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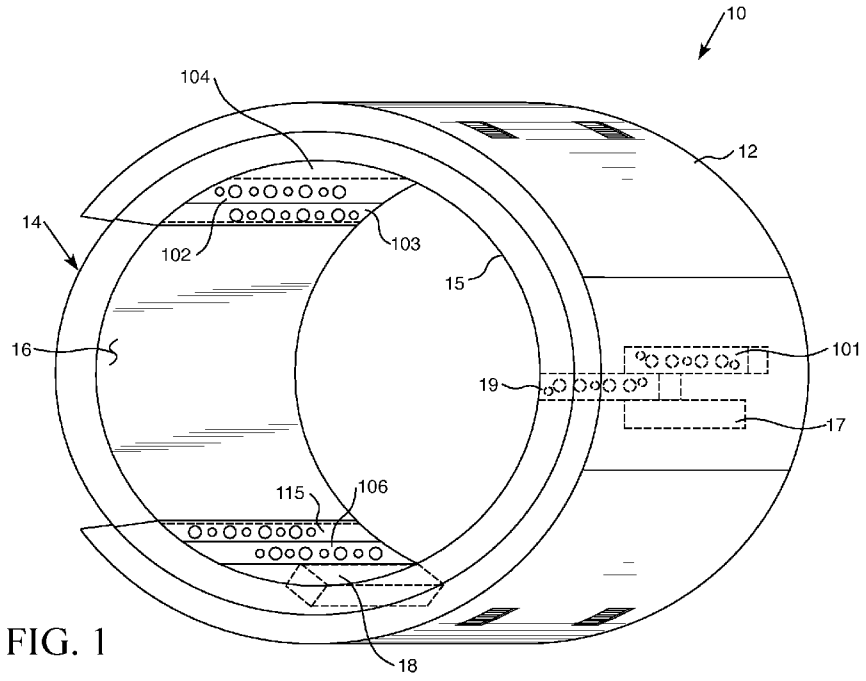

FIG. 1

(57) Abstract: Systems and method relate to administering phototherapy. A device includes a hollow structure having at least a first open end. The hollow structure includes a rotatable member, one or more coherent light generators, and, for each coherent light generator, one or more lenses or mirrors optically connected to the coherent light generator and configured to alter at least one aspect of a beam of coherent light. The device further includes a processing circuit including a processor and a memory storing instructions. The instructions, when executed by the processor, cause the processor to accept an input from an operator and generate one or more beams of coherent light according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site. Additionally, the rotatable member is configured to be rotated to direct the one or more beams of coherent light to the targeted treatment site.

WO 2019/165302 A1

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DEVICE FOR DELIVERING PRECISION PHOTOTHERAPY

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This application claims priority from Provisional Application US Application 62/634,655, entitled "DEVICE FOR DELIVERING PRECISION PHOTOTHERAPY," filed February 23, 2018, incorporated herein by reference in its entirety.

BACKGROUND

[0002] The present disclosure relates to a device for delivering precision phototherapy, also known more specifically as photodynamic phototherapy or photobiomodulation therapy ("PBMT"). Light (photonic radiation) at certain wavelengths is more readily absorbed by molecules in certain tissues, identified as "chromophores," which in turn can stimulate or retard certain metabolic processes. This can include stimulating, suppressing, or denaturing cellular tissues, interstitial tissues, and intracellular tissue components. The deliberate exposure of tissues to light for this purpose is known as "phototherapy," "photobiomodulation therapy," "low level light therapy," "photodynamic therapy," or "laser physiotherapy" in various applications. The oldest and most well-known phototherapy is the administration of natural sunlight to human skin, which stimulates the production of Vitamin D. In this case, it is radiation at the 280–315 nm wavelength, also known as "UV-B" radiation, that stimulates the process.

SUMMARY

[0003] One embodiment relates to a device for administering phototherapy. The device includes a hollow structure having at least a first open end through which the hollow structure receives at least a portion of patient anatomy. The hollow structure includes a rotatable member configured to rotate around at least one rotary axis. The device also includes one or more coherent light generators mounted to the hollow structure. Each coherent light generator is configured to generate a beam of coherent light. The device further includes, for each coherent light generator, one or more lenses or mirrors optically connected to the coherent light generator and mounted to the hollow structure. The one or more lenses or mirrors are configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator. The device further includes a processing circuit including a processor and a memory storing instructions. The instructions, when

executed by the processor, cause the processor to accept an input from an operator and generate one or more beams of coherent light via the one or more coherent light generators according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on the patient anatomy. Additionally, the rotatable member is configured to be rotated to direct the one or more beams of coherent light to the targeted treatment site on the patient anatomy.

[0004] Another embodiment relates to a device for administering phototherapy. The device includes a handheld probe configured to be optically connected to a coherent light generator configured to generate a beam of coherent light. The handheld probe is configured to receive the beam of coherent light from the coherent light generator. The handheld probe includes a closed tip from which coherent light is emitted after the beam of coherent light is received. The device further includes a processing circuit including a processor and a memory storing instructions. The instructions, when executed by the processor, cause the processor to accept an input from an operator and generate a beam of coherent light via the coherent light generator optically connected to the handheld probe. The beam is generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient.

[0005] Another embodiment relates to a device for administering phototherapy. The device includes a handheld probe configured to be optically connected to a coherent light generator configured to generate a beam of coherent light of at least 10 W. The handheld probe is configured to receive the beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received. The handheld probe further includes a cooling structure configured to deliver a coolant to at least a portion of the handheld probe or a portion of anatomy of a patient. The device further includes a processing circuit including a processor and a memory storing instructions. The instructions, when executed by the processor, cause the processor to accept an input from an operator and generate a beam of coherent light via the coherent light generator optically connected to the handheld probe. The beam is generated according to a plurality of settings configured to produce a therapeutic effect at the targeted treatment site.

[0006] Another embodiment relates to a device for administering phototherapy. The device includes a hollow structure having at least a first open end through which the hollow structure receives at least a portion of patient anatomy. The hollow structure includes a

rotatable member configured to rotate around at least one rotary axis. The device also includes one or more coherent light generators mounted to the hollow structure. Each coherent light generator is configured to generate a beam of coherent light. The device further includes, for each coherent light generator, one or more lenses or mirrors optically connected to the coherent light generator and mounted to the hollow structure. The one or more lenses or mirrors are configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator. The device further includes a handheld probe configured to be optically connected to a coherent light generator. The handheld probe is configured to receive a beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received. The device further includes a processing circuit including a processor and a memory storing instructions. The instructions, when executed by the processor, cause the processor to accept an input from an operator and generate one or more beams of coherent light via the one or more coherent light generators and/or the coherent light generator optically connected to the handheld probe according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on the patient anatomy.

[0007] Another embodiment relates to a method for administering phototherapy. The method includes accepting an input from an operator and generating one or more beams of coherent light via one or more coherent light generators. The one or more beams are generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient. The one or more coherent light generators are mounted to a hollow structure. The hollow structure includes at least a first open end through which the hollow structure receives at least a portion of patient anatomy including the targeted treatment site. The hollow structure further includes a rotatable member configured to rotate around at least one rotary axis. Each coherent light generator is optically connected to one or more lenses or mirrors mounted to the hollow structure. The one or more lenses or mirrors are configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator. The rotatable member is configured to be rotated to direct the one or more beams of coherent light to the targeted treatment site.

[0008] Another embodiment relates to a method for administering phototherapy. The method includes optically connecting a handheld probe to a coherent light generator configured to generate a beam of coherent light. The handheld probe is configured to

receive the beam of coherent light from the coherent light generator. The handheld probe also includes a closed tip from which coherent light is emitted after the beam of coherent light is received. The method further includes accepting an input from an operator and generating a beam of coherent light via the coherent light generator optically connected to the handheld probe according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient.

[0009] Another embodiment relates to a method for administering phototherapy. The method includes optically connecting a handheld probe to a coherent light generator configured to generate a beam of coherent light of at least 10 W. The handheld probe is configured to receive the beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received. The handheld probe further includes a cooling structure. The method further includes accepting an input from an operator, generating a beam of coherent light via the coherent light generator optically connected to the handheld probe according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient, and delivering, by the cooling structure, a coolant to at least one of a portion of the handheld probe or a portion of anatomy of the patient.

[0010] Another embodiment relates to a method for administering phototherapy. The method includes optically connecting a handheld probe to a coherent light generator configured to generate a beam of coherent light. The handheld probe is configured to receive the beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received. The method further includes accepting an input from an operator and generating one or more beams of coherent light via one or more coherent light generators and/or the coherent light generator optically connected to the handheld probe. The one or more beams are generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient. The one or more coherent light generators are mounted to a hollow structure. The hollow structure includes a first open end through which the hollow structure receives at least a portion of patient anatomy including a targeted treatment site. The hollow structure further includes a rotatable member configured to rotate around at least one rotary axis. Each of the one or more coherent light generators is optically connected to one or more lenses or mirrors mounted to the hollow structure. The one or more lenses or mirrors are

configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator.

[0011] Another embodiment relates to a device for administering phototherapy. The device includes a stationary hollow structure having at least a first open end through which the hollow structure receives at least a portion of patient anatomy and at least one coherent light generator. Each coherent light generator is configured to generate a beam of coherent light. The device also includes at least one of a plurality of coherent light generators mounted to an interior of the hollow structure, the plurality of coherent light generators including the one or more coherent light generators, or a plurality of lenses mounted to the interior of the hollow structure. The device further includes a processing circuit comprising a processor and a memory storing instructions. The instructions, when executed by the processor, cause the processor to accept an input from an operator and generate one or more beams of coherent light, via the at least one coherent light generator or the plurality of coherent light generators, according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on the patient anatomy. The instructions further cause the processor to direct the one or more beams of coherent light to the targeted treatment site by generating the one or more beams of coherent light in a sequence.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 depicts a perspective view of an embodiment of a treatment cylinder portion of a phototherapy device.

[0013] FIG. 1A depicts a perspective view of another embodiment of a treatment cylinder portion of a phototherapy device.

[0014] FIG. 1B depicts a perspective view of another embodiment of a treatment cylinder portion of a phototherapy device.

[0015] FIG. 1C depicts another perspective view of the treatment cylinder portion of FIG. 1B.

[0016] FIG. 2 depicts a block diagram of one embodiment of a computer control unit used to operate a phototherapy device.

[0017] FIG. 3 depicts an abstracted perspective view of another embodiment of a treatment cylinder portion of a phototherapy device.

[0018] FIG. 3A depicts a perspective close-up view of one embodiment of a gimbal-mounted lens/collimator assembly.

[0019] FIG. 4 depicts a perspective view of another embodiment of a treatment cylinder portion of a phototherapy device.

[0020] FIG. 5 depicts a perspective view of another embodiment of a treatment cylinder portion of a phototherapy device.

[0021] FIG. 5A depicts a perspective view of another embodiment of a treatment cylinder portion of a phototherapy device.

[0022] FIG. 5B depicts a perspective view of another embodiment of a treatment cylinder portion of a phototherapy device.

[0023] FIG. 5C depicts a perspective view of another embodiment of a treatment cylinder portion of a phototherapy device.

[0024] FIG. 6 depicts a perspective view of a treatment cylinder portion of a phototherapy device including an embodiment of an optical assembly.

[0025] FIG. 6A depicts a flow chart setting forth steps used by a computer control unit to accept and act upon data from the optical assembly of FIG. 6.

[0026] FIG. 7 depicts a perspective view of an embodiment of a horizontally rotatable gantry assembly for mounting a treatment cylinder portion of a phototherapy device.

[0027] FIG. 7A depicts a perspective view of another embodiment of a treatment cylinder portion of a phototherapy device mounted on another embodiment of a support assembly.

[0028] FIG. 7B depicts another perspective view of the treatment cylinder portion and support assembly of FIG. 7A.

[0029] FIG. 7C depicts another perspective view of the treatment cylinder portion and support assembly of FIG. 7A.

[0030] FIG. 7D depicts a top view of the treatment cylinder portion of FIG. 7A.

[0031] FIG. 8 depicts a cross-sectional view of an embodiment of a probe of a phototherapy device.

[0032] FIG. 8A depicts a cross-sectional view of another embodiment of a probe of a phototherapy device.

[0033] FIG. 8B depicts a cross-sectional view of another embodiment of a probe of a phototherapy device.

[0034] FIG. 8C depicts a perspective view of another embodiment of a probe of a phototherapy device.

[0035] FIG. 8D depicts a perspective and cross-sectional view of the probe of FIG. 8C.

[0036] FIG. 8E depicts a cross-sectional view of a tip of the probe of FIG. 8C.

[0037] FIG. 8F depicts a cross-sectional view of another embodiment of a probe of a phototherapy device.

[0038] FIG. 8G depicts a cross-sectional view of another embodiment of a probe of a phototherapy device.

[0039] FIG. 8H depicts a cross-sectional view of another embodiment of a probe of a phototherapy device.

[0040] FIG. 8I depicts a perspective and cross-sectional view of another embodiment of a probe of a phototherapy device.

[0041] FIG. 9 depicts a perspective view of an embodiment of a coherent light emitter assembly of a phototherapy device.

[0042] FIG. 10 depicts a cross-sectional view of another embodiment of a probe of a phototherapy device in use with an endoscope.

[0043] FIG. 11 depicts a front view of a first patient including example treatment areas.

[0044] FIG. 12 depicts a side view of the patient of FIG. 11 including example treatment areas.

[0045] FIG. 13 depicts a back view of the patient of FIG. 11 including example treatment areas.

[0046] FIG. 14 depicts a front view of on a second patient including example treatment areas.

[0047] FIG. 15 depicts a side view of the patient of FIG. 14 including example treatment areas.

[0048] FIG. 16 depicts a back view of the patient of FIG. 14 including example treatment areas.

[0049] FIG. 17 depicts a side view of a treatment cylinder portion of a phototherapy device in use.

[0050] FIG. 18 depicts a side perspective view of the treatment cylinder portion of FIG. 17 in use.

[0051] FIG. 19 depicts a side view of a treatment area with respect to a pelvic region of a female patient.

[0052] FIG. 20 depicts a front view of the treatment area of FIG. 19 with respect to the pelvic region of the female patient.

[0053] FIG. 21 depicts a top view of the treatment area of FIG. 19 with respect to pelvic bones of the female patient.

[0054] FIG. 22 depicts a side view of pelvic structures of a female patient.

[0055] FIG. 23 depicts a side view of pelvic structures of a male patient.

[0056] FIG. 24 depicts a top view of pelvic structures of a female patient.

DETAILED DESCRIPTION

[0057] Physiotherapy energy of various wavelengths in the entire light spectrum may include infrared (e.g., 700 nm to 1 mm) and near-infrared wavelengths (e.g., 700 nm to 1400 nm). The administration of light in the near-infrared can reduce pain in muscles and the tissues of the lower back. Laser energy at various wavelengths of the entire spectrum, including the 694 nm wavelength of ruby lasers, is useful for photothermolysis (energetic hair removal).

[0058] There are multiple areas in which the administration of phototherapy is limited and/or of limited effectiveness. First and foremost, the phototherapy must be targeted with precision to avoid the light energy either being absorbed by tissues that are not meant to be treated, or not absorbed by the tissues toward which it is being directed. A device that could more precisely target phototherapy would be desirable.

[0059] Most systems for administering phototherapy use a human operator to target and deliver the phototherapy. While humans can become very skilled at this task, human administration is inherently inconsistent and imprecise. A device for allowing a human operator to administer phototherapy that allows more consistent and precise administration of the phototherapy would be desirable.

[0060] Most systems for administering phototherapy have only one exit portal that directs the light energy, and that exit portal has only a single directional axis of operation. Optimal phototherapy treatment often requires treatment of a volume of tissues, which may require the administration of phototherapy from a specific locus of angles that are dependent on the wavelength of the light and the depth of the tissue to be treated. A device for allowing the administration of phototherapy from a controlled locus of angles, taking into account the depth of the tissue to be treated and the physical characteristics of the light energy used would be desirable.

[0061] Most systems for administering phototherapy target only relatively shallow tissues. There are multiple subsurface tissue types that would benefit from the administration of phototherapy, but targeting subsurface tissues for phototherapy is inherently difficult, especially for a human operator. A device for allowing the efficient and precise targeting of subsurface tissues for phototherapy would be desirable.

[0062] The simultaneous delivery of multiple wavelengths of light for phototherapy has the potential to increase the benefits of phototherapy. Such delivery is difficult to do with known phototherapy devices. A device that can simultaneously target the same or closely-located tissues with multiple wavelengths of light would be desirable.

[0063] The delivery of light for phototherapy toward a volume of tissues to be treated may require delivery of light from a locus of angles circumferential to the volume of tissues to be treated, at a precise angle relative to the surface of those tissues. A device that can deliver light from a locus of angles circumferential to the volume of tissues to be treated, at a precise angle to the surface of those tissues, would be desirable.

[0064] The delivery of phototherapy to tissues can cause excess heating and tissue damage if not precisely controlled. When using higher power sources for phototherapy, this becomes more likely. A device that can deliver relatively high-powered phototherapy while allowing tissues to cool between applications and still deliver the phototherapy in a fast and efficient manner would be desirable. The present disclosure addresses these and other concerns according to various illustrative embodiments.

[0065] Reference will now be made in detail to embodiments of the disclosure that are illustrated in accompanying drawings. Whenever possible, the same or similar reference numerals are used in the drawings and the description to refer to the same or like parts or steps. The drawings are in simplified form and are not to precise scale. For purposes of convenience and clarity only, directional terms such as top, bottom, left, right, up, down, over, above, below, beneath, rear, and front, may be used with respect to the drawings. These and similar directional terms are not to be construed to limit the scope of the disclosure in any manner. The words attach, connect, couple, and similar terms with their inflectional morphemes do not necessarily denote direct or intermediate connections, but may also include connections through mediate elements or devices.

[0066] It should be noted that while some embodiments are configured for use with human patients, the devices described herein can be used with any animal that would benefit from phototherapy, including but not limited to higher mammals such as dogs, cats, or horses. The word "patient" as used herein refers to any animal, including a human being, to which phototherapy may usefully be applied by the devices described herein. Further,

unless otherwise indicated, the example embodiments can be utilized with any biological systems, including human patients, other animal patients, or any portions thereof.

[0067] Additionally, it should be understood that while the phototherapy devices described herein are primarily described as providing phototherapy to a patient, these devices may also be used for non-biological functions. For example, the devices described herein may be used to selectively heat polymers and other materials and/or substrates to their T_g or T_m temperatures.

[0068] The present disclosure relates to devices for delivering precision phototherapy (e.g., "phototherapy devices") in the form of targeted and dose-controlled light. In various embodiments, a phototherapy device partially or wholly surrounds the part of the body to be treated and allows the targeting of specific tissues at specific depths while minimizing energy transfer to non-targeted tissues. In some embodiments, the phototherapy device includes a rotating device containing optical elements that is used to target the tissue to be treated (e.g., the "targeted treatment site") from a plurality of angles and a plurality of wavelengths. In some embodiments, the phototherapy device includes galvanometrically-controlled optical elements that allow targeting of a volume of tissues from a plurality of angles. In some embodiments, the phototherapy device includes a probe that may be used to provide targeted phototherapy. The probe may be used with the aforementioned embodiments, or the probe may be used separately (e.g., with an independent light source for the phototherapy). Additionally, in some embodiments the phototherapy device may include a mounting system for various phototherapy elements.

[0069] The person(s) operating the phototherapy device may be referred to herein as "therapists," "operators," or "doctors." While the persons operating the device may be licensed medical doctors, it is not required. Where safe, useful, and within the bounds of applicable law and regulation, the phototherapy device embodiment(s) may or may not be operated by a licensed health care professional.

[0070] Additionally, various phototherapy device embodiments described herein may be operated partially robotically (e.g., with some automation, such as using robotic system to guide a human operator) or fully robotically (e.g., with full automation). For example, partial or full robotic guidance of the phototherapy device may be provided to deliver therapy to a treatment area for a specific time period and then systematically move the

treatment to another area, thereby allowing for delivery of the maximum dose without creating too much heat in one area. In various embodiments, a computer control unit, which is described in further detail below, may provide this partial or full robotic guidance. Further, in some embodiments, this robotic guidance may be provided at least partially through one or more robotic arms, which may be controlled by the operator and/or the computer control unit. Thus, it should be understood that, in some embodiments, where input or other action is described as being received from or taken by an "operator" or "user", such "operator" or "user" may be or include a robotic system or other manner of computing device.

[0071] The phototherapy devices described herein should not be used to treat, cure, or prevent disease or injury in any way not compliant with applicable regulatory controls. Such regulatory controls will vary by jurisdiction and do not form part of the embodiment(s) of the disclosure or their basic operation, and will not be further described herein. To the extent that any regulatory controls apply, security controls may be incorporated into the devices described herein that restrict operation of the device by other than authorized operators in compliance with applicable regulatory controls.

[0072] For purposes of this application, phototherapy applied by the device takes the form of light of a selected and controlled wavelength or tight group of wavelengths. If multiple wavelengths are used, the light may be formed of a plurality of light beams, each having a specific selected and controlled wavelength or tight group of wavelengths. In some embodiments, the light used is coherent light (e.g., with the photons of the light having the same or nearly the same wavelengths, being in phase, and identical or nearly identical in amplitude). Further, in some embodiments, the coherent light used is generated by a laser. Many coherent light generators, as the term is used herein, are laser generators (which may also be referred to as "laser power sources"): lasers produce coherent light by means of a process called "lasing." Other devices or systems of coherent light generation and/or the generation of light of a controlled wavelength or tight group of wavelengths can also be used.

[0073] The wavelengths used to provide the phototherapy described herein may be selected based on the depth of desired penetration into the patient anatomy, as each wavelength may be associated with a different depth of soft tissue penetrance. Additionally, limited penetration of wavelengths may be addressed by applying phototherapy partially or

completely around the targeted tissue site circumferentially. For example, in an arthritic knee, 7.5 cm may be the deepest that laser photons will propagate into soft tissues. As such, greater therapeutic effects may be achieved in treating the average 15 cm-diameter arthritic knee of a male patient, for instance, when the therapy is delivered completely around the knee. Delivering the therapy circumferentially around the knee will help the most Joules of photon energy penetrate into the deepest areas of the knee joint where most of the destructive inflammatory disease state exists that is causing the chronic and progressive knee pain.

[0074] For consistency and preference, the term "coherent light" will be used in this application, with the understanding that this refers to a selected and controlled wavelength or tight group of wavelengths. However, it should be understood that at least some of the embodiments described herein may be operated with non-coherent light. For purposes of this application, if a particular beam of coherent or non-coherent light is referred to as having a specific wavelength, it should be understood that so long as the coherent or non-coherent light beam is tightly grouped around that wavelength (e.g., with a bandwidth of not more than 20 nm for at least 90% of the total energy output of the beam), that beam of coherent or non-coherent light "has" that specific wavelength.

[0075] Additionally, other suitable sources of coherent or non-coherent light that may be used with the phototherapy devices described herein include, without limitation, the following: (1) non-coherent light sources such as light emitting diodes ("LEDs") or incandescent lamps (e.g., halogen lamps) connected to filters; (2) organic LEDs ("OLEDs") using small organic molecules as the electroluminescent material, which allow emission from large and/or flexible surfaces; and (3) specifically, lasers with very narrow spectral-emission bandwidths and the ability to produce 'pulses' of light with durations on the order of 12 attoseconds, often referred to as "superpulse" lasers. These sources may be used based on the type of phototherapy to be applied, the location and type of the treatment site tissue, and/or the type of injury or disease state to be treated. For example, superpulse lasers may have the ability to administer high levels of energy while allowing time for the relaxation of tissue, which may be beneficial in delivering therapy to treat diseases with higher intense vascularity (e.g., a case of higher acute injury as opposed to a chronic disease state). As another example, LEDs may provide low-level therapy, thereby allowing for longer

treatment times with lower energy photons. This may be beneficial for cellular adenosine triphosphate ("ATP") generation.

[0076] It should be understood that the phototherapy devices described herein may be used to provide therapy to a variety of tissue types, including bone. For example, the phototherapy devices described herein may be used to provide phototherapy that penetrates and is absorbed by bone marrow and bone matrix (e.g., cortical and trabecular bone) or phototherapy that passes through bone.

[0077] By referring to the exemplary embodiment of FIG. 1, the basic function of the systems and methods described herein can be easily understood. In various embodiments, including the embodiment shown in FIG. 1, a phototherapy device includes a hollow structure with at least a first open end through which at least a portion of patient anatomy can be inserted into the hollow structure. This hollow structure may take on a variety of geometrical shapes, such as a cylinder, tube, drum, sphere, or dome. While this hollow structure is referred to herein as a "treatment cylinder" based on the configurations shown in most of the Figures (e.g., treatment cylinder 10 of FIG. 1), it should be understood that structures performing the functions of the treatment cylinder described below may not necessarily be cylindrical. For example, FIG. 1A illustrates an embodiment of a treatment cylinder 11 that includes the same components as treatment cylinder 10, shown in FIG. 1, but is configured as an elliptic cylinder rather than a circular cylinder. Treatment cylinder ("TC") 10 includes exterior member 12, which is an open-ended cylinder interrupted by gap 16, and rotatable member 15. Rotatable member 15 can be rotated within TC 10 independently of exterior member 12 around a rotary axis, which may or may not be located through the center of TC 10. Gap 16 can be closed by cap 14, which slides into rotatable member 15 when the device is not in use. When used to provide treatment, the portion of the patient's body to be treated is inserted into TC 10 either through one of its open ends or through gap 16. Additionally, in various arrangements, TC 10 is connected to a computer control unit, described in further detail below. The computer control unit may also allow finite movement of TC 10 (e.g., limited movement in the x, y, and z directions) for proper positioning of the patient anatomy within TC 10.

[0078] In some embodiments, the phototherapy device includes gap 16 to make it easier to insert the patient's body into TC 10. Further, if gap 16 is included, cap 14 may be used to close gap 16 during treatment. This both prevents coherent light from escaping and reduces

the chance (a) that foreign objects will be inserted during treatment that may interfere with or damage the moving parts of the device or (b) that the patient's body will be engaged by the rotatable member 15, potentially causing injury. Alternatively, cap 14 may be a hinged member of TC 10 configured to swing open to allow insertion of the patient's anatomy and swing closed to close gap 16. This hinged member may further be provided with a locking mechanism to keep the hinged member in place and closed during operation of the phototherapy device. In some embodiments, one end of TC 10 may also be closed (not shown). This provides further protection from the escape of coherent light and the introduction of foreign objects but may make TC 10 much less versatile in relation to how the patient's body can be introduced into TC 10.

[0079] It should be understood, however, that the configuration of the treatment cylinder shown in FIG. 1 is intended to be exemplary. Treatment cylinder may be configured differently in other embodiment. For example, in one embodiment, the treatment cylinder may alternatively be thin with a diameter much greater with its width (e.g., shaped like a hula hoop). The treatment cylinder may deliver focused energy and moved in the x, y, and z directions to provide therapy over the treatment area.

[0080] FIGS. 1B and 1C show another alternate embodiment of a treatment cylinder. TC 20 includes exterior member 22 and includes rotatable member 25 separated into two halves. Exterior member 22 includes a first exterior member half 22a and a second exterior member half 22b, and rotatable member 25 includes a first rotatable member half 25a and a second rotatable member half 25b. Exterior member halves 22a and 22b are configured to receive rotatable member halves 25a and 25 b, which may rotate within exterior member halves 22a and 22b. All of these halves (e.g., to receive the patient anatomy to be treated), as shown in FIG. 1B, and brought back together to form the whole exterior member 22 and whole rotatable member 25, as shown in FIG. 1C. Accordingly, TC 20 has the appearance of a clam shape. In some arrangements, first rotatable member half 25a must be flush with first exterior member half 22a and second rotatable member half 25b must be flush with second exterior member half 22b, as shown in FIG. 2B, before exterior member 22 and rotatable member 25 may be separated. TC 20 may be configured for treating smaller areas of anatomy (e.g., TC 20 may have a diameter of 30 cm) or treating larger areas of anatomy (e.g., TC 20 may have a diameter of 70 cm). TC 20 may also have a width appropriate for treating a certain amount of patient anatomy (e.g., TC 20 may have a width of 32 cm).

[0081] As shown, exterior member 22 and rotatable member 25 include spring hinge system 150 to facilitate the separation of halves 22a, 22b, 25a, and 25b, as well as piston system 151 configured to move halves 22a, 22b, 25a, and 25b apart and back together. Spring hinge system 150 may be configured to apply pressure to the halves 22a, 22b, 25a, and 25b to bias them closed or to bias them open, depending on the embodiment. Piston system 151 may be a static hydraulic piston. Alternatively, in some embodiments piston system 151 may be replaced with a counter pressure spring (e.g., configured to apply a counter pressure to spring hinge system 150 to keep the halves 22a, 22b, 25a, and 25b separated or apart) or a manual or motorized gear system for opening and closing rotatable member 15. Additionally, TC 20 includes locking mechanism 152 to lock halves 22a, 22b, 25a, and 25b together during operation of TC 20. Locking mechanism 152 may be either manual or automatic (e.g., controlled by computer control unit). TC 20 further includes stabilizing pins 154 provided on one end of each of rotatable member halves 25a and 25b, where stabilizing pins 154 configured to be received in pin holes 155 provided on the other end of each of halves 25a and 25b. In this way, stabilizing pins 154 and pin holes 155 fit together to stabilize halves 25a and 25b together during operation of TC 20 (e.g., to help prevent halves 25a and 25b from slipping relative to each other during rotation of rotatable member 15).

[0082] In some embodiments, the treatment cylinder (e.g., TC 10, TC 20) could be enclosed in a cabinet with a door or other closure structure. The door or other closure structure prevents external objects from being inserted into gap 16 when closed**.** Unlike cap 14, such embodiments would not protect the patient from becoming caught in gap 16 during operation of the device. However, if TC 10 has no moving parts that the patient could become caught in, the use of a cabinet may be practical. In some embodiments including a cabinet with a door, the device may have a lockout mechanism configured to prevent the rotatable member and/or the coherent light generators, discussed below, from activating unless the door is closed. Alternatively, the phototherapy device may require a positive override by the operator to activate rotatable member and/or the coherent light generators when the door is not closed.

[0083] In some embodiments, the cabinet may be provided with a motorized mechanism for opening and closing such a door or other closure structure. Similarly, some embodiments may, for example, include a motorized mechanism that closes gap 16 (not

shown) with cap 14. If a motorized mechanism configured for performing either of these operations is present, the motorized mechanism may operate automatically and/or the operator may manually operate the motorized mechanism.

[0084] Referring back to FIG. 1, coherent light generators 17, 18, and 104, collectively "CLG," are mounted within TC 10. In some embodiments, the CLG are mounted directly to or within rotatable member 15. Each individual coherent light generator can be capable of generating a fixed wavelength of coherent light, or can be capable of generating multiple wavelengths of coherent light, either in the alternative or concurrently. Each individual coherent light generator can have the same coherent light generation selection parameters as any other coherent light generator, or can have its own unique coherent light generation selection parameters. Additionally, each CLG can emit a single beam of coherent light, or multiple beams of coherent light. Each beam of coherent light can be further divided by an optical mechanism, such as a beam splitter. Additionally, the CLG with various power outputs may be used, such as CLG capable of operating at less than 1 W, CLG capable of operating at 100 mW or more, and/or CLG capable of operating at greater than 200 W.

[0085] In some embodiments, the CLG emit coherent light in the form of laser energy through laser diodes. More specifically, the CLG emit illumination energy (e.g., from laser diodes, as described, or from another light source). This illumination is provided in a beam. The CLG can emit coherent light as various pulse types, including a continuous beam, as a pulsed (intermittent) beam, as a "superpulsed" beam, or in any combination thereof. For example, the CLG may pulse one wavelength and then pulse another wavelength, where the wavelengths span a broad range of wavelengths. Alternatively or additionally, the CLG can emit coherent light in a chirped beam, a chopped beam (e.g., a beam interrupted by an optical chopper), a shaped or patterned beam (e.g., a beam emitted in a non-circular shape), or in any combination thereof. As an example, the light could be emitted in a shape that best delivers phototherapy to the targeted treatment site, such as a petal formation, particularly if different areas of the treatment site require different amounts of light energy for treatment. As another example, the light could be emitted in a shape, such as a donut shape, that avoids areas that should not receive phototherapy treatment, such as a mole, a tattoo, or an implantable subcutaneous heart defibrillator. The CLG can also direct, or be directed such that, the light is moved in the x, y, and z and rotational directions, as discussed in further detail below. The CLG can also emit light using other optical sources and with a wide range

of wavelengths, as also discussed in further detail below. In some embodiments, at least some of the CLG may be replaced with non-coherent light generators.

[0086] The CLG are optically connected to coherent light emitter rails, collectively "CLER." Coherent light generator 17 is optically connected to coherent light emitter rail 19 and coherent light emitter rail 101. Coherent light generator 18 is optically connected to coherent light emitter rail 106 and coherent light emitter rail 115. Coherent light generator 104 is optically connected to coherent light emitter rail 102 and coherent light emitter rail 103. In some embodiments, the CLG and the CLER are connected by fiber optics (not shown). However, it should be understood that any reasonable and efficient method of optical connection can be used to optically connect the CLG and CLER. Moreover, in an alternate embodiment (not shown), the CLG are laser diodes or similar sources of coherent light that are mounted directly on the CLER.

[0087] Any reasonable number of sources of coherent light may be mounted directly on the CLER and/or directly on the interior surface of TC 10. Additionally, although three CLG are shown herein as part of the phototherapy device, it should be understood that any number of CLG may be used to deliver any number of wavelengths of coherent light. For example, a single diode, dual diodes, or more than three diodes may be mounted on rotatable member 15. Further, in some arrangements, self-contained, removable, and swappable CLG may be used in the phototherapy device for purposes of selection of wavelength and power of the coherent light generated and for ease of replacement. If the CLG are mounted directly on the CLER or the interior surface of the TC 10, any desired number of CLG can be mounted in any desired configuration. For instance, a configuration suitable for a wide variety of phototherapy applications can include eight 60 W laser diodes on each of three CLER, which would allow the simultaneous delivery of multiple wavelengths (if the CLG are of different wavelengths) at high power to multiple sections of the volume of tissues to be treated.

[0088] The CLER contain a plurality of lenses and/or collimators (e.g., as described in further detail below with reference to FIG. 9) configured to alter at least one aspect of the coherent light produced by the CLG. As such, the CLER can, depending on the intended use(s) of the phototherapy device, diffuse, focus, or collimate coherent light as it is emitted from the CLER. The CLER may also alter the optical path of the coherent light. In some embodiments, the CLER are directed toward the rotary axis of TC 10, such that the coherent

light, once emitted, will be directed toward the portion of the patient's body inside TC 10 and thus to the tissues which are to receive the administered phototherapy. In some embodiments, the lenses and/or collimators may be replaceable, manually adjustable, or automatically adjustable such that the diffusion pattern/spread/focus of the emitted coherent light can be changed according to the desired administration of phototherapy. Additionally, in some embodiments, a holographic film and/or optical system may modify the generated light field before it reaches the tissue to be treated and/or before it reaches other components of the CLER, such as lenses, prisms, films, and/or digital mirror arrays. For example, the light be projected through a holographic film including a holographic picture or other details that filter the light to better target specific areas within the treatment zone according to the holographic picture or details.

