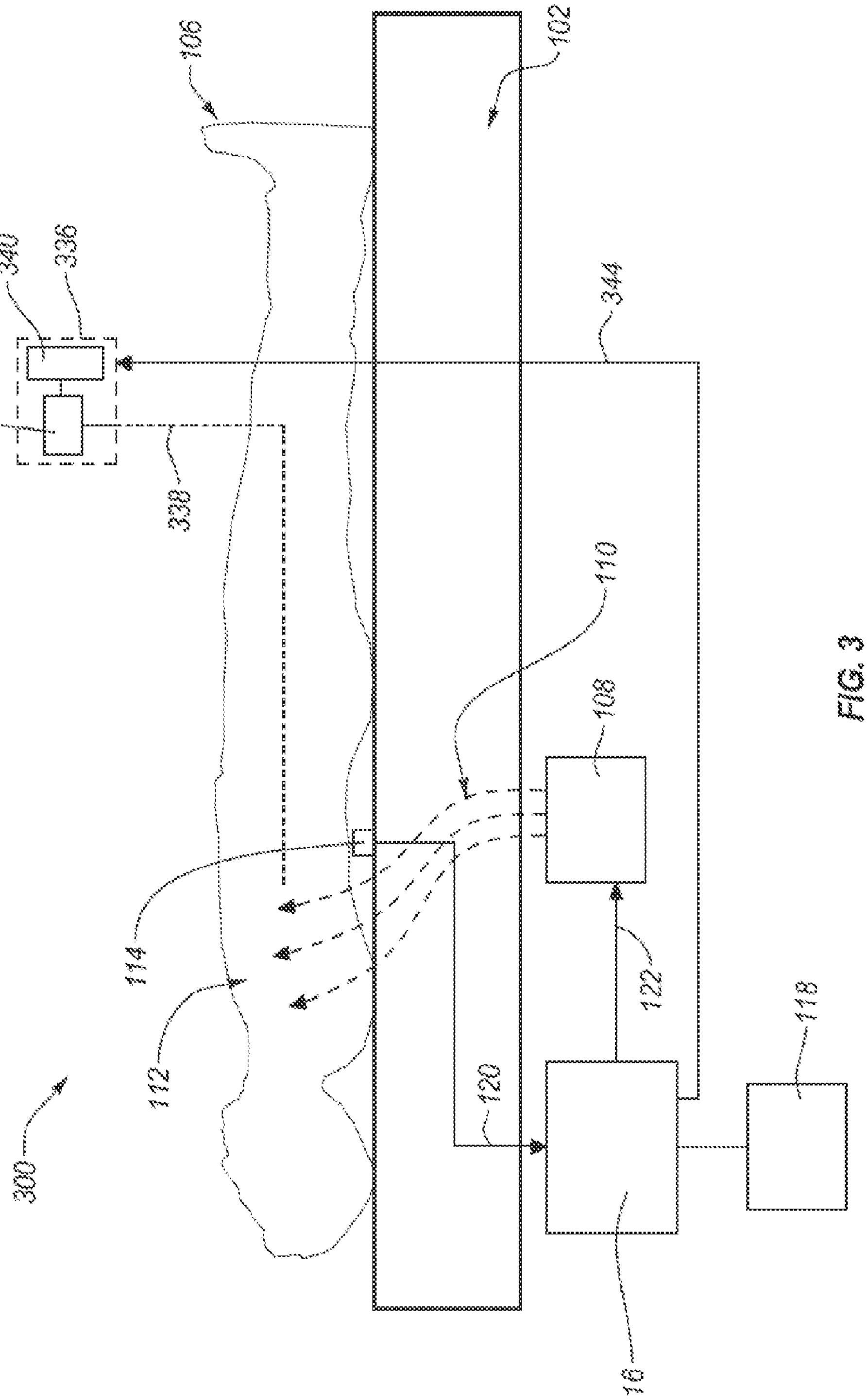


FIG. 3

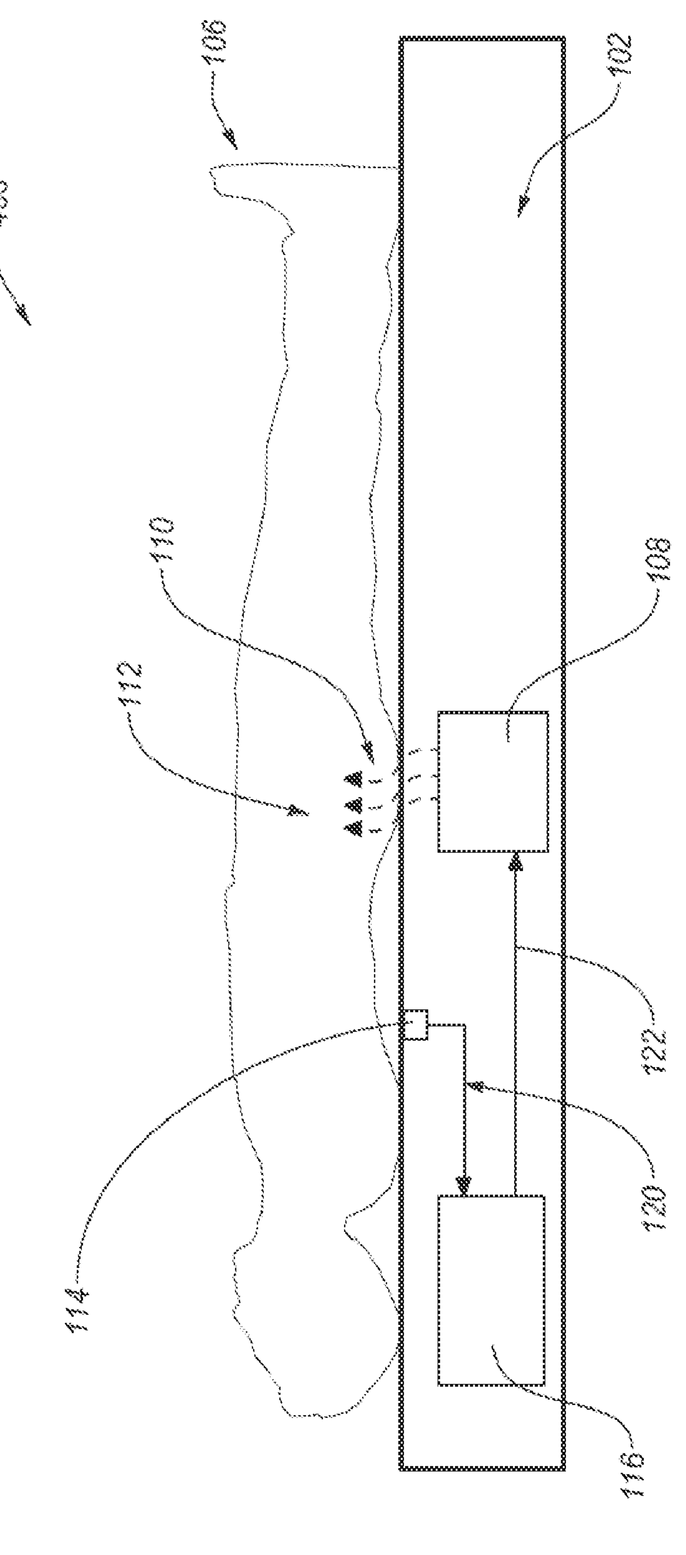


FIG. 4A

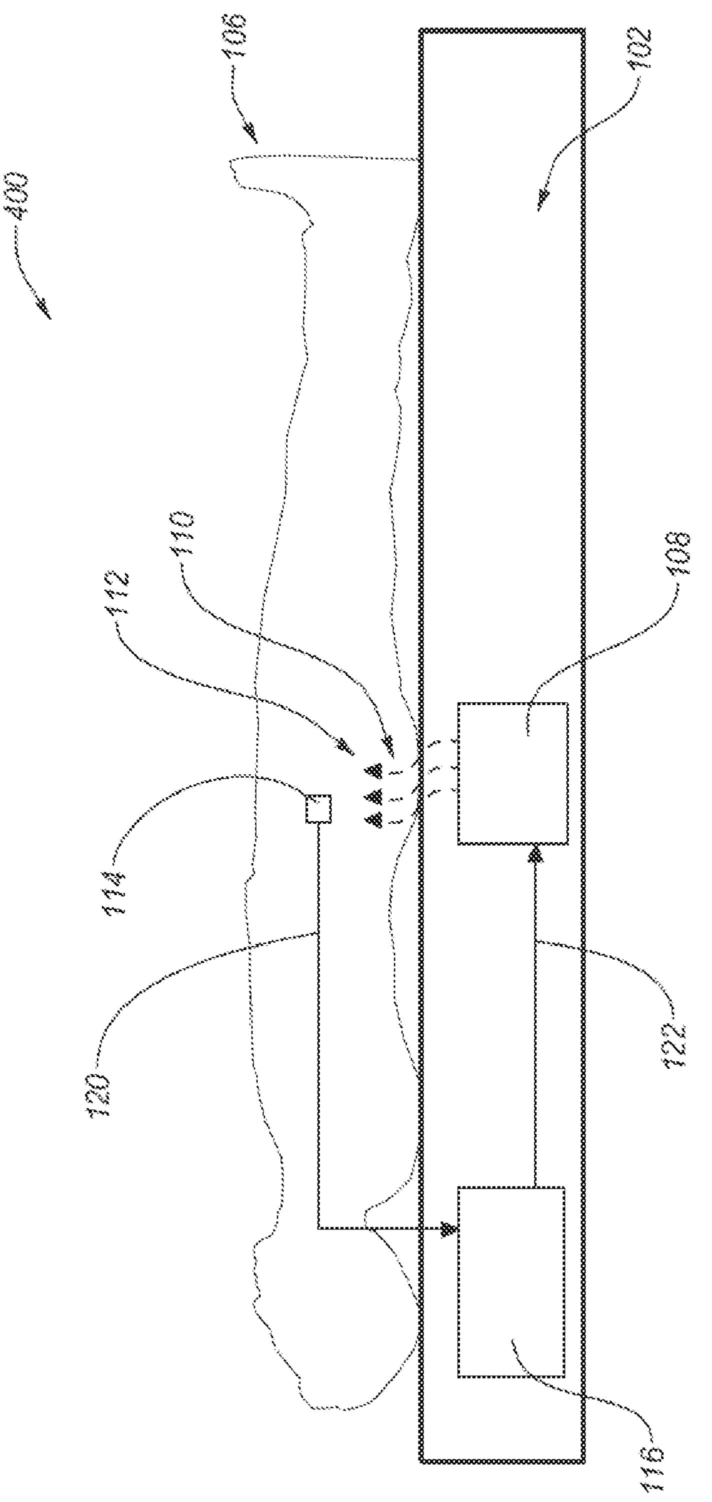


FIG. 4B

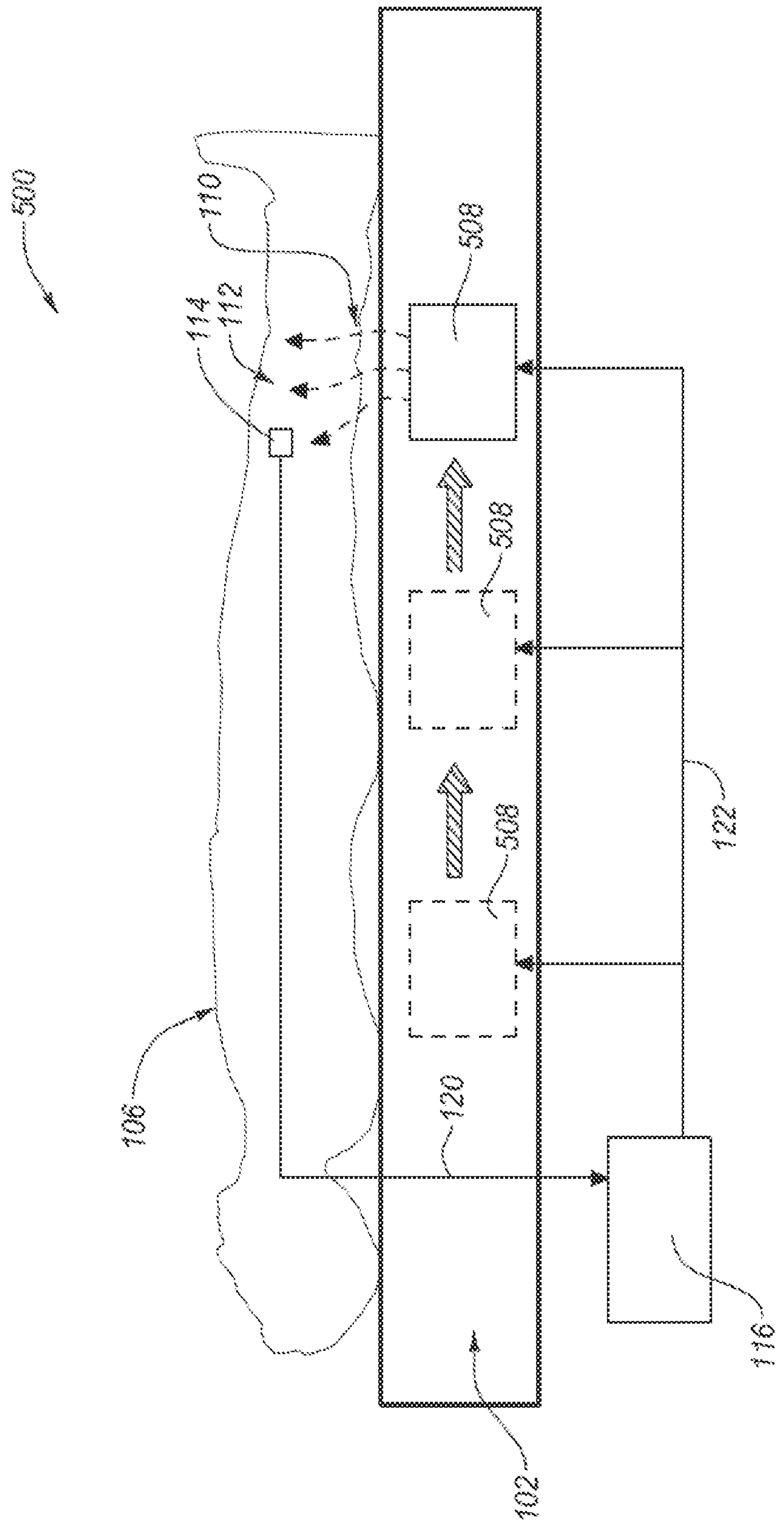


FIG. 5

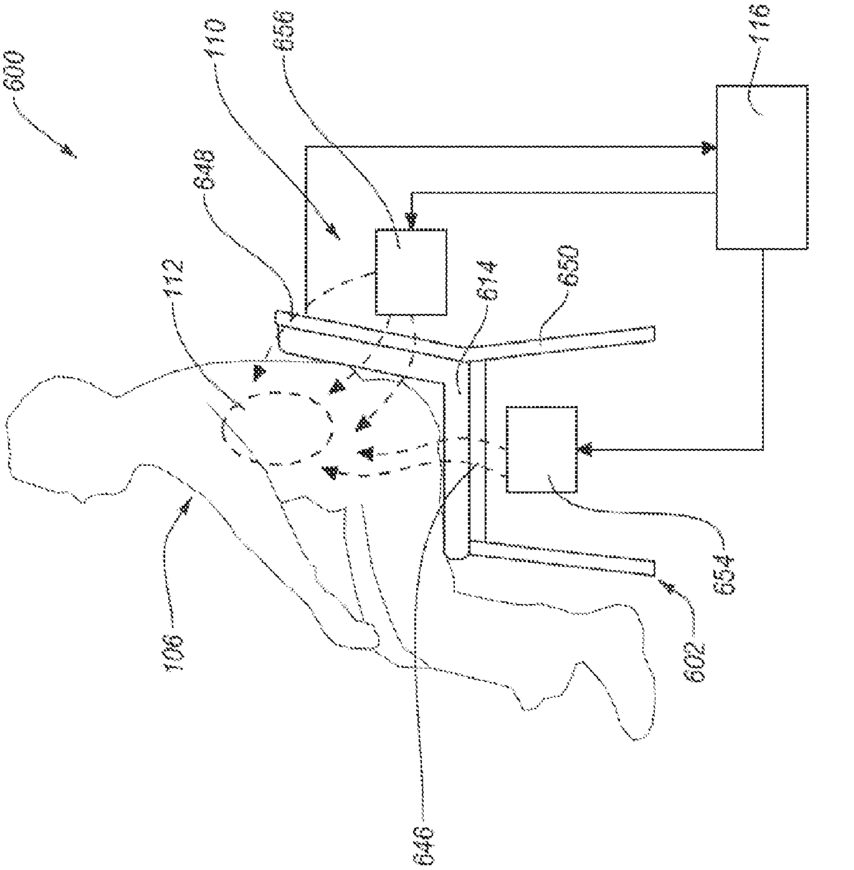


FIG. 6

SYSTEMS AND METHODS FOR TREATING HYPOTHERMIA

[0001] If an Application Data Sheet (ADS) has been filed on the filing date of this application, it is incorporated by reference herein. Any applications claimed on the ADS for priority under 35 U.S.C. §§119, 120, 121, or 365(c), and any and all parent, grandparent, great-grandparent, etc. applications of such applications, are also incorporated by reference, including any priority claims made in those applications and any material incorporated by reference, to the extent such subject matter is not inconsistent herewith.

CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] The present application claims the benefit of the earliest available effective filing date(s) from the following listed application(s) (the "Priority Applications"), if any, listed below (e.g., claims earliest available priority dates for other than provisional patent applications or claims benefits under 35 USC §119(e) for provisional patent applications, for any and all parent, grandparent, great-grandparent, etc. applications of the Priority Application(s)).

PRIORITY APPLICATIONS

[0003] None.

[0004] If the listings of applications provided above are inconsistent with the listings provided via an ADS, it is the intent of the Applicant to claim priority to each application that appears in the Domestic Benefit/National Stage Information section of the ADS and to each application that appears in the Priority Applications section of this application.

[0005] All subject matter of the Priority Applications and of any and all applications related to the Priority Applications by priority claims (directly or indirectly), including any priority claims made and subject matter incorporated by reference therein as of the filing date of the instant application, is incorporated herein by reference to the extent such subject matter is not inconsistent herewith.

SUMMARY

[0006] Embodiments disclosed herein are directed to systems and methods for treating hypothermia. In an embodiment, a hypothermia treatment system includes a support structure, an electromagnetic energy source, at least one temperature sensor, and a control system. The support structure is configured to support a subject having a target region thereon. The electromagnetic energy source is configured to output electromagnetic energy toward the target region of the subject to selectively heat the target region. The electromagnetic energy source is located external to the subject. The at least one temperature sensor is configured to determine or measure a temperature of the target region of the subject. The control system is operably coupled to the electromagnetic energy source and the at least one temperature sensor. The control system is configured to control at least one operational parameter of the electromagnetic energy output by the electromagnetic energy source responsive to the at least one temperature sensor determining or measuring the temperature of the target region so that the temperature of the target region is maintained below a tissue damaging temperature of the target region.

[0007] In an embodiment, a method for treating hypothermia in a subject is disclosed. A temperature of a target region of the subject, such as a subsurface target region, is determined or measured. Responsive to determining or measuring the temperature, electromagnetic energy is directed at an external surface of a target region of the subject effective to heat the target region to a temperature of less than an ablation temperature of the target region.

[0008] Features from any of the disclosed embodiments can be used in combination with one another, without limitation. In addition, other features and advantages of the present disclosure will become apparent to those of ordinary skill in the art through consideration of the following detailed description and the accompanying drawings.

[0009] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE FIGURES

[0010] FIG. **1**A is a schematic diagram of an embodiment of a hypothermia treatment system.

[0011] FIG. **1**B is a schematic diagram of an embodiment of a hypothermia treatment system including a medical imaging system.

[0012] FIG. **1**C is a schematic diagram of an embodiment of a hypothermia treatment system including a thermography system.

[0013] FIG. **1**D is a schematic diagram of an embodiment of a hypothermia treatment system including a reflective material.

[0014] FIG. **1**E is a schematic diagram of an embodiment of a hypothermia treatment system including an energy absorptive material.

[0015] FIG. **2**A is a schematic diagram of an embodiment of a hypothermia treatment system including an array of sensors.

[0016] FIG. **2**B is a schematic diagram of an embodiment of a hypothermia treatment system including an array of electromagnetic energy sources.

[0017] FIG. **3** is a schematic diagram of an embodiment of a hypothermia treatment system including a supply of electromagnetic energy absorption agents.

[0018] FIG. **4**A is a schematic diagram of an embodiment of a hypothermia treatment system including one or more components integrated into a support structure.