[0089] In various arrangements, the CLER are affixed to the surface of TC 10 and oriented in such a way as to deliver coherent light toward the central axis of rotation of TC 10. Alternatively, if TC 10 does not rotate, the CLER may be affixed and oriented to deliver coherent light toward the physical axis of TC 10. In some embodiments, as discussed above, the phototherapy may be delivered along the central axis of TC 10 in an orthogonal fashion relative to the patient's skin. In other embodiments, the phototherapy may be delivered along a different position relative to TC 10 and/or at a different angle, such as less than 90 degrees (within a margin of error).

[0090] Another CLER configuration is shown in FIGS. 1B and 1C. In TC 20, three CLER are provided on rotatable member 25 spaced equidistant apart, with CLER 156 including CLG 162 (e.g., emitting light at 810 nm) provided on rotatable member half 25a and with CLER 158 including CLG 164 (e.g., emitting light at 905 nm) and CLER 160 including CLG 166 (e.g., emitting light at 980 nm) provided on rotatable member half 25b.

[0091] Referring to TC 10 shown in FIG. 1, to use the phototherapy device, the portion of the patient's body to be treated is placed within TC 10. Once the portion of the patient's body to be treated is placed within TC 10, a computer control unit is activated by an operator (not shown), and one or more inputs (e.g., a command to use the TC 10, inputs relating to a saved or desired plan for the patient) are provided by the operator to the computer control unit. The computer control unit then energizes the CLG to provide the phototherapy. The computer control unit may also provide guidance to an operator or

provide automatic control of the TC 10 to deliver the phototherapy to the targeted treatment site.

[0092] Referring to FIG. 2, an embodiment of the computer control unit of a phototherapy device is shown. Computer control unit 200 includes input/output circuit 202, display 204, treatment cylinder movement circuit 206, and treatment circuit 208. Computer control unit 200 is also communicably coupled to treatment cylinder 210 (e.g., similar to TC 10, TC 20, or another embodiment of a treatment cylinder) and/or probe 212 (e.g., similar to a probe described below with reference to FIGS. 8-8E). As shown, computer control unit 200 may also be communicably coupled to one or more cameras 214 or other visualization devices, one or more sensors 216, an external imaging device 218, and/or an external therapy device 220. Some or all of the features of computer control unit 200 may be implemented using one or more processors and one or more computer-readable storage media. The one or more processors may be any type of processor, such as a general purpose processor, a field programmable gate array (FPGA), and application specific integrated circuit (ASIC), etc. The one or more computer-readable media may be any type of computer-readable medium or memory, such as RAM, ROM, flash media, optical media, etc. In some embodiments, various features may be implemented as instructions stored on the computer-readable media and executed by the processors to implement the functions.

[0093] These connections may be wired connections or wireless connections. For example, computer control unit 200 may include a network interface configured to communicate with devices external to computer control unit 200. A network interface may be or include, for example, any of a cellular transceiver (Code Division Multiple Access (CDMA), Global System for Mobile Communications (GSM), Long-Term Evolution (LTE), etc.), a wireless network transceiver (e.g., 802.11X, ZigBee, or Bluetooth), or a combination thereof (e.g., both a cellular transceiver and a Bluetooth transceiver). In some arrangements, a network interface includes hardware and machine-readable media sufficient to support communication over multiple channels of data communication.

[0094] Input/output circuit 202 is structured to receive communications from and provide communications to a user of computer control unit 200 (e.g., the operator). In this regard, input/output circuit 202 is structured to exchange data, communications, instructions, etc. with an input/output component (e.g., an input/output device) of computer control unit 200. An input/output device may include hardware and associated logics configured to enable the

user to exchange information with computer control unit 200. For example, an input aspect of an input/output device may include a touchscreen, a mouse, a keypad, a camera, a microphone, or a user input device engageable with computer control unit 200 through a wired or wireless connection. An output aspect of an input/output device may include a display, a printer, a speaker, or an output device engageable with computer control unit 200 through a wired or wireless connection.

[0095] Display 204 may be a screen, a touchscreen, and the like. Computer control unit 200 may use display 204 to communicate information to the user (e.g., by displaying the information on display 204) and/or to receive communications from the user (e.g., through a keyboard provided on a touchscreen of display 204). In some arrangements, display 204 may be a component of an input/output device.

[0096] TC movement circuit 206 is configured to move treatment cylinder 210 (e.g., as part of delivering therapy, as part of situating the patient anatomy within treatment cylinder 210). In some embodiments, TC movement circuit 206 may also move probe 212 (e.g., through one or more robotic arms communicably connected to computer control unit 200).

[0097] Treatment circuit 208 is configured to control treatment cylinder 210 and/or probe 212 to deliver therapy to the targeted treatment site. In various embodiments, the treatment circuit 208 is configured to accept an input from an operator (e.g., a command to start treatment, an input of a setting for the treatment, a selection of a saved treatment plan for the patient, etc.). In some embodiments, treatment circuit 208 is configured to receive an input from an operator related to a treatment plan for the patient and deliver the therapy according to the treatment plan input. The treatment plan input may be a selection of the treatment area by the operator (e.g., via user interfaces provided on display 204, via markings made by the operator on the patient anatomy to indicate the treatment area and sensed by camera(s) 214), a selection of a type of therapy by the operator, a selection of parameters of the therapy by the operator, and so on. Additionally, treatment circuit 208 may use inputs from one or more external devices (e.g., from camera(s) 214, from sensor(s) 216, from external imaging device 218, and/or from external therapy device 220) to control or modify the therapy.

[0098] Example operation of computer control unit 200 to control treatment cylinder 210 and deliver phototherapy may be understood with reference to TC 10. As discussed above,

in various embodiments, the operator provides computer control unit 200 with one or more inputs. The input(s) is used to determine the power setting, the duration, and the wavelength(s) of coherent light to be administered to the tissues of the patient. As an illustration, a treatment plan input can comprise an entirely automatic group of settings for placement (e.g., in the x, y, and z directions, as well as time of placement and time between illuminations), power, wavelength and duration, a group of manual and automatic settings, or a group of manual settings. In some embodiments, many of the settings may be predetermined to reduce the possibility of error. Further, in some embodiments, the computer control unit may have limits on any and all manual settings such that the risk of injury to the patient by the delivery of too much energy to a particular group of tissues is minimized.

[0099] As an example, computer control unit 200 may accept inputs directed to a continuous mode output or pulsed mode output, a pulse duration, a frequency (Hz), a power (W), and specific available wavelength(s) of the coherent light. As noted above, the ranges for these settings may lie between predetermined limits. To illustrate, there may be a specific ceiling of frequency settings for the pulsed mode for each millisecond level of pulse duration, and vice versa. As a more specific illustration, when using the 30 W power setting of an 810 nm laser for a probe (e.g., as described below with reference to FIGS. 8-8E) or when using the 30 to 60 W power setting of an 810 nm laser for a treatment cylinder, if the pulse duration is set to 30 ms, the frequency cannot be increased higher than 12 Hz. Similarly, if the operator has set the frequency to 12 Hz and increases the pulse duration to 31 ms, computer control unit 200 automatically reduces the frequency to 11 Hz.

[0100] In some embodiments, once computer control unit 200 receives the input, computer control unit 200 rotates rotatable member 15 such that one or more of the CLER are in a position suitable for the administration of phototherapy to the designated tissues of the patient according to the input. Computer control unit 200 then energizes one or more of the CLG so that they emit one or more beams of coherent light according to a plurality of settings (e.g., power, pulse duration, wavelength, frequency, pulse type, etc.) configured to produce a desired therapeutic effect at the targeted treatment site, which is then directed to the corresponding CLER and thus to the tissues of the patient. In various embodiments, the CLG are energized using batteries, direct coupling, induction charging, and the like. Computer control unit 200 can, according to the input, send different levels of coherent light

energy to any desired number of emitters in the CLER. For example, for maximum delivery of energy, the maximum safe output of the CLG can be sent to a single emitter. Alternatively, for maximum volume of exposure at minimal energy, the minimum output of the CLG can be sent to all of the emitters on a CLER.

[0101] Additionally, as discussed above, computer control unit 200 may move TC 10 as part of delivering the phototherapy. For example, computer control unit 200 may rotate rotatable member 15 of TC 10. Computer control unit 200 may also move TC 10 along x, y, and z directions to deliver therapy (e.g., using a support or mounting system to which TC 10 is coupled, as described in further detail below). Moreover, in treatment cylinder embodiments including optical elements that may be controlled electronically, computer control unit 200 may move one or more optical elements as part of delivering the phototherapy (e.g., computer control unit 200 may move one or more galvanometrically-controlled lenses or mirrors, as described in further detail below).

[0102] By controlling the output of the CLER and/or by moving TC 10, computer control unit 200 may produce particular effects in the emitted beams making up the phototherapy, which in turn may provide particular therapeutic effects. For example, computer control unit 200 may deliver the phototherapy with specific speed and power to provide a therapeutic dose while allowing for diffusion of heat in the targeted treatment site. As one illustration, computer control unit 200 may control the output of the CLER and/or move TC 10 to provide ratcheting, rocketing, or rotating beams around and/or across portions of the targeted treatment site or multiple targeted treatment sites. As another illustration, computer control unit 200 may control the output of the CLER and/or move TC 10 to provide waving or sweeping beams across the targeted treatment site. For example, a wiping motion may involve movement of the beam from right to left, then down the width or diameter of the beam, and then left to right. A sweeping motion may involve moving a wide beam (e.g., produced by three diodes side-by-side, such as a 9 cm beam emitted by three rectangular diodes 3 cm wide by 0.2 cm thick) over a wide swath of the treatment area such that, as computer control unit 200 rotates rotatable member 15, the beam produces a sweeping motion. These motions could be slow and smooth, or these motions could be fast or very fast (e.g., beyond the physical ability of a human), which may allow the delivery of higher energy photons without overheating the skin surface or tissues below the skin's surface. As another illustration, computer control unit 200 may control the output of the CLER and/or

move TC 10 to point the beam at a specific angle toward the targeted treatment site. The beam may be stationary and may be provided under, for example, Magnetic Resonance Imaging ("MRI") and/or global positioning system ("GPS") guidance. As another illustration, computer control unit 200 may control the output of the CLER to produce beams in an oval pattern that administers phototherapy but reduces heat buildup.

[0103] Additionally, in various embodiments, computer control unit 200 may vary phototherapy directed toward different treatment zones and settings or parameters of the phototherapy (e.g., intensity, speed, length, etc.) based on treatment zones. In some embodiments, a targeted treatment site includes three treatment zones. The first treatment zone is a primary treatment zone ("PTZ") that covers, for example, the mid 0 to 8 cm or more of the targeted treatment site. The size of the PTZ may vary depending on the size of the treatment site and how beneficial it may be to treat the areas surrounding the targeted treatment site. The proximal secondary treatment zone ("PSTZ") is the next 0 to 8 cm or more past the PTZ, but still within the targeted treatment site, that is closest to the heart. Similarly, the distal secondary treatment zone ("DSTZ") is the next 0 to 8 cm or more past the PTZ, but still within the targeted treatment site, that is furthest of from the heart. The treatment zones are discussed in further detail below with reference to FIGS. 10-15. It should be noted that, in other embodiments, a targeted treatment site may include any number of treatment zones, including a single treatment zone, less than three treatment zones, or greater than three treatment zones, and all such modifications are contemplated within the scope of the present disclosure.

[0104] Further, it should be understood that computer control unit 200 may produce, control, and/or modify the phototherapy automatically or semi-automatically, depending on the embodiment. For example, in one embodiment, the operator may provide the one or more inputs, and computer control unit 200 may automatically provide the phototherapy to the patient based on the input(s). In another embodiment, computer control unit 200 may automatically provide the phototherapy in certain locations but may require at least some manual control or input from the operator, such as requiring the operator to manually move TC 10 in x, y, and z directions so that computer control unit 200 may better direct the phototherapy. In another embodiment, computer control unit 200 may energize the one or more CLG according to the input(s), and the operator may be required to manually move TC 10 to deliver the phototherapy. In another embodiment, computer control unit 200 may

energize the one or more CLG according to the input(s) and provide guidance to the operator (e.g., via user interfaces shown on display 204) for providing the phototherapy. As such, it should be understood that references to computer control unit 200 producing, controlling, and/or modifying the phototherapy may contemplate at least some manual input or interaction from the operator. In some embodiments, the input from the operator may be selection of a particular treatment plan stored in computer control unit 200, such that computer control unit 200 energizes one or more CLG in accordance with the selected treatment plan. In some embodiments, the input from the operator may be a command to activate one or more CLG, and the one or more CLG may be activated in response for automated and/or manual application of light to one or more treatment areas.

[0105] Depending on the size of the area to be treated and the optimal angles of incidence for the coherent light, computer control unit 200 can administer coherent light of a fixed power, wavelength, and duration from the first position of rotatable member 15, rotate rotatable member 15 to a new position, and then administer additional coherent light of the same or a different fixed power, wavelength, and duration. This cycle of rotating and administering coherent light can repeat as many times as, for example, a treatment plan input calls for or as decided by the operator. This allows for cooling of the tissues in between treatments (e.g., through the blood circulation) while allowing the delivery of the total energy required for effective treatment as fast as safely possible. It also allows the delivery of the maximum safe level of energy per administration as the delivery of the coherent light (e.g., in terms of targeted area/volume, power, duration, and wavelength) is controlled by computer control unit 200. It further allows the CLG to deliver, if appropriate, relatively high levels of power safely, which increases efficiency and reduces total treatment time as the delivery of the coherent light is controlled by computer control unit 200.

[0106] For example, in one embodiment, computer control unit 200 may administer coherent light to the targeted treatment site on the order of one to two seconds, then not administer coherent light to the site on the order of ten seconds, and then repeat the cycle until the desired level of energy has been delivered to that particular site. However, the time of administration could be less, or be greater, depending on the benefits desired. For example, in severe knee arthritis within the central part of the knee structure, the goal would be to administer the highest amount of photon energy into the deepest depths of the knee

joint and surrounding tissues for maximum therapeutic benefit. As such, the time of administration may be increased relative to the above embodiment.

[0107] In some embodiments, as discussed above, the coherent light may be administered to the patient at an angle of incidence at or near 90 degrees (e.g., so that the coherent light strikes the body perpendicular to the surface). This may reduce the total amount of tissue that the light must traverse to reach the tissue to be treated. However, in other embodiments, the coherent light may be administered to the patient at an angle of incidence less than 90 degrees. For example, depending on the size of the area to be treated and the optimal angles of incidence for the coherent light, computer control unit 200 may direct the coherent light onto the patient at an angle of incidence significantly diverging from 90 degrees. In such embodiments, computer control unit 200 may be configured to adjust the power and/or duration of the coherent light administration to compensate for the additional depth of tissue that the coherent light must traverse to reach the tissue to be treated.

[0108] Treatment of the human knee may be used as an example of the operation and benefit of a treatment cylinder operating in conjunction with a computer control unit, such as TC 10 operating in conjunction with computer control unit 200. A human knee 15 cm in diameter over a 22 cm long axis extending above and below the knee joint's fulcrum produces a 1036 cm^2 treatment area. A typical therapeutic phototherapy dose is a radiant exposure of 8.7 Joules/cm^2 over this area. A coherent light beam 3 cm in diameter at the emitter diverges to a 7.1 cm^2 planar intersection with the area to be treated at a typical focal length and an angle of incidence at or near 90 degrees. Therefore, at least 147 individual pulses of coherent light are needed to cover the entire treatment area. For a human using a single emitter wand to deliver phototherapy, this would require at least 147 individual applications of phototherapy, carefully spaced, aimed, and timed. Advantageously, the phototherapy device described herein can completely automate this process, ensuring that the entire area to be treated is uniformly (or as otherwise most therapeutically effective) and entirely covered, at the proper distance, power setting, and duration of coherent light emission.

[0109] According to various embodiments, phototherapy may be delivered with any wavelength within the spectrum with both a narrow and broad spectrum approach, where the wavelength is based on the therapy that is required for the patient. For example, phototherapy may be delivered with an infrared or near-infrared wavelength. As another

example, phototherapy may be delivered in a range of 400-1200 nm, 600-1100 nm, 800-1100 nm, and/or 400-10,000 (e.g., to allow for the use of CO_2 lasers). As another example, phototherapy may be delivered at or near (e.g., within 5%) the following wavelengths: (1) 980 nm, which will penetrate soft tissues to a depth of approximately 4 to 4.5 cm; (2) 905 nm, which will in some applications produce an immediate analgesic effect by reducing nerve impulses in the treated tissues; (3) 808-810 nm, which will penetrate soft tissues to a depth of approximately 8 cm, the maximum depth to which phototherapy can be safely and efficiently applied under most conditions; or (4) 1064 nm, which is less readily absorbed by the surface tissues of patients with darker skin and can penetrate to a reasonable depth without causing as much surface heating as coherent light with shorter wavelengths, increasing energy delivery to the tissues to be treated and reducing the risk of excessive surface tissue heating in such patients. Additionally, in various embodiments, the phototherapy device is configured to deliver at least a certain level of therapy, such as beams of coherent light with a radiant exposure in the range of 0.1 to 50 J/cm^2 of therapy (e.g., 4-12 J/cm^2 of therapy, 5-8 J/cm^2 of therapy, 8-12 J/cm^2 of therapy).

[0110] In one embodiment of delivering therapy using the phototherapy devices described above, an initial series of treatments with the device could deliver approximately 60 W of power, or more, to the targeted tissues for the prescribed surface area. Follow-up treatments could be delivered at the same, lower, or higher wattages of power (e.g., follow-up treatments could be delivered at approximately 20 W of power). Follow-up photon administration could be applied, for example, in maintenance therapies to manage the disease state or to treat and further suppress diseases that are prone to inflammation flare-ups. Regardless of the use of milliwatts to megawatts, the power can be controlled based on the amount of heat dissipation or cooling of the tissue. The operator and/or computer control unit 200 can change wattage, treatment area, pulse duration, frequency, pulse width, and/or overall treatment duration according to the targeted treatment site. This real-time adjustability in power allows the prescribed therapy to be tailored to the disease state.

[0111] The therapy may also be tailored to the type of disease state that is being treated. For example, specific therapy parameters may be used for certain central nervous system ("CNS") diseases or conditions (e.g., dementia, depression, post-traumatic stress disorder ("PTSD"), Alzheimer's, Parkinson, and stroke). More specifically, therapy could be applied

that causes or triggers cellular changes or interstitial changes that affect the progression of these disease states.

[0112] Additionally, a variety of aspects of the light beam used for phototherapy may be manipulated, either physically (e.g., by changing out optical components) or electronically (e.g., by using the computer control unit to change out optical components or power only certain optical components), depending on the therapy. For example, the beam may be diffusing or non-diffusing. The beam may be collimated or not collimated. As discussed above, the beam's diameter, size, and shape may be adjustable, and the beam may be provided at a static spot or may be movable. The beam may also be ablative (e.g., for performing a laser vaginal rejuvenation treatment). For instance, one or more CLER may emit an ablative erbium laser beam or a CO_2 laser beam to perform a laser peel on the skin's surface or to penetrate through the epidermis and into the dermis for skin tightening, abdominal stretch marks appearance reduction, and age spot reduction.

[0113] In various embodiments, and as discussed above, an aim of the phototherapy device is to deliver the coherent light energy as fast as safely possible to diminish heat buildup, as heating causes vasodilation in the intervening tissues, making them absorb more energy and reducing the effectiveness of the treatment. However, if it is determined by the operator that more and slower treatments will produce better results, the operator and/or computer control unit 200 can adjust the parameters of the phototherapy accordingly. In some embodiments, the phototherapy device may include, or the operator may separately apply, a structure for cooling the patient's surface tissues to reduce vasodilation. The cooling structure may be used before and/or during a treatment session to cool the skin's surface prior to the beam hitting the skin at the targeted treatment site. The cooling structure may also be used to decrease heat discomfort from heat buildup at the beam-skin surface interface ("BSSI") and within the dermis and subdermal tissues. For example, the cooling structure may be used to keep patient tissues from heating over 41°C when treated by a treatment cylinder. Additionally, pretreating the skin with the cooling structure may result in vasoconstriction and skin blanching that can lead to more photons passing through the superficial skin and subdermal tissues, thereby aiding photons in penetrating into deeper soft tissues where disease states tend to reside.

[0114] The mechanism of the cooling structure could include forced-air ventilation, the application of cold water, ice, or cooling gel, or any other reasonable, safe, and efficient

mechanism for cooling the surface tissues. For example, the cooling mechanism may cool patient tissues using coolants such as cooled-chilling, flowing, distilled water or sterile normal saline (e.g., 0.9% NaCl), 10% menthol, compressed CO_2, nitrous oxide, liquid nitrogen, nitrogen gas, and/or isopropanol or another cooled fluid from an external cooling system. Additionally, in some embodiments, the cooling mechanism may be delivered to the patient internally.

[0115] Various cooling mechanisms could be applied to both the treatment cylinder (e.g., TC 10, TC 20) and the targeted treatment area. In some embodiments, the cooling mechanism may provide direct or indirect cooling of components of the phototherapy device, such as the CLG or a probe tip of the phototherapy device (e.g., as discussed in further detail below with reference to FIGS. 8-8E), and/or indirect cooling of the surrounding tissue. For example, the phototherapy device could include a cooling mechanism at the coupling mechanisms or interfaces of the fiber optics and/or laser beam transfer structures used to move coherent light from CLG to CLER (e.g., the coupling beam laser highway). In other embodiments, the cooling mechanism could be external to the treatment cylinder (e.g., provided directly on the patient) and/or there could be a source arising from the TC 10 itself at the beam-surface interface. For example, a cooling blanket could be provided on the patient during treatment of the knee. By cooling the patient's blood upstream, the blood is cooled before reaching the treatment zone, thereby extending the photon exposure time and/or allowing for an increased amount of photon administration at any given time.

[0116] Additionally, the cooling mechanism may include various structures. For example, a cooling mechanism may include one or more pumps for pumping the coolant or cooling media to the patient site or site on the phototherapy device to be cooled. The cooling mechanism may further include tubes or conduits for guiding the coolant or the cooling media to and from the site to be cooled.

[0117] Furthermore, in some embodiments, the dermal layer, subdermal tissues, and/or subcutaneous tissues may be treated (e.g., physically, physiologically, or neurologically) before photons are administered onto the skin surface of the treatment site to improve treatment efficacy. To illustrate, the skin may be cooled, numbed, made less reflective to incoming photons, and/or vasoconstricted before administration of photons. For example, a cream, gel, oil, or spray containing a topical numbing anesthetic such as lidocaine may be

applied to the skin surface. As another example, a skin cooling and vascular constricting cream, gel, oil, or spray, containing substances like menthol, CO_2, eucalyptus globulus leaf oil, phenylephrine HCl, epinephrine, witch hazel, or menthol may be applied to the skin surface. Prior to the administration of photons, an operator can also apply agents, chemicals, or other substances that block or absorb part or all of the delivered photons to the skin and/or into deeper anatomical layers. These can include specific photon-absorbing chromophores, such as biologically friendly inks, that can enhance the absorption of photons and thus enhance the propagation of photons through tissues within the targeted treatment site.

[0118] As an illustration, a hemoglobin-enriched sterile bile acid that preferentially adheres to tumor cells could be injected into a pancreatic tumor. The chosen type of photons could then be delivered into the mid-upper abdominal skin area above the top areas of the pancreas using TC 10. Additional photons could also be delivered through MRI or GPS guidance through an independent probe or a probe coupled to a treatment cylinder, such as TC 10. For example, the probe could be interfaced with or attached to the end of an endo gastro duodenum ("EGD") endoscope. Such probes are described in further detail below with reference to FIGS. 8-8E.

[0119] As another illustration, a gel containing lidocaine and phenylephrine HCl that numbs the skin and vasoconstricts the blood vessels could be applied within the targeted treatment site. This numbing allows higher energy photon delivery into the skin without the patient sensing the usually intolerant higher temperatures of 41 to 45°C (e.g., depending on the type of tissue being treated) produced by the photons. Additionally, the use of these topically applied vasoconstrictors could reduce the blood flow within the targeted treatment site, thus reducing the presence of the chromophore hemoglobin within these shallower surface tissues. Hemoglobin is known to preferentially absorb a 980 nm diffused beam of photons, and these vasoconstrictors could thus produce a blanched skin environment that allows more photons in such a beam to travel deeper into the subdermal tissues and beyond.

[0120] In some embodiments, the phototherapy device may be used with one or more cameras (e.g., camera(s) 214 of FIG. 2). Cameras can be used, for example, to view a body part or orifice of interest in 2D or 3D with a time circumferential view of the targeted tissue site. As another example, an infrared camera may be used to locate hot spots at the targeted tissue site. In some embodiments, the camera may be incorporated into the phototherapy

device (e.g., provided on TC 10), while in other embodiments, the camera may be used separately or externally from the phototherapy device.

[0121] In various embodiments, user interfaces may be provided to the operator of the phototherapy device (e.g., on display 204 of computer control unit 200) before, during, and after use of the device to deliver therapy to a patient. These user interfaces may include various indicators, such as a power indicator, a readout of the rotation speed of the treatment cylinder, a readout of the frequency, pulse width, and rotation of the coherent light provided by the CLG, a readout of the power level of the CLG, and/or a readout of the sequence of the energy emission on the CLER. Additionally, in some embodiments, the user interfaces may be interactive (e.g., with clickable buttons on a monitor or on a touchscreen) such that the operator can control and modify delivery of the phototherapy treatment using the user interfaces. As examples, the user interfaces may include an ON/OFF button, an emergency stop button, buttons or other indicators that the operator can select to modify the power levels of the CLG (e.g., such that the operator can modify the power levels of the CLG individually and/or as a whole), and/or buttons or other indicators that the operator can select to modify the sequence of the energy emission on the CLER. The user interfaces may also allow an operator to position the CLG, individually or as a group (e.g., using robotics), into selective areas of the targeted treatment site. Moreover, the user interfaces may be provided on a touchscreen displaying the treatment site such that the operator can mark and draw areas to be treated and/or areas to avoid treatment on the displayed treatment site.

[0122] In some embodiments, the user interfaces may be used to control a camera or other imaging system used to visualize the treatment area. To illustrate, the user interfaces may allow the operator to move the camera (e.g., in a 360° rotation), show an infrared visualization of the treatment site (e.g., recording and measuring in real-time), show a visualization of the veins of the treatment site (e.g., an AccuVein® visualization of the treatment site), and/or show a visualization of a body part different from the treatment site. Further, the user interfaces may show images from other diagnostic or imaging modalities, such as MRI images, to help the operator target areas of interest on or below the body surface.

[0123] In various embodiments, the treatment cylinder (e.g., TC 10, TC 20) may be used with one or more sensors to aid in the treatment process. The sensors may produce data relating to the operation of the phototherapy device and/or a parameter of the targeted

treatment site, as discussed in further detail herein. The one or more sensors may be integrated with the treatment cylinder or may be used separately from treatment cylinder and, for example, configured to feed back into treatment cylinder and/or the computer control unit (e.g., computer control unit 200). In various arrangements, the computer control unit may use sensor data may to control or modify the phototherapy treatment, such as by controlling the treatment cylinder to re-treat areas, move on to other areas for treatment (e.g., move the coherent light to other treatment areas), redirect the phototherapy (e.g., at least one beam of coherent light forming the phototherapy), or modify one or more settings for the phototherapy (e.g., by decreasing the power level for the therapy). More specific illustrations are discussed below.

[0124] As examples, a treatment cylinder may be used with one or more sensors to detect temperature (e.g., a skin temperature sensor, a device temperature sensor), to detect rotation of the phototherapy device (e.g., a motion detector or encoder), to detect movement of the phototherapy device or of the patient (e.g., an accelerometer, a linear variable differential transformer ("LVDT")), to detect an energy level of the phototherapy device, to detect an audible noise or a visual cue while the phototherapy device is in use, and/or to detect patient vital signs or monitor other biological or physiological systems (e.g., weight, heart rate, blood pressure, PCO_2, PO_2, CO_2). To illustrate, TC 10 may include temperature sensors positioned on rotatable member 15 to continuously capture tissue or skin temperature information before and after each CLER or CLG passes and applies energy to the treatment area. As another illustration TC 10 may be used with contact and/or non-contact temperature sensors mounted on the patient or on a control cabinet. In some embodiments, camera data (e.g., relating to a parameter of the targeted treatment site, such as the temperature of the site) may also be used similar to sensor data to modify, redirect, or otherwise control the phototherapy.

[0125] Accordingly, in some embodiments, the phototherapy device receives temperature information from one or more temperature sensors integrated into and/or separate from the phototherapy device. As such, the computer control unit may receive temperature information and may be configured to shut off the laser output at a skin temperature greater than 45°C, as determined by the one or more temperature sensors, for biological reasons (e.g., to prevent the patient's tissue from overheating and sustaining damage). Alternatively, or additionally, the treatment cylinder may include a shutter that stops the laser treatment to

protect the patient if the sensor data indicates that the device has stalled or is not rotating. However, at least some embodiments of the phototherapy device may be used for non-biological applications (e.g., industrial use), and in such embodiments the temperature could range from negative degrees to very high temperatures.

[0126] As one example, the device may be used in a non-biological application to melt metals at their T_g temperatures. Accordingly, the device configured for such applications may include a temperature sensor configured to sense high temperatures. As another example, for pin creation, the pin usually rotates to create threads. Using this device, the pin could remain stationary while the one or more laser beams rotate 360 degrees around the pin. As another example, the device may be used to cut deep channels or crevices (e.g., 3 cm deep) into and completely circumferentially around stationary steel columns (e.g., solid steel columns 200 feet long by 3 feet in diameter). As another example, the device may be used to laser a company's logo onto a steel column circumferentially (e.g., laser a logo 6 feet high by 15 feet wide onto a stationary 200-foot-long steel column 1.5 times the distance around the column). As another example, the device may be used to laser cut partially or completely through, from all sides, an existing support column embedded in a concrete foundation. This may be done using a device including a hollow structure with a clamshell configuration (e.g., as shown in FIGS. 1B and 1C), which allows the hollow structure to be enclosed around the support column. Once enclosed, the hollow structure may cut the column from all directions, individually or simultaneously, to a desired depth using the laser diodes on the hollow structure. As another example, again using a device including a hollow structure with a clamshell configuration, the hollow structure may be enclosed around a tree and used to cut down the tree in a rapid fashion. As another example, a device may be used to apply photons to the surface of an object, such as a meat carcass, to kill bacteria on the object. The photons could be topically applied in a sweeping fashion around the entire object in an ablative laser mode to kill surface bacteria or applied in a diffuse-beam mode that would penetrate several cm deep to kill live bacteria and parasites (e.g., living under flaps of fat and soft tissues not reachable by gamma radiation, which is a current method used to kill bacteria in meat carcasses).

[0127] Additionally, the treatment cylinder (e.g., TC 10, TC 20) may be used with one or more sensors and/or cameras capable of distinguishing sections of the human anatomy and facilitating the treatment cylinder in providing therapy to those sections. For example, as

noted above, the operator may be provided with user interfaces showing the patient anatomy of the treatment site. The operator can mark, label, or otherwise identify sections of the treatment site for the application of therapy, for the application of a higher level of therapy (e.g., with additional Joules, with additional wavelengths, at a different rotational speed), and/or for the avoidance of therapy using the user interfaces. As another example, the operator may mark, label, or otherwise identify these sections directly on the patient anatomy, and the computer control unit (e.g., computer control unit 200) can identify the sections based on the markings, labels, or identifications. To illustrate, the operator may mark these sections in a specific color, place radio-frequency identification ("RFID") markers around the sections, or place optical markers around these sections, and the computer control unit may identify the sections using a camera or an RFID sensor. The computer control unit may then automatically provide therapy to the identified sections, increase therapy to the identified sections (e.g., by modifying one or more therapy settings, such as the power level), and/or avoid providing therapy to the identified sections. Alternatively, the computer control unit may guide the operator in providing therapy, providing increased therapy, and/or avoiding therapy in the identified sections.

[0128] As an illustration, the operator may mark target points directly on the patient anatomy or using user interfaces corresponding to areas of more intense soft tissue tenderness (e.g., muscle tenderness or palpitation). The computer control unit may then provide increased therapy to those areas once those areas are reachable by the diodes of the rotating treatment cylinder.

[0129] In various embodiments, and as discussed above, the phototherapy device may be used with various other imaging modalities and/or treatment devices. For example, the device may be used with an MRI machine, an x-ray machine or other imaging machine like an MRI and/or a Global Positioning System ("GPS")-like locating device (e.g., that uses chips or emitting signal beads that are implanted, for example, within a probe, which is described in further detail below), a computerized tomography ("CT") scanner, an ultrasound machine, one or more operative scopes, one or more endoscopes, one or more fluoroscopes, one or more optical/visual cameras (e.g., charge-coupled device ("CCD") cameras, color sensors, or other image sensors), and/or one or more thermal cameras. In some embodiments, the computer control unit (e.g., computer control unit 200) for the phototherapy device may be configured to interface or otherwise automatically connect to

imaging and/or treatment devices to assist the operator in positioning the device, in making treatment decisions, in targeting the tissue surface, and so on.

[0130] To illustrate, the phototherapy device may include a trans-esophageal probe, and imaging modalities may be used to track the beam location with respect to targeted tissue and visualize the effects of treatment in real-tine. More specifically, a rapid CT scan may be used to help the operator visualize the effects of the phototherapy and adjust both the location and parameters for the phototherapy. Alternately, ultrasonic, endoscopic, and/or fluoroscopic imaging could be used for visualization of the tissue and the phototherapy device (e.g., a probe of the phototherapy device, as discussed below, and the probe photon emission window (e.g., the beam dimensions and direction(s)) to observe the effects of adjustments to the phototherapy. The phototherapy device may also be imaged with an x-ray machine to confirm placement of the phototherapy device (e.g., placement of a treatment cylinder or a probe tip, as discussed below) over the treatment site both pre- and post-phototherapy administration (e.g., by determining the location of the phototherapy device with respect to organs and bone structures of the patient).

[0131] In various embodiments, and as discussed above, the computer control unit (e.g., computer control unit 200) may use inputs from these various external devices and/or devices incorporated as part of the phototherapy device to produce, control, and/or modify the phototherapy (e.g., as part of a feedback control loop). For example, as shown in FIG. 2, computer control unit 200 may receive inputs from camera(s) 214 and modify treatment based on the camera location. Computer control unit 200 may use various temperature sensors 216 (e.g., thermistors, thermocouples, infrared imaging, ultraviolet imaging, etc., which may be incorporated on treatment cylinder 210, external to treatment cylinder 210, provided on a cabinet for treatment cylinder 210, etc.) to modify the therapy, such as by moving the beam if computer control unit 200 senses that the targeted tissues are becoming too hot. Computer control unit 200 may also use spectrometers or spectroscopy information indicating skin ailments, temperature, or other information about the body to modify the therapy.

[0132] Further, computer control unit 200 may use internal inputs as sensed via internal electronics (e.g., via information provided to computer control unit 200 by the CLG and/or CLER components). These internal inputs may include information about the light beam itself, including the length, width, shape, profile, and Gaussian distribution of the beam.