[0019] FIG. **4**B is a schematic diagram of an embodiment of a hypothermia treatment system including at least one temperature sensor deployed internally within a patient.

[0020] FIG. **5** is a schematic diagram of an embodiment of a hypothermia treatment system including a movable electromagnetic energy source.

[0021] FIG. **6** is a schematic diagram of an embodiment of a hypothermia treatment system including a support structure including a chair.

DETAILED DESCRIPTION

[0022] Embodiments disclosed herein are directed to systems and methods for treating hypothermia. In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be strictly limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein.

[0023] FIG. **1**A is a schematic diagram of a hypothermia treatment system **100**, according to an embodiment. The hypothermia treatment system **100** includes a support structure **102** configured to support the subject **106** thereon. For example, the support structure **102** can include a support surface **104** that supports the subject **106**. In an embodiment, the support surface **104** is substantially rigid. In an embodiment, the support surface **104** can be flexible. In an embodiment, the support surface **104** includes a substantially rigid portion and a substantially flexible portion. In an embodiment, the support surface **104** can include one or more cushioning materials. The support structure **102** can exhibit a variety of different configurations selected for a particular application. For example, the support structure **102** can include a chair, a bed, a surgical table, a stretcher, a gurney, a platform, a couch, a sleeping bag, or a hypothermia wrap. The support structure **102** can include a patient support structure or a subject support structure.

[0024] In an embodiment, the support structure **102** can include any suitable conventional operating table. For example, the support structure **102** can include, but is not limited to, the Elite 6300 General Purpose Table, commercially available from Skytron, Grand Rapids, Mich.; The Alphamaquet **1150**, commercially available from MAQUET Holding GmbH & Co. KG, Rastatt, Germany; the DRE Versailles P100 Powered Mobile Surgery Table, commercially available from DRE, Inc., Louisville, Ky. Of course, other individually adapted operating tables can be employed for the support structure **102**.

[0025] The hypothermia treatment system **100** further includes an electromagnetic energy source **108**. In the illustrated embodiment, the electromagnetic energy source **108** is positioned under the support structure **102**. However, in an embodiment, the electromagnetic energy source **108** is incorporated in the support structure **102**. In an embodiment, the electromagnetic energy source **108** is positioned over the support structure **102**. In an embodiment, the electromagnetic energy source **108** is positioned around at least a portion of the subject **106**. For example, the electromagnetic energy source **108** can be wrapped around at least a portion of a leg of the subject **106**. In an embodiment, the electromagnetic energy source **108** is wrapped around the back of the subject **106**. In an embodiment, the hypothermia treatment system **100** can include a plurality of electromagnetic energy sources **108** (shown in FIG. 2B).

[0026] In an embodiment, the electromagnetic energy source **108** is configured to selectively output electromagnetic energy **110** into the subject **106** in order to treat hypothermia. In an embodiment, the electromagnetic energy source **108** is configured to selectively output electromagnetic energy **110** into the subject **106** in order to prevent hypothermia. For example, the electromagnetic energy source **108** can be configured to selectively output electromagnetic energy **110** into the subject **106** to provide uniform heating over the target region **112** (e.g., the volume of the subject **106**) during surgery to prevent patient hypothermia. Hypothermia is characterized by a lowering of core body temperature below physiological normal limits, which is typically less than 35° C. for a human and results when a subject's body heat loss exceeds body heat production. Hypothermia can be classified as accidental or intentional, primary or secondary, and by the degree of hypothermia. Accidental hypothermia can result from unanticipated exposure to cold and wet conditions. Intentional hypothermia is an induced state generally directed at neuroprotection after an at-risk situation. Primary hypothermia is due to environmental exposure, with no underlying medical condition causing disruption of temperature regulation. Secondary hypothermia is low body temperature resulting from a medical illness. Hypothermia can be life-threatening, impairing neurological, cardiovascular, respiratory, and gastrointestinal systems. In an embodiment, the subject **106** is a patient in surgery. In an embodiment, the subject **106** is a patient being treated for primary hypothermia. In an embodiment, the subject **106** is a patient being treated for secondary hypothermia. In an embodiment, the subject **106** is being treated for accidental hypothermia. In an embodiment, the subject **106** is a patient in an induced state of hypothermia. In an embodiment, the subject is a human. However, in an embodiment, the subject **106** can include any warm-blooded animal susceptible to hypothermia, including, but not limited to, a horse, a canine, a feline, primates, or cattle.

[0027] In an embodiment, the electromagnetic energy source **108** can selectively output electromagnetic energy **110** toward a target region **112** of the subject **106** to heat the target region **112**. In an embodiment, the target region **112** can include a surface region including, but not limited to, the neck, the armpits, the head, the groin, palms of the hands, the chest, the abdomen, or the back. In an embodiment, the target region **112** can include a subsurface region including, but not limited to, internal body organs (e.g., the brain, the heart, the lungs, the kidneys), the thorax, the gastrointestinal tract, the vertebral arteries, the common carotid arteries, the internal carotid artery, the external carotid artery, the axillary artery, the brachial artery, the ulnar artery, the radial artery, the femoral artery, the popliteal artery, the tibial arteries, or the dorsal pedal artery. In an embodiment, the target region **112** can include surface regions and subsurface regions. In an embodiment, the target region **112** can include one or more locations.

[0028] In an embodiment, the electromagnetic energy source **108** can include an array of electromagnetic energy sources to substantially, uniformly heat the target region **112**. In an embodiment, the electromagnetic energy source **108** can include a scanning system to substantially, uniformly heat the target region **112**. In an embodiment, the electromagnetic energy source **108** can include an antenna system that continuously shifts the electromagnetic energy **110** over the target region **112** to substantially uniformly heat the target region **112**. For example, the electromagnetic energy source **108** can include an array of antennas configured to transmit the electromagnetic energy **110** toward the target region **112**. By controlling one or more of the antennas, the control system **116** can direct the electromagnetic energy source **110** to substantially uniformly heat the target region **112**.

[0029] In an embodiment, the heat produced by the electromagnetic energy **110** can directly heat the target region **112**. For example, the target region **112** can include the groin of the subject **106**. The electromagnetic energy source **108**

can output the electromagnetic energy **110** toward the groin. The electromagnetic energy **110** output from the electromagnetic energy source **108** can be absorbed by the groin. As the electromagnetic energy **110** is absorbed, the electromagnetic energy **110** can cause molecules to vibrate, producing heat in the groin that warms the groin. Thus, the electromagnetic energy source **108** can selectively output electromagnetic energy **110** toward the groin to heat the groin of the subject. In an embodiment, the target region **112** can include the palms of the hands of the subject **106**. The electromagnetic energy source **108** can output the electromagnetic energy **110** toward the palms of the hands. The electromagnetic energy **110** output from the electromagnetic energy source **108** can be absorbed by the palms of the hands. As the electromagnetic energy **110** is absorbed, the electromagnetic energy **110** can produce heat in the palms of the hands that warms the hands. In an embodiment, the target region **112** can include the abdomen of the subject **106**. The electromagnetic energy source **108** can output the electromagnetic energy **110** toward the abdomen. The electromagnetic energy **110** output from the electromagnetic energy source **108** can be absorbed by the abdomen. As the electromagnetic energy **110** is absorbed, the electromagnetic energy **110** can produce heat in the abdomen that warms the abdomen. In an embodiment, the electromagnetic energy **110** can be configured to directly heat a subsurface target region **112**. For example, in an embodiment, the electromagnetic energy **110** is configured to penetrate a depth with the subject's body depending on the nature of the tissue being targeted (e.g., fat, muscles, bones, or organs).

[0030] In an embodiment, the heat produced by the electromagnetic energy **111** can indirectly heat the target region **112**. For example, the target region **112** can include the lungs, brain, or heart of the subject **106**. The electromagnetic energy source **108** can selectively output or emit the electromagnetic energy **110** towards the skin surface of the subject **106**. The output electromagnetic energy **110** can then be absorbed by the skin, tissue underlying the skin, and one or more major arteries in or near the underlying tissue (e.g., the axillary artery). As the electromagnetic energy **110** is absorbed, the electromagnetic energy **110** produces heat in the skin, underlying tissue, and the one or more major arteries. From the one or more major arteries, blood flow and conductive heat flow can transfer the heat produced by the electromagnetic energy **110** to heat or warm the subject's brain, lungs, or heart, thereby raising the body temperature of the subject **106**. In an embodiment, the electromagnetic energy **110** is selected to raise or maintain the body temperature of the subject **106** to above 35° C., above 36° C., or above 37° C. In an embodiment, the electromagnetic energy **110** is selected configured to raise the body temperature of the subject **106** to a temperature between about 35° C. and about 40° C., between about 36° C. and about 39° C., or between about 37° C. and about 38° C. In an embodiment, the electromagnetic energy **110** can directly and indirectly heat the target region **112**.

[0031] The electromagnetic energy source **108** can include, but is not limited to, a microwave energy source, a radio-frequency energy source, or a magnetic energy source. In an embodiment, the electromagnetic energy source **108** includes a microwave energy source that outputs microwave energy **110** to selectively heat the target region **112**. In an embodiment, the microwave energy source **108** includes a steerable microwave energy source. For example, the steerable microwave energy source **108** can include a physically steered or translated microwave energy source **108**. In an embodiment, the steerable microwave energy source can include a phased-array microwave energy source **108**. In an embodiment, the steerable microwave energy source can include a metamaterial array microwave energy source. For example, the metamaterial array microwave energy source can include a metamaterial surface antenna array commercially available from Kymeta Corporation. In an embodiment, the electromagnetic energy source **108** includes an alternating magnetic field.

[0032] In an embodiment, the electromagnetic energy source **108** can include, but is not limited to, a radio-frequency energy source that outputs radio-frequency energy **110** to selectively heat the target region **112**. In an embodiment, the electromagnetic energy source **108** can include a magnetic energy source that outputs alternating magnetic energy **110** to selectively heat the target region **112**. For example, the electromagnetic energy **110** has a frequency greater than about 1 GHz, about 5 GHz, about 10 GHz, or about 50 GHz. In an embodiment, the electromagnetic energy source **108** includes a plurality of electromagnetic energy sources, such as two or more, or three or more electromagnetic energy sources. In an embodiment, the electromagnetic energy **110** includes multiple types of electromagnetic energy. For example, the electromagnetic energy can include microwave energy, magnetic energy, and light energy. In an embodiment, the electromagnetic energy source **108** can include a plurality of electromagnetic energy sources. For example, the electromagnetic energy source **108** can include a microwave energy source and a radio-frequency energy source. In an embodiment, the electromagnetic energy source **108** can include a microwave energy source and a magnetic energy source. In an embodiment, the electromagnetic energy source **108** can include a radio-frequency energy source and a magnetic energy source. In an embodiment, the electromagnetic energy source **108** can include a microwave energy source, a radio-frequency energy source, and a magnetic energy source. In an embodiment, the electromagnetic energy source **108** can include a plurality of at least one of a microwave energy source, a radio-frequency energy source, or a magnetic energy source. For example, the electromagnetic energy source **108** can include two, three, or any other suitable number of microwave energy sources.

[0033] The hypothermia treatment system **100** further includes one or more sensors **114**. In the illustrated embodiment, the one or more sensors **114** is coupled (e.g., mounted) to the support structure **102**. However, in an embodiment, the one or more sensors **114** are deployed internally within the subject **106**. In an embodiment, the one or more sensors **114** are physically coupled to a skin surface of the subject **106**. In an embodiment, the one or more sensors **114** are incorporated in the support structure **102**.

[0034] In an embodiment, the one or more sensors **114** are configured to determine or measure a temperature of the target region **112** of the subject **106**. In an embodiment, the one or more sensors **114** determine a temperature of the target region **112** by directly measuring the temperature of the target region **112**. In an embodiment, the one or more sensors **114** determine a temperature of the target region **112** by measuring one or more non-target temperatures in a non-target region of the subject **106** and inferring the temperature of the target region **112** from the one or more non-target temperatures. For example, the one or more sensors **114** can be configured to determine the temperature of the esophagus of the subject **106** by measuring the temperature of skin covering the esophagus and inferring the temperature of the esophagus from the temperature of the skin covering the esophagus. In an embodiment, the one or more sensors **114** are configured to determine a temperature of the target region **112** by scanning one or more regions of the subject **106**. For example, the one or more sensors **114** can include one or more infrared sensors that sweep across and scan the skin surface on or covering target region **112**. In an embodiment, the one or more sensors **114** can include one or more radiometers that sense subsurface target region temperatures.

[0035] In an embodiment, the one or more sensors **114** are configured to determine a temperature of the target region **112** before the electromagnetic energy **110** arrives at the target region **112**. In an embodiment, the one or more sensors **114** are configured to determine the temperature of the target region **112** after the electromagnetic energy **110** arrives at the target region **112**. Accordingly, the electromagnetic energy source **108** and the one or more sensors **114** (e.g., temperature sensors) can be asynchronous so that they do not interfere with one another. In an embodiment, asynchronous operation of the electromagnetic energy source **108** and the one or more sensors **114** can be provided by interleaving operational periods of the electromagnetic energy source **108** with measurement periods of the one or more sensors **114**. In an embodiment, the one or more sensors **114** are configured to determine the temperature of the target region **112** simultaneously with the electromagnetic energy **110** arriving at the target region **112**. The one or more sensors **114** can include, but are not limited to, fiber-optic temperature sensors, optical coherency tomography sensors, electromagnetic energy detectors, thermography sensors, temperature probes, thermistors, surface temperature sensors, thermobeads, thermopiles, tympanic thermometers, chip-infrared temperature sensors, mini-chip thermistors, thermocouples, clinical thermometers, recording thermometers, rectal thermometers, or resistance thermometers. For example, the one or more sensors **114** can include a thermistor inserted within the target region **112** to measure the temperature of the target region **112**. In an embodiment, the one or more sensors **114** can include a radiometer (e.g., using infrared or microwaves) that remotely determines the temperature of the target region **112**. The one or more sensors **114** can include a single sensor or a plurality of sensors. The one or more sensors **114** can be small in size, such as a sensor or a sensor array that is a chip-infrared sensor.

[0036] In an embodiment, the one or more sensors **114** is configured to determine or measure physiological or other characteristics of the target region **112**, which include, but are not limited to, electrical resistivity thereof, blood flow, position, chemical composition thereof, or density thereof. One or more of these sensing capabilities can be present in a single sensor or the array of sensors; sensing capabilities are not limited to a particular number or type of sensors. The one or more sensors **114** can include, but are not limited to, ultrasound sensors, pressure sensors, light sensors, sensors including piezoelectric crystals, encoders, transducers, motion sensors, position sensors, flows sensors, viscosity sensors, shear sensors, time detectors (e.g., timer, clocks), imaging detectors, acoustic sensors, temperature sensors, chemical and biological detectors, electromagnetic energy detectors, pH detectors, or electrical sensors. In an embodiment, the one or more sensors **114** including one or more electromagnetic energy detectors can be configured to determine the absorption, reflection, or emission of the electromagnetic energy **110** in the target region **112**. The one or more sensors **114** including a machine-vision system can detect location, quality of location, or quality of output placement of the electromagnetic energy **110** in the target region **112**. In an embodiment, the one or more sensors **114**, including a contactless, infrared sensor or optical coherency tomography sensor can detect one or more physiological conditions of a subject **106**, including, but not limited to, tissue swelling or inflammation.