Computer control unit 200 may also be able to detect, via internal inputs, partial or total diode energy output failure of the CLG or inadequate and/or improper movement of one or more components of the phototherapy device (e.g., such that the treatment cylinder is not moving a specific way or speed for safe and efficacious treatment administration). If computer control unit 200 senses these issues, computer control unit 200 may immediately stop all laser output while alerting the operator by sound and/or user interfaces that an error has occurred. In this way, when phototherapy is controlled by a computer control unit, the therapy may be more optimized through feedback mechanisms, resulting in shorter dwell times and safer phototherapy delivery.

[0133] It should be understood that the various configurations and properties of the phototherapy device described above with respect to FIGS. 1-1C may also be applied to other phototherapy device embodiments, including or not including a treatment cylinder (e.g., instead including a standalone probe), described herein. For example, other embodiments of the phototherapy device may be used with one or more cameras, various user interfaces, one or more sensors, one or more imaging modalities, and/or one or more other treatment devices.

[0134] FIG. 3 shows an alternate embodiment of the treatment cylinder. As shown in FIG. 3, TC 30 can alternatively be a single member (shown) or an outer stationary member and an inner rotatable member (not shown). The CLG are optically connected to galvanometrically-controlled lens assemblies 32a, 32b, and 32c, collectively "GCLA." There is no limit as to how many GCLA can be used or how many emitters GCLA can contain, but it is required that each GCLA contain at least one coherent light emitter. The GCLA are operably connected to the computer control unit (e.g., computer control unit 200), which can use the GCLA to more precisely target the beams of coherent light generated by the CLG (e.g., as described in further detail with regard to FIG. 3A below). Galvanometrically-controlled mirrors 31a, 31b, and 31c (collectively "GCM") can allow light emitted from the GCLA to be aimed at a mirror and then reflected toward the patient as opposed to being directly aimed at the patient by the GCLA. Including the galvanometrically-controlled mirrors 31a, 31b, and 31c allows the coverage of more angles of transmission with the same or fewer GCLA and/or rotational increments of TC 30.

[0135] Similar to the CLER, the GCLA are configured to alter at least one aspect of the coherent light produced by the CLG (e.g., the optical path of the light, the diameter of the

light, the collimation of the light, etc.), except that the GCLA are more specifically galvanometrically-controlled. In some embodiments, whether through GCLA, a lens, a mirror, or another mechanism of directing light, the light to be used for the administration of phototherapy may be directed through or toward an emitter that controls its direction and directs it toward, for example, central axis of the TC 30. In general, any "beam steering" device, as that term is used in the art, whether now known or later invented, can be used to accomplish this function. This can include, without limitation, physical devices or controlled electromagnetic fields. Further, in some embodiments, the path of the light to through the emitters may end in a type of "beam conditioner," as that term is used in the art, whether now known or later invented. These beam conditioners may include, without limitation, lenses, collimators, partial mirrors, optical ports, or diffusers.

[0136] FIG. 3A shows the detail of a single light emitter component of a GCLA. Galvanometric gimbal 304 is mounted over the end of the optical connection to one of the CLG. Coherent light travels through galvanometric gimbal 304, which can be electromagnetically positioned by signals from the computer control unit (e.g., computer control unit 200). Mounted in galvanometric gimbal 304 are first diffusing lens 303, second diffusing lens 302, and collimator 301, collectively the "diffuser assembly." By controlling the position of galvanometric gimbal 304, the lens assembly can be aimed to more precisely target the coherent light generated by the CLG and direct it to the tissues to be treated. Some embodiments may include any particular number of diffusing lenses and/or collimators, but many embodiments include at least one lens or collimator so as to give the beam of coherent light the proper dispersion/diffusion to safely and effectively transmit the beam of coherent light toward the patient.

[0137] In some embodiments, TC 30 includes CLER and GCLA. Additionally, some embodiments include more than one galvanometrically-controlled emitter in a GCLA. The GCLA, the CLER, or any other emitter for coherent light used in any embodiment described herein can be configured either to maintain a constant diameter of the illuminated area where the coherent light initially strikes the patient's body or to provide a variable diameter of the illuminated area where the coherent light initially strikes the patient's body. Selecting for a constant-diameter configuration or a variable-diameter configuration can be via electromechanical control of the optical components of the emitter (e.g., via the computer control unit), or by adding or removing a collimator or diffusing element from/to the

coherent light beam's optical path where it leaves the device and enters the space between the emitter and the patient's body.

[0138] In some embodiments, the GCLA include one or more physical or electrical mechanisms for moving lens 302 on the axis of the coherent light beam toward or away from galvanometric gimbal 304 and/or collimator 301 and thus the source of the coherent light. Using this mechanism changes the net focal length of the GCLA and thus the size and energy-per-square-unit-of-area of the coherent light beam where it intersects the patient's body. The mechanism for moving lens 302 can be manually implemented by the operator or controlled by the computer control unit, either in response to a treatment plan input, a manual setting by the operator, or the computer control unit determines the optimum parameters for the delivery of phototherapy as described above or below (e.g., with reference to FIG. 6A).

[0139] FIG. 4 shows another alternate embodiment of the treatment cylinder. As shown in FIG. 4, TC 40 can alternatively be a single member (shown) or an outer stationary member and an inner rotatable member (not shown). The CLG are optically connected to galvanometrically-controlled mirror assemblies 41a and 41b, 42a and 42b, and 43a and 43b, collectively "GCMA." As opposed to the prior embodiments, the emitters of the CLG are now permanently targeted toward the GCMA. As such, the GCMA may alter at least one aspect of the coherent light produced by the CLG, such as the optical path of the coherent light.

[0140] The treatment cylinder may include a single (or at least a non-rotatable) member in an embodiment using GCMA. Alternatively, the treatment cylinder may include a rotatable member that can be used without interfering with the functioning of the device. Unless a rotatable member is used, all targeting of the coherent light beams may be performed by controlling the positions of the GCMA. Further, it should be understood GCLA and/or CLER may also be included in an embodiment including GCMA.

[0141] It should further be understood that TC 10, TC 20, TC 30, and TC 40 described above are intended to be exemplary and that a phototherapy device may include another alternate embodiment of a treatment cylinder. For example, in one embodiment, the treatment cylinder does not include a rotatable member and instead includes a fixed ring. A plurality of optical fibers is permanently or temporarily mounted on the fixed ring and

attached to a fiber-coupled laser provided with linear actuation. The plurality of optical fibers may be mounted in any desirable configuration, such as a vertical or a horizontal straight line or in a circular cluster. Additionally, the plurality of optical fibers may be mounted in a single area on the fixed ring or in multiple areas on the fixed ring. During therapy, the fixed ring remains stationary. Instead, the linear actuator moves from optical fiber to optical fiber, thereby illuminating different locations on the fixed ring, and thus the treatment site, based on the optical fiber(s) that are used by the laser. The treatment cylinder may also be mounted onto a frame holding the electronics for controlling the phototherapy device inside and including wheels for moving the treatment cylinder. This treatment cylinder configuration thus requires no rotational components and may be powered by remote electronics, although this configuration may require complex fiber insertion and placement accuracy and a treatment plan that avoids inconsistent hot spots.

[0142] In another embodiment, a treatment cylinder includes ring of a plurality of mirror assemblies (e.g., GCMA) mounted on the inside surface of a rotating member of the treatment cylinder. One or more laser inputs (which may be galvanometrically-controlled) are aimed at the mirror assemblies, which direct the emitted light to the treatment site within the treatment cylinder. The laser inputs may be external to the treatment cylinder and aimed at the ring of mirror assemblies, for example, directly or through additional mirrors on the treatment cylinder or external to the treatment cylinder configured to aim the laser inputs to the ring of mirror assemblies. In this way, the electronics are removed from the rotating member, and a stand is not required for the treatment cylinder itself to house the electronics. This embodiment may require complex software programmed into the computer control unit to ensure that the phototherapy reaches the treatment site and avoids light path interruptions.

[0143] In another embodiment, a treatment cylinder is fabricated with a gap, where one of the ends of member forming the gap is a mirror-polished end. A mirror side of the mirror-polished end may be accessible from within cladding of the member of the treatment cylinder. A laser (e.g., provided via a fiber optic cable) is inserted through the cladding of the member of the treatment cylinder into the core of the treatment cylinder. The emitted light is directed to the treatment site via the mirror-polished end (e.g., by mirror side accessible from within the cladding). The treatment cylinder rotates on a rotational axis, and all of the electronics are positioned outside of the rotational axis. Thus, this embodiment is advantageous because a stand is not required to house electronics (e.g., because at least

some of the electronics are within the cladding of the treatment cylinder itself), though this embodiment may require complex fabrication and some insertion loss of may be incurred.

[0144] In another embodiment, instead of a treatment cylinder, the phototherapy device may instead include a treatment globe. The treatment globe may be configured similarly to embodiments of the treatment cylinder discussed above (e.g., including one or more CLER, GCLA, and/or GCMA on the inside of the treatment globe, including a rotatable member) but may instead be globe-shaped. The treatment globe may be configured to rotate on one or more axes (e.g., rotate around an axis going through the center of the treatment globe). The treatment globe may also be connected to a support arm (e.g., similar to the support arms discussed below with reference to FIGS. 7-7D), allowing for further rotation and movement of the treatment globe.

[0145] In some arrangements, the treatment globe includes a single opening to the interior of the treatment globe such that the patient anatomy to be treated can be inserted through the opening into the interior of the globe. In other arrangements, the treatment globe may include an opening extending through the treatment globe such that patient anatomy may be inserted through the treatment globe. Additionally, the treatment globe may be provided with one or more caps or coverings (e.g., photon-absorbing caps or coverings) configured to fit around the opening(s) such that the patient anatomy can be inserted into the opening(s) and the caps or coverings can be used to surround the patient anatomy and close off the opening(s). In this way, photons may be absorbed by the cap or covering such that they do not escape the treatment globe. Further, the treatment globe may also be provided with other features discussed herein with reference to the treatment cylinder (e.g., sensors, user interfaces, use with various imaging modalities, etc.).

[0146] In another embodiment, instead of a treatment cylinder, the phototherapy device may instead include a treatment chamber. The treatment chamber may be cylindrical, spherical, dome-shaped, etc. Additionally, the treatment chamber may be large enough for the patient to fit entirely within the treatment chamber, or the treatment chamber may be sized to receive only a portion of the patient's anatomy. In some arrangements, the treatment chamber includes a table for the patient to rest on during the treatment procedure, and the operator may position the patient on the table according to the disease to be treated (e.g., based on where on the patient the phototherapy should be directed). The treatment chamber is further provided with a multi-mirrored surface, such as a mirrored sphere. The

multi-mirrored surface may be provided on the ceiling, wall(s), or floor of the treatment chamber. Additionally, the treatment chamber is provided with one or more laser power plants positioned on the walls or other surfaces of the treatment chamber. For example, the laser power plants may be configured similarly to the GLC discussed above (e.g., including an optical apparatus for delivering the photon beam, such as a fiber optic cable, a diffusing lens, one or more mirrors for beam reduction, and/or a beam collimator).

[0147] The laser power plants are configured to emit laser beams, and the direction of the beams may be modified via a galvanometric control by the computer control unit. Additionally or alternatively, one or more laser power plants may be provided on one or more robotic arms that are also controlled by the computer control unit. The robotic arm(s) may be mounted outside of the treatment chamber or inside the treatment chamber. In various arrangements, the laser power plants and/or robotic arms may be automatically controlled, manually controlled, or both.

[0148] In some arrangements, after the operator situates the patient on the table, the operator selects a prescribed treatment protocol from user interfaces provided to the operator (e.g., on a monitor on the outside of the treatment chamber or near the treatment chamber). Additionally, the operator may make one or more selections via the user interfaces to modify or further refine the therapy, as described above. For example, the operator can select areas shown on the user interfaces to designate sections for treatment, increased treatment, and avoiding treatment. Once the treatment has begun, at least some of the laser beams may be directed to the multi-mirrored surface, which may be stationary, turning or rotating, or moving. The target treatment site may thus receive phototherapy from one or more of the following sources: (1) directly from the laser power plants, (2) reflected off of the multi-mirrored surface (e.g., from the laser power plants mounted inside the treatment chamber and/or from the laser power plants mounted on the one or more robotic arms), and/or (3) directed by the one or more robotic arms. The phototherapy may also be applied by the operator manually, with guidance from the computer control unit, or automatically controlled by the computer control unit.

[0149] In some embodiments, a treatment cylinder may also be mounted on various types of supports. FIG. 5 shows an embodiment of a mounted treatment cylinder. TC 50 includes exterior member 52 and rotatable member 55. In some arrangements, rotatable member 55 includes welded cross-braces as shown in FIG. 5. One or more CLG are mounted on

rotatable member 55, along with one or more CLER. Accordingly, TC 50 includes CLG 57 and CLER 59. Alternatively, TC 50 may additionally or alternatively include GCLR and/or GCMA. To avoid unnecessary rotating electronics (e.g., power cords), CLG 57 may be powered, for example, through a slip ring, through induction, or through battery packs.

[0150] The entire TC 50 assembly is mounted above cabinet 500, which may be provided as part of exterior member 52 (shown) or as a separate component (not shown). Cabinet 500 may be configured to hold electronic components for TC 50, such as some or all of the components of the computer control unit for TC 50. Additionally, cabinet 500 includes wheels to increase the portability of the phototherapy device. In this way, the phototherapy device may include most or all of the electronic components in a compact fashion (e.g., on TC 50 or within cabinet 500), while preserving the through-hole design, though this embodiment may also result in rotating electronics and a complex support system.

[0151] TC 50 may be rotated through a drive system provided between TC 50 and cabinet 500. For example, in FIG. 5, the phototherapy device includes drive wheels 502 configured to rotate TC 50. The phototherapy device also includes an idle wheel 504. In some configurations, the idle wheel 504 may be spring-loaded (e.g., biased to return TC 50 to a neutral position). The drive system, including the drive wheels 502 and the idle wheel 504, is actuated by a servo motor 506 provided below TC 50. The servo motor 506 may be manually activated by the operator and/or automatically activated by the computer control unit to rotate TC 50 via drive wheels 502 and idle wheel 504.

[0152] FIGS. 5A and 5B show alternative embodiments of mounted treatment cylinders. Referring first to FIG. 5A, TC 1800 includes TC member 1802 (e.g., configured as a cylinder that is 61 cm in diameter) split into first half 1802a and second half 1802b. TC member 1802 separate into first half 1802a and second half 1802b at hinges 1804, as shown in FIG. 5A, to allow an operator to move a patient into position with respect to TC 1800, for storage, and so on. The interior sides of first half 1802a and second half 1802b in FIG. 5A illustrate alternative configurations for delivering phototherapy via TC 1800. In some arrangements, as shown on first half 1802a, TC 1800 may include rotatable member 1805 provided with a number of optical components (e.g., 30 to 40 lenses 2 cm in diameter) arranged as one or more CLER 1809. Rotatable member 1805 rotates around a track provided on the inside of TC member 1802 to deliver phototherapy generated one or more CLG (not shown). The CLG may be chosen for TC 1800 based on the power requirements

for the phototherapy (e.g., 60 W for each 2 cm lens). In other arrangements, as shown on second half 1802b, the interior of TC member 1802 may be provided with stationary optical components (e.g., 902 diffusing lenses 2 cm in diameter, which may be the most lenses required to treat the circumference of a male hip 22 cm in width with each lens capable of treating 3.14cm^2) arranged as one or more stationary CLER 1811 that provide phototherapy from one or more CLG (not shown). In other arrangements, TC 1800 may include both rotatable member 1805 (e.g., on first half 1802a) and stationary CLER 1811 (e.g., on first half 1802b). For example, TC 1800 may include 30 to 40 lenses on rotatable member 1805 on first half 1802a, with the track for rotatable member 1805 provided on just the interior of first half 1802a, and 451 stationary lenses on second half 1802b (e.g., to provide 1416 cm^2 of emitting lenses 2 cm in diameter). Additionally, TC 1800 may be mounted on cabinet 1808, which may store various electrical components for the phototherapy device (e.g., some or all of the computer control unit) and may be provided with wheels (as shown) to allow for easy transportation and positioning of TC 1800.

[0153] TC 1900 of FIG. 5B may be configured similarly to TC 1800. As shown in FIG. 5B, TC 1900 includes TC member 1902 (e.g., configured as a cylinder that is 32 cm in diameter) split into first half 1902a and second half 1902b. Similar to TC 1800, TC member 1902 may be separated into first half 1902a and second half 1902b at hinges 1904. In various arrangements, TC 1900 includes multiple rotatable members 1905, each provided with optical components arranged as CLER, represented by CLER 1909. Rotatable members 1905 rotate around a track provided on the inside of TC member 1902 to deliver phototherapy generated by one or more CLG (not shown). For example, CLER 1909 may provide a 3.0 cm beam diameter at the skin-beam interface. The track may extend all the way around the interior of TC member 1902, or the track may be divided up according to the number of rotatable members 1905 (e.g., with a track provided in each of the four quarters of TC member 1902 in FIG. 5B). TC 1900 may also be mounted on cabinet 1908 storing, for example, electrical components for the phototherapy device and/or provided with wheels (as shown).

[0154] FIG. 5C shows another alternative embodiment of a treatment cylinder. As shown, TC 2100 is similar to second half 1802b of TC 1800. Rather than including a rotatable member, TC 2100 includes stationary member 2102. The interior of stationary member 2102 is provided with a plurality of optical components 2104. For example, optical

components 2104 may be provided in a continuous stacked array across the internal surface of TC 2100 (e.g., an array of 240 to 560 optical components), as shown in FIG. 5C. In other arrangements, optical components 2104 may be provided in a different configuration, such as in rows of components 2104 spaced out from each other. Further, optical components 2104 may be provided entirely around an interior surface of stationary member 2102 (as shown), or optical components 2104 may be provided partially around or in only a band or strip of surface area around the interior surface of stationary member 2102.

[0155] In various arrangements, optical components 2104 include numerous CLG and/or numerous lenses. The CLG and/or lenses may be capable of producing (in the case of CLG) or transmitting (in the case of lenses) coherent light in one or more wavelengths towards patient anatomy provided within TC 2100. In some arrangements, optical components 2104 may be entirely or primarily CLG. In other arrangements, optical components 2104 may be entirely or primarily lenses (e.g., including a few CLG for providing the coherent light or including external CLG not mounted to TC 2100 for providing the coherent light). It should also be understood that TC 2100 may include additional types of optical components, such as mirrors (e.g., such that the interior of stationary member includes GCMA and/or GCLA).

[0156] Phototherapy in a wide range of power levels may be provided to a patient via optical components 2104 of TC 2100. As an example, the CLG and/or lenses of optical components 2104 may produce/transmit phototherapy from 0.1 W to 150 W to a targeted treatment site within TC 2100. More specifically, stationary TC 2100 may provide phototherapy to a patient by activating CLG in a particular sequence. For example, a computer control unit (e.g., computer control unit 200) may activate individual CLG of optical components 2104 to directly aim photons at a targeted treatment site, and/or to aim photons at the targeted treatment site via lenses of optical components 2104, in a pattern. As another example, the computer control unit may activate laser power sources for CLG (e.g., CLG of optical components 2104 and/or external CLG) to aim photons at the targeted treatment site in a pattern. To illustrate the foregoing, coherent beams may be directed from adjacent optical components 2104 in a sweeping motion to sequentially sweep over the targeted treatment site. However, it should be understood that coherent beams may be directed from adjacent optical components 2104 in any pattern that may provide phototherapy to the treatment site (e.g., according to a treatment plan automatically or manually selected for the patient). As such, various features and capabilities of rotating

treatment cylinder embodiments described above may be implemented in stationary TC 2100 through this individual control of CLG for TC 2100.

[0157] In some embodiments, TC 2100 may be capable of rotating as well as, or in the alternative from, providing therapy as described above. In such embodiments, TC 2100 may include a rotational member and include similar capabilities and functions as rotating treatment cylinder embodiments discussed above. Additionally, it should be understood that TC 2100 may include systems, components, functionalities, etc. of various treatment cylinders discussed above. As an example, TC 2100 may include a cooling system configured to cool portions of the phototherapy device and/or portions of a patient's anatomy.

[0158] As an example of an industrial use of a phototherapy device with a stationary or fixed treatment cylinder (e.g., TC 2100), switchgrass or pond scum may be pumped through the fixed cylinder (e.g., with the fixed cylinder serving as a "laser pipe" as part of the pumping). The fixed cylinder may then be used to apply photons to the switchgrass, or similar substrate, to accelerate the process of turning the switchgrass into motor fuel (e.g., an alternative ethanol biofuel). A similar process may also be used to accelerate or scale up the production of other substances, such as nanomaterials (e.g., fullerene) and botulinum toxin and other biomolecules often limited to micro-bench scale production. Accordingly, the fixed cylinder may be used as a laser-emitting pipe as part of a fermentation system for producing pharmaceuticals; for batch, semi-batch, semi-continuous, and continuous processing of chemical, biochemical, and/or photochemical reaction processes for pure and applied research; and for therapeutic and industrial applications involving any naturally occurring or manmade substrate.

[0159] FIG. 6 shows an embodiment of an improvement, which can be used with any of the described embodiments, including a plurality of cameras and/or spectroscopic analyzers that are in electronic communication with the computer control unit (e.g., computer control unit 200). It should be understood that spectroscopic analyzers may include a non-limiting variety of sensors and may, in some embodiments, further include cameras. Optical sensor assemblies 61, 62, and 63 individually contain cameras 61a, 62a, and 63a and spectroscopic sensors 61b, 62b, and 63b. The computer control unit follows a predefined method (e.g., as described below with reference to FIG. 6A) to use input from the optical sensor assemblies to control the administration of phototherapy. Cameras 61a, 62a, and 63a feed an optical

view of the portion of the patient's body being treated to the computer control unit (e.g., camera views of one or more areas of the targeted tissue site). Spectroscopic sensors 61b, 62b, and 63b feed spectroscopic data including infrared/temperature/reflectivity information about the portion of the patient's body being treated to the computer control unit. Also shown are CLG 67, 68, and 64, with output ports 67a, 68a, and 64a, which can be used to provide coherent light to accessories such as the probes described in association with FIGS. 8-8E.

[0160] FIG. 6A shows a method that may be implemented by the computer control unit (e.g., computer control unit 200). With reference to FIG. 6A, it should be understood that some embodiments of the phototherapy device may include fewer optical sensor assemblies (e.g., two or less). In some embodiments, such as embodiments including fewer than three optical sensor assemblies, the method may include an extra step where the computer control unit rotates the rotatable member to allow at least one optical sensor assembly to have a line-of-sight view of the area of the patient's body to be treated. Various embodiments may include one optical sensor assembly located proximately to each CLER so that the computer control unit can use data for the optical line-of-sight corresponding with that CLER to aim and control the output of coherent light from that CLER. For simplicity, FIG. 6A will discuss only those steps for using a single optical sensor assembly: if more than one optical sensor assembly is included, the method may include additional steps in which the computer control unit processes the data from the additional optical sensor assemblies.

[0161] In Step 601, camera 61a transmits an optical signal describing the portion of the patient's body present in the treatment cylinder to the computer control unit (e.g., computer control unit 200).

[0162] In Step 602, spectroscopic sensor 61b collects spectroscopic data from the portion of the patient's body and transmits it to the computer control unit. For example, spectroscopic sensor 61b may be one of various types of sensors, such as the sensors described herein, and may further be a camera.

[0163] In Step 603, the computer control unit performs optical recognition procedures upon the optical signal from camera 61a. Optical recognition procedures are well-known in the art and will not be described in detail herein. In summary, the computer control unit will look for predetermined properties of the optical signal and either process them

algorithmically against predefined geometries or compare them to a number of previously obtained and stored optical signals.

[0164] In Step 604, the computer control unit evaluates the results of the optical recognition procedures and acts upon the results thereof. Acting upon the results thereof can comprise any reasonable step, including but not limited to one or more of the following: (1) alerting the operator to move, or tell the patient to move, the portion of the patient's body to be treated to a more optimal position; (2) allowing the operator to designate, preferably by a touchscreen, the precise areas of the patient's body to be targeted by the coherent light emissions; (3) rotating the rotatable member, if included in the embodiment being used, to more precisely target the tissues to be treated; (4) adjusting the galvanometric gimbals of either GCLA or GCMA, if either is included in the embodiment being used, to more precisely target the tissues to be treated; and/or (5) extrapolating the depth of the tissues to be treated by determining the position of the portion of the patient's body to be treated and/or determining the amount of tissue the coherent light will have to traverse to reach the tissues to be treated and adjusting the power and/or duration of the output of coherent light accordingly. If the phototherapy device includes additional sensors, the output from the additional sensors may also be incorporated into the step(s) taken.

[0165] It should be understood that, in some embodiments, the computer control unit may perform one or more of the above steps automatically such that the operator or patient does not need to make adjustments. For example, the computer control unit may automatically designate areas of the patient's body to be targeted by the coherent light emission based on results of the optical recognition procedures (e.g., based on a favorable comparison to previously obtained and stored examples of treatment sites).

[0166] In Step 605, the computer control unit performs spectroscopic analysis procedures on the spectroscopic data provided by spectroscopic sensor 61b. Spectroscopic analysis procedures are well-known in the art and will not be described in detail herein. In summary, the computer control unit will evaluate the spectroscopic data for parameters including but not limited to reflectance and/or absorption, color, and emission in various spectra (e.g., active infrared analysis, which provides temperature information by extrapolation).

[0167] In Step 606, the computer control unit evaluates the results of the spectroscopic analysis procedures and acts upon the results thereof. Acting upon the results thereof can

comprise any reasonable step, including but not limited to one or more of the following: (1) automatically adjusting, or signaling a manual adjustment indication to the operator, of the power, duration, and/or wavelength of coherent light to be used to administer phototherapy based upon the estimated reflectance/absorption of the patient's skin and surface tissues; (2) automatically adjusting, or signaling a manual adjustment indication to the operator, of the power, duration, and/or wavelength of coherent light to be used to administer phototherapy based upon the estimated vascularity of the patient's skin and surface tissues; (3) if the spectroscopic analysis is performed after at least one coherent light emission, estimating the change in reflectivity/absorbance and/or vascularity of the patient's skin and surface tissues and adjusting, or signaling a manual adjustment of, the power, duration, and/or wavelength of subsequent coherent light emissions to maintain an optimal temperature; and/or (4) if the spectroscopic analysis is performed after at least one coherent light emission, measuring the temperature of the patient's skin and surface tissues and adjusting or signaling a manual adjustment of the power, duration, and/or wavelength of subsequent coherent light emissions to maintain an optimal temperature range. If the phototherapy device includes additional sensors, the output from the additional sensors may also be incorporated into the step(s) taken.

[0168] As an illustration of the foregoing, if the computer control unit is analyzing a mole, the computer control unit may analyze the patient's skin based on camera and/or spectrometer data and make adjustments to avoid harming the patient's skin. For example, the computer control can determine, via data from a camera, the patient's skin type and color based on a Fitzpatrick scale. If the patient has Fitzpatrick Skin Type V or VII, the therapy dose may be delivered more slowly due to the increased absorption of darker skin. This may be important in the 800-850 nm wavelength range when treating a patient with a higher Fitzpatrick Skin Type. Alternately, if the patient has Fitzpatrick's Skin Type I or II, the therapy dose may be administered at a higher dose and/or rate that is more rapid.

[0169] In some embodiments, the phototherapy device may include both a camera and a spectroscopic sensor. In other embodiments, only one of the two can be included in the device. If only one is included, either the computer control unit can detect that only one is present and execute only those commands and evaluations utilizing the one which is present, or the computer control unit's controlling software may not include the portions of the method of FIG. 6A that apply to the one which is not present. Accordingly, in some

embodiments, the computer control unit may recognize the presence of either or both the camera and the spectroscopic sensor and execute only those commands and evaluations utilizing whichever is present.

[0170] In an optional improvement or alternate embodiment, the phototherapy device may include an illumination mechanism. This can be the light source already included for phototherapy or a separate light source. This illumination can be used, without limitation, to enhance the steps set forth above in the following ways: (1) it can provide additional illumination to help the camera obtain a better optical signal; (2) it can provide consistent and known levels of illumination to be used in spectroscopic analysis; and/or (3) it can be used to enable Light Detection and Ranging ("LIDAR") functionality for the device, which allows the computer control unit to more precisely determine the size, position, and/or volume of the portion of the patient's body to be treated.

[0171] It should be noted that while the image data must be collected before image recognition can be performed and the computer control unit can respond to the results thereof, and likewise spectroscopic data must be collected before spectroscopic analysis can be performed and the computer control unit can respond to the results thereof, otherwise the image data collection, image recognition, spectroscopic data collection and spectroscopic analysis, and the computer control unit's response to image recognition and spectroscopic analysis can be performed in any desired order.

[0172] It should be noted that the operator can manually evaluate various relevant physical parameters of the patient and the tissues to be treated and the surface tissues above them. This information can then be input into the computer control unit, which can either recommend adjustments to the operator to be manually input as part of the treatment plan or used by the computer control unit to adjust the treatment plan automatically. These parameters could include, but are not limited to the following.

[0173] (1) The presence and nature of open wounds. It should be noted that the phototherapy device can be used to treat open wounds and speed healing through the general benefits of the administration of phototherapy. A wound may require different doses inside and outside the edges of the wound. The computer control unit may use spectrometry imaging to subsequently adjust the dose differently for each section of the wound.

[0174] (2) The presence and extent of inflammation. The dose could be adjusted manually or automatically downward in an area of intense inflammation where the targeted tissue could be absorbing more photons. As the inflammation dissipates, the administration of the photon dose could be gradually increased accordingly.

[0175] The presence and extent of skin pigmentation, either as a general property of the patient's tissue (e.g., relative levels of melanin) or specifically as to the area to be treated (e.g., the presence of birthmarks or other skin pigmentation irregularities.) For example, the computer control unit may use the Fitzpatrick scale to adjust the therapy dose, as described above.

[0176] Blood flow, temperature, and/or vascularity of the tissues. Certain wavelengths could be absorbed more readily by blood within the vessels causing coagulation problems. Blood vessels and/or the flow of blood could be visualized with infrared imaging, ultrasonic imaging, and/or other vessel structure or blood flow imaging technologies and could be avoided and prevented from receiving incoming photons. These imaging techniques could also detect the temperature of the vessels to allow for real-time adjustments in dose, rate, etc.

[0177] Size and distance of the tissues to be treated from the CLER or other emitter location, including the presence and extent of atypically thick or thin skin. The beam's size and the beam's distance, if the beam is not collimated, to the targeted tissues could be adjusted given the thickness of the skin, which can vary given the patient's weight, etc. CLER or other emitter devices could detect these variations in skin thickness, and the operator can manually change the treatment dose inputs or the computer control unit can adjust the treatment dose automatically.

[0178] Reflectivity (albedo) of the patient's skin. If the spectrometer detects an abnormal reflection on or around the targeted tissue (e.g., there is an unknown gel or cream on the skin), steps can be taken before or during the administration to remove or avoid this reflectivity or account for this in the treatment dose inputs to this reflective area.

[0179] Weight of the patient and thickness of adipose tissue. A person of higher weight, such an obese person, with a thicker layer of fat tissue will have a greater distance between the skin surface and targeted tissue. Therefore, a similar therapeutic dose, relative to a thin person, within the abdominal muscles will require a higher input delivery at the beam/skin

surface interface. For example, when treating the abdominal wall of an obese person, the treatment cylinder might have to rotate twice as many times, thereby delivering a radiant exposure of 12 J/cm^2 onto the skin surface, as opposed to the 6 J/cm^2 radiant exposure onto the skin surface used for a thin person, in order to get the same dose within the abdominal wall muscles and/or the target treatment area of the obese patient.

[0180] FIG. 7 shows an embodiment of an improvement including a horizontally rotatable gantry assembly for a treatment cylinder. TC 70 is mounted in bracket 77, which is mounted on horizontal arm 72 and which is, in turn, mounted on vertical member 75. The whole assembly is mounted on base 76. (TC 70 is shown separate from bracket 77 for ease of review; normally it is mounted inside bracket 77.) TC 70 has gap 716 through which the portion of the patient's body to be treated can travel and then be closed with cap 714. By rotating horizontal arm 72 and/or rotating base 76 on casters 760a, 760b, 760c, and 760d, any portion of the patient's body, whether the patient is standing, sitting, lying or reclining, can easily and comfortably be introduced into TC 70 through gap 716. As such, TC 70 may be moved in one or more degrees of freedom due to this support structure. Drivers 721 interface with rotators 720 to rotate the components of TC 70 relative to each other.

[0181] In some embodiments, the phototherapy device according to FIG. 7 may include a cap (not shown, see FIG. 1) or an enclosing cabinet (not shown) to prevent the escape of coherent light from gap 716 and/or potential damage to the phototherapy device by the insertion of foreign objects that may prevent the rotation of TC 70 or otherwise interfere with moving parts thereof.

[0182] Also shown in FIG. 7 are optional additional CLG 750 and 751, which can be used to provide coherent light to accessories such as the probes shown in FIGS. 8-8E. CLG 750 and 751 may be located such that they will not interfere with the travel of horizontal arm 72, whether above its highest vertical travel or below its lowest vertical travel (the latter is shown). Additionally, optional control panel 770 is mounted on top of vertical member 75. Control panel 770 interfaces with and/or includes the computer control unit. Control panel 770 also controls the movement and rotation of the components of the gantry assembly and includes a display screen (e.g., a touchscreen) and/or control input devices such as buttons, dials, etc.

[0183] However, it should be understood that a treatment cylinder may be provided with a different support system from bracket 77 mounted on horizontal arm 72 on base 76, as shown in FIG. 7. For example, in one embodiment, a treatment cylinder is provided with one open end. The other end is closed and mounted on a support (e.g., similar to horizontal arm 72). The treatment cylinder includes one or more CLER, GCLA, and/or GCMA as described above. One or more power supplies for the CLG of the CLER, GCLA, and/or GCMA may be provided on the outside of the treatment cylinder. Additionally, power for the treatment cylinder as a whole may be provided via the support and the closed end (e.g., through cables connecting to a power source and running through the support and the closed end to the treatment cylinder). To use the treatment cylinder, the tissue to be treated is inserted through the open end into the interior of the cylinder. For example, the treatment cylinder may be 70 cm in diameter and thus sized to receive a limb of a patient.

[0184] Accordingly, this embodiment includes a clear support system for the treatment cylinder. This embodiment also includes simple connections, for example, to the power source for powering the treatment cylinder and associated electronics (e.g., the CLER, GCLA, and/or GCMA), although the patient tissue to be treated must be entirely receivable in the interior of the treatment cylinder due to the closed end and at least some of the electronics may need to be configured to remain unaffected by rotation of the treatment cylinder (e.g., the laser power supply provided on the outside of the treatment cylinder). Variations of this embodiment may include using slip rings to input the power and light into the treatment cylinder and inputting the light through the support and the closed end (e.g., by running a fiber optic cable through the support and closed end).

[0185] FIGS. 7A-7D show another embodiment of a treatment cylinder mounted on a support. TC 310 includes an exterior member 312 and a rotatable member 315. Additionally, TC 310 includes a number of CLG, represented by CLG 317, positioned around the interior of TC 310. Any number of CLG may be used, such as the configuration of six sets of three laser diodes as shown in FIGS. 7A-7D. The CLG are connected to CLER, represented by CLER 319, also positioned around the interior of TC 310. Alternatively, the CLG may be connected to GCLA and/or GCMA positioned around the interior of TC 310. The CLER, GCLA, and/or GCMA are shown as emitting coherent light beams, represented by beam 331.