[0037] The hypothermia treatment system **100** further includes a control system **116** including control electrical circuitry (not shown), along with a user interface **118** (e.g., a touchscreen, keypad, etc.) for user input. The control system **116** is operably coupled to the electromagnetic energy source **108** and the one or more sensors **114** to control operation of one or more of the foregoing system components. In an embodiment, the control system **116** is configured to direct the electromagnetic energy source **108** to emit the electromagnetic energy **110** based on feedback or the one or more sensing signals from the one or more sensors **114**. For example, in operation, the electromagnetic energy source **108** and the one or more sensors **114** are positioned near or adjacent to the target region **112**. One or more sensing signals **120** are output from the one or more sensors **114** to the control system **116** that encodes sensing information. In an embodiment, automatically responsive to the one or more sensing signals **120**, the control system **116** outputs one or more emitting information signals **122** to the electromagnetic energy source **108** that encode emitting information or directions. Responsive to the emitting information signals **122**, the electromagnetic energy source **108** can emit the electromagnetic energy **110** toward the target region **112** of the subject **106**. The control system **116** can also output one or more sensing instructions to the one or more sensors **114**. In an embodiment, the one or more sensors **114** determine the temperature of the target region **112** in accordance with the sensing instructions. Thus, in an embodiment, the control system **116** is configured to control operation of both the electromagnetic energy source **108** and the one or more sensors **114**. In an embodiment, the control system **116** is wirelessly connected to the electromagnetic energy source **108** and the one or more sensors **114**. In an embodiment, the control system **116** can adjust the output of the electromagnetic energy **110** from the electromagnetic energy source **108** to achieve a substantially uniform temperature of the target region **112**. For example, in an embodiment, the electromagnetic energy source **108** can include an antenna system and the control system **116** can control the antenna system of the electromagnetic energy source **108** to continuously shift the electromagnetic energy **110** to achieve a substantially uniform temperature of the target region **112**. In an embodiment, the control system **116** can control the antenna system to continuously shift the electromagnetic energy **110** in one or more patterns. In an embodiment, the electromagnetic energy source **108** can include a scanning system and the control system **116** can control the scanning system of the electromagnetic energy source **108** to continuously shift the electromagnetic energy **110** to achieve a substantially uniform temperature of the target region **112**.

In an embodiment, the electromagnetic energy source **108** is configured to pulse the target region **112** with the electromagnetic energy **110**.

[0038] In an embodiment, the control system **116** is configured to control at least one operational parameter of the electromagnetic energy source **108** to achieve a uniform temperature of the target region **112**. For example, the one or more emitting information signals **122** can include one or more directions to emit the electromagnetic energy **110** toward the target region **112** as the electromagnetic energy source **108** moves over the target region **112**. As another example, the one or more emitting information signals **122** can include one or more locations of the electromagnetic energy **110**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to emit the electromagnetic energy **110** toward a portion of the target region **112** determined to have a temperature lower than another portion of the target region **112**.

[0039] In an embodiment, the one or more emitting information signals **122** include one or more directions to emit the electromagnetic energy **110** after the one or more sensors **114** determine the temperature of the target region **112**. In an embodiment, the one or more emitting information signals **122** include one or more directions to stop emitting the electromagnetic energy **110** after the one or more sensors **114** determine the temperature of the target region **112**. In an embodiment, the one or more emitting information signals **122** include one or more directions to emit the electromagnetic energy **110** substantially and simultaneously with the electromagnetic energy source **108** emitting the electromagnetic energy **110** toward the target region **112**.

[0040] In an embodiment, the one or more emitting information signals **122** include one or more directions to control at least one operational parameter of the electromagnetic energy source **108**. The one or more emitting information signals **122** can include one or more directions to control the intensity of the electromagnetic energy **110**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to control the duration of the electromagnetic energy **110** applied to the target region **112**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to control the direction of the electromagnetic energy **110** emitted from the electromagnetic energy source **108**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to control the type of electromagnetic energy **110**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to control the phase of electromagnetic energy **110**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to control the frequency of electromagnetic energy **110**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to control the pulse frequency of the electromagnetic energy **110** emitted from the electromagnetic energy source **108**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to control the position of the electromagnetic energy source **108**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to control the alignment of the electromagnetic energy source **108** with the target region **108**. In an embodiment, the one or more emitting information signals **122** include one or more directions to control the electromagnetic energy source **108** in order to vary the electromagnetic absorption profile within the subject **106**. In an embodiment, the one or more emitting information signals **122** include one or more directions to emit the electromagnetic energy **110** in one or more timed intervals. For example, the time intervals include, but are not limited to, fixed timed intervals, periodic time intervals (e.g. pulses), programmable or programmed time intervals, triggered time intervals, manually determined time intervals, automatic time intervals, remotely controlled time intervals, or time intervals based on feedback from the one or more sensors **114**. In an embodiment, the one or more emitting information signals **122** include one or more directions to aim the electromagnetic energy **110** toward the target region **112**. In an embodiment, the one or more emitting information signals **122** include one or more directions to move the electromagnetic energy source **108** toward the target region **112**. In an embodiment, the one or more emitting information signals **122** include one or more directions to align the electromagnetic energy **110** with the target region **112**.

[0041] In an embodiment, the one or more emitting information signals **122** include one or more directions to emit the electromagnetic energy **110** in one or more pulses. For example, the one or more emitting information signals **122** include one or more directions to direct the electromagnetic energy source **108** to emit a first electromagnetic energy and, before the electromagnetic energy source **108** stops emitting the first electromagnetic energy, the one or more directions direct the electromagnetic energy source **108** to emit a second electromagnetic energy. The one or more emitting information signals **122** can also include one or more directions to stop emitting the first electromagnetic energy and to emit a third electromagnetic energy. In an embodiment, the first electromagnetic energy, the second electromagnetic energy, or the third electromagnetic energy are different.

[0042] In an embodiment, the one or more emitting information signals **122** include one or more directions to stop emitting the electromagnetic energy **110** if one or more conditions are detected. For example, the one or more emitting information signals **122** can include one or more directions to stop emitting the electromagnetic energy **110** if the temperature of the target region **112** reaches an upper threshold temperature. In an embodiment, the upper threshold temperature is any temperature below about 40° C., about 42° C., about 44° C., about 46° C. or about 48° C. In an embodiment, the upper threshold temperature is any temperature between about 40° C. and about 49° C. or between about 40.5° C. and about 45° C. The upper threshold temperature may vary depending on the target region **112** or tissue type (fat, muscles, bones, normal tissue, etc.). The upper threshold temperature may vary depending on the thermal history of the target region **112** or on a length of time at which the temperature of the target region **112** will be at or exceed the upper threshold temperature.

[0043] In an embodiment, the upper threshold temperature is selected to be below a tissue damaging temperature. For example, the tissue damaging temperature can be any temperature above about 40° C., about 42° C., about 44° C., about 46° C. or about 48° C. In an embodiment, the tissue damaging temperature is any temperature between about 40° C. and about 49° C. or between about 40.5° C. and about 45° C. The tissue damaging temperature may vary depending on the target region or type of tissue. In an embodiment, the tissue damaging temperature is associated with apoptosis. In an embodiment, the tissue damaging temperature is associated with necrosis. In an embodiment, the tissue damaging temperature is associated with mitotic catastrophe. In an embodiment, the tissue damaging temperature is associated with senescence. In an embodiment, the tissue damaging temperature is associated with autophagy. The tissue damaging temperature may vary depending on the target region, thermal history, or type of tissue.

[0044] In an embodiment, the one or more emitting information signals **122** can include one or more directions to emit the electromagnetic energy **110** if the temperature of the target region **112** or the body temperature of the subject **106** falls below a lower threshold temperature. In an embodiment, the lower threshold temperature is any temperature below about 35° C. In an embodiment, the lower threshold temperature is any temperature below about 34° C. In an embodiment, the lower threshold temperature is any temperature below about 33° C. In an embodiment, the lower threshold temperature is between about 20° C. and about 35° C., about 22° C. and about 33° C., about 24° C. and about 31° C., or about 25° C. and about 30° C.

[0045] In an embodiment, the control system **116** includes processing hardware (e.g., processing electrical circuitry) and an operating system configured to run one or more application software programs. In an embodiment, the control system **116** can use one or more processing techniques on the one or more sensing signals **120** to determine at least location, direction, movement, or presence of the electromagnetic energy **110**. For example, an analysis of the one or more sensing signals **120** can generate distances to the one or more sensors **114**. From determined temperatures and the distances to the one or more sensors **114**, spatial information (e.g., position, three-dimensional position, distribution, presence) of the electromagnetic energy **110** can be determined by the control system **116**. In an embodiment, the control system **116** can send one or more instructions to the electromagnetic energy source **108** to emit and direct the electromagnetic energy **110** at a colder portion of the target region **112** to heat the colder portion or bring the temperature of the colder portion into uniformity with other portions of the target region **112**. In addition to determining spatial information, the control system **116** can determine motion information for the electromagnetic energy **110** based on the one or more sensing signals **120** received from the one or more sensors **114**.

[0046] In an embodiment, the processing hardware or processor numerically models electromagnetic propagation. For example, the control system **116** can use one or more processing techniques on the one or more sensing signals **120** to numerically model electromagnetic propagation. In an embodiment, the processing hardware or processor numerically models energy absorption. For example, the control system **116** can use one or more processing techniques on the one or more sensing signals **120** to numerically model energy absorption. In an embodiment, the control system **116** determines an electromagnetic absorption pattern for the target region **112** at least partially based on the one or more sensing signals **120** including physiological data of the subject **106**. In an embodiment, the electromagnetic energy pattern is determined by forming a three-dimensional pattern directly from the one or more sensing signals **120** including physiological data of the subject **106**. In an embodiment, the control system **116** directs the one or more sensors **114** to scan a focal region of the target region **112**. The electromagnetic energy pattern is determined from the one or more sensing signals **120**. In an embodiment, the processing hardware or processor numerically models thermal transport within the subject **106**. The numerical model of thermal transport can include the effects of thermal transport via blood flow and thermal transport via thermal conduction and diffusion within tissue. For example, the control system **116** can use one or more processing techniques on the one or more sensing signals **120** to numerically model thermal transport. In an embodiment, the control system **116** can use one or more processing techniques to numerically model thermal transport within the subject **106** resulting from absorption of the electromagnetic energy **110**. In an embodiment, the control system **116** controls the electromagnetic energy source **108** based on real time feedback from an output from any of the numerical models generated by the processing hardware or processor.

[0047] In an embodiment, the control system **116** uses computational analysis to generate an electromagnetic energy irradiation profile to treat the subject **106** for hypothermia. In an embodiment, the control system **116** uses computational analysis to generate the electromagnetic energy irradiation profile at least partially based on feedback from the one or more sensors **114**. For example, the control system **116** uses computational analysis to generate the electromagnetic energy irradiation profile at least partially based on the one or more sensing signals **120** from one or more sensors **114** including one or more electromagnetic energy detectors. In an embodiment, the control system **116** uses computational analysis to select an amount of electromagnetic energy **110** to treat the subject **106** based on feedback from the one or more sensors **114**. For example, the control system **116** can use computational analysis to select an amount of electromagnetic energy **110** to treat the subject **106** based on the one or more sensing signals **120** from the one or more sensors **114** including one or more skin temperature sensors.

[0048] Referring to FIG. 1B, in an embodiment, the hypothermia treatment system **100** includes medical imaging equipment **124** operably associated with the control system **116**. In the illustrated embodiment, the medical imaging equipment **124** is incorporated in the support structure **102**. However, in an embodiment, the medical imaging equipment **124** is positioned under the support structure **102**. In an embodiment, the medical imaging equipment **124** is positioned over the support structure **102**. In an embodiment, the medical imaging equipment **124** is configured to determine subject-specific body data. In an embodiment, the subject-specific body data includes one or more physiological parameters of the subject **106**. The one or more physiological parameters can include, but is not limited to, temperature, body temperature, peripheral temperatures, heart rate, blood pressure, blood flow, respiration, blood volume, shivering, physiological electrical fields, electromagnetic energy radiation levels, tissue density, body shape, or movement. The medical imaging equipment **124** can include, but is not limited to, a magnetic resonance imaging device or a computed tomography system. For example, the medical imaging equipment **124** can include a magnetic resonance imaging device that produces anatomical images of the subject **106** in a plurality of different orientations.

[0049] In operation, one or more physiological information signals **126** are output from the medical imaging equipment **124** to the control system **116** that encodes body-specific or physiological data. In an embodiment, responsive to the physiological information signals **126**, the control system **116** outputs one or more emitting information signals **122** to the electromagnetic energy source **108**. Responsive to the emitting-information signals **122**, the electromagnetic energy source **108** can emit the electromagnetic energy **110** toward the target region **112** of the subject **106**. The control system **116** can also output one or more instructions to the medical imaging equipment **124**. In an embodiment, the medical imaging equipment **124** can determine physiological parameters in accordance with the instructions from the control system **116**. In an embodiment, the control system **116** can use one or more processing techniques on the one or more physiological information signals **126** to generate an electromagnetic irradiation information profile within the target region **112**. For example, an analysis of the one or more physiological information signals **126** can generate the level of electromagnetic energy at different locations within the target region **112**. From the electromagnetic energy levels and locations, an electromagnetic irradiation information profile of the target region **112** can be determined by the control system **116**. Based on an electromagnetic irradiation information profile of the target region **112**, the control system **116** can control at least one operational parameter of the electromagnetic energy source **108**, such as output or movement. In an embodiment, the control system **116** controls the electromagnetic energy source **108** based on real time feedback from the medical imaging equipment **124**. In an embodiment, the control system **116** controls the electromagnetic energy source **108** based on previously received feedback from the medical imaging equipment **124**.

[0050] In an embodiment, the control system **116** determines an electromagnetic absorption pattern for the target region **112** at least partially based on the one or more physiological information signals **126** from the medical imaging equipment **124**. In an embodiment, the electromagnetic energy pattern is determined by forming a three-dimensional pattern directly from the one or more physiological information signals **126**. In an embodiment, the control system **116** directs the medical imaging equipment **124** to scan a focal region of the target region **112** and the electromagnetic energy pattern is determined from the one or more physiological information signals **126**.

[0051] Referring to FIG. **1C**, in an embodiment, the one or more sensors **114** are included in a thermography system **128** operably coupled to the control system **116**. In the illustrated embodiment, the thermography system **128** is incorporated in the support structure **102**. However, in an embodiment, the thermography system **128** is positioned under the support structure **102**. In an embodiment, the thermography system **128** is remote from the electromagnetic energy source **108**.

[0052] In an embodiment, the thermography system **128** is configured to determine a temperature distribution in a subsurface target region **112**. In an embodiment, the thermography system **128** is configured to determine a temperature distribution in a surface target region **112**. In an embodiment, the thermography system **128** can provide feedback control over the electromagnetic energy source **108**. For example, the control system **116** can direct the thermography system **128** to determine a temperature profile in the target region **112**.

[0053] In an embodiment, the thermography system **128** includes an antenna **156** and a transceiver (not shown) or a transmitter and a receiver (not shown). In an embodiment, the transceiver can supply electric current to the antenna **156** and the antenna **156** can radiate energy from the current as electromagnetic waves. In reception, the antenna **156** can receive electromagnetic energy and produce a voltage that is converted into one or more thermography signals **130**. Optionally, the voltage is applied to the transceiver to be amplified. In an embodiment, the one or more sensors **114** can share one or more components with the antenna **156**. For example, in an embodiment, the one or more sensors **114** and the antenna **156** can share a transmitter. In an embodiment, the antenna can be incorporated in the one or more sensors **114**.

[0054] The one or more thermography signals **130** can be output from the thermography system **128** to the control system **116**. In an embodiment, the one or more thermography signals **130** can include temperature profile information. Responsive to the feedback from the thermography system **128**, the control system **116** can control at least one operational parameter of the electromagnetic energy source **108**. For example, if the temperature profile information indicates a portion of the target region **112** exhibits a lower temperature than other portions of the target region **112**, the control system **116** can direct the electromagnetic energy source **108** to align the electromagnetic energy **110** with the lower temperature portion and emit the electromagnetic energy **110** toward the lower temperature portion. In an embodiment, based on the temperature profile information, the control system **116** can direct the electromagnetic energy source **108** to scan the target region **112**.

[0055] In an embodiment, the control system **116** can control the electromagnetic energy source **108** based on real time feedback from the thermography system **128**. In an embodiment, the control system **116** can calibrate the electromagnetic energy source **108** based on previously received feedback from the thermography system **128**. For example, the control system **116** can receive one or more thermography signals **130** from the thermography system **128** that includes temperature profile information. Based on the temperature profile information, the control system **116** can calibrate an electromagnetic energy deposition profile of the electromagnetic energy source **108**. In an embodiment, the control system **116** can calibrate the amount of electromagnetic energy **110** emitted or outputted from the electromagnetic energy source **108**.

[0056] In an embodiment, the thermography system **128** includes a thermographic camera. In an embodiment, the thermography system **128** includes microwave energy. In an embodiment, the thermography system **128** includes a microwave radiometer. In an embodiment, the thermography system **128** includes a magnetic resonance imaging system. In an embodiment, the thermography system **128** includes a radiography system. In an embodiment, the thermography system **128** includes invasive probes. In an embodiment, the thermography system **128** uses radiography. In an embodiment, the thermography system **128** includes particles carried in the blood of the subject **106** with temperature-dependent electromagnetic (e.g., microwave energy) properties. In an embodiment, the thermography system includes temperature-dependent ultrasound contrast agents.

[0057] In an embodiment, the control system **116** is configured to determine an electromagnetic absorption pattern for the target region **112** at least partially based on the one or more thermography signals **130** from the thermography system **128**. In an embodiment, the control system **116** determines the electromagnetic absorption pattern by forming a three-dimensional pattern directly from the one or more thermography signals **130**. In an embodiment, the control system **116** directs the thermography system **128** to scan a focal region of the target region **112** and the electromagnetic absorption pattern is determined from the one or more thermography signals **130**. In an embodiment, the control system **116** or the thermography system **128** scans the electromagnetic absorption pattern using thermal inertia of the tissue of the target region **112** as a thermal ballast.

[0058] In an embodiment, the control system **116** uses computational analysis to select or simulate an electromagnetic energy irradiation profile to treat the subject **106** for hypothermia. In an embodiment, the control system **116** uses computational analysis to select or simulate an electromagnetic energy irradiation profile from a database of electromagnetic energy irradiation profiles. In an embodiment, the control system **116** uses computational analysis to select or simulate an electromagnetic energy irradiation profile at least partially based on feedback from the thermography system **128**. For example, the control system **116** can select the electromagnetic energy irradiation profile at least partially based on subject-specific body data from a magnetic resonance imaging system.

[0059] In an embodiment, the control system **116** uses computational analysis to select an amount or type of electromagnetic energy **110** to treat the subject **106** for hypothermia. In an embodiment, the control system **116** uses computational analysis to select an amount of electromagnetic energy **110** to treat the subject **106** from one or more electromagnetic energy dosage tables. In an embodiment, the control system **116** uses computational analysis to select an amount of electromagnetic energy **110** to treat the subject **106** from a database. In an embodiment, the control system **116** uses computational analysis to select a type of electromagnetic energy (e.g., microwave, radio frequency, or alternating magnetic field) to treat the subject **106** for hypothermia from a database of properties of electromagnetic energy. In an embodiment, the control system **116** uses computational analysis to select an amount or type of electromagnetic energy **110** based on feedback from the thermography system **128**. For example, the control system **116** can use computational analysis to select an amount or type of electromagnetic energy **110** based subject-specific body data from a computed tomography scan.

[0060] Referring to FIG. 1D, in an embodiment, the hypothermia treatment system **100** includes a reflective material **132**. In the illustrated embodiment, the reflective material **132** is a reflective patient covering positioned over the subject **106**. However, in an embodiment, the reflective material **132** is positioned under the subject **106**, such as the reflective material **132** can be disposed on a portion of the support structure **102** on which the subject **106** rests or form part of the support structure **102** on which the subject **106** rests. For example, the electromagnetic energy source **108** can be positioned over the subject **106** and the reflective material **132** can be incorporated in the support structure **102**. In an embodiment, the reflective material **132** extends around one or more portions of the subject **106**. For example, the reflective material **132** can at least partially extend around one or more legs of the subject **106**. In an embodiment, the reflective material **132** can at least partially extend around the groin of the subject **106**. In an embodiment, the reflective material **132** can at least partially extend around the back or abdomen of the subject **106**.

[0061] The reflective material **132** can exhibit a variety of different configurations selected for a particular application. For example, the reflective material **132** can be configured as a blanket, a sheet, a surgical gown, or a pad. In an embodiment, the reflective material **132** can be sized to generally correspond to the body of the subject **106**. However, in an embodiment, the reflective material **132** can be sized to generally correspond to the size of one or more portions of the target region **112**. In an embodiment, the reflective material **132** can be configured to leave a surgical region on the subject **106** uncovered by the reflective material **132**. In an embodiment, the reflective material **132** can be sized proportional to the size of the target region **112**. For example, the reflective material **132** can exhibit a lateral dimension that is between about 1.1 and about 3 times greater than a lateral dimension of the target region **112**. In an embodiment, the reflective material **132** can exhibit a lateral dimension that is between about 1.2 and about 2.5 times greater than a lateral dimension of the target region **112**. The reflective material **132** can include, but is not limited to, mylar, aluminum, reflective fabric, metallic foil, silver, or gold. In an embodiment, the reflective material **132** can include two or more layers of material. In an embodiment, the reflective material **132** can include different reflective materials. In an embodiment, the reflective material **132** can be configured as an aerosol, including reflective particles that is sprayable onto a skin surface of the subject **106** over the target region **112**. In an embodiment, the reflective material **132** can be configured as a coating.

[0062] In an embodiment, the reflective material **132** is configured to at least partially control irradiation of the electromagnetic energy **110**. For example, the reflective material **132** can be positioned over the subject **106** supported on the support structure **102**. The reflective material **132** and the support structure **102** can form a containment area for containing the electromagnetic energy **110**. As the electromagnetic energy source **108** outputs the electromagnetic energy **110** into the containment area, the reflective material **132** can reflect the electromagnetic energy **110** within the containment area back toward the subject **106** or electromagnetic energy **108** to limit leakage of the electromagnetic energy **110** therefrom. In an embodiment, the containment area can be configured to contain, intercept, or trap more than about 80%, about 85%, about 90%, about 95%, or 99% of the electromagnetic energy **110** irradiating away from the subject **106**. In an embodiment, the reflective material **132** can at least partially control irradiation of the electromagnetic energy **110** by reflecting electromagnetic energy **110** that passes through the subject **106** back into or through the subject **106**. For example, the reflective material **132** can reflective the electromagnetic energy **110** toward the target area **112**. As the reflected electromagnetic energy **110** passes into the subject **106** over the target region **112**, the reflected electromagnetic energy **110** can be absorbed by the subject **106**, thereby producing heat to further heat the target region **112**. In an embodiment, the reflective material **132** can also be configured to impede heat transfer via conduction or convection. For example, the reflective material **132** can include two or more layers spaced apart by one or more gaps therebetween.

[0063] In an embodiment, the reflective material **132** can be configured to shield medical personnel from the electromagnetic energy **110**. For example, in an embodiment, the reflective material **132** can be configured to direct or reflect electromagnetic energy **110** away from medical personnel including nurses, doctors, or technicians. In an embodiment, the reflective material **132** can be configured as a bag and the subject **106** and the electromagnetic energy source **108** are positionable within the bag.

[0064] Referring to FIG. **1**E, in an embodiment, the hypothermia treatment system **100** includes an energy absorptive material **134**. In the illustrated embodiment, the energy absorptive material **134** is positioned between the subject **106** and the support structure **102**. However, in an embodiment, the energy absorptive material **134** is incorporated in the support structure **102**. In an embodiment, the energy absorptive material **134** can include a patient covering. The energy absorptive material is sized similar to the reflective material **132**. For example, the energy absorptive material **134** can be sized to generally correspond to the size of the target region **112**. In an embodiment, the energy absorptive material **134** is configured to leave a surgical region on the subject **106** uncovered by the energy absorptive material **134**. The energy absorptive material **134** can include, but is not limited to, composite materials, ceramic materials, multilayer insulation materials, nonlinear magnetic materials, iron, graphite, or lead. In an embodiment, the energy absorptive material **134** can include two or more layers of material.

[0065] The energy absorptive material **134** can be configured to at least partially control irradiation of the electromagnetic energy **110**. For example, the energy absorptive material **134** can be distributed to distribute heat over the target region **112**. In an embodiment, the energy absorptive material **134** can enhance heat generated from the electromagnetic energy **110**. In an embodiment, the energy absorptive material **134** is configured to shield medical personnel from the electromagnetic energy **110**. For example, in an embodiment, the energy absorptive material **134** is positioned between the electromagnetic energy source **108** and medical personnel including doctors, nurses, or technicians.