[0186] Specifically, the CLER, GCLA, and/or GCMA are positioned on diode mounts, represented by diode mount 330. The diode mounts may be configured to allow the CLER, GLCA, and/or GCMA to be moved into and away from the interior of TC 10 (e.g., through galvanometric controls). Each diode mount is further positioned on a diode track, represented by diode track 332. The diode track enables the diode mount, and the CLER, GLCA, and/or GCMA on the diode mount, to be moved along the rail toward each of the open ends of TC 10. Additionally, the diode tracks are provided on rotatable member 315. In some arrangements, the diode tracks are stationary on rotatable member 315, and the diode tracks may be moved circumferentially around TC 10 by rotating rotatable member 315 as a whole. In other arrangements, the diode tracks may be individually moved around rotatable member 315 (e.g., rotatable member 315 may itself be a rail for the diode tracks). In such arrangements, rotatable member 315 may be stationary or may also be rotatable such that the diode tracks may all be rotated together. In this way, the emitted light beams may be manipulated around the patient anatomy inserted into the center of TC 10 to provide optimal therapy.

[0187] Furthermore, TC 10 as a whole is mounted onto a support system 334. Support system 334 includes vertical track 336 extending from a base of the support system 334; the base may be provided with wheels to facilitate maneuverability of phototherapy device as shown in FIGS. 7A-7C. Similarly, TC 10 includes a crossbar 338 extending across the width of TC 10. Crossbar 338 is mounted onto vertical track 336 via mounting plate 340. As shown in FIGS. 7A-7C, mounting plate 340 may be coupled to vertical track 336 such that mounting plate 340 can (1) rotate with respect to the plane parallel to mounting plate 340 (e.g., rotate in 360 degrees) and (2) move vertically along vertical track 336. As such, mounting plate 340 provides movement in multiple degrees of freedom to TC 10, which may assist an operator and/or the computer control unit (e.g., the computer control unit 200) in positioning TC 10 over the targeted treatment site.

[0188] FIG. 8 shows an embodiment of a handheld probe. In some arrangements, the handheld probe may work in conjunction with a treatment cylinder (e.g., TC 10, TC 20, TC 30, TC 40, TC 50, TC 70, and/or TC 310 described above). Probe 80 has optical conduit 82, which is optically connected to one or more CLG of any of the embodiments of the treatment cylinder discussed above. If each of the CLG connected to probe 80 emits a different wavelength, this allows the operator to select the CLG that emits the desired

wavelength of coherent light for a given course of treatment. If the CLG are mounted on the rotatable member of the treatment cylinder connected to probe 80, in an embodiment that uses a rotatable member, the rotatable member may be configured to be kept stationary when using probe 80 so that the connection of the CLG to probe 80 will be stable. Alternatively, in some arrangements, probe 80 may be incorporated into a compartment external to the treatment cylinder as part of a standalone machine that could be connected to, or implemented with, the treatment cylinder through one or more fiber optic cables or through laser-beam emitting and beam energy collection devices. As yet another alternative, in some arrangements, probe 80 may be implemented as an entirely standalone device not connected to a treatment cylinder and instead connected to one or more independent CLG. In some embodiments, the CLG optically connected to the probe is a 10 W or more laser diode (e.g., capable of providing 4-12 J/cm^2 or more of radiant exposure per treatment). In other embodiments, the CLG optically connected to the probe is a 2-15 W laser diode.

[0189] Coherent light from the CLG (not shown, see previous figures) travels into the body of probe 80 and to diffuser element 83, which diffuses it to a predetermined beam diameter. The diffused coherent light then travels through diffusing chamber 87, where it continues to spread, and then into collimator 84, which redirects the coherent light into a consistent and well-defined beam with a constant circular cross-section. The coherent light beam then travels to mirror 85 and is directed out of the body of probe 80 through portal 86 at the tip of probe 80. Portal 86 may be optically neutral or may have the property of diffusing or concentrating the beam, as is appropriate in any particular therapeutic application. For example, in some embodiments, portal 86 incorporate a second diffuser element (e.g. a lens) that further diffuses the beam, as probe 80 may be built on a scale such that the beam will still be quite small when it emerges from portal 86.

[0190] In some embodiments, the end or tip of probe 80 may be an open system such that there is an open air space bridge between the end of the emitting lens and the surface of the mucosa or skin surface being treated. Alternatively, in other embodiments, the end or tip of probe 80 may be a closed system such that a lens or transparent glass or plastic surface is in direct contact with the receiving mucosal or skin surface. Additionally, it should be understood that while probe 80 of FIG. 8 is described with reference to a single portal 86, other embodiments of probe 80 may include additional portals 86.

[0191] In various embodiments, probe 80 may be configured to include various additions or changes to manipulate and/or configure the emissions from probe 80. These additions may include the following: differently-shaped or different types of lenses (e.g., a diffusing lens, a mirror, a convex lens, a concaved lens, a dome lens, a flat lens), prisms (e.g., to change the shape of the beam), coils, fiber direct illumination, direct illumination from LEDs, other types of diodes or other energy-emitting devices, or reflections from differently shaped mirrors to change the beam profile (e.g., such that the emitted beam is in a circular, oval rectangular, linear, square, or other shape). Moreover, more than one of these additions/changes may be used simultaneously. Probe 80 may also receive one or more fiber optic cables (e.g., having a diameter less than 2 mm, of 2 mm, or greater than 2 mm) rather than having light emitted into probe 80. These additions may, for example, change the profile, diffusion, shape, and/or frequency of the emitted light beam. Alternatively, in some embodiments, probe 80 may include a straight light pathway for the beam with no changes or modifications.

[0192] Furthermore, in various embodiments, the emitted wavelength is collimated, though it should be understood that the emitted wavelength may alternatively be non-collimated. The emitted beam may also have various diameters or widths, such as less than 2 cm, equal to 2 cm, or greater than 2 cm. The emitted beam may also be configured such that the diffused beam diameter at the mucosa or skin/mucosa interface is less than 3 cm or greater than 3 cm. Further, the light used in probe 80 may be energized, for example, through batteries, direct coupling of energy, or induction charging.

[0193] To use probe 80, a human operator, a robotic operator (e.g., a robotic arm), or other manual or automated positioning system (e.g., all of which may be considered an "operator" with respect to probe 80) grips probe 80 and positions probe 80 to direct coherent light onto the tissues to be treated. Examples of grips that may be included in probe 80 include upper grips and lower grips configured for proper handling. The operator manipulates the end of probe 80 emitting phototherapy through portal 86 toward the targeted tissue site. The operator then engages a power switch, which may be on or within the probe, attached to or within a fiber optic cable harness, or a wireless switch (e.g., the operator may switch on the power via a mobile device). Once powered on, light flows from the CLG and is emitted through portal 86 (e.g., at any angle and at any power output, such

as watts or Joules, depending on the configuration of probe 80 and parameters used for the therapy).

[0194] Delivery of phototherapy from probe 80 may be partially or fully controlled by the computer control unit (e.g., computer control unit 200), similar to the treatment cylinder as described above. Furthermore, various aspects of the treatment cylinder embodiments and operation of the treatment cylinder embodiments discussed above may be applied to probe 80, such as use of the probe with one or more cameras, user interfaces, one or more sensors, one or more imaging modalities, and/or one or more external treatment devices. For example, the probe may include a temperature sensor at the tip or surrounding one or more portals of the probe. Any sensors implemented in the probe may be in constant contact with the computer control system (e.g., via a wireless or wired connection).

[0195] While the probe (e.g., probe 80) can be used for surface treatments/on the exterior of the body, in various embodiments the probe is used for the delivery of coherent light to the inner core of the body not reachable by transdermal or transepithelial means. The probe can be used to deliver coherent light to the interior of the body by any reasonable means and/or through any suitable orifice, including but not limited to the following methods: (1) transesophageal insertion, which allows treatment of the interior of the mouth, the throat, the esophagus, and the interior of the torso, including the pericardial area, and further allows transintestinal insertion, allowing treatment of the intestines and other tissues proximate to the intestines; (2) transvaginal insertion, which allows treatment of the vaginal canal, the cervix, and with dilation if necessary, the uterus and other tissues proximate to the vagina and uterus; (3) transrectal insertion, which allows treatment of the rectum and other tissues proximate to the rectum, and further allows transintestinal insertion, allowing treatment of the intestines and other tissues proximate to the intestines; and/or (4) transbronchial insertion, which allows treatment of the lungs and other tissues proximate to the lungs.

[0196] In addition, the probe (e.g., probe 80) may be configured for, or configured to be modified for, insertion into the patient as a transureteral probe, a transnasal probe, a transcolonic probe, transauricular canal probe, transpharyngeal probe, translaryngeal probe, transluminal or orifice probe, intervascular probe, and joint or intermuscular probe, subcutaneous or subdermal probe. The probe may further be a handheld or robotically-controlled probe for open cavity surgery. Additionally, in some embodiments, the probe

may be incorporated as part of an injectable subdermal, dermal, or deeper injection device, including an inter-joint injectable delivery device.

[0197] In some embodiments, an illuminated endoscope (not shown) may be included in the body of probe 80, such that the operator can see exactly where the coherent energy will leave portal 86 and enter the patient's tissues. For example, an illuminated endoscope may be included in the transesophageal configuration of the probe. In some embodiments, a standard flexible endoscopy system may be used to control the position of probe 80. If this is done, the standard flexible endoscopy system attaches to probe 80 somewhere under semi-rigid sleeve 81. Semi-rigid sleeve 81 then rolls up and over the connection, sealing it and allowing probe 80 to be directed by the standard flexible endoscopy system.

[0198] In some embodiments, the probe (e.g., probe 80) may be introduced into the body through an incision instead of a natural orifice. Such incision, and operation of the probe through it, may be performed by a medical doctor or someone trained and legally authorized to perform such a procedure. With a properly sized probe, introduction can be made via catheterization of a blood vessel, allowing treatment of the circulatory tissues and other tissues proximate to the circulatory system up to and including cardiac catheterization and treatment. Such catheterization, and operation of the probe through it, may be performed by a medical doctor or someone trained and legally authorized to perform such a procedure.

[0199] Each probe may include a unique identifier. This identifier could include, without limitation, a permanently or semi-permanently affixed bar code or QR code, a permanently or semi-permanently affixed RFID tag, or an integrated circuit of some kind that can be queried to retrieve an identification parameter, such as a number or string of characters permanently or semi-permanently stored on the integrated circuit, by a wired or wireless connection. In some embodiments, the unique identifier may be associated with a particular patient, such that during that patient's course of treatment with the device, that probe is used only for that patient. This can be done by any reasonable manner, from making a note in the patient's medical records as to the unique identifier of that patient's associated probe, to including software in the computer control unit that retrieves the unique identifier and checks it (e.g., against a patient identification database) and advises the operator whether the correct probe is being used, to including software in the computer control unit that will not allow the device to send coherent light from the CLG to the probe unless the probe's unique identifier matches a unique identifier associated with the patient (e.g., an optically

readable code or an RFID tag on a standard medical info bracelet). In some embodiments, the probe could even require information or biometric conformation from the patient prior to use, such as reading a fingerprint from the patient or asking the operator to input information requested from the patient that only the patient would know.

[0200] In some embodiments, the unique identifier described above may be used to track the usage of the probe and to ensure that it is not used more times than is recommended by the manufacturer and/or that it is not used for a longer period after the initial use than is recommended by the manufacturer. For instance, the unique identifier can be tracked each time the probe is used, and after the sixth time, the computer control unit can advise the operator and/or not allow coherent light to be sent from the CLG to the probe. Similarly, the first day the unique identifier is used can be tracked, and after fifteen days, the computer control unit can advise the operator and/or not allow coherent light to be sent from the CLG to the probe.

[0201] In some embodiments, the probe may include a control chip that can be screwed/inserted into the handle of probe. The control chip allows a certain number of photon treatments to be administered through probe before the photon energy emission is automatically turned off through a wired or wireless connection to the source of the laser used for probe (e.g., similar to treatment cylinder with an identification number or code, as discussed above). Alternatively, a closing aperture system may close an aperture within probe or external to probe after a certain number of treatments, where the closing of the aperture prevents the emission of the photon beam down the fiber optic network connected to and through probe.

[0202] In some embodiments, the probe is configured for disposal after one or more uses. Alternatively, in other embodiments, the probe may be reusable on the same patient and/or for multiple patients after cleaning and sterilization.

[0203] If the probe is small and/or flexible enough, it can be further inserted, like an endoscope, into the intestines and eventually allow the delivery of phototherapy to almost every volume of tissue inside the abdominal cavity. A sufficiently small and flexible probe can also be inserted transurethrally, allowing treatment of the urethra, the bladder, and other tissues proximate to those organs such as the kidneys. Accordingly, the size of the probe may be provided as follows: (1) the length of the probe could be less than a rigid anoscope

or more than a flexible colonoscope; (2) the width of the probe (e.g., a shaft of the probe, the end of the probe, portions of the probe, or the entire probe) could be less than 1 cm, up to 5 cm, or greater than 5 cm (e.g., the diameter of the probe could be 0.5 to 2 cm or near the diameter of existing rigid scopes or flexible scopes, such as an EGD scope or sigmoidoscope); and (3) the probe (e.g., the shaft, the end, portions, or the entire probe) could allow for no rotation, less than 90 degrees of rotation, up to 90-180 degrees of rotation, or up to 210 degrees of rotation.

[0204] Accordingly, various objectives of the probe (e.g., probe 80) can be summarized as follows. The probe acts as a device for administering precision phototherapy. As described above, the therapy may be applied via the probe either manually or robotically (e.g., controlled by the computer control unit, controlled by a robotic arm). More specifically, the probe serves as a device for administering precision phototherapy that is inserted into a lumen or an orifice of the body to provide treatment via precise targeting of the treatment site, which may be any area of the body. The probe may also be used during open surgery, or the probe may be used with endoscopic procedures. The probe may thus safely and efficiently administer the highest amount of phototherapeutic energy into deep, diseased soft tissues. When used with imaging modalities that scan the body of the patient being treated, the probe may be used to automatically target the tissues to be treated while adjusting the energy of the phototherapy accordingly (e.g., via automatic control by the computer control unit or recommended steps provided by the computer control unit). The probe may also serve as a device for administering precision phototherapy that can simultaneously deliver light of multiple wavelengths to the tissues to be treated.

[0205] Additionally, the probe (e.g., probe 80) may be used with one or more agents, chemicals, or substances that cool the treatment area, numb the treatment area, cause the treatment area to be less reflective to incoming photons, vasoconstrict the treatment area, and/or block or absorb part or all of the delivered photons, as similar to the process discussed above with reference to the treatment cylinder. For example, a substance or agent may be applied to the probe's tip or onto the surfaces of the targeted treatment site before photons are delivered to the targeted treatment site. As an illustration, a laser-photon coupling gel and/or a gel or oil mixed with phenylephrine could be placed on the tip of a transvaginal probe or inserted into the vagina minutes before administering PBMT photons transvaginally into the pelvis. The clear coupling gel or oil could help the photons travel,

with less deflection and reflection off the mucosal surfaces of the vagina, thus allowing more photons to eventually propagate into the deeper pelvic structures where disease states may exist. The phenylephrine could also temporarily vasoconstrict the blood vessels within the vaginal mucosa causing mucosal blanching and thus providing a vaginal mucosa environment with less blood flow and less hemoglobin. Having less hemoglobin at the interface between the vaginal mucosal surface and submucosal tissues allows the photons from a 980 nm diffused beam to propagate into the deeper structures and tissues within the chosen targeted treatment site within the pelvis, as discussed above.

[0206] FIG. 8A shows an alternate embodiment for the probe (e.g., a configuration meant for transvaginal or transrectal use). For example, probe 830 may be connected to a treatment cylinder (e.g., TC 10, TC 20, TC 30, TC 40, TC 50, TC 70, and/or TC 310 described above), allowing for simultaneous delivery of PBMT energies into the pelvis and into the lower abdomen topically or transdermally through the suprapubic area via transvaginal probe 80. Alternatively, probe 830 may be used as a standalone device with a separate light source. It should be understood that probe 830 of FIG. 8A may include any and all of the features described above with reference to probe 80. Moreover, it should be understood that probe 830 may be configured to be or may be modified to be used as a probe in other areas of the body, such as a transesophageal probe or a transbronchial probe.

[0207] Fiber optic cable 835 optically connects probe 830 with a CLG (not shown; see, e.g., FIGS. 1, 5, or 7). Coherent light flows through interior fiber optic 839 within body 840 and reaches first diffusing lens 836, where it is diffused and then directed toward mirror 837. Alternatively, in some arrangements, lens 836 may not be a "diffusing lens" but be used to shape the light to illuminate in a predictable pattern without being diffusing by definition. Mirror 837 in turn directs the coherent light through convex diffusing dome lens 838, where it is transmitted to the tissues to be treated. In some embodiments, the light emerging from diffusing lens 836 is divergent. In other embodiments, the light emerging from diffusing lens 836 may be a diffuse beam that is collimated prior to delivery of the beam/photons to the targeted tissue's surface. Furthermore, in some embodiments, the coherent light beam must be diffused by the end of its travel through probe 830. If diffusing lens 836 does not diffuse the beam significantly or at all, the optical properties of mirror 837 and/or convex diffusing dome lens 838 may need to be adjusted to produce the net diffusion desired.

[0208] The use of first diffusing lens 836, mirror 837 and convex diffusing dome lens 838 allows a very small fiber optic to be used (e.g., for most handheld applications, the fiber optic will be approximately 2 mm in diameter) and for the body of the probe to thus be smaller while producing a large and controlled diffused output of coherent light. For most handheld applications, the probe can be approximately 2 cm in diameter, the convex diffusing dome lens 838 adding only slightly to the effective diameter, and yet an effective diffused beam of at least 3 cm in diameter is readily produced for the treatment of tissues with phototherapy.

[0209] To use the probe, the operator holds probe 830 in the area of upper grips 833 and lower grips 834. Alternatively, and as described above with reference to probe 80, probe 830 may be configured to receive a rigid or flexible endoscope, and the operator may manipulate the endoscope to manipulate probe 830. The operator then inserts probe 830 (e.g., according to the medical best practices for such insertions) into the patient's vagina and aims it at the tissues to be treated. The operator then engages power switch 832. This sends a signal to the computer control unit to energize the CLG (not shown) to which fiber optic cable 835 is attached and begins the flow of coherent light into the probe. The coherent light is then delivered according to the treatment plan input and/or any manual control inputs made by the operator.

[0210] FIG. 8B shows another alternate embodiment for a probe. As with the probes discussed above, probe 930 may be configured for use with a treatment cylinder or may be configured as a standalone device with a separate light source. Additionally, probe 930 may include all the features described above with reference to probes 80 and 830 and may be modified to be used in various areas of the body.

[0211] Probe 930 is generally similar to probe 830, with a fiber optic cable connecting probe 930 to a CLG via fiber optic cable interface 935. Coherent light flows through interior fiber optic 939 within body 940 and reaches first diffusing lens 936, where it is diffused. However, probe 930 does not include a mirror; instead the coherent light is directed straight to convex diffusing dome lens 938. The light may also pass through one or more additional lenses (e.g., diffusing lenses, diffusing mirrors) or other optical elements before reaching convex diffusing dome lens 938. As such, similar to probe 830, the use of first diffusing lens and convex diffusing dome lens 938 allow a very small fiber optic to be used to still produce an emitted beam 942 with a diameter sufficient for the phototherapy application.

[0212] However, body 940 of probe 930 differs from probe 830 in that body 940 is more curved, particularly at the tip where emitted beam 942 emerges from probe 930. For example, the tip may be at a 30 degree curve from the rest of body 940. Additionally, probe 930 includes ergonomic bottom grips 934 and a button 932 (e.g., that the operator can press to turn probe 930 on and thereby provide phototherapy).

[0213] FIGS. 8C-8E show another alternate embodiment for a probe. As with the probes discussed above, probe 1030 may be configured for use with a treatment cylinder or may be configured as a standalone device with a separate light source. Additionally, probe 1030 may include all of the features described above with reference to probes 80, 830, and 930 and may be modified to be used in various areas of the body.

[0214] Probe 1030 is generally similar to probe 930, with a fiber optic cable connecting probe 1030 to a CLG via fiber optic cable interface 1035. Coherent light flows through interior fiber optic 1039 within body 1040 and reaches first diffusing lens 1036, where it is diffused. The coherent light is also directed to convex diffusing dome lens 1038, where it is emitted as beam 1042 (e.g., as shown in more detail in FIG. 8E, illustrating the tip of probe 1030). Before being emitted, the beam may also pass through one or more additional lenses or other optical elements.

[0215] Body 1040 of probe 1030 is also similar to body 940 of probe 930, though is more streamlined than body 940 of probe 930. Body 1040 additionally includes ergonomic grips 1034, which held the operator control and maneuver the photon-emitting tip of probe 1030. Further, the thumb indentation at the 11 o'clock position in ergonomic grips 1034 helps the operator of probe 1030 to better sense the location and direction of the upward curve (e.g., 30 degree curve) of the tip of probe 1030, for example, toward targeted pelvic organs and/or pelvic floor muscles and structures if probe 1030 is used as a transvaginal probe. Body 1040 also includes a button 1032 (e.g., that the operator can press to turn probe 930 on and thereby provide phototherapy).

[0216] These alternate probe embodiments may be further modified to include desirable features for providing phototherapy. For example, body 1040 of probe 1030 may include one or more openings for cooling a portion of probe 1030 (e.g., on or near the handle of probe 1030, incorporated as part of interface 1035). Stainless steel tubing forming one or more channels within body 1040 of probe 1030 may be connected to the opening(s) to

transport, for instance, water coolant, compressed CO_2 gas, or chilled air from a source external to probe 1030, through probe 1030, and out again. The tubing may be configured to cool the targeted tissues (e.g., through an opening in convex diffusing dome lens 1038), the tip of probe 1030 (e.g., convex diffusing dome lens 1038), and/or first diffusing lens 1036 and any other optical components housed in the tip of probe 1030 (e.g., a diffusing mirror). In some arrangements, more than one section of tubing may be provided to cool probe 1030, and the different sections may be of different calibers (e.g., with smaller-diameter tubing used to transport a coolant into probe 1030 and with larger-diameter tubing used to transport used coolant out of probe 1030). Alternatively, a refrigerant coil may be provided at the base of probe 1030 and/or within the wall at the connection between body 1040 of probe 1030 and convex diffusing dome lens 1038.

[0217] In some embodiments, probe 1030 may house a temperature sensor near the optical components of the tip to detect any heat buildup with these beam-interfacing components. For example, a temperature sensor may be provided on an external surface of convex diffusing dome lens 1038 (e.g., with an insulating layer between the sensor and lens 1038) to monitor, for instance, the vaginal mucosa being treated. As another example, a ring temperature sensor could be provided around the base of lens 1038 to measure the temperature underneath convex diffusing dome lens 1038. As another example, a temperature sensor may be provided within a chamber positioned before first diffusing lens 1036 to measure the temperature at the connection between interior fiber optic 1039 and the optical assembly within probe 1030. In response to detecting heat buildup via the temperature sensor, for example, the computer control unit may automatically shut down operation of probe 1030 or warn the operator of the potential heat buildup.

[0218] FIGS. 8F-8H show additional alternate embodiments for a probe. As with the probes discussed above, probe 1230, probe 1330, and probe 1430 may be configured for use with a treatment cylinder or may be configured as standalone devices with separate light sources. Additionally, probe 1230, probe 1330, and 1430 may include all of the features described above with reference to probes 80, 830, 930, and 1130 and may be modified to be used in various areas of the body.

[0219] Referring first to FIG. 8F and probe 1230, probe 1230 is generally similar to probe 1030 and probe 930, with a fiber optic cable connecting to probe 1230 (not shown). Coherent light flows through interior fiber optic 1239 within body 1240 and reaches first

diffusing lens 1236, where it is diffused into diffused beam 1242. The coherent light is also directed to convex diffusing dome lens 1238, where it is emitted from the tip of probe 1230. In some arrangements, before being emitted, the beam may also pass through one or more additional lenses or other optical elements. However, as shown in FIG. 8F, dome lens 1238 is much smaller than, for example, dome lens 938 of probe 930 and dome lens 1038 of probe 1030 (e.g., dome lens 1238 being 2.5 mm high, being 5 mm high). Additionally, the tip of probe 1230 is provided with one or more temperature sensors 1244 drilled into the side of the probe (e.g., such that temperature sensors 1244 extend up to 2 mm above the base of dome lens 1038). Wires 1246 connecting to temperature sensors 1244 may be provided within probe 1230, external to probe 1230 (as shown), or extending from within probe 1230 to the exterior. The configuration of the smaller dome lens 1238 and temperature sensors 1244 may allow temperature sensors 1244 to more easily contact and collect temperature data from vaginal mucosal wall 1248 or cervix 1250 while keeping temperature sensors 1244 isolated from the components of probe 1230 that also create heat.

[0220] Probe 1330 of FIG. 8G is configured similarly to probe 1230, with interior fiber optic 1339 extending through body 1340. However, interior fiber optic 1339 ends by emitting the coherent light of interior fiber optic 1339 on first diffusing mirror 1336 positioned on the side of the interior of probe 1330 (e.g., near the upward curve at the tip), with first diffusing mirror 1336 directing the coherent light as diffused beam 1342 to convex diffusing dome lens 1338 and out of probe 1330. In some arrangements, before being emitted, the beam may also pass through one or more additional lenses or other optical elements. Similar to dome lens 1238, convex diffusing dome lens 1338 is much smaller than, for example, dome lens 938 of probe 930 and dome lens 1038 of probe 1030, but dome lens also has a larger diameter than dome lens 1238 of probe 1230 (e.g., 2.9 cm diameter instead of 2.5 cm diameter). The larger diameter of dome lens 1338 may allow dome lens 1338 to sit on top of the tip of probe 1330 (e.g., glued to the top of probe 1330). Surrounding dome lens 1338 around the circumference of body 1340 is plastic end ring 1352. End ring 1352 may help secure dome lens on the tip of probe 1330. Additionally, as shown in FIG. 8F, end ring 1352 may have a thickness wide enough that one or more holes can be drilled lengthwise through end ring 1352 and one or more temperature sensors 1344 may be inserted through the hole(s). Wires 1346 connecting to temperature sensors 1344 may be provided within probe 1330, external to probe 1330 (as shown), or extending from within probe 1330 to the exterior. Similar to probe 1230, this configuration of end ring

1352, temperature sensors 1344, and dome lens 1338 may allow temperature sensors 1344 to more easily contact and collect temperature data from vaginal mucosal wall 1248 or cervix 1250 while keeping temperature sensors 1344 isolated from the components of probe 1330 that also create heat.

[0221] As discussed above, embodiments of the probe may include a cooling structure. For example, in some arrangements, probe 1230, probe 1330, or a similar probe may include a cooling structure, such as a Peltier thermoelectric cooler cylinder or another structure described above with reference to the treatment cylinder, provided on or around the circumference of the probe just before or past a point where the coherent light is diffused (e.g., past first diffusing lens 1236 in probe 1230 or past first diffusing mirror 1336 in probe 1230). The cooling structure may be used to prevent patient tissues from reaching temperatures above 45°C.

[0222] Probe 1430 of FIG. 8H is configured similarly to probe 1230 and probe 1330, with interior fiber optic 1439 extending through body 1440, and interior fiber optic 1439 ends by emitting the coherent light of interior fiber optic 1439 on first diffusing mirror 1436a (e.g., a stage 1 convex diffusing mirror) positioned on the side of the interior of probe 1430. However, in probe 1430, first diffusing mirror 1436a diffuses and redirects the coherent light to second diffusing mirror 1436b (e.g., a stage 2 convex diffusing mirror). Second diffusing mirror 1436b redirects the coherent light as diffused beam 1442 to convex diffusing dome lens 1438 and out of probe 1430. In some arrangements, before being emitted, the beam may also pass through one or more additional lenses or other optical elements. Similar to dome lens 1238 and dome lens 1338, convex diffusing dome lens 1338 is much smaller than, for example, dome lens 938 of probe 930 and dome lens 1038 of probe 1030. Dome lens 1438 may be sized to fit on the end of probe 1430 (e.g., 2.5 cm in diameter and 2.5 mm in height). The tip of probe 1430 is also provided with multiple temperature sensors, similar to probe 1230 and probe 1330. For example, as shown in FIG. 8H, probe 1430 includes first temperature sensor 1444a is positioned at the edge of come lens 1438 and extends up to the same height as dome lens 1438 (e.g., 2.5 mm in height). As such, first temperature sensor 1444a may be used to capture the vaginal mucosa temperature distally (e.g., distal from the vaginal mucosa when probe 1430 is curved towards the vaginal mucosa as shown in FIG. 8H). Probe 1430 also includes second temperature sensor 1444b positioned lower than the top of dome lens 1438 (e.g., 1.5 mm in height), with the second

temperature sensor 1444b configured to capture the vaginal mucosa temperature proximally (e.g., proximal to the vaginal when probe 1430 is curved towards the vaginal mucosa as shown in FIG. 8H).

[0223] It should be understood that other embodiments of the probe may also include more and/or different types of optical component from the optical components shown with respect to probe 1230, probe 1330, and probe 1430. For example, instead of a dome lens, any of these probe embodiments may include a glass dome or an acrylic dome that encloses the tip of the probe.

[0224] FIG. 8I shows another alternate embodiment for a probe. Probe 2030 may be used, for example, as an endoscopic probe for transesophageal, transgastric, or transgastric treatments. As with the probes discussed above, probe 2030 may be configured for use with a treatment cylinder or may be configured as a standalone device with a separate light source. As shown in FIG. 8I, probe 2030 is generally similar to various probes discussed above. External fiber optic 2035 connects to probe 2030 such that coherent light flows through body 2040 of probe 2030 through external fiber optic 2035 (e.g., 0.3 cm in diameter transporting a 0.2 cm in diameter laser beam). Interior fiber optic 2039 is provided within channel 2000 (e.g., having a diameter of 0.35 cm), which may also be used, for example, as a biopsy forceps channel. Body 2040 may be configured with endoscope section 2003 such that at least a portion of probe 2030 may be used as an endoscope itself, such as a pediatric flexible endoscope. For example, body 2040 may be 0.9 cm in diameter and sized to fit within a 1.2 cm diameter opening (e.g., the esophagus of a pediatric patient). To this end, body 2040 may include a flexible segment 2002 (e.g., 2.1 cm long) configured to allow articulation of probe 2030.

[0225] As external fiber optic 2035 extends through body 2040 towards the tip, body 2040 transitions to thicker transition area 2004 (e.g., 1.92 cm long). Transition area 2004 may partially overlap with flexible segment 2002 (e.g., such that only 0.31 cm of transition area 2004 do not include flexible segment 2002). The end of transition area 2004 may mark the end of endoscope section 2003 of body 2040 of probe 2030 and the beginning of combination chasis section 2005 of probe 2030 and thus be provided with endoscope-probe interface 2006. Interface 2006 may include connector 2008 (e.g., a male-female connector) for connecting external fiber optic 2035 to interior fiber optic 2039 such that coherent light is emitted into interior fiber optic 2039. As shown, connector 2008 may be provided within

pipe-like bridge 2010 (e.g., such that interface 2006 and bridge 2010 are together 0.62 cm long).

[0226] Moving to the tip of probe 2030, coherent light travels through interior fiber optic 2039 within cable bridge 2012 (e.g., 1.04 cm long) to diffusing lens 2036 (e.g., 0.33 cm thick), where interior fiber optic 2039 may terminate. Diffusing lens 2036 diffuses the coherent light beam through diffusing chamber 2014 (0.25 cm long) to collimator 2016 (e.g., 0.25 cm long), which collimates the diffused coherent light beam. From collimator 2016, the coherent light is directed to convex diffusing mirror 2018 (e.g., the top of which may be positioned 0.25 cm from the end of collimator 2016 and may extend, from that end, 0.55 cm towards the tip of probe 2030). As shown in FIG. 8I, convex diffusing mirror 2018 is provided at an angle (e.g., a 45 degree angle) such that mirror 2018 redirects the coherent light out of probe 2030 via portal 2020. In some arrangements, portal 2020 may be provided with a closing aperture such that portal 2020 may be closed. The tip of probe 2030 is provided with rounded cap 2022 (e.g., for ease of insertion into a patient). In various embodiments, probe 2030 may be covered in a sheath (e.g., for ease of insertion and manipulation within the patient).

[0227] The probe, in whatever embodiment, may be connected to the CLG through a removable optical connection. This allows the probe to receive coherent light from the CLG without the addition of additional coherent light generation sources. Further, if the CLG are provided as part of a treatment cylinder, this allows the computer control unit to be aware that a probe is being used to administer phototherapy in conjunction with the treatment cylinder and to control the emission of coherent light through the probe by controlling the emission of light at the CLG. If no optical connection between the probe and a CLG exists, some other source of coherent light is instead optically connected to the probe.

[0228] The probe, in whatever embodiment, may also be removably electrically connected to other components of the phototherapy device and ultimately the computer control unit. This allows the computer control unit to detect when the probe is switched on and can also allow it to confirm the unique identity of the probe, if such can be determined electronically, and that it is appropriate to allow the probe to be used (e.g., it is not out of date, it has not been used the maximum number of times, it is correlated to the patient being treated, etc.) if such can be determined electronically.

[0229] In some embodiments, the probe may be removably connected, either optically or electronically, or both, to other components of the phototherapy device to allow the coordination of phototherapy between the treatment cylinder and the probe. If the probe is electronically connected to the computer control unit, the computer control unit may be configured to control the duration, power, and wavelength of the coherent light to be administered through the probe according to a predetermined treatment plan. Moreover, in such cases, the computer control unit may signal the operator as to the depth and alignment of the insertion of the probe, and further signal the operator as to any position adjustments that should be made as the treatment progresses. The computer control unit may also make similar signals regarding the treatment cylinder, when therapy is being delivered simultaneously via the probe and the treatment cylinder.

[0230] If the probe has an endoscope (e.g., as described above with reference to FIG. 8), the operator may be shown a live view of the endoscope's field-of-view to assist in positioning the probe. If the computer control unit allows optical recognition of the endoscope's field of view (e.g., as described above with reference to FIG. 6), the computer control unit may signal the operator as to the ongoing positioning of the probe based upon its determination as to the current location of the tissues to be treated relative to the probe.

[0231] In some embodiments, the probe includes a spectroscopic sensor in the probe. If the probe has a spectroscopic sensor (e.g., as described above with reference to FIG. 6), the computer control unit may use data from the spectroscopic sensor to control the power, duration, and wavelength of the coherent light to maximize the delivery of therapeutic energy while minimizing the risk of burning the patient's tissues.

[0232] In some embodiments, a treatment plan selected (e.g., by the computer control unit 200) based on a treatment plan input includes the administration of phototherapy by the treatment cylinder and the probe concurrently or in a predetermined sequence. As an example and without limitation, if phototherapy is being administered to address pelvic pain in a female, the treatment cylinder can direct coherent light toward the pelvic region of the patient while the probe is inserted transvaginally and simultaneously, or in a controlled alternating pattern, directs coherent light toward tissues in the interior of the pelvic region that the coherent light emitted from the treatment cylinder cannot reach.