[0066] In an embodiment, energy absorptive material **134** includes different energy absorptive materials. In an embodiment, the energy absorptive material **134** is configured as an aerosol spray including absorptive particles that can be deposited onto a skin surface of the subject **106** over the target region **112**. In an embodiment, the energy absorptive material **134** is configured as a coating.

[0067] In any of the disclosed hypothermia treatment systems, the hypothermia treatment system can include an array of sensors associated with an electromagnetic energy source to determine one or more parameters. For example, referring to the embodiment shown in FIG. **2**A, an array of sensors **114***a*-**114***n* are operably associated with the electromagnetic energy source **108**. In the illustrated embodiment, the array of sensors **114***a*-**114***n* is incorporated in the support structure **102**. However, in an embodiment, the array of sensors **114***a*-**114***n* is physically coupled to a skin surface of the subject **106**. In an embodiment, each of the sensors **114***a*-**114***n* is respectively operably coupled to the electromagnetic energy source **108**.

[0068] The array of sensors **114***a*-**114***n* can include any suitable sensors configured to determine a temperature of the target region **112**. For example, one or more of the array of sensors **114***a*-**114***n* can include, but are not limited to, fiber optic temperature sensors, thermography sensors, temperature probes, thermistors, surface temperature sensors, thermobeads, thermopiles, tympanic thermometers, infrared temperature sensors, mini-chip thermistors, and thermocouples, clinical thermometers, recording thermometers, rectal thermometers, and resistance thermometers. In addition, the array of sensors **114***a*-**114***n* can include other types of sensors, such as, for example, ultrasound sensors, pressure sensors, light sensors, sensors including piezoelectric crystals, encoders, transducers, motion sensors, position sensors, flow sensors, viscosity sensors, shear sensors, time detectors (e.g., timer, clocks), imaging detectors, acoustic sensors, temperature sensors, chemical and biological detectors, electromagnetic energy detectors (e.g., optical energy such as near IR, UV, visual), pH detectors, or electrical sensors. The array of sensors **114***a*-**114***n* can be configured to determine various other characteristics of the target region **112**, such characteristics including, but not limited to, electrical resistivity thereof, position, chemical composition thereof, or density thereof. One or more of these sensing capabilities can be present in a single sensor or the array of sensors **114***a*-**114***n*; sensing capabilities are not limited to a particular number or type of sensors.

[0069] In an embodiment, the array of sensors **114***a*-**114***n* detects temperature over an area of the body of the subject **106**, such as the target region **112**, to facilitate the determination of a temperature gradient or profile. The array of sensors **114***a*-**114***n* covert thermal energy to one or more sensing signals **120** in the form of electrical energy. In an embodiment, one or more analog-to-digital converters (ADC) convert the electrical energy to digital data that is sent to the control system **116**. The ADC can be a separate component, can be integrated into the control system **116**, or can be integrated into the array of sensors **114***a*-**114***n*. In an embodiment, the control system **116** includes processing hardware (e.g., processing electrical circuitry) and an operating system configured to run one or more application software programs. The control system **116** can use one or more processing techniques to analyze the digital data in order to determine different parameters, including temperature gradient, position of the target region **112** or electromagnetic energy **110**, temperature profile of the target region **112**, or electromagnetic radiation profile of the target region **112**.

[0070] In any of the disclosed hypothermia treatment systems, the hypothermia treatment system can include a plurality of electromagnetic energy sources associated with one or more sensors. For example, referring to the embodiment shown in FIG. **2**B, a plurality of electromagnetic energy sources **108***a*-**108***n* are operably associated with an array of sensors **114***a*-**114***n* and the control system **116**. In the illustrated embodiment, the plurality of electromagnetic energy sources **108***a*-**108***n* are positioned below the support structure **102**. However, in an embodiment, the plurality of electromagnetic energy sources **108***a*-**108***n* are incorporated in the support structure **102**. The plurality of electromagnetic energy sources **108***a*-**108***n* can include any suitable electromagnetic energy source. For example, one or more of the plurality of electromagnetic energy sources **108***a*-**108***n* can include, but are not limited to, a microwave energy source, a radio-frequency source, or a magnetic energy source. In an embodiment, the electromagnetic energy sources **108***a*-**108***n* are the same as one another. For example, each of the electromagnetic energy sources **108***a*-**108***n* can include a microwave energy source. In an embodiment, the electromagnetic energy sources **108***a*-**108***n* are different from one another. For example, the electromagnetic energy sources **108***a*-**108***n* can include a microwave energy source and a radio-frequency energy source.

[0071] In an embodiment, the array of sensors **114***a*-**114***n* detects temperature over an area of the body of the subject **106**, such as a target region including target regions **112***a*-**112***n*. For example, the array of sensors **114***a*-**114***n* can convert thermal energy to one or more sensing signals **120** which are then sent to the control system **116** by the array of sensors **114***a*-**114***n*. The control system **116** can use one or more processing techniques to analyze the one or more sensing signals **120** to determine one or more different parameters, including, but not limited to, temperature gradient, position of the target regions **112***a*-**112***n* or electromagnetic energy **110**, temperature profile of the target regions **112***a*-**112***n*, or electromagnetic radiation profile of the target regions **112***a*-**112***n*. In an embodiment, the electromagnetic energy sources **108***a*-**108***n* are controlled together, individually, or in one or more groups by the control system **116**. The control system **116** can output one or more emitting information signals **122** to the electromagnetic energy sources **108***a*-**108***n* based on the parameters determined by the control system **116**, such as a temperature gradient or profile. The one or more emitting information signals **112** can include one or more directions to emit electromagnetic energy **110** from one or more of the electromagnetic energy sources **108***a*-**108***n*. In an embodiment, the one or more emitting information signals **112** can include one or more directions to aim or move one or more of the electromagnetic energy sources **108***a*-**108***n* toward the target regions **112***a*-**112***n*.

[0072] FIG. **3** is a schematic diagram of an embodiment of a hypothermia treatment system **300** including a supply **336** of electromagnetic energy absorption agent **338**. The hypothermia treatment system **300** includes many of the same components as the hypothermia treatment system **100** shown in FIGS. **1**A through **2**B. Therefore, in the interest of brevity, components of the hypothermia treatment system **300** that are identical or similar to each other have been provided with the same reference numerals, and an explanation of their structure and function will not be repeated unless the components function differently in the hypothermia treatment systems **100** and **300**. However, it should be noted that the principles of the hypothermia treatment system **300** are employed with any of the embodiments described with respect to FIGS. **1**A through **2**.

[0073] The hypothermia treatment system **300** can include a support structure **102** configured to support a subject **106**. The hypothermia treatment system **300** further includes an electromagnetic energy source **108** positioned under the support structure **102**. The electromagnetic energy source **108** is configured to selectively output electromagnetic energy **110** toward a target region **112** of the subject **106** to heat the target region **112**. Heating the target region **112** with the electromagnetic energy **110** can increase the core body temperature of the subject **106** via thermal conduction, thermal convection, or thermal radiation. In an embodiment, the target region **112** can include one or more locations on or within the body of the subject **106**. The electromagnetic energy source **108** can include, but is not limited to, a microwave energy source, a radio-frequency energy source, or a magnetic energy source. The hypothermia treatment system **300** further includes one or more sensors **114** that are configured to determine a temperature or other characteristics of the target region **112** of the subject **106**. The hypothermia treatment system **300** further includes a control system **116** including control electrical circuitry (not shown). The control system **116** is operably coupled to the electromagnetic energy source **108**, the one or more sensors **114**, and a supply **336** of electromagnetic energy absorption agent **338** to control operation of one or more of the foregoing system components.

[0074] The supply **336** of electromagnetic energy absorption agent **338** is delivered to the subject **106** to absorb the electromagnetic energy **110**. For example, the electromagnetic energy absorption agent **338** can be delivered to the target region **112** and the electromagnetic energy **110** can be delivered to and absorbed by the electromagnetic energy absorption agent **338** to at least partially heat the target region **112**. In an embodiment, absorption of the electromagnetic energy **110** by the electromagnetic energy absorption agent **338** can be temperature-dependent. In an embodiment, the electromagnetic energy absorption agent **338** can absorb the electromagnetic energy **110** at a target temperature. For example, the electromagnetic energy absorption agent **338** can include one or more magnetic particles or ferromagnetic particles and the target temperature can include a selected curie temperature. The curie temperature is the temperature of the reversible ferromagnetic or paramagnetic transition of the magnetic particles. Below this temperature, the magnetic particles heat in the electromagnetic energy **110** (e.g., an alternating magnetic field). However, above the Curie Temperature, the magnetic particles become paramagnetic and their magnetic domain becomes unresponsive to the electromagnetic energy **110**. In an embodiment, the electromagnetic energy absorption agent **338** can include one or more antiferromagnetic or ferromagnetic particles and the target temperature can include a selected Néel temperature. In an embodiment, the target temperature can include a temperature or thermal profile. In an embodiment, the energy absorption agent **338** can include nanomagnetic material.

[0075] In an embodiment, the electromagnetic energy absorption agent **338** can include liquids, solutions, suspensions, mixtures, mist, reagents, micro-particles, molecules, emulsions, or any other fluids suitable to be administered to the subject **106**. In an embodiment, the electromagnetic energy absorption agent **338** can include one or more particles. In an embodiment, the one or more particles can include non-bound, blood-carried particles. For example, the electromagnetic energy **110** can be deposited within the non-bound, blood-carried particles within the target region **112** to heat the target region **112**. In an embodiment, the particles are incorporated with red blood cells. In an embodiment, the particles are incorporated with ghost cells. In an embodiment, the particles are incorporated with liposomes. In an embodiment, the particles are smaller than 1 μm, and can be absorbed one or more body organs (e.g., liver, spleen, the kidneys, or the lungs). For example, in an embodiment the particles can include ferrite particles.

[0076] In an embodiment, the one or more particles can exhibit selective temperature-dependent absorption to deposit the electromagnetic energy **110** into or on the subject **106** or the target region **112**. In an embodiment, the one or more particles can exhibit selective temperature dependent electric absorption to deposit the electromagnetic energy **110** into or on the subject **106** or the target region **112**. In an embodiment, the one or more particles exhibit selective temperature dependent magnetic absorption to deposit the electromagnetic energy **110** into the subject **106** or the target region **112**.

[0077] In an embodiment, the electromagnetic energy absorption agent **338** can include metallic particles. In an embodiment, the electromagnetic energy absorption agent **338** can include magnetic particles. In an embodiment, the magnetic particles can include iron oxide. In an embodiment, the magnetic particles can include an iron-nickel alloy. In an embodiment, the magnetic particles can exhibit a curie temperature below an ablation temperature (e.g., 40° C.) of the target region **112**. In an embodiment, the electromagnetic energy absorption agent **338** can exhibit a peak absorption temperature below 40° C.

[0078] The electromagnetic energy absorption agent **338** can be delivered to the target region **112** orally, topically, via inhalation, via injection, via implantation, or another suitable delivery method. In an embodiment, the electromagnetic energy absorption agent **338** can include nanoparticles, such as, for example, spheres, rods, and shells. In an embodiment, the nanoparticles can include gold nanoparticles.

[0079] In an embodiment, the supply **336** of the electromagnetic energy absorption agent **338** can include one or more containers **340** that hold one or more different electromagnetic energy absorption agents **338**. The one or more containers **340** can be operably coupled to a delivery unit **342**. In an embodiment, the delivery unit **342** can include at least one of a fluid dispensing unit, a force generating mechanism, an actuator, a piston, a pump (e.g., a mechanical pump, or an electro-mechanical pump), or another suitable delivery device. For example, the delivery unit **342** can include at least one of a pneumatic actuator, a hydraulic actuator, a piezoelectric actuator, a linear actuator, an electromechanical actuator, or another suitable actuator for actuating a pump or other device for delivering the electromagnetic energy absorption agent **338**. The delivery unit **342** is configured to deliver the electromagnetic energy absorption agent **338** to the subject **106**. In an embodiment, the delivery unit **342** is configured to deliver the electromagnetic energy absorption agent **338** into the subject **106**. In an embodiment, the delivery unit **342** is configured to deliver the electromagnetic energy absorption agent **338** into a bloodstream of the subject **106**. In an embodiment, the delivery unit **342** is configured to deliver the electromagnetic energy absorption agent **338** to the subject intravenously, intramuscularly, or intra-arterially, or subcutaneously. In an embodiment, the delivery unit **342** is configured to deliver the electromagnetic energy absorption agent **338** to the subject orally. In an embodiment, the delivery unit **342** is configured to deliver the electromagnetic energy absorption agent **338** via inhalation or topically. In an embodiment, the delivery unit **342** is configured to deliver the electromagnetic energy absorption agent **338** to the subject **106** rectally. In an embodiment, the delivery unit **342** is configured to deliver the electromagnetic energy absorption agent **338** to the subject via the urethra of the subject **106**.

[0080] In an embodiment, the one or more containers **340** are individually, operably coupled to the delivery unit **342** via conduits or tubing and corresponding electronically controlled valves (not shown) that can be selectively opened and closed via one or more control signals from the control system **116** to allow the electromagnetic energy absorption agent **338** to be selectively delivered by the delivery unit **342** from the one or more containers **340**.

[0081] In an embodiment, the control system **116** can output one or more delivery information signals **344** to the supply **336** that encodes delivery information or directions. Responsive to the one or more delivery information signals **344**, the delivery unit **342** of the supply **336** can deliver the electromagnetic energy absorption agent **338** from the one or more containers **340** to the subject **106**. The control system **116** can also output emitting information signals **122** to the electromagnetic energy source **108**. Thus, in an embodiment, the control system **116** is configured to control operation of the supply **336** and the electromagnetic energy source **108**. In an embodiment, the delivery information includes information that the electromagnetic energy source **108** is going to output or emit the electromagnetic energy **110**. In an embodiment, the one or more delivery information signals **344** include one or more directions to deliver the electromagnetic energy absorption agent **338** internally within the subject **106**. In an embodiment, the one or more delivery information signals **344** include one or more directions to deliver the electromagnetic energy absorption agent **338** simultaneously with the electromagnetic energy source **108** emitting the electromagnetic energy **110**.

[0082] In an embodiment, the one or more emitting information signals **122** can include one or more directions to emit the electromagnetic energy **110** after the delivery unit **342** delivers the electromagnetic energy absorption agent **338**. In an embodiment, the one or more emitting information signals **122** can include one or more directions to aim or move the electromagnetic energy source **108** toward the electromagnetic energy absorption agent **338** within or on the subject **106**.

[0083] In operation, the subject **106** is positioned on the support structure **102**. The electromagnetic energy absorption agent **338** is delivered to the target region **112** of the subject **106** from the supply **336** (under the control of the control system **116**). In an embodiment, the electromagnetic energy **110** is then output or emitted from the electromagnetic energy source **108** (under the control of the control system **116**) toward the target region **112** to heat the target region **112**. The presence of the electromagnetic energy absorption agent **338** in the target region **112** can enhance absorption of the electromagnetic energy **110** to further heat the target region **112**. In an embodiment, prior to, substantially and simultaneously with, or after the electromagnetic energy source **108** outputs the electromagnetic energy **110**, the one or more sensors **114** determine the temperature of the target region **112**. Thus, the electromagnetic energy absorption agent **338** enhances heating of the target region **112**.

[0084] FIG. **4**A is a schematic diagram of an embodiment of a hypothermia treatment system **400** configured as a self-contained unit that includes all functionalities necessary for the operation of the hypothermia treatment system **400**. The hypothermia treatment system **400** includes many of the same components as the hypothermia treatment systems **100** and **300** shown in FIGS. **1**A through **3**. Therefore, in the interest of brevity, components of the hypothermia treatment system **400** that are identical or similar to each other have been provided with the same reference numerals, and an explanation of their structure and function will not be repeated unless the components function differently in the hypothermia treatment systems **100**, **300**, and **400**. However, it should be noted that the principles of the hypothermia treatment system **400** are employed with any of the embodiments described with respect to FIGS. **1**A through **3**.

[0085] The hypothermia treatment system **400** can include a support structure **102** configured to support a subject **106**. The hypothermia treatment system **400** further includes an electromagnetic energy source **108** configured to selectively output electromagnetic energy **110** toward a target region **112** of the subject **106** to heat the target region **112**. Heating the target region **112** with the electromagnetic energy **110** can increase the core body temperature of the subject **106** via thermal conduction, thermal convection, or thermal radiation. In the illustrated embodiment, the electromagnetic energy source **108** is incorporated in the support structure **102**. The hypothermia treatment system **400** can further include one or more sensors **114** that are also incorporated in the support structure **102**. The one or more sensors **114** are configured to determine a temperature of the target region **112** of the subject **106**. The hypothermia treatment system **400** also includes a control system **116** operably coupled to the electromagnetic energy source **108** and the one or more sensors **114**. In the illustrated embodiment, the control system **116** is also incorporated in the support structure **102**. Thus, the support structure **102**, the electromagnetic energy source **108**, and the one or more sensors **114** can form a single unit including all functionalities necessary for the operation of the hypothermia treatment system **400**.

[0086] Referring to FIG. **4**B, in an embodiment, the one or more sensors **114** are positioned internally within the subject **106**. In an embodiment, the one or more sensors **114** are delivered to the subject **106** orally, topically, via injection, via implantation, or another suitable delivery method. In an embodiment, the one or more sensors **114** are delivered to the target region **112** within the subject **106**. In an embodiment, the one or more sensors **114** can include a temperature probe positioned within the thorax of the subject **106**. For example, the one or more sensors **114** can include a temperature probe delivered to the thorax via a catheter, implantation, or inhalation. In an embodiment, the one or more sensors **114** include a chip sensor or biosensors positioned within the arteries of the subject **106**. For example, the one or more sensors **114** can be delivered intra-arterial via a catheter. In an embodiment, the one or more sensors **114** are positioned within rectum of the subject **106**. For example, the one or more sensors **114** can be delivered to the rectum via a suppository or enema. In an embodiment, the one or more sensors **114** are positioned within the subcutaneous tissue of the subject **106**. For example, in an embodiment, the one or more sensors **114** can be implanted in the subcutaneous tissue of the subject **106**. In an embodiment, the one or more sensors **114** are delivered to the subject **106** intramuscularly. In an embodiment, the one or more sensors **114** can travel within the subject **106**. For example, the one or more sensors **114** are delivered to one or more arteries or blood vessels of the subject **106** and configured to travel via blood flow. In an embodiment, the one or more sensors **114** are configured to travel via the gastrointestinal tract. In an embodiment, the control system **116** is wirelessly connected to the one or more sensors **114**.

[0087] FIG. **5** is a schematic diagram of an embodiment of a hypothermia treatment system **500** including a movable electromagnetic energy source **508**. The hypothermia treatment system **500** includes many of the same components as the hypothermia treatment systems **100**, **300**, and **400** shown in FIGS. **1**A through **4**B. Therefore, in the interest of brevity, components of the hypothermia treatment system **500** that are identical or similar to each other have been provided with the same reference numerals, and an explanation of their structure and function will not be repeated unless the components function differently in the hypothermia treatment systems **100**, **300**, **400**, and **500**. However, it should be noted that the principles of the hypothermia treatment system **500** are employed with any of the embodiments described with respect to FIGS. **1**A through **4**B.

[0088] The hypothermia treatment system **500** includes a support structure **102** configured to support a subject **106** exhibiting or in risk of exhibiting symptoms of hypothermia. An electromagnetic energy source **508** is incorporated in the support structure **102**. The electromagnetic energy source **508** is configured to selectively output electromagnetic energy **110** toward a target region **112** of the subject **106** to heat the target region **112**. Heating the target region **112** with the electromagnetic energy **110** can increase the core body temperature of the subject **106** via thermal conduction, thermal convection, or thermal radiation. In an embodiment, the target region **112** can include one or more locations on or within the body of the subject **106**. The electromagnetic energy source **508** can include, but is not limited to, a microwave energy source, a phase-array energy source, a metamaterial array energy source, a radio-frequency energy source, a light source, a laser, a semiconductor laser, or a magnetic energy source. The hypothermia treatment system **500** further includes one or more sensors **114** that are positioned within the subject **106**. The one or more sensors **114** can be configured to determine a temperature or other characteristics of the target region **112** of the subject **106**. The hypothermia treatment system **500** further includes a control system **116** including control electrical circuitry (not shown). The control system **116** is operably coupled to the electromagnetic energy source **508** and the one or more sensors **114** to control operation of one or more of the foregoing system components.

[0089] The electromagnetic energy source **508** is movable relative to the support structure **102** or the subject **106**. The electromagnetic energy source **508** can be configured to rotate, articulate, and translate relative to the support structure **102** or the subject **106**. In an embodiment, the electromagnetic energy source **508** is movable via a track system incorporated in the support structure **102**. In an embodiment, the electromagnetic energy source **508** is movable via an articulating arm operably coupled to the electromagnetic energy source **508**. In operation, the control system **116** outputs one or more emitting information signals **120** to the electromagnetic energy source **508**. The one or more emitting information signals **120** encode emitting information or directions. Responsive to the emitting information signals **122**, the electromagnetic energy source **508** can move, aim, or emit the electromagnetic source **508**. In an embodiment, the one or more emitting information signals **122** include or more directions to aim or direct the electromagnetic energy source **508** at the target region **112**. In an embodiment, the one or more emitting information signals **122** include or more directions to align the electromagnetic energy source

508 with the target region **112**. In an embodiment, the one or more emitting information signals **122** include one or more directions to move the electromagnetic energy source **508** toward the target region **112**. In an embodiment, the one or more emitting information signals **122** include one or more directions to move the electromagnetic energy source **508** away from the target region **112**. In an embodiment, the one or more emitting information signals **122** include one or more directions to emit the electromagnetic energy **110**. In an embodiment, the one or more emitting information signals **122** include one or more directions to stop emitting the electromagnetic energy **110**. Thus, in an embodiment, the control system **116** is configured to control movement and operation of the electromagnetic energy source **508**.

[0090] FIG. **6** is a schematic diagram of an embodiment of a hypothermia treatment system **600** including a support structure including a chair. The hypothermia treatment system **600** includes many of the same components as the hypothermia treatment systems **100**, **300**, **400**, and **500** shown in FIGS. **1**A through **5**. Therefore, in the interest of brevity, components of the hypothermia treatment system **600** that are identical or similar to each other have been provided with the same reference numerals, and an explanation of their structure and function will not be repeated unless the components function differently in the hypothermia treatment systems **100**, **300**, **400**, **500**, and **600**. However, it should be noted that the principles of the hypothermia treatment system **600** are employed with any of the embodiments described with respect to FIGS. **1**A through **5**.

[0091] The hypothermia treatment system **600** includes a support structure **602**. As described above, the support structure **602** can exhibit a variety of different configurations selected for a particular application. For example, the support structure **602** can include a bed, a surgical table, a stretcher, a gurney, a couch, a sleeping bag, or a hypothermia wrap. In the illustrated embodiment, the support structure **602** includes a chair having a seat portion **646** and a back portion **648** extending upward from the seat portion **646**. The chair **602** further includes a plurality of legs **650** extending downward from the seat portion **646**. Thus, the subject **106** can be positioned in the chair **602** in a seating position.

[0092] A first electromagnetic energy source **654** is positioned under the seat portion **646** of the chair **602**. A second electromagnetic energy source **656** is positioned on the back portion **650** of the chair **602**. The first electromagnetic energy source **654** and the second electromagnetic energy source **656** are configured to selectively output electromagnetic energy **110** toward a target region **112** of the subject **106** to heat the target region **112**. In an embodiment, the target region **112** can include one or more locations on or within the body of the subject **106**. The first electromagnetic energy source **654** and the second electromagnetic energy source **656** can include, but is not limited to, a microwave energy source, a phase-array energy source, a radio-frequency energy source, or a magnetic energy source. In an embodiment, the first electromagnetic energy source **654** and the second electromagnetic energy source **656** are the same. In an embodiment, the first electromagnetic energy source **654** and the second electromagnetic energy source **656** are different from one another. The hypothermia treatment system **600** further includes one or more sensors **614** that are positionable on the seat portion **646** and the back portion **648** of the chair. In an embodiment, the one or more sensors **614** can include a sheet positioned between the chair **602** and the subject **106**. The one or more sensors **614** can be configured to determine a temperature or other characteristics of the target region **112** of the subject **106**. The hypothermia treatment system **600** further includes a control system **116** including control electrical circuitry (not shown). The control system **116** is operably coupled to the first electromagnetic energy source **654**, the second electromagnetic energy source **656**, and the one or more sensors **614** to control operation of one or more of the foregoing system components.