[0233] In some embodiments, the computer control unit may track the position of the probe, such as through visual/optical tracking, inertial tracking, or radiolocation of any appropriate kind. If the computer control unit can track the position of the probe, the computer control unit may use information about the position of the probe to do one or more of the following: (1) advise the operator as to whether the probe is properly placed and/or oriented for the desired treatment plan; (2) warn the operator and/or disable the probe if it determines that the probe is not in the proper placement/orientation to administer the desired phototherapy; (3) ensure that the coherent light being emitted by the probe is not directed at the same tissues to which the treatment cylinder emitters are simultaneously administering coherent light, which could result in excessive exposure or overheating and potential tissue damage; or (4) coordinate the treatment cylinder emitters with the probe's emission of coherent light to improve the overall efficacy of the phototherapy.

[0234] As discussed above, the probe may have its own source of coherent light. If the probe has its own source of coherent light, the probe and/or its source of coherent light may have one or both of the following properties: (1) the probe and/or light source is in electronic communication with the computer control unit such that the computer control unit can coordinate the output of the probe with a treatment plan input; or (2) the probe and/or light source has a specification, and the computer control unit is able to accept a specification input such that the computer control unit can advise the operator as to the appropriate application of the probe and the power, duration, and wavelength of the coherent light to be applied with the probe during the application of phototherapy.

[0235] Additionally, any of the phototherapy device embodiments discussed above including a probe may include a network interface (e.g., provided in the probe, provided at the CLG optically connected to the probe, and/or provided at the computer control unit communicating with the probe and CLG). As such, the phototherapy device may include a wireless connection with a mobile device including a display, such as a smartphone or a tablet. Alternatively, the phototherapy device may include a wired connection with a mobile device, or the mobile device may serve as the computer control unit for the phototherapy device. In some embodiments, the mobile device may operate an application or other program that allows the operator, via the mobile device, to view data from the computer control unit communicating with the probe (e.g., data relating to the operation of the probe, sensor data from the probe). In some embodiments, the operator may also view, via the

mobile device, a unique identifier for the probe (e.g., stored in a control chip implanted in or a tracking number on the probe's handle).

[0236] Various operations and settings of the phototherapy device that may be viewed by the mobile device include the selected type of wavelength; the selected number of watts output ("MNW") for the probe; the estimated corrected number of watts ("CNW") actually being emitted by the probe (e.g., which may account for Joules of energy lost as the laser beam travels from the CLG through external fiber optics, internal fiber optics, and the probe's optical components, such as a 810 nm laser set at 14.5 W having a 10 W diffused-beam actually delivered from the probe); the selected beam delivery mode of either a continuous mode or a pulsed mode, the latter including the selected frequency (Hz) and pulse width (milliseconds) of the beam; an energy delivered meter to keep track of the number of Joules being delivered during a treatment session (e.g., in CNW); and a time meter showing the number of seconds that the laser beam has been emitted for the treatment session, the number of times the laser beam has been automatically turned off due to the treatment site temperature reaching an undesirable level (e.g., 45°C), the number of times the laser beam has been automatically turned off because gyroscope movement sensors detected no movement for a certain amount of time (e.g., 1.75 seconds), and/or the number of times the laser beam has been automatically turned off based on another sensor within the probe (e.g., the probe's handle) monitoring incoming CO_2 gas pressure per square inch ("PSI"), flow rate, and/or temperature. Additionally, in some embodiments, the operator may be able to select or modify various operations and settings of the phototherapy device via the mobile device.

[0237] In some embodiments, the probe may further include one or more markers, such as sensors or beads, that an external monitoring system can use to show the location of the probe relative to other anatomical structures of the patient. For example, the probe may include one or more radiopaque markers visible on x-rays or CT scans and/or one or more resonant markers visible on MRI images. Alternatively, the probe may include one or more markers that emit location and/or direction data of the markers, allowing the location of the probe to be tracked via an external monitoring system. As an example, the markers may be RFID markers that can be tracked via an RFID tracking system set up in a medical procedure room.

[0238] Additionally, the external monitoring system may display images showing the location of the probe relative to the anatomy of the patient via the mobile device (e.g., through a wired or wireless connection between the external monitoring system and the mobile device). Viewing the location of the probe via the mobile device may allow the operator to better position the probe and/or direct the coherent light from the probe, either completely manually or with guidance from the computer control unit. With reference to the latter, for example, the computer control unit may analyze the location of the probe relative to the anatomical structures of the patient and provide visual prompts to the display of the mobile device for altering the location and/or direction of the probe to provide the best treatment therapy. Alternatively, the computer control unit may use location/direction data for the probe provided by the external monitoring system to automatically reposition the probe or alter the direction of the coherent light emitted from the probe (e.g., by moving internal optical components of the probe, such as a mirror or diffusing lens), such as through a robotic maneuvering system controlling the probe.

[0239] As an illustration of the foregoing, a transesophageal probe including resonant markers may be manually positioned or automatically positioned in the esophagus based on MRI scanning of the esophagus-heart structures. The probe may thereby be manipulated to best apply the PBMT only to the posterior heart muscle of a struggling-to-pump ventricle chamber. As another illustration of the foregoing, a mobile device receiving location images for a transvaginal probe including markers may show that the probe deep inside the vaginal vault is actually next to the top left side of the external intravaginal cervical tip and that the PBMT beam is reaching toward and into the left upper lateral side of the bladder wall. The images and data regarding the location and operation of the probe could be used to view the probe's location, the specific areas of the pelvic organs, the direction, location, and strength of the probe's coherent light beam, and the level of coherent light being delivered to the vaginal mucosal subdermis, as well as the left upper lateral bladder wall.

[0240] In some embodiments, the mobile device may also display information about the patient being treated (e.g., retrieved based on the patient's medical records or a unique identifier for the probe associated with the patient). For example, the mobile device may display basic patient demographic data (e.g., Health Insurance Portability and Accountability Act ("HIPAA")-compliant protected data), as well as medical history data, including current medications, prior surgeries, past and present medical diagnoses,

psychological history, and, depending on the targeted treatment site, pertinent prior chronic pelvic pain ("CPP") treatments, prior interstitial cystitis ("IC") treatments, prior dyspareunia treatments, prior and current gynecological diseases and problems, prior and current urology diseases and problems, prior and current gastrointestinal diseases and problems, and the current working diagnoses for planned PBMT. In some embodiments, the patient or the operator in conjunction with the patient may complete a targeted review of symptoms (e.g., "yes" and "no" answers to symptom questions or rating the applicability of symptoms on a scale of 1 to 10) via the mobile device, such as for CPP, IC, dyspareunia, urological-bladder symptoms/complaints, gynecological-reproductive tract symptoms/complaints, and gastrointestinal symptoms/complaints. The patient may need to answer these targeted review of symptoms questions before the mobile device accepts the identifier for the probe and allows the first PBMT treatment session to begin. Further, in some arrangements, before each of all or some of subsequent treatments (e.g., five treatments), the patient may similarly need to answer a series of follow-up questions, the answers of which are recorded on the mobile device before treatment can begin via the probe. Additionally, if an identifier for the probe (e.g., stored on a control chip in the probe) connected to the mobile device does not match up with an identifier stored for the patient, the mobile device may prevent follow-up treatments from being administered via the probe (e.g., to ensure the same probe is used for the first six treatment sessions). The patient's answers to the symptom questions may also be transmitted to the manufacturer of the probe (e.g., under encryption) such that the patient information may be centrally stored and, for example, retrieved by the mobile device when the patient returns for another follow-up treatment session.

[0241] Moreover, embodiments of the phototherapy device including a treatment cylinder (instead of or in addition to the probe) may also be capable of connecting to a mobile device and providing the mobile device functionalities discussed above. For example, phototherapy devices including a treatment cylinder may allow the operator to view and modify operations and settings of the treatment cylinder, view the location of the treatment cylinder relative to patient anatomy, and display information about the patient being treated via a mobile device.

[0242] In some embodiments, various components of a phototherapy device may be tested before use (e.g., use for the first time, use for the day, use before each treatment session). For example, testing a phototherapy device including a transvaginal probe may include

testing the transvaginal probe itself, testing a laser machine providing power to diodes optically connected to the transvaginal probe (e.g., one or two different wavelength-generating diodes), and/or testing functions of a control unit box (e.g., incorporated as part of the computer control unit for the phototherapy device). In some arrangements, the control unit box may include different sound generators, a screen that displays incoming sensor data and the laser machine's control settings (e.g., which may be controlled on the laser machine screen and relayed to the control unit box), and a master control to control the laser machine's ON/OFF functionality (e.g., manually and/or automatically) if, for example, one of the sensors senses that a critical shutdown should occur based on temperature or lack of probe motion. In some arrangements, the control unit box may further house components storing software that operates and reacts according to the incoming sensor information to allow for safe operation of the probe during PBMT treatment. As such, the control unit box may actively receive and respond to various feedback from sensors and controls within the laser machine (e.g., ON/OFF controls).

[0243] The phototherapy device may further include, for example, a CO_2 gas cooling system formed from a compressed bone dry CO_2 gas tank, insulated tubing with an in-line filter that transports CO_2 gas from an adjustable regulator mounted on the tank, and a PSI meter sensing wire from the regulator. The CO_2 gas cooling system may further include an in-line CO_2 flow meter. As such, the components of the CO_2 gas cooling system may also be tested before the phototherapy device is used.

[0244] The phototherapy device may further include a wire-cable harness that connects the laser machine to, for instance, the end of the handle of the transvaginal probe. In some arrangements, the wire-cable harness may include a number of electronic communication wires from the laser machine to the probe, from the laser machine to the control unit box, from a CO_2 tank regulator to the control unit box (e.g., in embodiments of the probe including the CO_2 cooling structure), from the probe to the control unit box, and from sensing lead wires connected to the probes sensors (e.g., for temperature, for CO_2 PSI-flow, for motion) to the control unit box. Alternatively, in some arrangements, one or more of these connections may be provided wirelessly. Further, the wire-cable harness may include low voltage electrical wires from the laser machine to the probe to supply energy to the probe (e.g., to power an LED safety alarm light, discussed below) and from the laser machine to the control unit box. Further, the wire-cable harness may include the fiber optic

cable that transports the laser beam from the power plant to the transvaginal probe. Accordingly, these components and connections may further be tested before the transvaginal probe is used.

[0245] Additionally, the phototherapy device may include various safety features to help ensure safe and effective phototherapy treatment. For example, a probe may include an LED alarm light on the handle of the probe, e.g., just ahead of a thumb indentation at the 12 o'clock position. When the laser beam is turned on (e.g., via a foot pedal), this LED may automatically turn on as a green color and stay green until the laser beam is turned off (e.g., by the operator taking their foot off of the foot pedal or the probe being automatically turned off) or a warning situation is reached. When any temperature sensor (e.g., either first temperature sensor 1444a or second temperature sensor 1444b) indicates that the treatment site is reaching a warning heat level (e.g., 43°C in the vagina), the LED may change to a flashing red light. At the same time, the control unit box may start to emit a gentle beeping sound (e.g., at the same frequency as the flashing red LED light). These two safety alerts indicate to the operator that the operator should move to a different location or quadrant, for example, within the patient's vaginal vault treatment site or take their foot off the foot pedal to stop emitting the laser beam. These alerts may automatically turn off once the temperature of the patient tissue sensed by the temperature sensors drops below the warning temperature level. However, if any temperature sensor indicates that the treatment site has reached a critical heat level (e.g., 45°C in the vagina), the control unit may automatically turn off the laser machine, and the LED may turn to a constant, non-flashing red light. The beeping from the control unit box may also be replaced, for example, with a voice that says, "Laser off temp," or a double antique car horn sound.

[0246] In some arrangements, the probe may also include a motion sensor such that when the laser beam is on, the motion sensor is automatically turned on and when the laser beam is off, the motion sensor is automatically turned off. If, when the laser beam is on, the motion sensor does not sense back-and-forth movement for a certain amount of time (e.g., 1.25 seconds), the LED may change to a flashing green light. The control unit box may further make an alarm sound, such as sound constant, quick bursts of standard car horn sounds, until movement is again detected, at which point these alerts may stop. If the motion sensor does not detect movement for a greater amount of time (e.g., 1.75 seconds), the control unit may automatically turn the laser off. Further, the alert sound may

immediately go on for a certain amount of time (e.g., for a full second) and then turn off. Once the laser is off, the motion sensor also turns off automatically, but the LED may keep flashing green until the laser beam is turned back on.

[0247] FIG. 9 shows the components of one embodiment of the CLER (e.g., described above with reference to FIG. 1) in detail. First fiber optic 92a and second fiber optic 92b deliver coherent light from the CLG (not shown) to one or more of emitter assemblies 93a, 94a, 95a, and 96a. All of the emitter heads function similarly: their assembly and operation will be described in relation to emitter assembly 96a. Fiber optic 92b optically communicates with fixed diffusing lens 97. Coherent light travels from fixed diffusing lens 97 to adjustable diffusing lens 99, which can be moved toward and away from fixed diffusing lens 97 by gear assembly 98. Gear assembly 98 can be manually adjusted by the operator or adjusted by the computer control unit. Coherent light, having been diffused to the desired diameter by the diffusing lenses, travels through collimator 910, where it is collimated to the desired diameter and then directed toward the tissues to be treated. Any or all of the emitter heads can be energized at any given time, according to a treatment plan input, operator adjustment, or automatic adjustment by the computer control unit. The computer control unit can adjust the position of any individual lens or collimator with regard to any other lens or collimator, or they can be adjusted by the operator either electronically or manually. This allows the beam to be controlled to a constant diameter no matter the distance between the emitter and the patient's body and/or to allow a desired diameter of beam to be applied in any given configuration.

[0248] In some embodiments, each emitter assembly may emit only one wavelength of coherent light at a time. Additionally, in some embodiments, each emitter assembly may also have a source of visible light that is introduced into it and follows the same focal path as the coherent light, the visible light may be referred to as the "guidance light," "target light," or "safety light" (herein, "safety light"). Because the coherent light is often outside the visible spectrum (e.g., coherent light at a 1064 nm wavelength is in the near-infrared, and most human beings will not be able to see it), the use of the safety light allows the operator to see where the coherent light beam is intersecting, or will intersect, the surface of the patient's body. Safety lights can be used with any of the alternate embodiments described herein. One or more safety lights can also be used as an illumination source to

assist optical or spectroscopic sensor analysis as described above. Alternatively, a coherent light beam that is in the visible spectrum may be its own safety light.

[0249] As an example, if emitter assembly 93a is emitting coherent light at 808 nm, emitter assembly 94a is emitting coherent light at 905 nm, and emitter assembly 95a is emitting coherent light at 980 nm, a blue safety light at 440 nm could be introduced into emitter assembly 93a, a green safety light at 540 nm could be introduced into emitter assembly 94a, and a red safety light at 700 nm could be introduced into emitter assembly 95a. The safety light beams may have similar initial diameters and follow the same optical paths as the corresponding coherent light beams so that the areas they illuminate will be as close as reasonably possible to the area of incidence of the corresponding coherent light beams. Because different wavelengths of light are affected differently by optical components, if it is required that the illuminated areas be *exactly* the same for a safety light beam and the corresponding coherent light beam, the safety light beam may either travel a different optical path or be of a slightly different initial diameter than the corresponding coherent light beam. If it is required that the illuminated areas be exactly the same *at all focal lengths*, they may travel a different optical path that will dynamically compensate for the different effects of optical components on the safety light beam and the coherent light beam.

[0250] There are no preferred associations of visible light wavelengths to coherent light wavelengths, though in some embodiments, the safety lights may follow the same relative length order as in the corresponding coherent light wavelengths (i.e., the shortest wavelength of coherent light used is associated with the shortest wavelength of visible light being used.) However, in various embodiments, the operator may have the ability to manually change the visible light wavelength associated with any given coherent light wavelength so that if one or more visible light wavelengths are not suitable in any given phototherapy session (e.g., one or more of the visible light wavelengths are particularly hard to see against the patient's particular skin tone), a more suitable one may be used.

[0251] As an example of a phototherapy device incorporating various systems and components discussed above, including a probe, an endoscope, and a cooling system, FIG. 10 shows another alternate embodiment of a probe configured to be attached or connected to the end of a flexible EGD endoscope. Probe 1530 includes three sections. First section 1500 is similar to the probes described above. More specifically, first section 1500 houses

fiber optic cable 1539 that connects to diffusing chamber 1502 (e.g., containing one or more diffusing elements, such as diffusing lenses or diffusing mirrors at or near interface 1535 between fiber optic cable 1539 and diffusing chamber 1502, or containing no optical elements). The interior of interface 1535 between fiber optic cable 1539 and diffusing chamber 1502 may include one more temperature sensors, such as temperature sensor 1544a, to monitor the temperature of the fiber optic connection. Additionally, the exterior of interface 1535 may include a secondary temperature sensor, such as temperature sensor 1544b, to monitor the temperature of the mucosa of the treatment site. As shown in FIG. 10, coherent light travels through diffusing chamber 1502 until it reaches flat mirror 1536 at the end of diffusing chamber 1502 that angles light beam 1542 (e.g., 45 degrees) out through diffusing chamber 1502. In some arrangements, diffusing chamber 1502 is transparent, or may include an optical component, such that light beam 1542 may be emitted through diffusing chamber 1502. In other arrangements, diffusing chamber 1502 may instead include a portal at the end of the diffusing chamber through which the coherent may be emitted to the target treatment site.

[0252] Second section 1506 is provided next to first section 1500 and is configured to receive EGD endoscope 1508. Specifically, the second section is configured to receive or include instrument channel 1510 for EGD endoscope 1508. A cable of EGD endoscope 1508 that may be rotated slowly (1) by an external motor, (2) by incoming cooling media pressure-flow from a third section, discussed further below (e.g., such that the rate or volume of flow of the media could be adjusted to set the rate of rotation), or (3) manually as the operator pulls EGD endoscope 1508. Instrument channel 1510 connects to mirror turbine 1512 provided parallel to diffusing chamber 1502 of first section 1500. Mirror turbine 1512 includes highly convex mirror 1514. Further, the end of mirror turbine 1512 connects to dome 1516 (e.g., similar to the convex diffusing dome lenses described above, or configured as a transparent glass or acrylic dome). Temperature sensor 1544c may be provided in mirror turbine 1512 to monitor the inside of mirror turbine 1512 and monitor the inside of dome 1516. Additionally, another temperature sensor 1544d may be provided on the outside of dome 1516 near mirror 1536 of first section 1500 to monitor the mucosal surfaces e.g., mucosal surfaces of the gastrointestinal tract) of the target treatment site receiving PBMT.

[0253] Third section 1518 is provided on the other side of second section 1506 (e.g., such that first section 1500 and third section 1518 are opposite each other across second section 1506). Third section 1518 is configured to includes irrigation (e.g., cooling) channel 1520 for EGD endoscope 1508, which may be formed of insulated stainless steel. Channel 1520 connects to tube 1522 provided parallel to mirror turbine 1512 and diffusing chamber 1502. Cooling media 1521 is received in tube 1522. Further, tube 1522 is connected to diffusing chamber 1502 via mirror turbine 1512 such that cooling media 1521 flows into tube 1522, through mirror turbine 1512, and into diffusing chamber 1502. First section 1500 is provided with one or more suction channels 1524 parallel to fiber optic cable 1539 that then suck cooling media 1521 out of diffusing chamber 1502 and back to the source. Tube 1522 may further contain convex mirror 1526 such that the degree of beam divergence coming out of first section 1500 is the same as mirror 1536 of first section 1500.

[0254] In some arrangements, probe 1530 may be provided as one piece (e.g., configured to receive a fiber optic cable and an EGD endoscope). In other arrangements, at least some sections of probe 1530 may be separable from each other (e.g., interface 1535 may serve as the connection apparatus between a section for an EGD endoscope and a section for a fiber optic cable).

[0255] FIGS. 11-13 show example areas on a first patient that may be treated using the phototherapy device embodiments discussed above. FIGS. 14-16 show different or additional example areas on a second patient (e.g., based on the gender of the second patient) that may be treated using the phototherapy device embodiments discussed above. Each of these areas represents an expanded therapeutic treatment area ("ETTA") 1100, which may be one of the targeted treatment sites discussed herein. Each ETTA 1100 includes a primary treatment zone ("PTZ") 1102 and a secondary treatment zone 1104. Further, each secondary treatment zone may be divided into a proximal secondary treatment zone ("PSTZ") 1104a, or the section of the secondary treatment zone that is closest to the heart, and a distal secondary treatment zone ("DSTZ") 1104b, or the section of the secondary treatment zone that furthest from the heart. When therapy is delivered to the patient using a phototherapy device, the therapy is provided first to the PTZ 1102 and then to the PSTZ 1104a and the DSTZ 1104b. In some embodiments, the therapy delivered to the PTZ 1102 may also differ from the therapy delivered to the PSTZ 1104a and the DSTZ

1104b (e.g., the photons may be delivered at a higher energy to the PTZ 1102), or the therapy between all three zones may differ.

[0256] Using an arthritic knee as an example, during a treatment session, photons may be administered to the skin surface into soft tissues into the knee joint, 3 to 4 cm below the joint, and 3 to 4 cm above the joint, with this area representing the PTZ 1102. In addition, the inflamed and in-spasm muscles and ligaments 5 to 12 cm above and below the joint may also receive therapeutic photons during a treatment session. Expanding the treatment area in this way may result in a better and longer-lasting therapeutic response through the delivery of more photons into the tissues, triggering the creation of non-cellular ATP energy, which is a primary and essential ingredient that the body needs to help tissues heal. Additionally, this expanded targeted treatment site may suppress more areas and spots of inflammation and may improve the degree or level of symptom reduction, thereby increasing the positive response to the phototherapy.

[0257] The phototherapy device embodiments may be used in any medically safe and practical way to provide therapy to the targeted treatment sites, such as ETTA 1100 shown in FIGS. 11-16. For example, the phototherapy device may be used as shown in FIGS. 17 and 18. As illustrated in FIG. 17, treatment cylinder 1600 may be used to provide phototherapy to lower back and hip areas of patient 1602. These areas are treated by having patient 1602 lie face down on medical exam table 1604. The patient may rest their head on or into a pillow. The additionally, the patient's pelvic area may be positioned on secondary exam table 1606, which includes a narrower top end such that treatment cylinder 1600 can be placed around secondary exam table 1606 and the patient's lower back and hip areas. The patient's legs may be rested on medical exam table 1604 or secondary exam table 1606 (depending on which direction patient 1602 is facing) or, if medical exam table 1604 and secondary exam table 1606 are not long enough, on another exam table or support. The patient may also be propped with other pillows, such as a pillow provided under the patient's feet, to move the patient into a comfortable position and/or a position that best exposes the targeted treatment site.

[0258] As illustrated in FIG. 18, the patient's posterior neck, upper back, and/or posterior-lateral shoulders may also be treated by having patient 1602 lie down face first on medical exam table 1604. Patient 1602 may rest their head on or into a pillow configured to receive the patient's face. Additionally, the pillow may be provided on secondary exam table 1606

with a narrower top end such that treatment cylinder 1600 can be placed around secondary exam table 1606 and the patient's posterior neck, upper back, and/or posterior-lateral shoulders that are exposed by patient 1602 lying down on medical exam table 1604 and secondary exam table 1606. Patient 1602 may also be propped with other pillows, such as a pillow provided under the patient's feet, to move patient 1602 into a comfortable position and/or a position that best exposes the targeted treatment site. A similar position may be used to administer therapy via treatment cylinder 1600 onto the upper and/or mid back and onto and/or into the upper and/or lower chest areas, except that the patient's chest may be provided on the narrow portion of the secondary exam table such that the treatment cylinder can be placed around these back and chest areas.

[0259] However, it should be understood that the phototherapy device embodiments described herein may be used to provide phototherapy to a number of portions of patient anatomy. In one example, the patient's knee is treated by having the patient lie down on a medical exam table and place their leg through the treatment cylinder such that the treatment cylinder can target phototherapy to the knee. The patient may be provided with a secondary exam table or support for resting their other leg and feet. Additionally, the patient's leg being treated may be propped up with a pillow as needed to ensure that the patient's knee is in an optimal location within the treatment cylinder.

[0260] In another example, the patient's face, forehead, jaw, front of neck, ears, and/or side of head are treated by having the patient lie down on a medical exam table. The patient's head may be positioned on a secondary exam table with a narrower top end such that the treatment cylinder can be placed around the secondary exam table and the patient's head. Additionally, the patient may be propped with pillows, such as a pillow under the patient's head and a pillow under the patient's knees, to move the patient into a comfortable position and/or a position that best exposes the targeted treatment site.

[0261] In another example, the patient's lower torso is treated by having the patient stand and placing a treatment globe over the patient's lower torso such that the patient's legs extend below a lower opening of the treatment globe and the patients head and upper torso extend above an upper opening of the treatment globe. A similar procedure may be used to treat the patient's upper torso by having the patient stand or kneel and placing a treatment globe over the patient's lower torso. The gap between the upper opening and the patient's

anatomy may be covered with a cap or other covering to prevent photons from escaping from the treatment globe.

[0262] In another example, the patient's arm is treated by having the patient sit and placing a treatment globe over the patient's arm. A cap or other covering may be placed between the opening(s) through which the patient's arm is inserted and the patient's anatomy to prevent photons from escaping from the treatment globe. A cap or other covering may also be placed over the entirety of the opening opposite from where the patient's arm is inserted if the patient's arm does not extend through the treatment globe (e.g., the patient's arm is contained entirely within the treatment globe).

[0263] Additionally, FIGS. 19-21 illustrate areas of a female patient's anatomy that may be treated using a probe embodiment, such as any of the probe embodiments described above. Referring to FIG. 19 (which shows female anatomy from the side) and FIG. 20 (which shows female anatomy from the front), pelvic region 1700 of a female patient includes vagina 1702, cervix 1704, and uterus 1706. With reference to FIG. 20, vaginal opening 1710 and urethral opening 1712 may also be observed. In various arrangements, a probe may be inserted into vagina 1702 until the tip is in area 1708 near cervix 1704. If the probe is being used to deliver phototherapy to deep pelvic structures, the operator may manipulate the probe within vagina 1702 such that the probe moves the vaginal wall anteriorly, posteriorly, laterally to the right, and laterally to the left (e.g., 2.0-2.5 cm in any of these directions) to better position the probe to deliver therapy to the pelvic structures. In this way, phototherapy may be delivered to various pelvic structures (e.g., through the vaginal wall, which may be approximately 0.3 to 0.5 cm, the rectal wall, which may be approximately 0.3 cm, and/or the bladder wall, which may be 0.3 to 0.35 cm). Similarly, FIG. 21 shows pelvic bones 1714 with anterior side 1716 (e.g., leading to the pubic arch) and posterior side 1718 (e.g., leading to the coccyx). Treatment area 1708 with respect to pelvic bones 1714 is accordingly also shown in FIG. 21.

[0264] For reference, FIG. 22 illustrates distances between various pelvic structures of a female patient, and FIG. 23 illustrates distances between various pelvic structures of a male patient. Referring first to FIG. 22, in various female patients, distance A between the vaginal opening (introitus) to the cervix or area deep within the vaginal vault (e.g., where a probe tip may be placed during PBMT treatments to deep pelvic organs) may be 8.5 cm ± 2.0 cm. Distance B from the introitus to the bladder wall base may be 3.7 cm ± 1.5 cm.

Distance C from the introitus to the bladder wall base may be 6.5 cm. Distance d from the introitus to the urethral walls may be 2.4 cm ± 2.0 cm. Distance E, which represents the thickness between the anterior vaginal mucosal wall to the bladder wall base and to the urethral walls, may be 1.1 cm. Distance F, which may represent the thickness between the posterior vaginal mucosal wall and the rectal wall-rectal mucosa, may be 1.1 cm. Distance g from the anterior vaginal mucosal to the mid-bladder or to anterior bladder wall (e.g., representing the thickness of the soft tissues) may be 2.0 to 4.6 cm. Distance H from the deepest depth of the bladder wall to the ovaries and fallopian tubes and uterine fundus (e.g., representing the thickness of the soft tissues) may be 6.9 cm ± 3.0 cm. Distance I between the vaginal introitus to the level of pelvic floor muscles may be 2.3 to 3.0 cm.

[0265] Referring next to FIG. 23, in various male patients, distance A from the anal external opening to the leading edge of the prostate gland may be 4.3 cm. Distance B from the anal external opening to the bladder wall base may be 6.2 cm. Distance C from the rectal mucosal wall to the leading edge of the bladder wall base may be 1.7 cm. Distance d, which represents the thickness between the rectal mucosal wall to the top edge of the prostate gland, may be 3.0 cm. Distance E, which represents the thickness from the rectal mucosal wall to the leading edge of the prostate gland, may be 0.6 cm.

[0266] FIG. 24 also illustrates distances between various pelvic structures of a female patient with reference to bone and muscle. As such, in various female patients, Distance A from the vaginal mucosal surface laterally to the deepest edge of the deepest edge of the levator ani muscle and to the obturator muscles that are higher into the pelvis and next to or lateral to the vaginal walls may be 1.8 cm. Distance B from the lateral vaginal mucosa to the leading edge of the levator ani muscle and to the obturator muscle may be 0.7 to 1.0 cm. Distance C from the lateral vaginal mucosa to the piriformis muscle may be 6.5 cm. Distance e from the vaginal mucosa to the obturator internus may be 4.6 cm. Distance E from the vaginal mucosa to the coccygeus muscle may be 4.0 to 5.0 cm. These pelvic flor muscles may also be approximately 2.3 to 3.0 cm deep into the pelvis or beyond the vaginal opening (introitus) and beyond the level of the anal opening.

Examples of the Phototherapy Device

[0267] Example One. An example of the phototherapy device may be used in treating conditions such as chronic inflammatory prostatitis or interstitial cystitis (e.g., painful

bladder and/or irritable bladder muscle). The phototherapy device may include a probe, and the probe could be connected to a handle attached to a rigid or flexible endoscope. The device, the endoscope plus the probe, could be programmed by the user or automatically given the patient's data (e.g., heart rate, blood circulation, etc.). The probe could then be inserted in the lower or upper rectum to treat proctitis or higher into the colon to the sigmoid colon to treat inflammatory diverticulitis or Crohn's Disease and/or ulcerative colitis. The placement of the probe could be performed by a human operator or a robotic operator, as described above.

[0268] Adjustments could be made for proper position on all axis and/or vector planes. The pulse of the light could be programmed to provide 1 pulse per 1 picosecond to 1 pulse per 10 minutes, and the time-of-light emission could be set anywhere from 0.01 microsecond to 12 minutes. For example, different pulses could be used to allow for different levels of tissue relaxation, allowing the phototherapy device to administer higher levels of energy without causing tissue damage or tissue overheating. Additionally, the wavelength range for the photobiomodulation therapy could range from near-infrared to far infrared.

[0269] The light could then be emitted through portals at the tip of the probe (e.g., on the end or the sides of the probe), as discussed above with reference to FIGS. 8-8E. Direct illumination could be delivered using LEDs, diodes, or other energy-emitting techniques. Optical elements in the probe could change the profile, shape, diffusion, and frequency the beam to tailor the light administered to the patient. The width of the beam could be 0.1 cm to 5 cm. The probe could also be tracked (e.g., by GPS) prior to, during and post treatment to aide in delivering the therapy to specific location(s).

[0270] Example Two. An example of the phototherapy device may be used in transpharyngeal phototherapy delivery. This embodiment could be a probe that is inserted into the oral cavity and further into oral-pharyngeal cavity. The probe could be a straight or angled-end probe such that the emitted beam of light is a diffused-beam laser beam that is targeted toward and/or in direct contact with the pharyngeal mucosal surfaces, as well as targeted toward and/or onto the epiglottis to treat acute or chronic epiglottis and/or into the laryngeal orifice to treat diseases like laryngitis. The administered photons from this transphynygeal probe could be directed upward and outward toward the face's cheeks and the undersides of the maxillary sinuses. The delivered photons could also be configured as

one or more diffused-beam laser wavelengths for treating diseases like chronic maxillary sinusitis. Further, the administered photons could be directed upward and inward toward the front base of the cranial cavity where the base areas of the frontal lobes of the brain exist and where diseased CNS states like depression, anxiety, concussions, and strokes can originate or arise.

[0271] In some embodiments, this transpharyngeal probe's phototherapy (e.g., PBMT) could replace some surgical interventions, chronic antibiotic therapy and/or steroid therapy. Moreover, this transpharyngeal probe could be use as standalone therapy or in conjunction with other known therapies. The probe could also be used in conjunction with the same or similar phototherapy delivered or administered via the rotational treatment cylinder transcutaneously.

[0272] Furthermore, in some embodiments, the administered photons could be directed more posteriorly and upward or directly to the back of the pharynx or pharyngeal pharynx and onto the upper brainstem, the mid brainstem, and the lower brainstem and the upper spinal column. Delivering phototherapy via this transpharyngeal probe to the brainstem's sleep center or into a brainstem that has suffered a contusion or concussion injury may be more successful in delivering more amounts of photons into these CNS tissues than delivering phototherapy via further-away emitting photon sources (e.g., devices like a transcranially or topically applied low level laser therapy through the forehead's skin and frontal bone's skull bone areas).

[0273] This transpharyngeal probe could be connected to a handle or attached to a rigid or flexible endoscope. The device, the endoscope plus probe, could then be manually or automatically programmed upon being given the patient's data (e.g., heart rate, blood circulation, disease state(s), etc.). The probe could be manually inserted and strategically placed into oral cavity and onto surfaces of the pharyngeal pharynx. The actual pointing toward or the positioning of the probe to deliver the emitting photons toward specifics structures, and/or even intracranial structures, could be performed by a human operator or robotic-controlled operator, as discussed above. Further positioning of the probe and refined targeting of tissues could be adjusted on all axis and/or vector planes and coordinates with the guidance of an MRI-interfacing system, ultrasound interfacing guidance, and even by other x-ray guidance-targeting systems like fluoroscopy and/or CT-scanning systems.

[0274] The pulse of the light-photons could be programmed to provide 1 pulse per 1 picosecond to 1 pulse per 10 minutes, and the time-of-light emission can be set anywhere from 0.01 microsecond to 12 minutes. For example, different pulses could be used to allow for different levels of tissue relaxation, allowing the phototherapy device to administer higher levels of energy without causing tissue damage or tissue overheating. Additionally, the wavelength range for the photobiomodulation therapy could range from near-infrared to far infrared.

[0275] The light could then be emitted through portals or the sides of the probe, as discussed above with reference to FIGS. 8-8E. Direct illumination could be delivered using LEDs, diodes, or other energy-emitting techniques. Optical elements in the probe could change the profile, shape, diffusion, and frequency of the beam to tailor the light administered to the patient. The width of the beam could be 1 mm to more than one 1 cm. The probe could also be tracked (e.g., by GPS) prior to, during, and following the delivery session of the photons to aide in the specific deliver location(s) and to maneuver into and out of the cavity area where the administration was achieved.

[0276] In various embodiments, the photon-emitting tip or portals of the probe are not to exceed mucosal tissue-irritating temperatures below 33°C or above 40 to 41°C. This probe could be cooled using a chilled fluid such as water, a menthol solution, gases like CO_2, nitrous oxide, liquid nitrogen, chilled air, etc.