[0093] It will be understood that a wide range of hardware, software, firmware, or virtually any combination thereof can be used in the controllers described herein. In one embodiment, several portions of the subject matter described herein can be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), or other integrated formats. However, some aspects of the embodiments disclosed herein, in whole or in part, can be equivalently implemented in integrated circuits, as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof. In addition, the reader will appreciate that the mechanisms of the subject matter described herein are capable of being distributed as a program product in a variety of forms, and that an illustrative embodiment of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution.

[0094] In a general sense, the various embodiments described herein can be implemented, individually and/or collectively, by various types of electro-mechanical systems having a wide range of electrical components such as hardware, software, firmware, or virtually any combination thereof and a wide range of components that can impart mechanical force or motion such as rigid bodies, spring or torsional bodies, hydraulics, and electro-magnetically actuated devices, or virtually any combination thereof. Consequently, as used herein "electro-mechanical system" includes, but is not limited to, electrical circuitry operably coupled with a transducer (e.g., an actuator, a motor, a piezoelectric crystal, etc.), electrical circuitry having at least one discrete electrical circuit, electrical circuitry having at least one integrated circuit, electrical circuitry having at least one application specific integrated circuit, or a microprocessor configured by a computer program which at least partially carries out processes and/or devices described herein), electrical circuitry forming a memory device (e.g., forms of random access memory), electrical circuitry forming a communications device (e.g., a modem, communications switch, or optical-electrical equipment), and any non-electrical analog thereto, such as optical or other analogs.

[0095] In a general sense, the various aspects described herein which can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or any combination thereof can be viewed as being composed of various types of "electrical circuitry." Consequently, as used herein "electrical circuitry" includes, but is not limited to, electrical circuitry having at least one discrete electrical circuit, electrical circuitry having at least one integrated circuit, electrical circuitry having at least one application specific integrated circuit, or a microprocessor configured by a computer program which at least partially carries out processes and/or devices described herein), electrical circuitry forming a memory device (e.g., forms of random access memory), and/or electrical circuitry forming a communications device (e.g., a modem, communications switch, or optical-electrical equipment). The subject matter described herein can be implemented in an analog or digital fashion or some combination thereof.

[0096] The herein described components (e.g., steps), devices, and objects and the discussion accompanying them are used as examples for the sake of conceptual clarity. Consequently, as used herein, the specific exemplars set forth and the accompanying discussion are intended to be representative of their more general classes. In general, use of any specific exemplar herein is also intended to be representative of its class, and the non-inclusion of such specific components (e.g., steps), devices, and objects herein should not be taken as indicating that limitation is desired.

[0097] With respect to the use of substantially any plural and/or singular terms herein, the reader can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations are not expressly set forth herein for sake of clarity.

[0098] The herein described subject matter sometimes illustrates different components contained within, or connected with, different other components. It is to be understood that such depicted architectures are merely exemplary, and that in fact many other architectures can be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being "operably connected," or "operably coupled," to each other to achieve the desired functionality, and any two components capable of being so associated can also be viewed as being "operably couplable," to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

[0099] In some instances, one or more components can be referred to herein as "configured to." The reader will recognize that "configured to" or "adapted to" are synonymous and can generally encompass active-state components and/or inactive-state components and/or standby-state components, unless context requires otherwise.

[0100] While particular aspects of the present subject matter described herein have been shown and described, it will be apparent that, based upon the teachings herein, changes and modifications can be made without departing from the subject matter described herein and its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of the subject matter described herein. Furthermore, it is to be understood that the invention is defined by the appended claims. In general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims can contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, typically means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). Virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0101] With respect to the appended claims, any recited operations therein can generally be performed in any order. Examples of such alternate orderings can include overlapping, interleaved, interrupted, reordered, incremental, preparatory, supplemental, simultaneous, reverse, or other variant orderings, unless context dictates otherwise. With respect to context, even terms like "responsive to," "related to," or other past-tense adjectives are generally not intended to exclude such variants, unless context dictates otherwise.

[0102] While various aspects and embodiments have been disclosed herein, the various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. A system for treating hypothermia in a subject, the system comprising:

a support structure configured to support the subject thereon, the subject having a target region;

an electromagnetic energy source configured to output electromagnetic energy towards the target region of the subject to selectively heat the target region, the electromagnetic energy source located external to the subject;

at least one temperature sensor configured to determine or measure a temperature of the target region of the subject; and

a control system operably coupled to the electromagnetic energy source and the at least one temperature sensor, the control system configured to control at least one operational parameter of the electromagnetic energy output by the electromagnetic energy source responsive to the temperature sensor determining or measuring the temperature of the target region so that the temperature of the target region is maintained below a tissue damaging temperature of the target region.

2. (canceled)

3. The system of claim **1**, wherein the at least one temperature sensor is included in a thermography system.

4. The system of claim **3**, wherein the thermography system includes at least one of a magnetic resonance imaging system or a radiography system.

5. The system of claim **3**, wherein the thermography system includes an electromagnetic energy source antenna, and wherein the at least one temperature sensor shares at least one component with the electromagnetic energy source antenna.

6. The system of claim **1**, wherein the at least one temperature sensor is configured to be deployed internally within the subject.

7. The system of claim **1**, wherein the at least one temperature sensor is configured to be deployed external to the subject.

8. The system of claim **1**, wherein the at least one temperature sensor measures skin temperature.

9. The system of claim **1**, wherein the control system is configured to determine an electromagnetic energy irradiation profile for the target region at least partially based on physiological data of the subject.

10. (canceled)

11. (canceled)

12. The system of claim **1**, wherein the support structure includes a reflective material that is reflective to the electromagnetic energy.

13. The system of claim **1**, further including a patient covering including a reflective material.

14. (canceled)

15. The system of claim **1**, wherein the support structure includes an electromagnetic energy absorptive material disposed thereon that is absorptive to the electromagnetic energy.

16. The system of claim **1**, further including a patient covering including an energy absorptive material.

17. The system of claim **1**, wherein the electromagnetic energy source includes a microwave energy source, and wherein the electromagnetic energy includes microwave energy.

18. The system of claim **1**, wherein the electromagnetic energy source includes a steerable microwave energy source, and wherein the electromagnetic energy includes microwave energy.

19. (canceled)

20. (canceled)

21. The system of claim **1**, wherein the electromagnetic energy source includes a radio-frequency energy source, and wherein the electromagnetic energy includes radio-frequency energy.

22. The system of claim **1**, wherein the electromagnetic energy source includes a magnetic energy source, and wherein the electromagnetic energy includes magnetic energy.

23. The system of claim **1**, wherein the at least one operational parameter of the electromagnetic energy includes at least one of location of the electromagnetic energy, direction of the electromagnetic energy, intensity of the electromagnetic energy, duration of the electromagnetic energy applied to the target region, frequency of the electromagnetic energy, phase of the electromagnetic energy, or pulse frequency of the electromagnetic energy.

24. The system of claim **1**, wherein the control system is configured to control the at least one operational parameter to vary an electromagnetic absorption profile within the subject.

25. The system of claim **1**, wherein the control system is configured to control the at least one operational parameter to vary the direction of the electromagnetic energy.

26. The system of claim **1**, wherein the control system is configured to control the at least one operational parameter so that the temperature of the target region is maintained below about 40° C.

27. The system of claim **1**, wherein the control system is configured to control the at least one operational parameter so that the temperature of the target region is substantially uniform therewithin.

28. The system of claim **1**, wherein the electromagnetic energy source is positioned underneath the support structure.

29. The system of claim **1**, wherein the electromagnetic energy source is incorporated in the support structure.

30. (canceled)

31. The system of claim **1**, wherein the control system includes a processor that numerically models at least one of electromagnetic propagation, energy absorption, or thermal transport.

32. The system of claim **1**, wherein the control system includes a processor that numerically models thermal transport with the patient resulting from absorption of the electromagnetic energy.

33. The system of claim **1**, further including:

a supply of electromagnetic energy absorption agent having a peak absorption temperature below about 40° C.;

a delivery device configured to inject the electromagnetic energy absorption agent from the supply of electromagnetic energy absorption agent internally into the subject; and

wherein the control system controls the at least one at least one operational parameter of the electromagnetic energy to maximize absorption by the electromagnetic energy absorption agent.

34. A method for treating hypothermia in a subject, the method comprising:

determining a temperature indicative of the temperature of a subsurface target region of the subject; and

responsive to determining the temperature, directing electromagnetic energy at an external surface of the target region of the subject effective to heat the subsurface target region to a temperature of less than a tissue damaging temperature of the subsurface target region.

35. The method of claim **34**, wherein the tissue damaging temperature is less than about 40° C.

36. The method of claim **34**, further including controlling at least one operational parameter of the electromagnetic energy source so that the temperature of the target region is maintained below about 40° C.

37. The method of claim **36**, wherein the controlling the at least one operational parameter includes controlling at least one of a location of the electromagnetic energy, a direction of the electromagnetic energy, an intensity of the electromagnetic energy, duration of the electromagnetic energy applied to the subsurface target region, frequency of the electromagnetic energy, phase of the electromagnetic energy, or a pulse frequency of the electromagnetic energy.

38. The method of claim **34**, further including controlling at least one operational parameter of the electromagnetic energy responsive to measuring the temperature so that the temperature of the subsurface target region is substantially uniform.

39. The method of claim **34**, further including determining an electromagnetic energy irradiation profile for the subsurface target region at least partially based on physiological data of the subject.

40. The method of claim **39**, further including receiving the physiological data from a medical imaging instrument.

41. (canceled)

42. The method of claim **34**, further including supporting the subject on a support structure having a reflective material thereon that is reflective to the electromagnetic energy.

43. The method of claim **34**, further including supporting the subject on a support structure having an energy absorptive material thereon that is absorptive to the electromagnetic energy.

44. The method of claim **34**, further including at least partially covering the subject with a material that is reflective to the electromagnetic energy.

45. The method of claim **34**, further including at least partially covering the subject with a material that is absorptive to the electromagnetic energy.

46. The method of claim **34**, wherein the electromagnetic energy includes at least one of radio-frequency energy, microwave energy, or magnetic energy.

47. (canceled)

48. (canceled)

49. (canceled)

50. The method of claim **34**, wherein the temperature indicative of the temperature of the subsurface target region is determined substantially simultaneously with directing the electromagnetic energy at the external surface of the target region.

51. (canceled)

52. The method of claim **49**, further including operating a temperature sensor during a pause in the operation of the electromagnetic energy source.

53. The method of claim **34**, further including determining an electromagnetic absorption pattern for the target region at least partially based on the physiological data of the subject.

54. (canceled)

55. (canceled)

56. (canceled)

57. The method of claim **34**, further including numerically modeling at least one of the electromagnetic propagation, energy absorption, or thermal transport.

58. (canceled)

59. (canceled)

60. The method of claim **34**, further including:

introducing an electromagnetic energy absorption agent internally into the subject; and

wherein directing the electromagnetic energy at the external surface of the target region of the subject includes directing the electromagnetic energy at the electromagnetic energy absorption agent.

61. The method of claim **60**, wherein introducing an electromagnetic energy absorption agent includes introducing the electromagnetic energy absorption agent into a blood stream of the subject.

62. (canceled)

63. (canceled)

64. The method of claim **34**, wherein determining a temperature indicative of the temperature of a subsurface target region of the subject includes measuring the temperature with an external temperature sensor.

65. The method of claim **34**, wherein determining a temperature indicative of the temperature of a subsurface target region of the subject includes measuring the temperature with a temperature sensor disposed internally within the subject.

* * * * *

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摘要(译)

本文公开的实施例涉及用于治疗受试者体温低的系统和方法。在一个实施例中，一种方法包括确定或测量对象的目标区域的温度。所述方法还包括响应于确定或测量所述温度，将所述对象的目标区域的外表面上的电磁能量有效地将所述目标区域加热到小于所述目标区域的消融温度的温度。