[0277] Example Three. An example of the phototherapy device may be used in transurethral phototherapy delivery. This embodiment could include a standalone probe or a probe used in conjunction with another device. The additional device could include a flexible cable, endoscopic device(s), or non-endoscopic device(s) or a rigid or flexible laryngoscope or bronchoscope. This probe could be inserted into the urethral meatus, and phototherapy could be administered into the urethral mucosa, into the urethral soft tissues deeper past the mucosa, and into the tissues supporting the urethra and urethrovesicle junction, as well as into the lower bladder base and the bladder neck. This transurethral probe could be further passed into the bladder to administer phototherapy into the bladder and into structures that are connected to and/or support the blabber, as well as structures near the bladder including the pelvic boney structures and the ligaments and muscles that make up the pelvic floor.

[0278] The probe could be a straight or angled-end probe such that the emitted beam is a diffused-beam laser beam that is targeted toward, and/or in direct contact with, the urethral and bladder mucosal surfaces, as well as toward and/or into the ureters that drain urine and which lead to the kidneys.

[0279] While these probes are specifically positioned within the urethral lumen and/or within the bladder, the probe's phototherapy-emitting portals or tip(s) could be directed such that photons are targeted toward and into the urethral and the bladder soft tissues. Some of the diseases that could be treated with phototherapy via this transurethral and transvesical probe include acute and chronic urethritis and cystitis, as well as interstitial cystitis and detrusor instability or overactive bladder-causing tissues.

[0280] As described above, the probe may be used with an endoscope. The device, the endoscope plus probe, could then be manually or automatically programmed upon being given the patient's data (e.g., heart rate, blood circulation, disease state(s), etc.). The actual pointing and directing of the probe's photon emitting portals and/or tip(s) toward specifics structures could be performed by a human operator or robotic-controlled operator, as discussed above. Further positioning of the probe and refined targeting of tissues could be adjusted on all axis and/or vector planes and coordinates with the guidance of an MRI-interfacing system, ultrasound-interfacing guidance, and even by other x-ray guidance-targeting systems like fluoroscopy and/or CT-scanning systems.

[0281] The pulse of the light-photons could be programmed to provide 1 pulse per 1 picosecond to 1 pulse per 10 minutes, and the time-of-light emission could be set anywhere from 0.01 microsecond to 12 minutes. For example, different pulses could be used to allow for different levels of tissue relaxation, allowing the phototherapy device to administer higher levels of energy without causing tissue damage or tissue overheating. Additionally, the wavelength range for the photobiomodulation therapy could range from near-infrared to far infrared.

[0282] As discussed, the light could be emitted through portals or the sides of the probe, as discussed above with reference to FIGS. 8-8E. Direct illumination could be delivered using LEDs, diodes, or other energy-emitting techniques. Optical elements in the probe could change the profile, shape, diffusion, and frequency of the beam to tailor the light administered to the patient. The width of the beam could be 1 mm to more than one 1 cm.

The probe could also be tracked (e.g., by GPS) prior to, during, and following the delivery session of the photons to aide in the delivery to specific location(s) and to maneuver into and out of the cavity area used for the administration of phototherapy.

[0283] In various embodiments, the photon-emitting tip or portals of the probe are not to exceed mucosal tissue irritating temperatures below 33°C or above 40 to 41°C. This probe could be cooled using a chilled fluid such as water, a menthol solution, gases like CO_2, nitrous oxide, liquid nitrogen, chilled air, etc.

[0284] Example Four. An example of the phototherapy device may be used in translaryngeal and transbronchial phototherapy delivery. A probe could be used with a standalone rigid or flexible cable, endoscopic device(s), or nonendoscopic device(s) or could be a probe that is attachable and detachable to the end of a rigid or flexible laryngoscope or bronchoscope. This probe could be inserted into the mouth (e.g., oral cavity), down the oral pharyngeal cavity, and guided into (e.g., inserted into) the laryngeal lumen (or down through a tracheotomy portal or tube) and in some cases down into the bronchial tree's lumens.

[0285] The probe could be a straight or angled-end probe such that the emitted beam is a diffused-beam laser beam that is targeted toward and/or in direct contact with the laryngeal and/or inner bronchial mucosal surfaces as well as toward and/or down near the alveolar sacs within the lung's interstitial and parenchymal tissues.

[0286] While the probe is specifically positioned in laryngeal and/or bronchial lumen(s), the phototherapy-emitting portals or tip(s) of the probe could be directed such that photons are targeted toward and into the larynx and/or toward bronchial intralumenal diseases, parenchymal lung tissue diseases, and/or interstitial diseases like chronic pulmonary fibrosis and radiation inflammatory pulmonary fibrosis. Photons may even be targeted toward and into external to pulmonary-lung tissues and toward intrathoracic diseases (e.g., including mediastinal disease states and cardiac diseases like cardiomyopathy or coronary artery diseases and/or pericardial sac diseases like inflammatory pleurisy).

[0287] Further, this probe could administer photons from within the larynx or bronchi toward and into the thyroid lobes, parathyroid glands, into the thymus, the esophagus, etc. An intralumen and/or intractability phototherapy probe could deliver photons of one or more diffused-beam laser wavelengths into healthy and/or diseased tissues within the neck,

within the thoracic cavity, into the vertebral bodies, toward and into the spinal column and CNS nerve and interstitial tissues, as well as into and around exiting spinal column nerve and nerve roots. Additionally, photons from the intralumenal and/or intracavitary-positioned probe could be directed into rib bones, sternum bones, and ligaments and their surrounding muscles and other soft tissues.

[0288] The probe could be connected to a handle or attached to a rigid or flexible endoscope. The device, the endoscope plus probe, could then be manually or automatically programmed based on the patient's data (e.g., heart rate, blood circulation, disease state(s), etc.). The actual pointing and directing of the photon-emitting portals and/or tip(s) of the probe(s) toward specifics structures could be performed by a human operator or robotic-controlled operator, as described above. Further positioning of the probe(s) and refined targeting of tissues could be adjusted on all axis and/or vector planes and coordinates with the guidance of an MRI-interfacing system, ultrasound-interfacing guidance, and even by other x-ray guidance-targeting systems like fluoroscopy and/or CT-scanning systems.

[0289] The pulse of the light-photons could be programmed to provide 1 pulse per 1 picosecond to 1 pulse per 10 minutes, and the time-of-light emission can be set anywhere from 0.01 microsecond to 12 minutes. For example, different pulses could be used to allow for different levels of tissue relaxation, allowing the phototherapy device to administer higher levels of energy without causing tissue damage or tissue overheating. The wavelength range for the photobiomodulation therapy could range from near-infrared to far infrared.

[0290] As described above, the light could be emitted through portals or the sides of the probe, as discussed above with reference to FIGS. 8-8E. Direct illumination could be delivered using LEDs, diodes, or other energy-emitting techniques. Optical elements in the probe could change the profile, shape, diffusion, and frequency of the beam to tailor the light administered to the patient. The width of the beam could be 1 mm to more than one 1 cm. The probe could also be tracked (e.g., by GPS) prior to, during, and following the delivery session of the photons to aide in delivering the therapy to specific location(s) and to maneuver into and out of the cavity area used for the administration of phototherapy.

[0291] In various embodiments, the photon-emitting tip or portals of the probe are not to exceed mucosal tissue irritating temperatures below 33°C or above 40 to 41°C. This probe

could be cooled using a chilled fluid such as water, a menthol solution, gases like CO_2, nitrous oxide, liquid nitrogen, chilled air, etc.

[0292] This transpharyngeal probe's phototherapy (e.g., PBMT) could replace some surgical interventions, chronic antibiotic therapy, and/or steroid therapy. Moreover, this transpharyngeal probe could be use as standalone therapy or in conjunction with other known therapies. The probe could be also used in conjunction with the same or similar phototherapy delivered or administered via the rotational treatment cylinder transcutaneously.

[0293] Example Five. A treatment cylinder can be used to treat inflammation and/or torn tissue in the knee. The following are examples of parameters of the treatment cylinder and/or therapy parameters provided by the treatment cylinder:

- 90 W, 810 nm diode; DLCR rotates to administer 9 J/cm^2 into PSTZ;
- 90 W, 810 nm diode; DLCR rotates to administer 9 J/cm^2 into PTZ;
- 90 W, 810 nm diode; DLCR rotates to administer 9 J/cm^2 into DSTZ;
- 180 W, 980 nm diode; DLCR rotates to administer 5 J/cm^2 into PSTZ;
- 180 W, 980 nm diode; DLCR rotates to administer 5 J/cm^2 into PTZ;
- 180 W, 980 nm diode; DLCR rotates to administer 5 J/cm^2 into DSTZ;
- 180 W, 905 nm diode; DLCR rotates to administer 4 J/cm^2 into PSTZ;
- 180 W, 905 nm diode; DLCR rotates to administer 4 J/cm^2 into PTZ; and
- 180 W, 905 nm diode; DLCR rotates to administer 4 J/cm^2 into DSTZ.

[0294] Example Six. An example of the phototherapy device may be used in phototherapy delivery on a knee. A combination of wavelengths and wattage could be used independently or jointly to deliver treatment using a treatment cylinder embodiment. In one example, a three 70 W diode set (e.g., S3D) of 980 nm is used to treat the PSTZ of the knee at 50% power while another three 35 W diode set (e.g., S3D) of 810 nm is simultaneously administering therapy at 75% power onto the DSTZ of the knee. In another example, a three 70 W diode set (e.g., S3D) of 980 nm is used to treat the PSTZ of the knee at 50% power while another three 70 W diode set (e.g., S3D) of 980 nm is simultaneously administering PBMT at 50% power onto the DSTZ of the knee. In another example, a diode set of 70-80 W/980 nm is used to treat the PSTZ of the knee at 33% Power while another diode set of 35 W/810 nm is simultaneously administering therapy at 50% Power onto the DSTZ of the

knee and while still another diode set of 35 W/605-650 nm is administering PBMT at 35% Power (e.g., onto the PTZ).

[0295] In various embodiments, the frequency of the administration of the phototherapy is in according with the blood flow direction. For example, therapy is administered such that photons are delivered downstream before photons are delivered upstream, which avoids causing an increase in temperature of the treatment site that would negatively affect the photon penetration depth into the targeted tissues.

[0296] Example Seven. An example of the phototherapy device may be used in transauricular phototherapy delivery. An example of a transauricular phototherapy delivery probe could be a probe configured to transverse the external ear canal to deliver diffused-beam laser photons and low level laser therapy into inflamed tissues, diseased tissues, and/or infected tissues such as external otitis media (which involves the auditory canal) and internal otitis (within the inner ear) instead of administering or prescribing steroids and/or antibiotics. A transauricular probe could better deliver higher levels of low intensity and high intensity photons than a delivery system external to the ear canal, thus possibly enhancing potential therapeutic effects.

[0297] In addition, the internal ear structures, like the cochlea, that also are disease-prone could possibly benefit patients with tinnitus (ringing in the ears) or vertigo. Photons from transcranial or topically-applied low level laser therapy will result in fewer photons being delivered to the inner ear structures due to the depth that these structures lie within the skull and because more photons are blocked by the dense skull bones, thus reducing the number of applied photons that reach the inner ear. Using a transauricular probe could allow the photon-emitting source to be placed closer to these inner ear structures, allowing the photons to be applied with less bone mass to block photons from reaching the treatment site compared to transcranially-topically applied photons.

[0298] The transauricular probe could be connected to a handle or attached to a rigid or flexible endoscope. The device, the endoscope plus probe, could then be programmed by the user or automatically programmed based on the patient's data (e.g., heart rate, blood circulation, etc.). The probe could be manually inserted into the first 1 to 2 cm into the auricular canal, pointing the emitted photons toward specific external and internal ear structures and even intracranial structures, by a human operator or robotic operator, as

described above. Further positioning of the probe and refined targeting of tissues could be adjusted on all axis and/or vector planes and coordinates with MRI guidance, ultrasound guidance, fluoroscopy x-rays, etc.

[0299] The pulse of the light-photons could be programmed to provide 1 pulse per 1 picosecond to 1 pulse per 10 minutes, and the time-of-light emission can be set anywhere from 0.01 microsecond to 12 minutes. For example, different pulses could be used to allow for different levels of tissue relaxation, allowing the phototherapy device to administer higher levels of energy without causing tissue damage or tissue overheating. The wavelength range for the photobiomodulation therapy could range from near-infrared to far infrared.

[0300] The light could be emitted through portals or the sides of the probe, as described above with reference to FIGS. 8-8E. Direct illumination could be delivered using LEDs, diodes, or other energy-emitting techniques. Optical elements in the probe could change the profile, shape, diffusion, and frequency of the beam to tailor the light administered to the patient. The width of the beam could be 1 mm to more than one 1 cm. The probe could also be tracked (e.g., by GPS) prior to, during, and post treatment to aide in the delivering the therapy to specific location(s).

[0301] In various embodiments, the photon-emitting tip or portals of the probe are not to exceed a temperature between 37 to 45°C. This probe could be cooled using a chilled fluid such as water, a menthol solution, gases like CO_2, nitrous oxide, liquid nitrogen, chilled air, etc.

[0302] Example Eight. An example of the phototherapy device may be used in transesophageal, transgastric, and/or transduodenal phototherapy delivery. For example, a probe could be applied down into the esophagus, stomach, and intestinal structures such as the duodenum, either separately or incorporated with or within a tube (e.g., a percutaneous endoscopic gastronomy ("PEG") tube or a jejunostomy tube ("J-tube")), to treat and/or prevent gastritis or esophagitis. Additionally, the probe could be placed short-term or long-term in the patient.

[0303] The probe could be used to apply phototherapy in a continuous mode, in a pulsed mode, in a micropulsed mode, and/or in a superpulsed mode. The therapy could last for minutes to days at a low level of power, such as on the 0.1 mW range, 1.0 mW range, 10

mW range, 100 mW range, or 1000 mW range. For intermittent phototherapy, each treatment session could last for less than a second, for a second or more, or for several minutes or more. Additionally, the frequency of therapy could be once every several seconds, once every one or more minutes, once an hour, once a day, or several times a day. The probe could also be used with or include any of the probe features described above (e.g., a cooling structure).

[0304] While various embodiments and aspects of the phototherapy device have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of the present disclosure should not be limited by any of the above exemplary embodiments.

[0305] This application—taken as a whole with the abstract, specification, and drawings being combined—provides sufficient information for a person having ordinary skill in the art to practice the features as disclosed herein. Any measures necessary to practice the features described herein are well within the skill of a person having ordinary skill in this art after that person has made a careful study of this disclosure.

[0306] Because of this disclosure and solely because of this disclosure, modification of this device and method can become clear to a person having ordinary skill in this particular art. Such modifications are clearly covered by this disclosure.

[0307] As used herein, in various embodiments, the term "circuit" includes hardware structured to execute the functions described herein. In some embodiments, each respective "circuit" includes machine-readable media for configuring the hardware to execute the functions described herein. The circuit is embodied as one or more circuitry components including, but not limited to, processing circuitry, network interfaces, peripheral devices, input devices, output devices, sensors, etc. In some embodiments, a circuit takes the form of one or more analog circuits, electronic circuits (e.g., integrated circuits (IC), discrete circuits, system on a chip (SOCs) circuits, etc.), telecommunication circuits, hybrid circuits, and any other type of "circuit." In this regard, the "circuit" includes any type of component for accomplishing or facilitating achievement of the operations described herein. In one example, a circuit as described herein includes one or more transistors, logic gates (e.g., NAND, AND, NOR, OR, XOR, NOT, or XNOR), resistors, multiplexers, registers, capacitors, inductors, diodes, wiring, and so on.

[0308] In other embodiments, the "circuit" includes one or more processors communicably coupled to one or more memories or memory devices. In this regard, the one or more processors execute instructions stored in the memory or execute instructions otherwise accessible to the one or more processors. In various arrangements, the one or more processors are embodied in various ways and are constructed in a manner sufficient to perform at least the operations described herein. In some embodiments, the one or more processors are shared by multiple circuits (e.g., circuit A and circuit B include or otherwise share the same processor which, in some example embodiments, executes instructions stored, or otherwise accessed, via different areas of memory). Additionally, in various arrangements, a given circuit or components thereof (e.g., the one or more processors) are disposed locally (e.g., as part of a local server or a local computing system) or remotely (e.g., as part of a remote server such as a cloud-based server). To that end, in certain arrangements, a "circuit" as described herein includes components that are distributed across one or more locations. Further, in various arrangements, the functions of one or more circuits discussed above may be implemented by single circuit (e.g., a processing circuit), or the functions of one circuit discussed above may be implemented by multiple circuits.

[0309] As used herein, a processor is implemented as a general-purpose processor, an application specific integrated circuit (ASIC), one or more field programmable gate arrays (FPGAs), a digital signal processor (DSP), a group of processing components, or other suitable electronic processing components. Additionally, in some arrangements, a "processor," as used herein, is implemented as one or more processors. In certain embodiments, the one or more processors are structured to perform or otherwise execute certain operations independent of one or more co-processors. In other example embodiments, two or more processors are coupled via a bus to enable independent, parallel, pipelined, or multi-threaded instruction execution. In some arrangements, the one or more processors take the form of a single core processor, multi-core processor (e.g., a dual core processor, triple core processor, or quad core processor), microprocessor, etc. In some embodiments, the one or more processors are external to the apparatus, for example, the one or more processors are a remote processor (e.g., a cloud-based processor). Alternatively, or additionally, the one or more processors are internal and/or local to the apparatus. Accordingly, an exemplary system for implementing the overall system or portions of the embodiments might include general purpose computing computers in the form of

computers, including a processing unit, a system memory, and a system bus that couples various system components including the system memory to the processing unit.

[0310] Additionally, as used herein, a memory includes one or more memory devices including non-transient volatile storage media, non-volatile storage media, non-transitory storage media (e.g., one or more volatile and/or non-volatile memories), etc. In some embodiments, the non-volatile media takes the form of ROM, flash memory (e.g., flash memory such as NAND, 3D NAND, NOR, or 3D NOR), EEPROM, MRAM, magnetic storage, hard discs, optical discs, etc. In some embodiments, the volatile storage media takes the form of RAM, TRAM, ZRAM, etc. Combinations of the above are also included within the scope of machine-readable media. In this regard, machine-executable instructions comprise, for example, instructions and data which cause a general purpose computer, special purpose computer, or special purpose processing machines to perform a certain function or group of functions. In various arrangements, each respective memory device is operable to maintain or otherwise store information relating to the operations performed by one or more associated circuits, including processor instructions and related data (e.g., database components, object code components, or script components), in accordance with the example embodiments described herein.

WHAT IS CLAIMED IS:

1. A device for administering phototherapy, comprising:

a hollow structure having at least a first open end through which the hollow structure receives at least a portion of patient anatomy, wherein the hollow structure comprises a rotatable member configured to rotate around at least one rotary axis;

one or more coherent light generators mounted to the hollow structure, each coherent light generator configured to generate a beam of coherent light;

for each coherent light generator, one or more lenses or mirrors optically connected to the coherent light generator and mounted to the hollow structure, the one or more lenses or mirrors configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator; and

a processing circuit comprising a processor and a memory storing instructions that, when executed by the processor, cause the processor to:

accept an input from an operator; and

generate one or more beams of coherent light via the one or more coherent light generators according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on the patient anatomy;

wherein the rotatable member is configured to be rotated to direct the one or more beams of coherent light to the targeted treatment site on the patient anatomy.

2. The device of claim 1, wherein the input relates to a treatment plan for the patient, and wherein the instructions cause the processor to generate the one or more beams of coherent light based on the treatment plan input.

3. The device of claim 2, wherein the input is a selection of a treatment plan from a plurality of stored treatment plans, and wherein the instructions cause the processor to generate the one or more beams of coherent light based on the selected treatment plan.

4. The device of claim 2, wherein the instructions further cause the processor to direct the one or more beams of coherent light to the targeted treatment site on the patient anatomy by rotating the rotatable member.

5. The device of claim 1, wherein the rotatable member is configured to rotate 360 degrees around at least one rotary axis.

6. The device of claim 1, wherein each coherent light generator is configured to generate the beam of coherent light at an infrared or near-infrared wavelength.

7. The device of claim 1, wherein at least one coherent light generator is configured to generate the beam of coherent light at 400 to 1200 nm.

8. The device of claim 1, wherein the one or more coherent light generators are configured to deliver beams of coherent light with a radiant exposure in a range of 0.1 to 50 J/cm^2 to the targeted treatment site.

9. The device of claim 1, wherein the device comprises three or more coherent light generators.

10. The device of claim 1, wherein the one or more coherent light coherent light generators are configured to generate beams of coherent light at three or more wavelengths.

11. The device of claim 1, wherein the instructions further cause the processor to direct the one or more beams of coherent light to the targeted treatment site on the patient anatomy by rotating the rotatable member.

12. The device of claim 11, wherein at least one of the lenses or mirrors is mounted on at least one galvanometric gimbal; and

wherein the instructions further cause the processor to direct the beam of coherent light to the target treatment site by moving the at least one galvanometric gimbal.

13. The device of claim 11, wherein the targeted treatment site comprises a primary treatment zone and a secondary treatment zone, the secondary treatment zone comprising a first zone proximal to a heart of the patient and a second zone distal to the heart of the patient; and

wherein the instructions further cause the processor to:

direct the one or more beams of coherent light to each of the primary treatment zone, proximal secondary treatment zone, and distal secondary treatment zone.

14. The device of claim 13, wherein the instructions further cause the processor to modify at least one setting and/or direct a beam of coherent light generated by a different

coherent light generator to each of the primary treatment zone, proximal secondary treatment zone, and distal secondary treatment zone.

15. The device of claim 1, wherein the plurality of settings comprises a pulse type for each of the coherent light generators; and

wherein each pulse type is one of a continuous beam, a pulsed beam, a superpulsed beam, or a combination thereof.

16. The device of claim 1, wherein the instructions further cause the processor to:

receive data from at least one camera or sensor, the data relating to at least one of an operation of the device or a parameter of the targeted treatment site; and

in response to the data, perform at least one of:

modifying at least one of the plurality of settings controlling operation of the device; or

redirecting at least one beam of coherent light by at least one of rotating the rotatable member or moving at least one of the lenses or mirrors.

17. The device of claim 16, wherein the at least one sensor comprises a temperature sensor.

18. The device of claim 1, further comprising a display, and wherein the instructions further cause the processor to:

display, via the display, one or more user interfaces of the targeted treatment site to an operator;

receive, via the display, an identification of one or more areas within the targeted treatment site from the operator; and

perform one of:

directing one or more beams of coherent light to the one or more areas;

modifying at least one of the plurality of settings and directing one or more beams of coherent light to the one or more areas with the modified plurality of settings; or

avoid directing the one or more beams of coherent light to the one or more areas.

19. The device of claim 1, further comprising a cooling structure configured to deliver a coolant to at least a portion of the device or a portion of the patient anatomy.

20. The device of claim 19, wherein the cooling structure is configured to maintain the portion of the patient anatomy at a temperature below 41°C.

21. The device of claim 1, further comprising a handheld probe configured to be optically connected to a coherent light generator of the one or more coherent light generators;

wherein the handheld probe is configured to receive a beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received.

22. The device of claim 21, wherein the handheld probe comprises a closed tip.

23. The device of claim 21, wherein the coherent light generator optically connected to the handheld probe is configured to generate a beam of coherent light of at least 10 W.

24. The device of claim 21, wherein the handheld probe further comprises one or more markers configured to be sensed by an external monitoring device;

wherein the instructions further cause the processor to display to the operator a location of the handheld probe relative to anatomy of the patient based on data received from the external monitoring device.

25. The device of claim 1, wherein the instructions further cause the processor to:

receive images of the targeted treatment site from an external imaging system; and

guide the one or more beams of coherent light to the targeted treatment site based on the images from the external imaging system.

26. The device of claim 1, further comprising a support system on which the hollow structure is mounted, wherein the support system is configured to move the hollow structure according to one or more degrees of freedom.

27. The device of claim 1, wherein the hollow structure is a hollow cylinder.

28. A device for administering phototherapy, comprising:

a handheld probe configured to be optically connected to a coherent light generator configured to generate a beam of coherent light,

wherein the handheld probe is configured to receive the beam of coherent light from the coherent light generator, and

wherein the handheld probe comprises a closed tip from which coherent light is emitted after the beam of coherent light is received; and

a processing circuit comprising a processor and a memory storing instructions that, when executed by the processor, cause the processor to:

accept an input from an operator; and

generate a beam of coherent light via the coherent light generator optically connected to the handheld probe, the beam generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient.

29. The device of claim 28, wherein the input relates to a treatment plan for the patient, and wherein the instructions cause the processor to generate the beam of coherent light based on the treatment plan input.

30. The device of claim 28, wherein the coherent light generator is configured to generate the beam of coherent light at an infrared or near-infrared wavelength.

31. The device of claim 28, wherein the coherent light generator is configured to generate the beam of coherent light at 400 to 1200 nm.

32. The device of claim 28, wherein the coherent light generator is configured to generate a beam of coherent light of at least at 10 W.

33. The device of claim 28, wherein the coherent light generator is configured to deliver beams of coherent light with a radiant exposure in a range of 0.1 to 50 J/cm^2 to the targeted treatment site.

34. The device of claim 28, wherein the plurality of settings comprises a pulse type for the coherent light generator; and

wherein the pulse type is one of a continuous beam, a pulsed beam, a superpulsed beam, or a combination thereof.

35. The device of claim 28, wherein the instructions further cause the processor to:

receive data from at least one camera or sensor, the data relating to at least one of an operation of the handheld probe or a parameter of the targeted treatment site; and

in response to the data, modify at least one of the plurality of settings.

36. The device of claim 28, wherein the instructions further cause the processor to:

receive images of the targeted treatment site from an external imaging system; and

guide the beam of coherent light to the targeted treatment site based on the images from the external imaging system.

37. The device of claim 28, further comprising a cooling structure configured to deliver a coolant to at least one of a portion of the handheld probe or a portion of the patient anatomy.

38. The device of claim 37, wherein the cooling structure is configured to maintain the portion of the patient anatomy at a temperature below 45°C.

39. The device of claim 28, wherein the handheld probe further comprises one or more markers configured to be sensed by an external monitoring device; and

wherein the instructions further cause the processor to display to the operator a location of the handheld probe relative to anatomy of the patient based on data received from the external monitoring device.

40. A device for administering phototherapy, comprising:

a handheld probe configured to be optically connected to a coherent light generator configured to generate a beam of coherent light of at least 10 W,

wherein the handheld probe is configured to receive the beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received, and

wherein the handheld probe further comprises a cooling structure configured to deliver a coolant to at least a portion of the handheld probe or a portion of anatomy of a patient; and

a processing circuit comprising a processor and a memory storing instructions that, when executed by the processor, cause the processor to:

accept an input from an operator; and

generate a beam of coherent light via the coherent light generator optically connected to the handheld probe, the beam generated according to a plurality of settings configured to produce a therapeutic effect at the targeted treatment site.

41. The device of claim 40, wherein the input relates to a treatment plan for the patient, and wherein the instructions cause the processor to generate the beam of coherent light based on the treatment plan input.

42. The device of claim 40, wherein the coherent light generator is configured to generate the beam of coherent light at an infrared or near-infrared wavelength.

43. The device of claim 40, wherein the coherent light generator is configured to generate the beam of coherent light at 400 to 1200 nm.

44. The device of claim 40, wherein the coherent light generator is configured to deliver beams of coherent light with a radiant exposure in a range of 0.1 to 50 J/cm^2 to the targeted treatment site.

45. The device of claim 40, wherein the plurality of settings comprises a pulse type for the coherent light generator; and

wherein the pulse type is one of a continuous beam, a pulsed beam, a superpulsed beam, or a combination thereof.

46. The device of claim 40, wherein the instructions further cause the processor to:

receive data from at least one camera or sensor, the data relating to at least one of an operation of the handheld probe or a parameter of the targeted treatment site; and

in response to the data, modify at least one of the plurality of settings.

47. The device of claim 40, wherein the instructions further cause the processor to:

receive images of the targeted treatment site from an external imaging system; and

guide the beam of coherent light to the targeted treatment site based on the images from the external imaging system.

48. The device of claim 40, wherein the handheld probe further comprises one or more markers configured to be sensed by an external monitoring device; and

wherein the instructions further cause the processor to display to the operator a location of the handheld probe relative to anatomy of the patient based on data received from the external monitoring device.

49. The device of claim 40, wherein the cooling structure is configured to maintain the portion of the patient anatomy at a temperature below 45°C.

50. A device for administering phototherapy, comprising:

a hollow structure having at least a first open end through which the hollow structure receives at least a portion of patient anatomy, wherein the hollow structure comprises a rotatable member configured to rotate around at least one rotary axis;

one or more coherent light generators mounted to the hollow structure, each coherent light generator configured to generate a beam of coherent light;

for each coherent light generator, one or more lenses or mirrors optically connected to the coherent light generator and mounted to the hollow structure, the one or more lenses or mirrors configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator;

a handheld probe configured to be optically connected to a coherent light generator, wherein the handheld probe is configured to receive a beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received; and

a processing circuit comprising a processor and a memory storing instructions that, when executed by the processor, cause the processor to:

accept an input from an operator; and

generate one or more beams of coherent light via the one or more coherent light generators and/or the coherent light generator optically connected to the handheld probe according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on the patient anatomy.

51. The device of claim 50, wherein the input relates to a treatment plan for the patient, and wherein the instructions cause the processor to generate the one or more beams of coherent light based on the treatment plan input.

52. The device of claim 51, wherein the input is a selection of a treatment plan from a plurality of stored treatment plans, and wherein the instructions cause the processor to generate the one or more beams of coherent light based on the selected treatment plan.

53. The device of claim 51, wherein the instructions further cause the processor to direct the one or more beams of coherent light to the targeted treatment site on the patient anatomy by rotating the rotatable member.

54. The device of claim 50, wherein the rotatable member is configured to rotate 360 degrees around at least one rotary axis.

55. The device of claim 50, wherein the instructions further cause the processor to direct the one or more beams of coherent light to the targeted treatment site by rotating the rotatable member.

56. The device of claim 50, wherein the one or more coherent light generators mounted to the hollow structure comprise the coherent light generator optically connected to the handheld probe.

57. The device of claim 51, wherein the coherent light generator optically connected to the handheld probe is an external coherent light generator not coupled to the hollow structure.

58. The device of claim 57, wherein the instructions further cause the processor to, after the handheld probe is optically connected to a coherent light generator, generate the one or more beams of coherent light via the one or more coherent light generators and the coherent light generator optically connected to the handheld probe such that coherent light is directed to the targeted treatment site via the hollow structure and the handheld probe simultaneously.

59. The device of claim 51, wherein the hollow structure is a hollow cylinder.

60. A method for administering phototherapy, comprising:

accepting an input from an operator; and

generating one or more beams of coherent light via one or more coherent light generators, the one or more beams generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient,

wherein the one or more coherent light generators are mounted to a hollow structure,

wherein the hollow structure comprises at least a first open end through which the hollow structure receives at least a portion of patient anatomy comprising the targeted treatment site,

wherein the hollow structure further comprises a rotatable member configured to rotate around at least one rotary axis, and

wherein each coherent light generator is optically connected to one or more lenses or mirrors mounted to the hollow structure, the one or more lenses or mirrors configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator,

wherein the rotatable member is configured to be rotated to direct the one or more beams of coherent light to the targeted treatment site.

61. The method of claim 60, wherein the input relates to a treatment plan for the patient, and wherein generating the one or more beams of coherent light comprises generating the one or more beams of coherent light via the one or more coherent light generators based on the treatment plan input.

62. The method of claim 61, wherein the input is a selection of a treatment plan from a plurality of stored treatment plans, and wherein the generating the one or more beams of coherent light comprises generating the one or more beams of coherent light via the one or more coherent light generators based on the selected treatment plan.

63. The method of claim 61, further comprising directing the one or more beams of coherent light to the targeted treatment site on the patient anatomy by rotating the rotatable member.

64. The method of claim 60, wherein the rotatable member is configured to rotate 360 degrees around at least one rotary axis.

65. The method of claim 60, wherein each coherent light generator is configured to generate the beam of coherent light at an infrared or near-infrared wavelength.

66. The method of claim 60, wherein at least one coherent light generator is configured to generate the beam of coherent light at 400 to 1200 nm.

67. The method of claim 60, wherein the one or more coherent light generators are configured to deliver beams of coherent light with a radiant exposure in a range of 0.1 to 50 J/cm^2 to the targeted treatment site.

68. The method of claim 60, wherein three or more coherent light generators are mounted to the hollow structure.

69. The method of claim 60, wherein the one or more coherent light generators are configured to generate beams of coherent light at three or more wavelengths.

70. The method of claim 60, further comprising directing the one or more beams of coherent light to the targeted treatment site by rotating the rotatable member.

71. The method of claim 70, wherein at least one of the lenses or mirrors is mounted on at least one galvanometric gimbal; and

wherein the method further comprises directing the one or more beams of coherent light to the targeted treatment site by moving the at least one galvanometric gimbal.

72. The method of claim 60, wherein the targeted treatment site comprises a primary treatment zone and a secondary treatment zone, the secondary treatment zone comprising a first zone proximal to a heart of the patient and a second zone distal to the heart of the patient; and

wherein directing the one or more beams of coherent light to the targeted treatment zone by rotating the rotatable member comprises directing the one or more beams of coherent light to each of the primary treatment zone, proximal secondary treatment zone, and distal secondary treatment zone.

73. The method of claim 72, wherein directing the one or more beams of coherent light to each of the primary treatment zone, proximal secondary treatment zone, and distal secondary treatment zone comprises modifying at least one setting and/or directing a beam of coherent light generated by a different coherent light generator to each of the primary treatment zone, proximal secondary treatment zone, and distal secondary treatment zone.

74. The method of claim 60, wherein the plurality of settings comprises a pulse type for each of the coherent light generators; and

wherein each pulse type is one of a continuous beam, a pulsed beam, a superpulsed beam, or a combination thereof.

75. The method of claim 60, further comprising:

receiving data from at least one camera or sensor, the data relating to at least one of an operation of the device or a parameter of the targeted treatment site; and

in response to the data, perform at least one of:

modifying at least one of the plurality of settings; or

redirecting at least one beam of coherent light by at least one of rotating the rotatable member or moving at least one of the lenses or mirrors.

76. The method of claim 75, wherein the at least one sensor comprises a temperature sensor.

77. The method of claim 60, further comprising:

displaying, via a display, one or more user interfaces of the targeted treatment site to an operator;

receiving, via a display, an identification of one or more areas within the targeted treatment site from the operator; and

performing one of:

directing one or more beams of coherent light to the one or more areas;

modifying at least one of the plurality of settings and directing one or more beams of coherent light to the one or more areas with the modified plurality of settings; or

avoiding directing the one or more beams of coherent light to the one or more areas.

78. The method of claim 60, further comprising delivering, by a cooling structure, a coolant to at least a portion of the hollow structure or the targeted treatment site.

79. The method of claim 78, wherein the cooling structure is configured to maintain the portion of the patient anatomy at a temperature below 41°C.

80. The method of claim 60, further comprising optically connecting a handheld probe to a coherent light generator of the one or more coherent light generators, wherein the handheld probe is configured to receive a beam of coherent light from the coherent light

generator and emit the coherent light from the handheld probe after the beam of coherent light is received.

81. The method of claim 80, wherein the handheld probe comprises a closed tip.

82. The method of claim 80, wherein the coherent light generator optically connected to the handheld probe is configured to generate a beam of coherent light of at least 10 W.

83. The method of claim 80, wherein the handheld probe further comprises one or more markers configured to be sensed by an external monitoring device; and

wherein the method further comprises displaying to the operator a location of the handheld probe relative to the anatomy of the patient based on data received from the external monitoring device.

84. The method of claim 60, further comprising:

receiving images of the targeted treatment site from an external imaging system; and

guiding the one or more beams of coherent light to the targeted treatment site based on the images from the external imaging system.

85. The method of claim 60, wherein the hollow structure is further mounted on a support system configured to move the hollow structure according to one or more degrees of freedom.

86. The method of claim 60, wherein the hollow structure is a hollow cylinder.

87. A method for administering phototherapy, comprising:

optically connecting a handheld probe to a coherent light generator configured to generate a beam of coherent light,

wherein the handheld probe is configured to receive the beam of coherent light from the coherent light generator, and

wherein the handheld probe comprises a closed tip from which coherent light is emitted after the beam of coherent light is received;

accepting an input from an operator; and

generating a beam of coherent light via the coherent light generator optically connected to the handheld probe according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient.

88. The method of claim 87, wherein the input relates to a treatment plan for the patient, and wherein generating the beam of coherent light comprises generating the beam of coherent light via the coherent light generator optically connected to the handheld probe based on the treatment plan input.

89. The method of claim 87, wherein the coherent light generator is configured to generate the beam of coherent light at an infrared or near-infrared wavelength.

90. The method of claim 87, wherein the coherent light generator is configured to generate the beam of coherent light at 400 to 1200 nm.

91. The method of claim 87, wherein the coherent light generator is configured to generate a beam of coherent light at 10 W.

92. The method of claim 87, wherein the coherent light generator is configured to deliver a beam of coherent light with a radiant exposure in a range of 0.1 to 50 J/cm^2 to the targeted treatment site.

93. The method of claim 87, wherein the plurality of settings comprises a pulse type for the coherent light generator; and

wherein the pulse type is one of a continuous beam, a pulsed beam, a superpulsed beam, or a combination thereof.

94. The method of claim 87, further comprising:

receiving data from at least one camera or sensor, the data relating to at least one of an operation of the handheld probe or a parameter of the targeted treatment site; and

in response to the data, modifying at least one of the plurality of settings.

95. The method of claim 87, further comprising:

receiving images of the targeted treatment site from an external imaging system; and

guiding the beam of coherent light to the targeted treatment site based on the images from the external imaging system.

96. The method of claim 87, further comprising delivering, by a cooling structure, a coolant to at least one of a portion of the handheld probe or a portion of the patient anatomy.

97. The method of claim 96, wherein the cooling structure is configured to maintain the portion of the patient anatomy at a temperature below 45°C.

98. The method of claim 87, wherein the handheld probe further comprises one or more markers configured to be sensed by an external monitoring device; and

wherein the method further comprises displaying to the operator a location of the handheld probe relative to anatomy of the patient based on data received from the external monitoring device.

99. A method for administering phototherapy, comprising:

optically connecting a handheld probe to a coherent light generator configured to generate a beam of coherent light of at least 10 W,

wherein the handheld probe is configured to receive the beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received, and

wherein the handheld probe further comprises a cooling structure;

accepting an input from an operator;

generating a beam of coherent light via the coherent light generator optically connected to the handheld probe according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient; and

delivering, by the cooling structure, a coolant to at least one of a portion of the handheld probe or a portion of anatomy of the patient.

100. The method of claim 99, wherein the input relates to a treatment plan for the patient, and wherein generating the beam of coherent light comprises generating the beam of coherent light via the coherent light generator optically connected to the handheld probe based on the treatment plan input.

101. The method of claim 99, wherein the coherent light generator is configured to generate the beam of coherent light at an infrared or near-infrared wavelength.

102. The method of claim 99, wherein the coherent light generator is configured to generate the beam of coherent light at 400 to 1200 nm.

103. The method of claim 99, wherein the coherent light generator is configured to deliver a beam of coherent light with a radiant exposure in a range of 0.1 to 50 J/cm^2 to the targeted treatment site.

104. The method of claim 99, wherein the plurality of settings comprises a pulse type for the coherent light generator; and

wherein the pulse type is one of a continuous beam, a pulsed beam, a superpulsed beam, a chopped beam, a shaped beam, a chirped beam, or a combination thereof.

105. The method of claim 99, further comprising:

receiving data from at least one camera or sensor, the data relating to at least one of an operation of the handheld probe or a parameter of the targeted treatment site; and

in response to the data, modifying at least one of the plurality of settings.

106. The method of claim 99, further comprising:

receiving images of the targeted treatment site from an external imaging system; and

guiding the beam of coherent light to the targeted treatment site based on the images from the external imaging system.

107. The method of claim 99, wherein the handheld probe further comprises one or more markers configured to be sensed by an external monitoring device; and

wherein the method further comprises displaying to the operator a location of the handheld probe relative to anatomy of the patient based on data received from the external monitoring device.

108. The method of claim 104, wherein the cooling structure is configured to maintain the portion of the patient anatomy at a temperature below 45°C.

109. A method for administering phototherapy, comprising:

optically connecting a handheld probe to a coherent light generator configured to generate a beam of coherent light, wherein the handheld probe is configured to receive the beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received;

accepting an input from an operator; and

generating one or more beams of coherent light via one or more coherent light generators and/or the coherent light generator optically connected to the handheld probe, the one or more beams generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient,

wherein the one or more coherent light generators are mounted to a hollow structure,

wherein the hollow structure comprises a first open end through which the hollow structure receives at least a portion of patient anatomy comprising a targeted treatment site,

wherein the hollow structure further comprises a rotatable member configured to rotate around at least one rotary axis, and

wherein each of the one or more coherent light generators is optically connected to one or more lenses or mirrors mounted to the hollow structure, the one or more lenses or mirrors configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator.

110. The method of claim 109, wherein generating the one or more beams of coherent light comprises generating the one or more beams of coherent light via the one or more coherent light generators and/or the coherent light generator optically connected to the handheld probe based on the treatment plan input.

111. The method of claim 110, wherein the input is a selection of a treatment plan from a plurality of stored treatment plans, and wherein generating the one or more beams of coherent light comprises generating the one or more beams of coherent light via the one or more coherent light generators and/or the coherent light generator optically connected to the handheld probe based on the selected treatment plan.

112. The method of claim 110, further comprising directing the one or more beams of coherent light to the targeted treatment site on the patient anatomy by rotating the rotatable member.

113. The method of claim 109, wherein the rotatable member is configured to rotate 360 degrees around at least one rotary axis.

114. The method of claim 109, further comprising rotating the rotatable member to direct the one or more beams of coherent light to the targeted treatment site.

115. The method of claim 109, wherein the one or more coherent light generators mounted to the hollow structure comprise the coherent light generator optically connected to the handheld probe.

116. The method of claim 109, wherein the coherent light generator optically connected to the handheld probe is an external coherent light generator not coupled to the hollow structure.

117. The method of claim 116, wherein generating the one or more beams of coherent light comprises generating the one or more beams of coherent light via the one or more coherent light generators and the coherent light generator optically coupled to the handheld probe such that coherent light is directed to the targeted treatment site via the hollow structure and the handheld probe simultaneously.

118. The method of claim 109, wherein the hollow structure is a hollow cylinder.

119. A device for administering phototherapy, comprising:

a stationary hollow structure having at least a first open end through which the hollow structure receives at least a portion of patient anatomy;

at least one coherent light generator, each coherent light generator configured to generate a beam of coherent light;

at least one of:

a plurality of coherent light generators mounted to an interior of the hollow structure, the plurality of coherent light generators including the one or more coherent light generators, or

a plurality of lenses mounted to the interior of the hollow structure; and

a processing circuit comprising a processor and a memory storing instructions that, when executed by the processor, cause the processor to:

accept an input from an operator; and

generate one or more beams of coherent light, via the at least one coherent light generator or the plurality of coherent light generators, according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on the patient anatomy;

wherein the instructions cause the processor to direct the one or more beams of coherent light to the targeted treatment site by generating the one or more beams of coherent light in a sequence.

120. The device of claim 119, wherein a total of the plurality of coherent light generators and/or the plurality of lenses mounted to the interior of the hollow structure is at least 200.

121. The device of claim 119, wherein the instructions cause the processor to direct the one or more beams of coherent light to the targeted treatment site via adjacent coherent light generators and/or lenses in a sweeping sequence.

122. The device of claim 119, wherein the input relates to a treatment plan for the patient, and wherein the instructions cause the processor to generate the one or more beams of coherent light in a sequence based on the treatment plan input.

123. The device of claim 119, further comprising a cooling structure configured to deliver a coolant to at least a portion of the device or a portion of the patient anatomy.

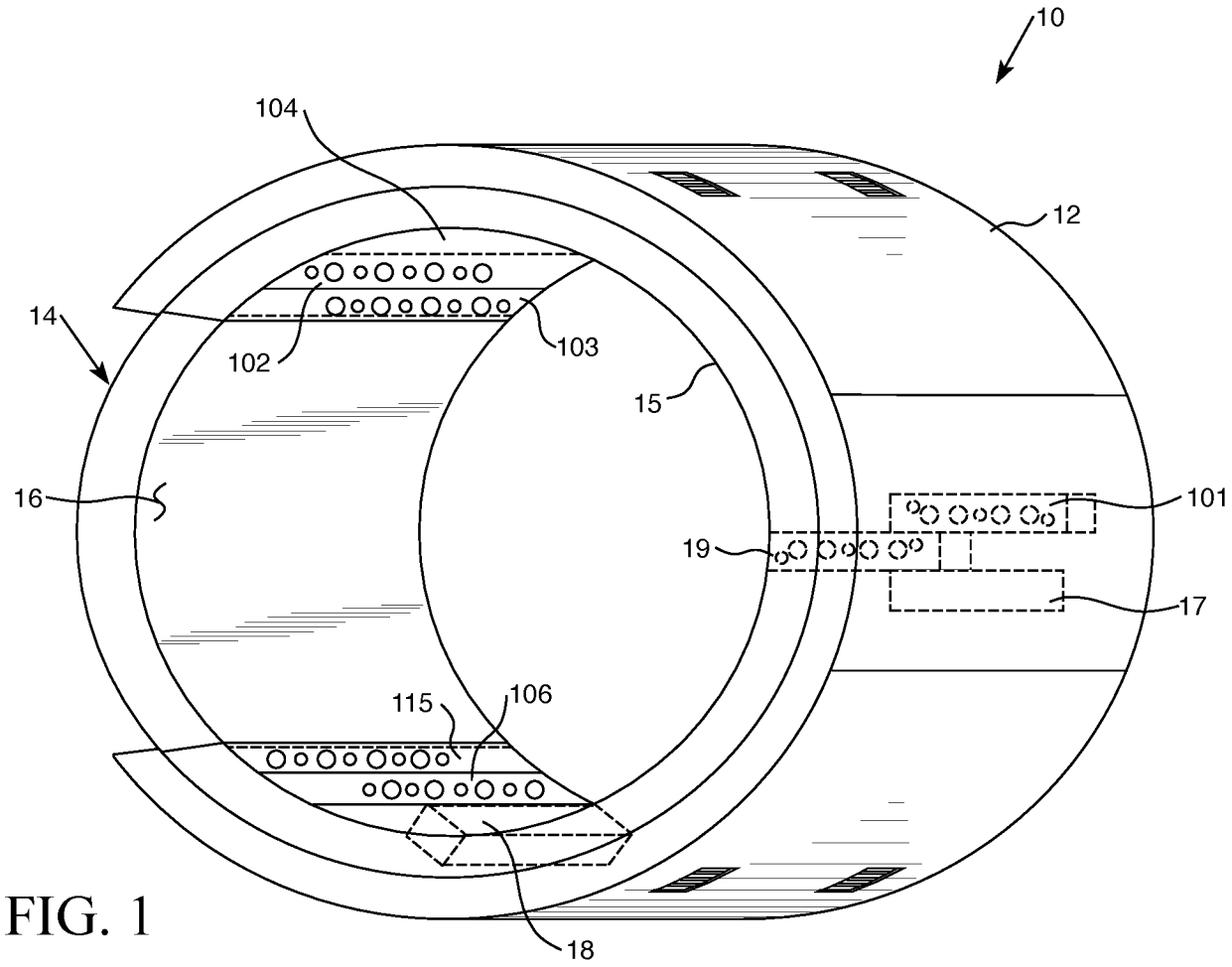


FIG. 1

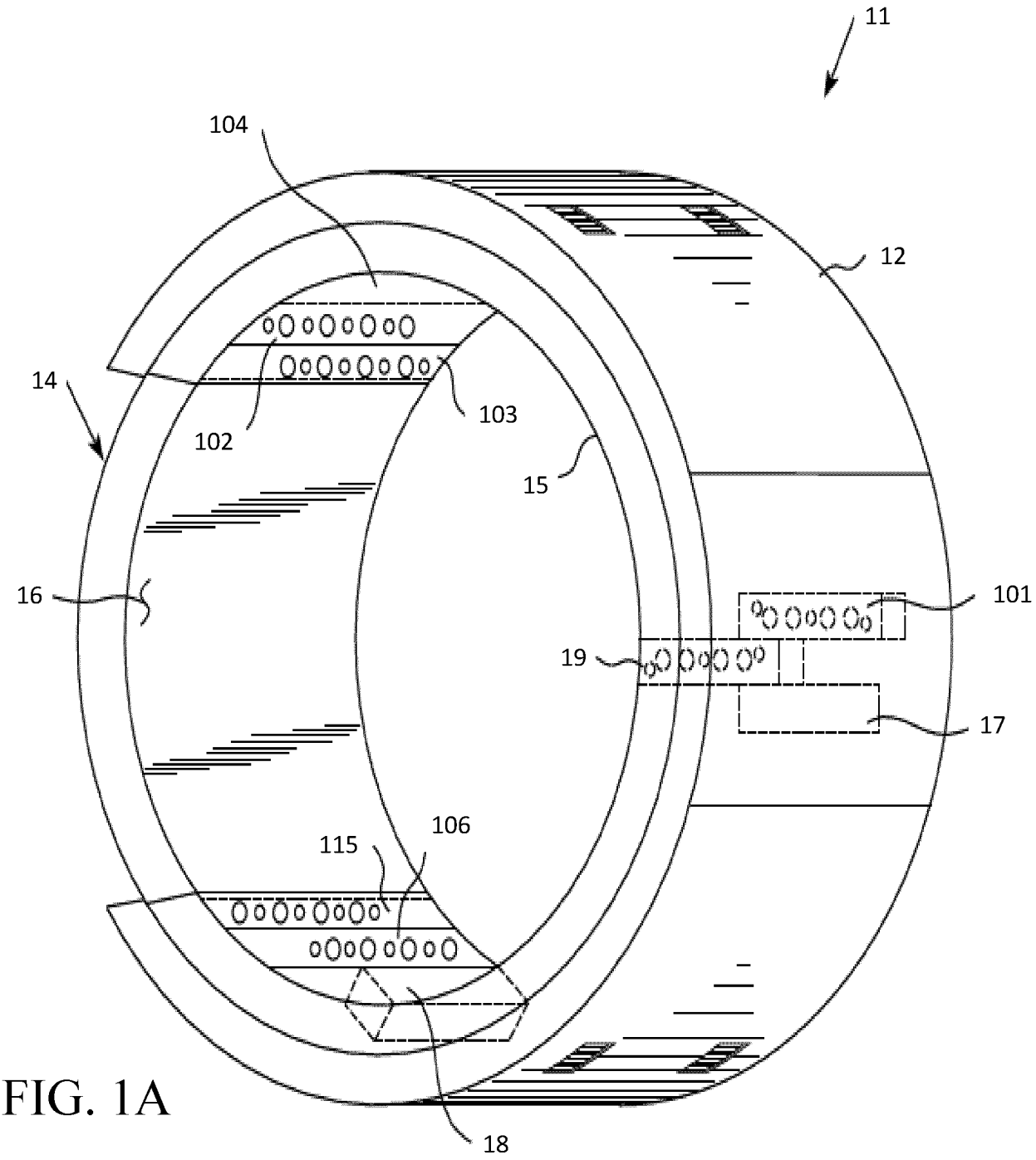
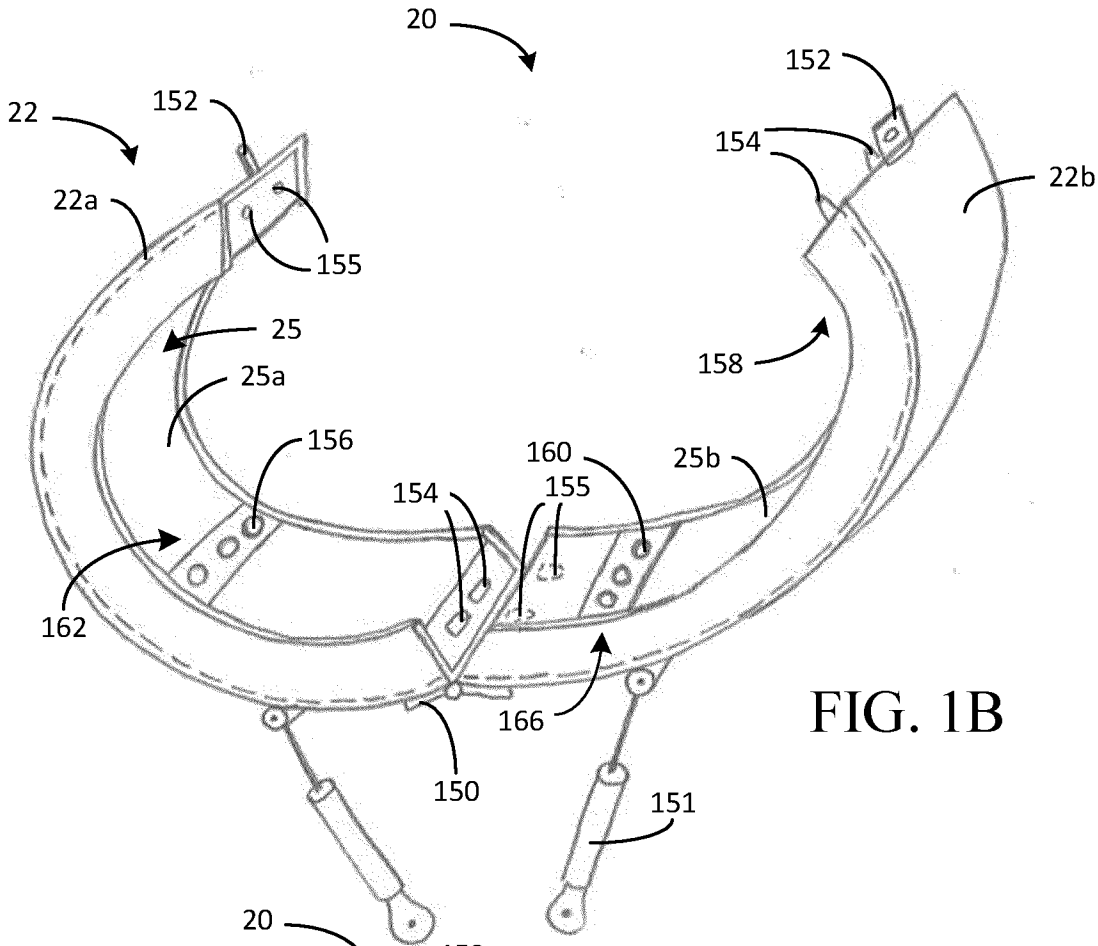


FIG. 1A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22
152
22a
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25b
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22b
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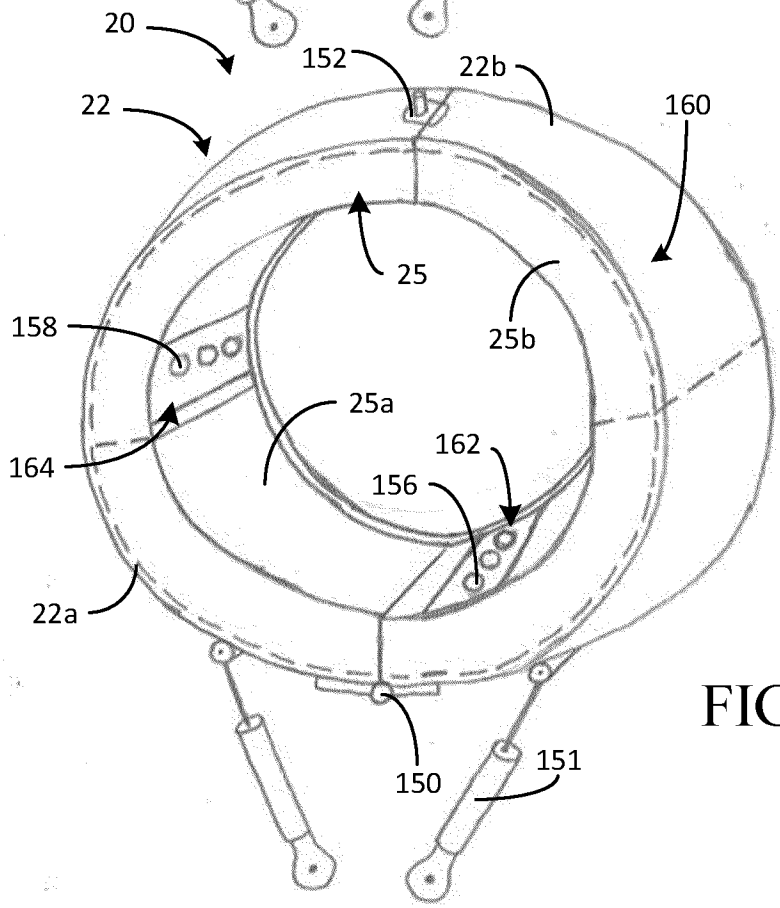
166
150
151

FIG. 1B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25a
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22a
150
151

FIG. 1C

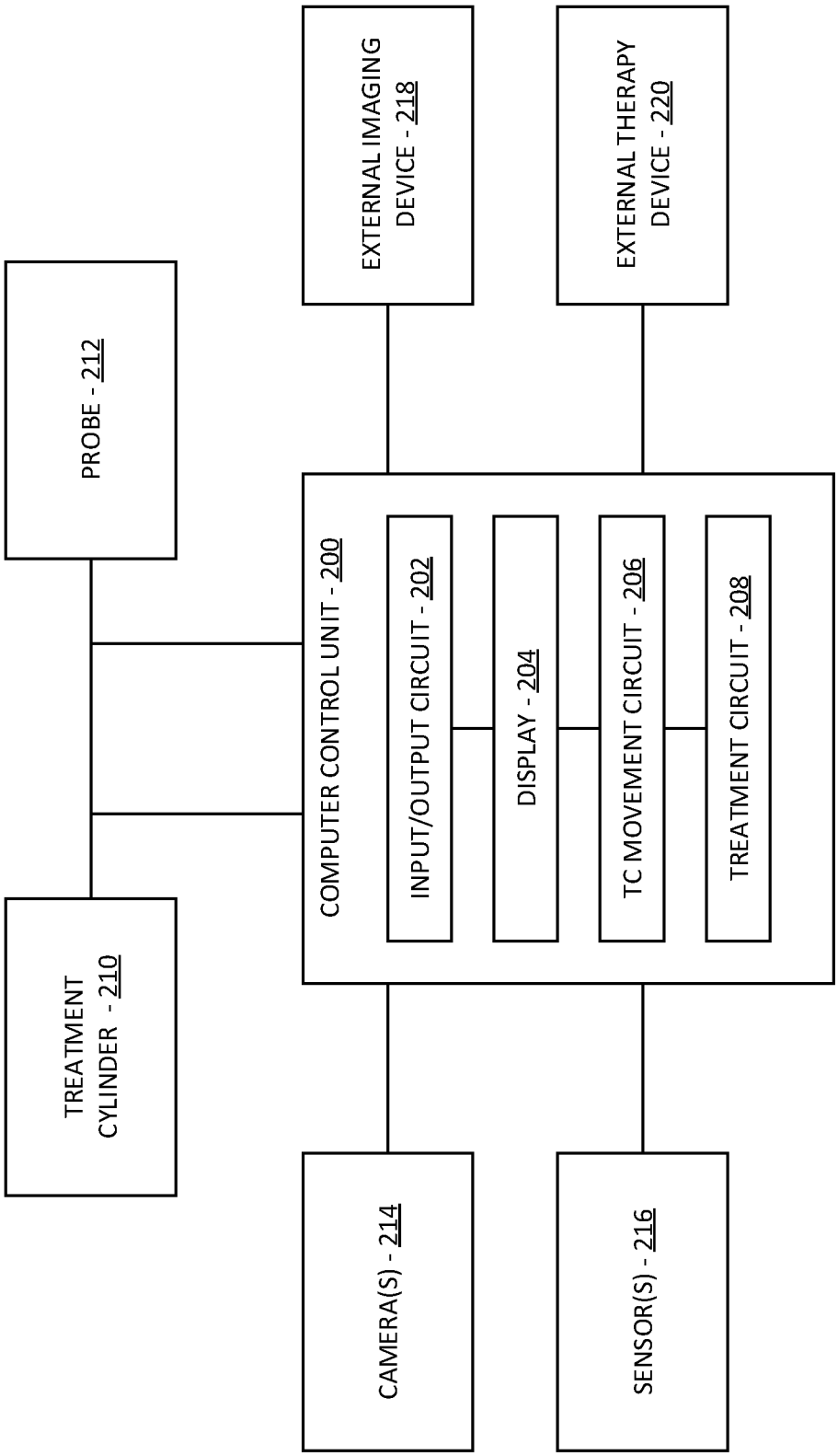
EXTERNAL IMAGING DEVICE - 218
EXTERNAL THERAPY DEVICE - 220
PROBE - 212
COMPUTER CONTROL UNIT - 200
INPUT/OUTPUT CIRCUIT - 202
DISPLAY - 204
TC MOVEMENT CIRCUIT - 206
TREATMENT CIRCUIT - 208
TREATMENT CYLINDER - 210
CAMERA(S) - 214
SENSOR(S) - 216

FIG. 2

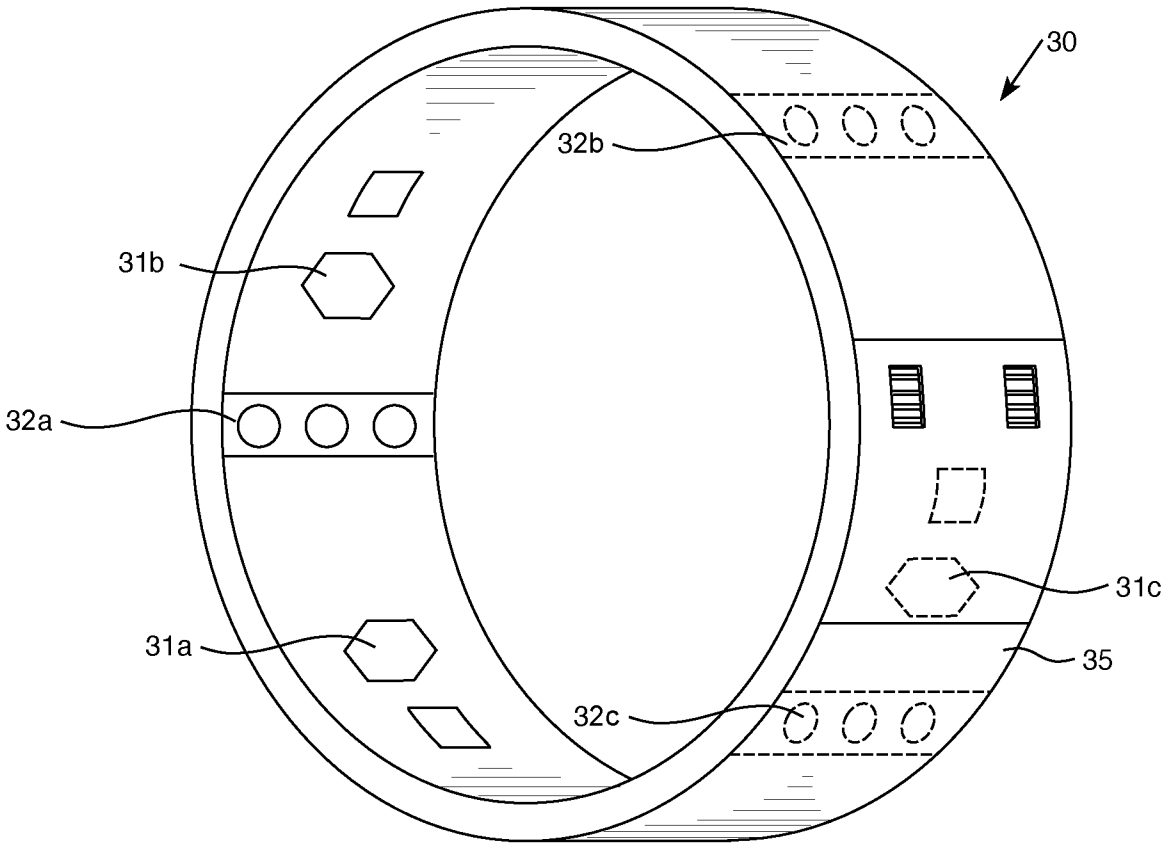

FIG. 3

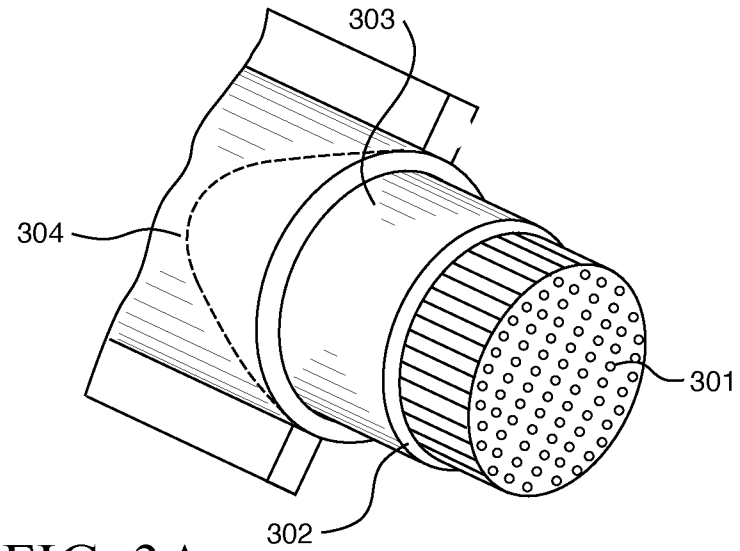

FIG. 3A

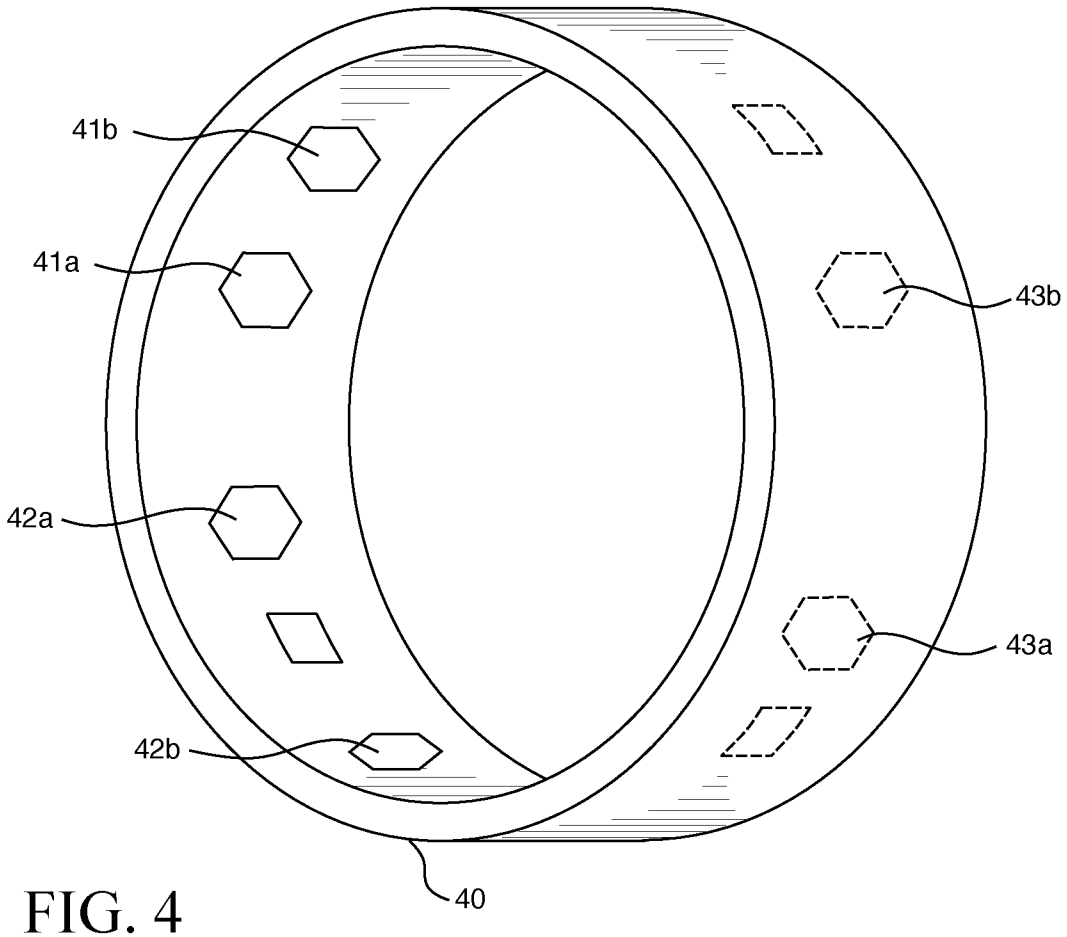

FIG. 4

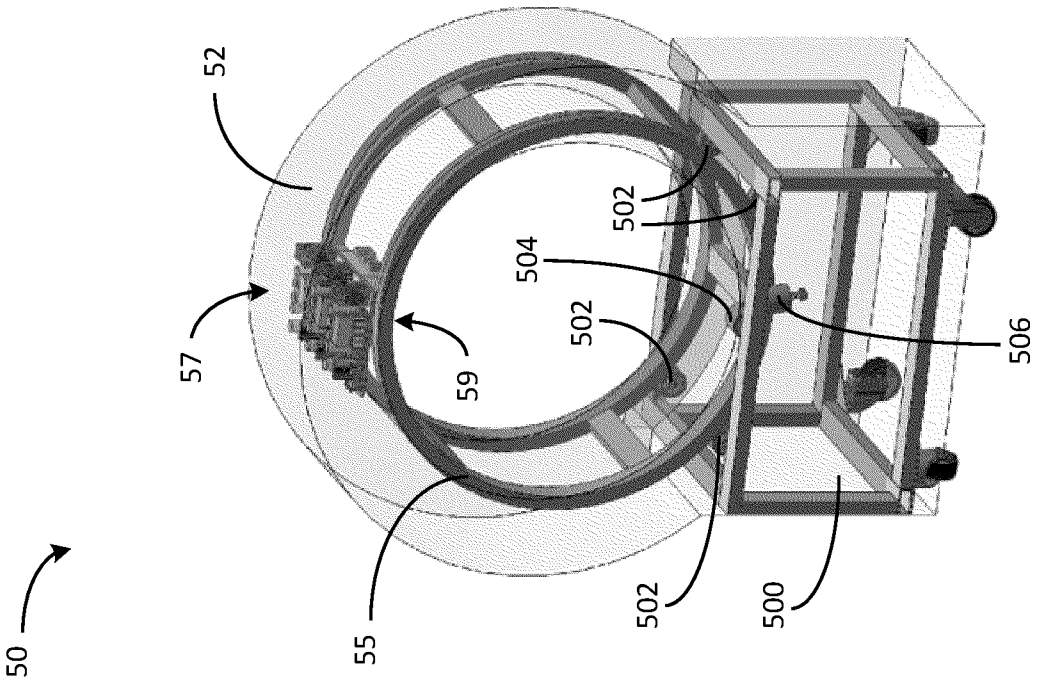

FIG. 5

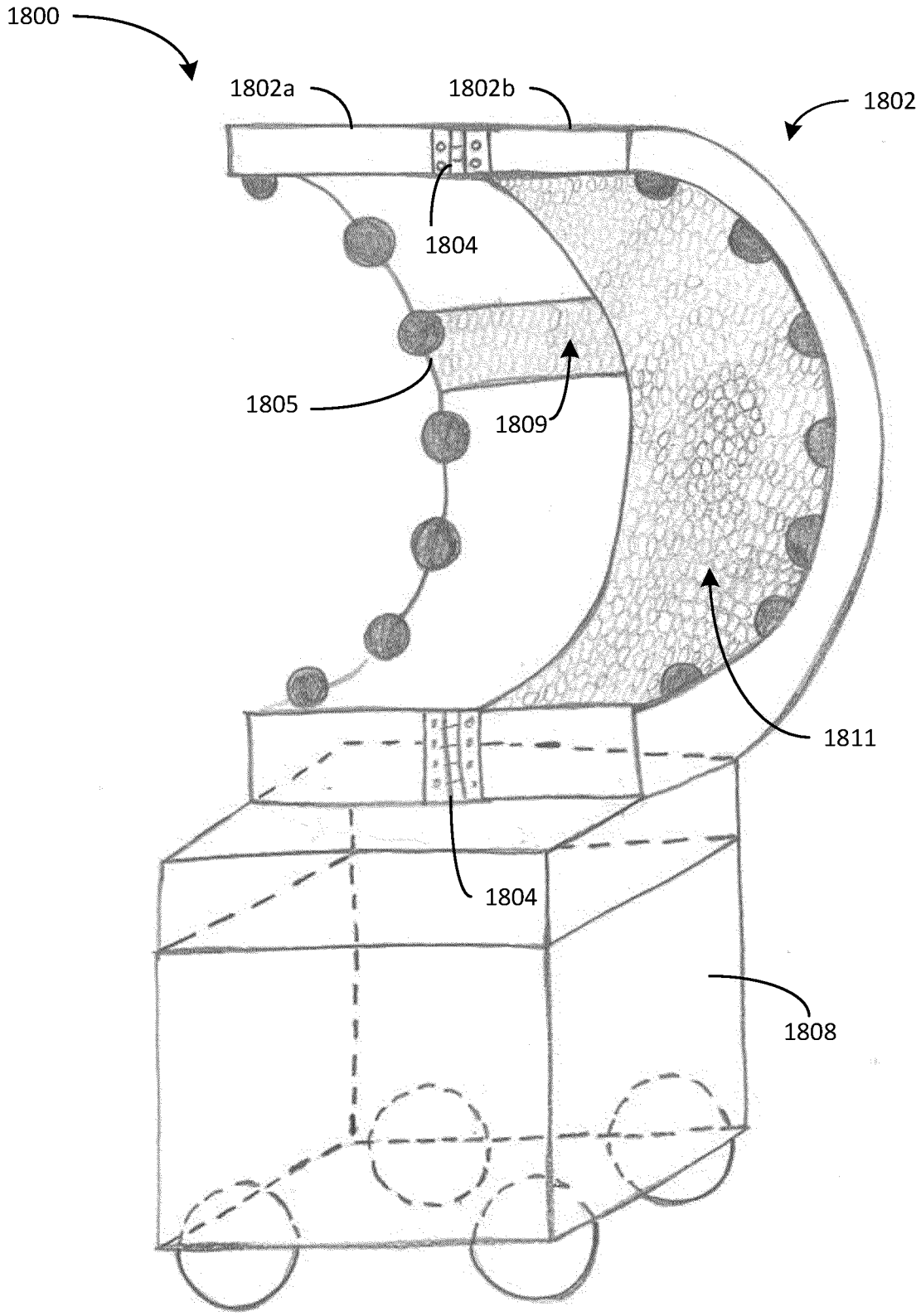

FIG. 5A

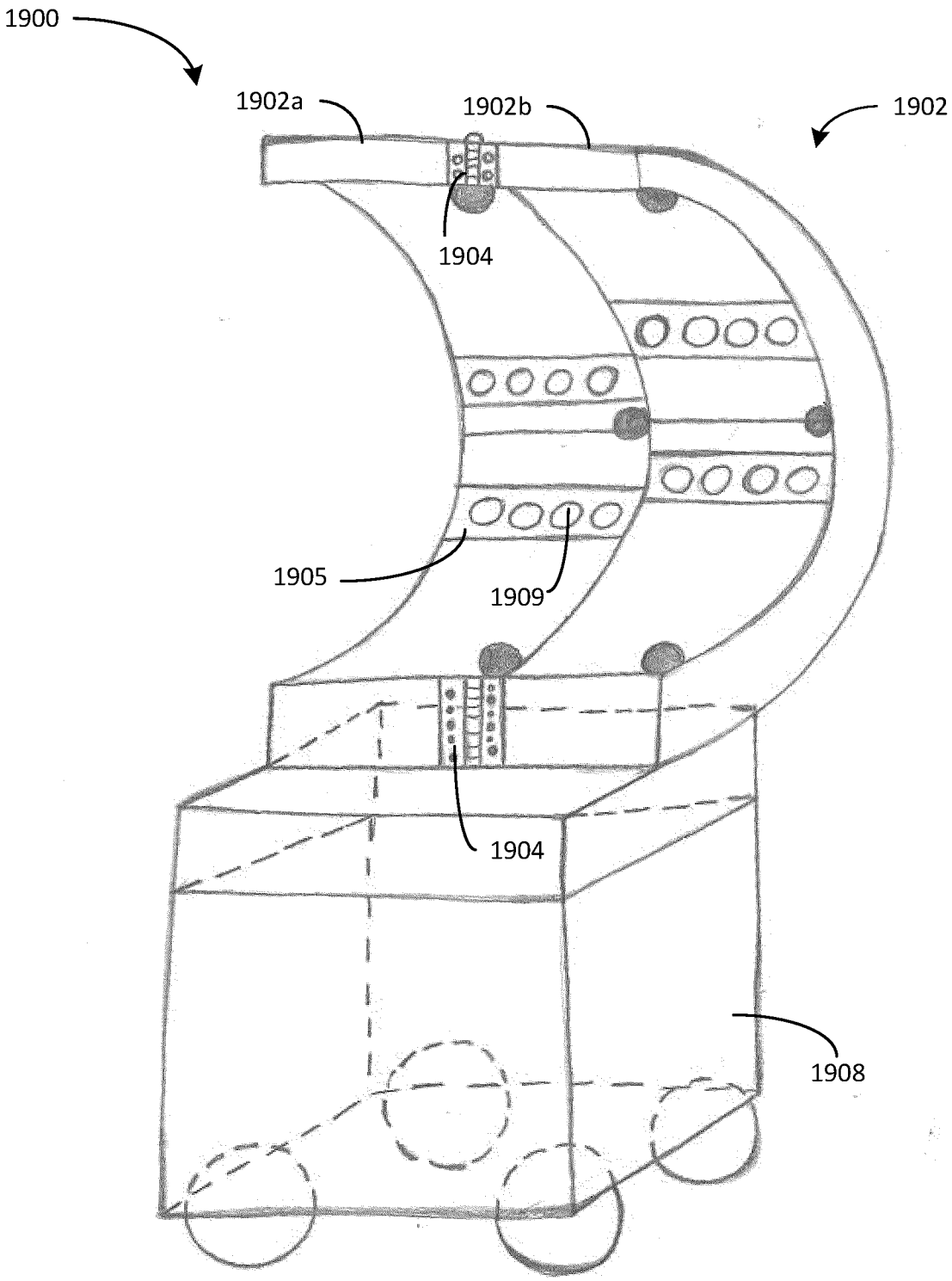

FIG. 5B

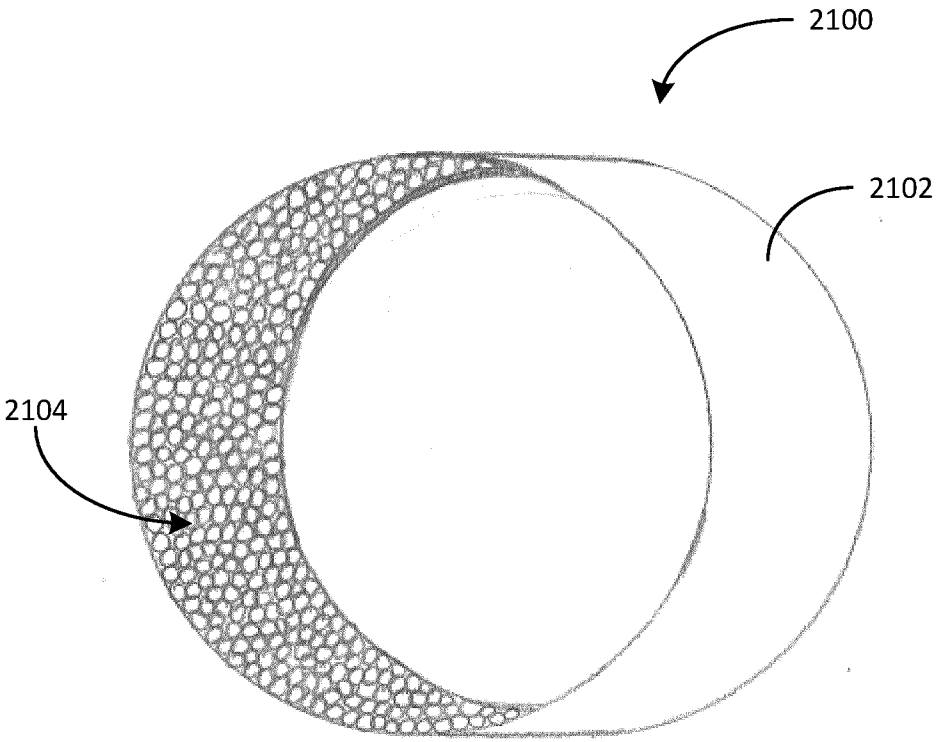

FIG. 5C

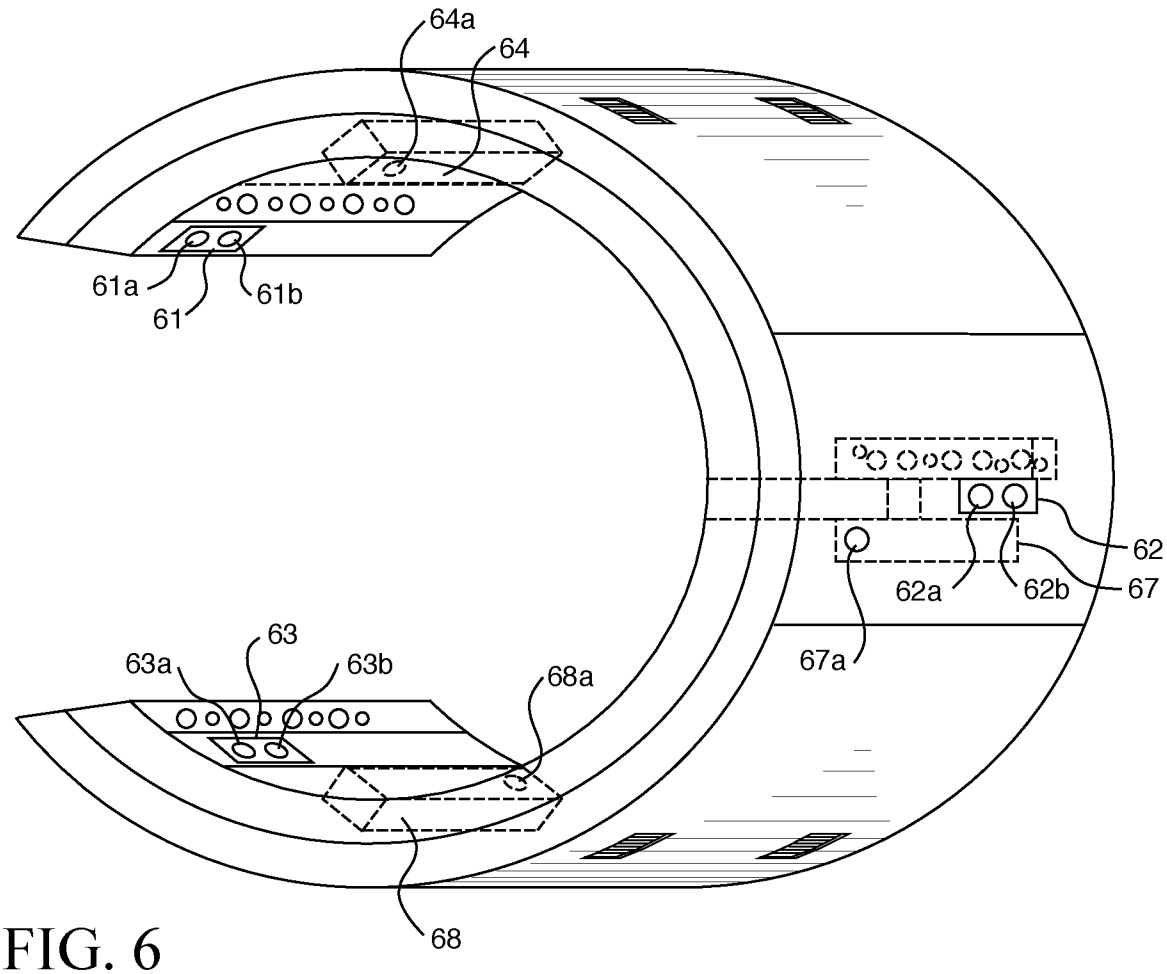

FIG. 6

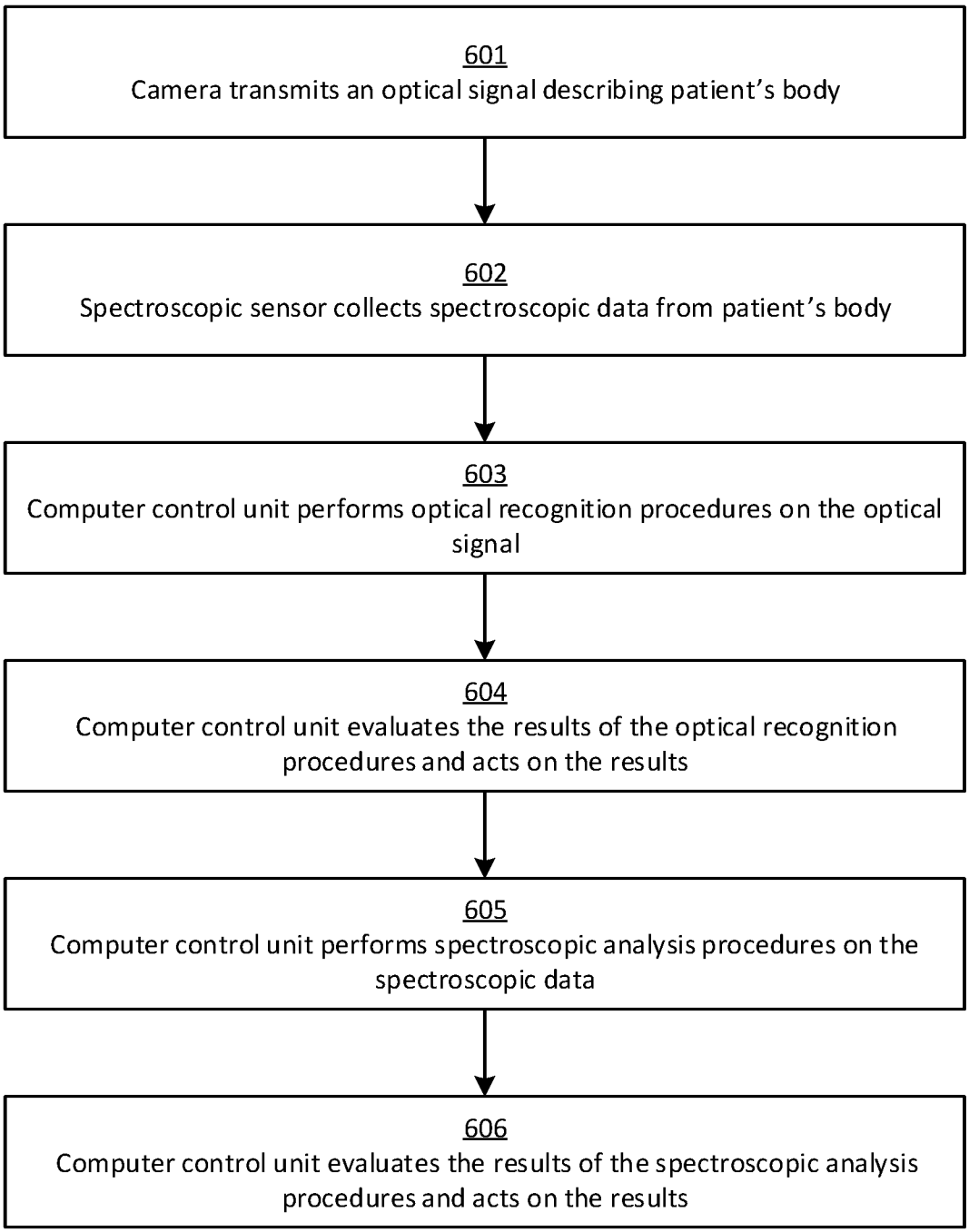
601
Camera transmits an optical signal describing patient's body
602
Spectroscopic sensor collects spectroscopic data from patient's body
603
Computer control unit performs optical recognition procedures on the optical signal
604
Computer control unit evaluates the results of the optical recognition procedures and acts on the results
605
Computer control unit performs spectroscopic analysis procedures on the spectroscopic data
606
Computer control unit evaluates the results of the spectroscopic analysis procedures and acts on the results

FIG. 6A

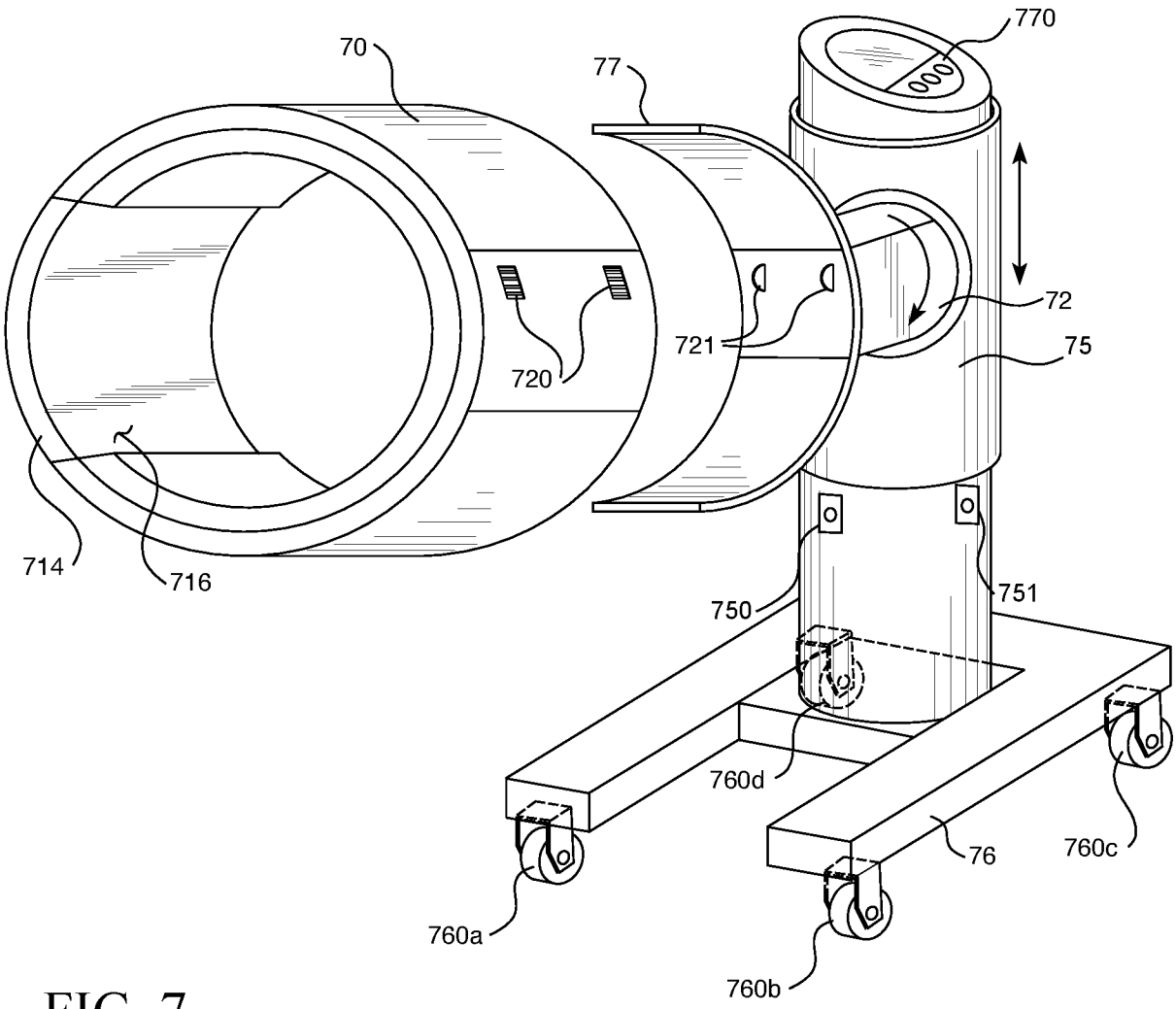

FIG. 7

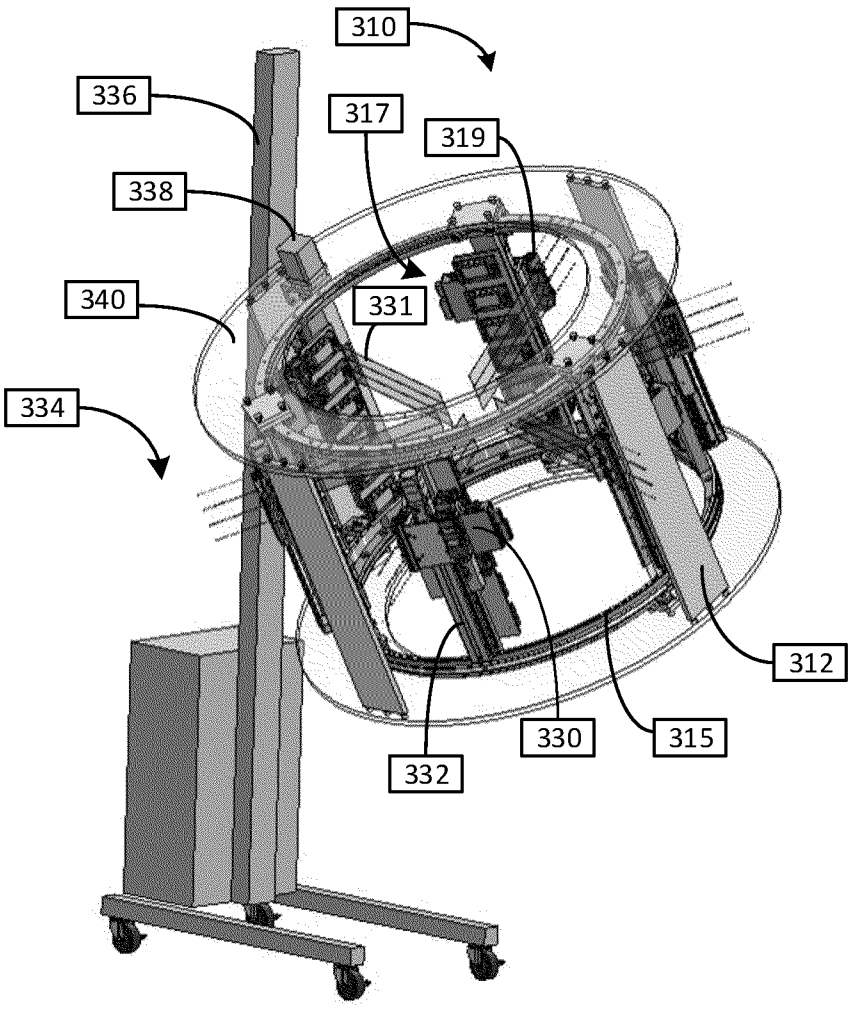

FIG. 7A

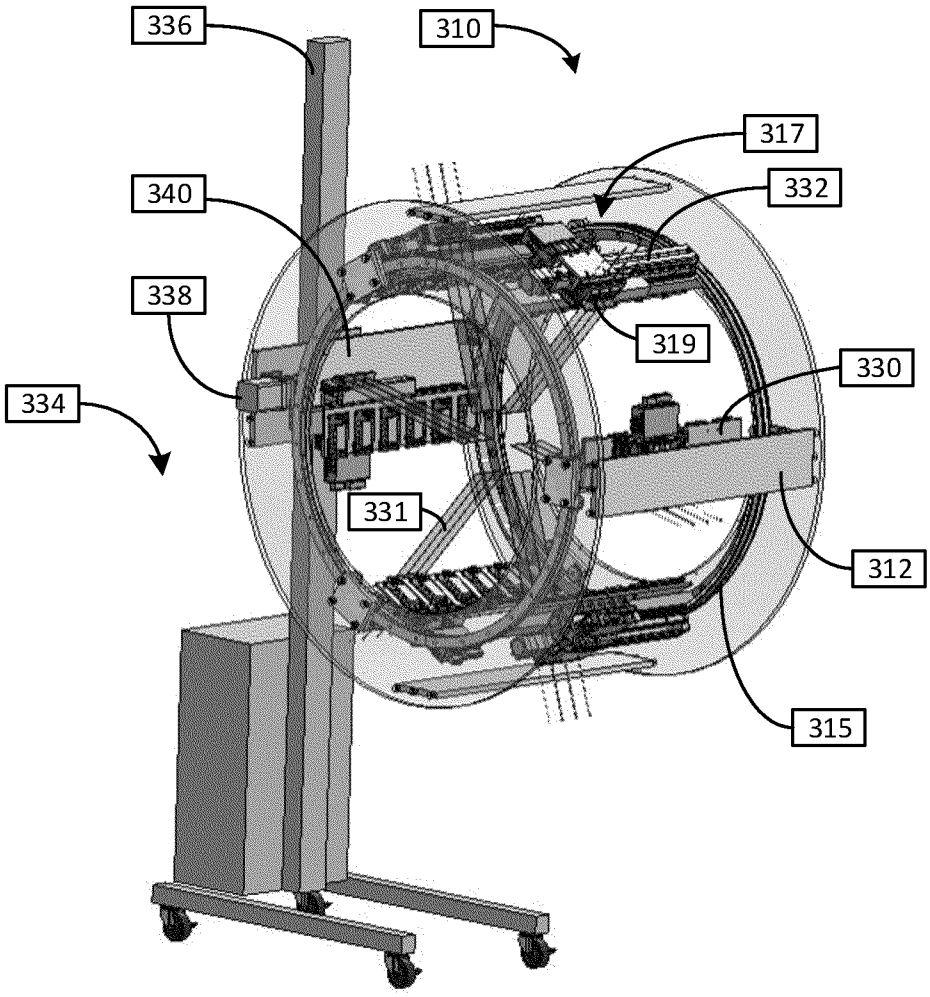

FIG. 7B

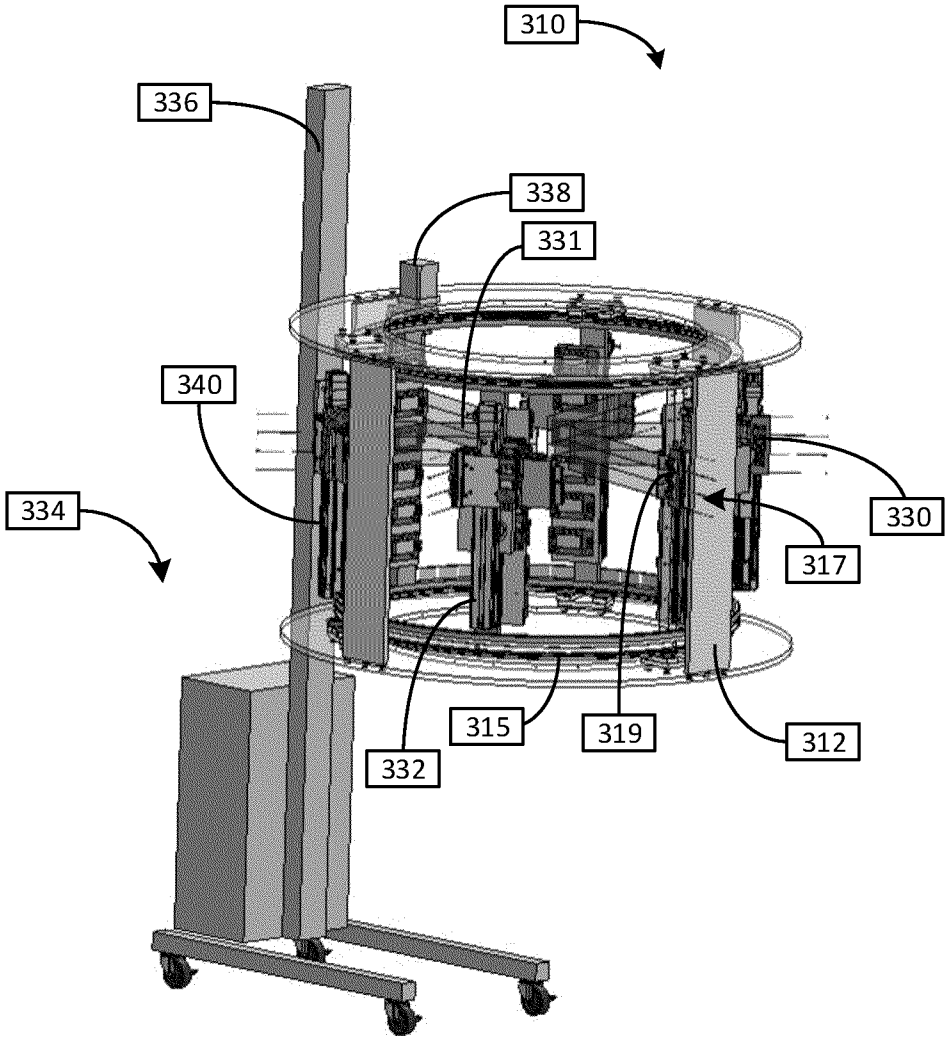

FIG. 7C

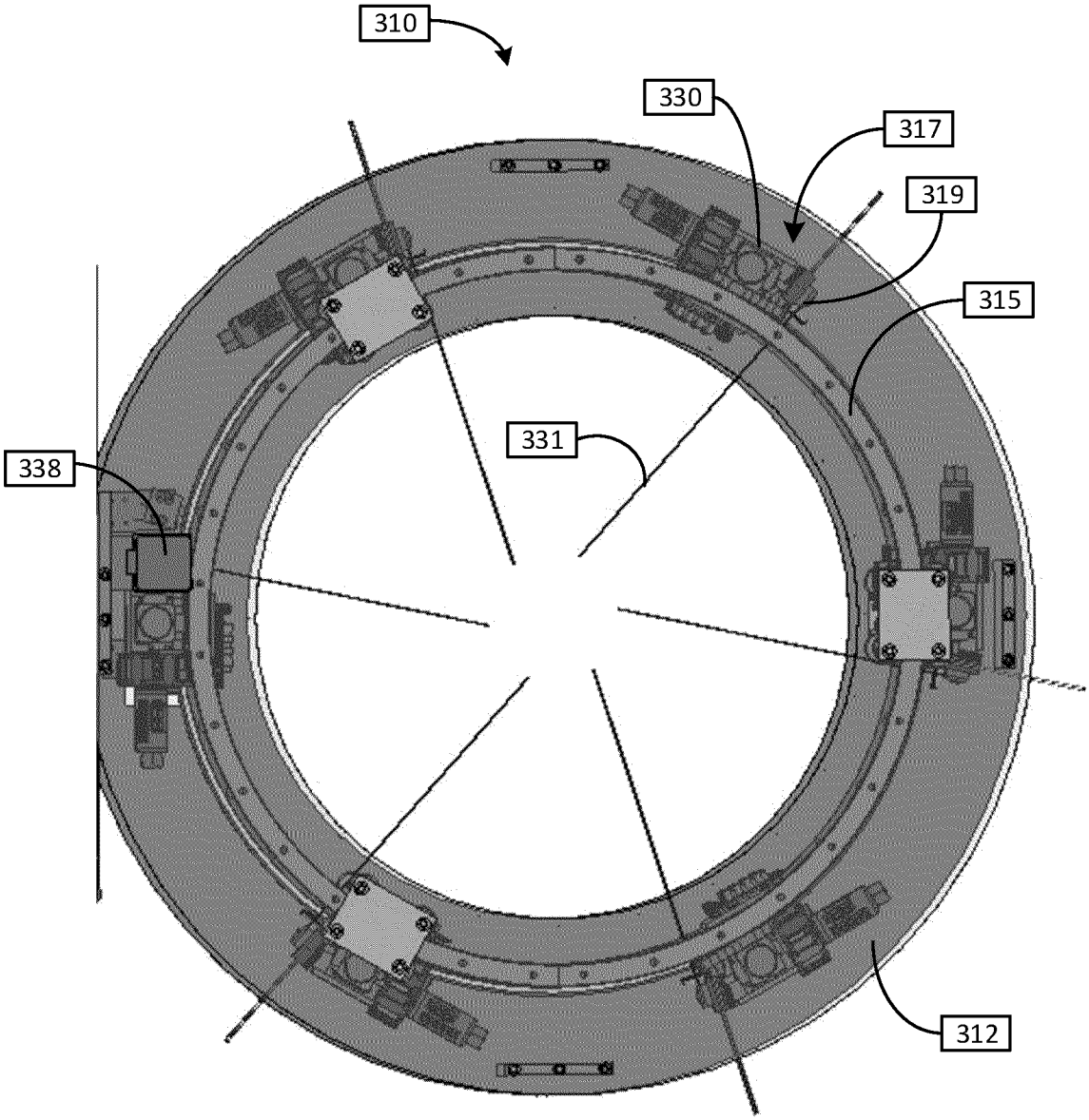

FIG. 7D

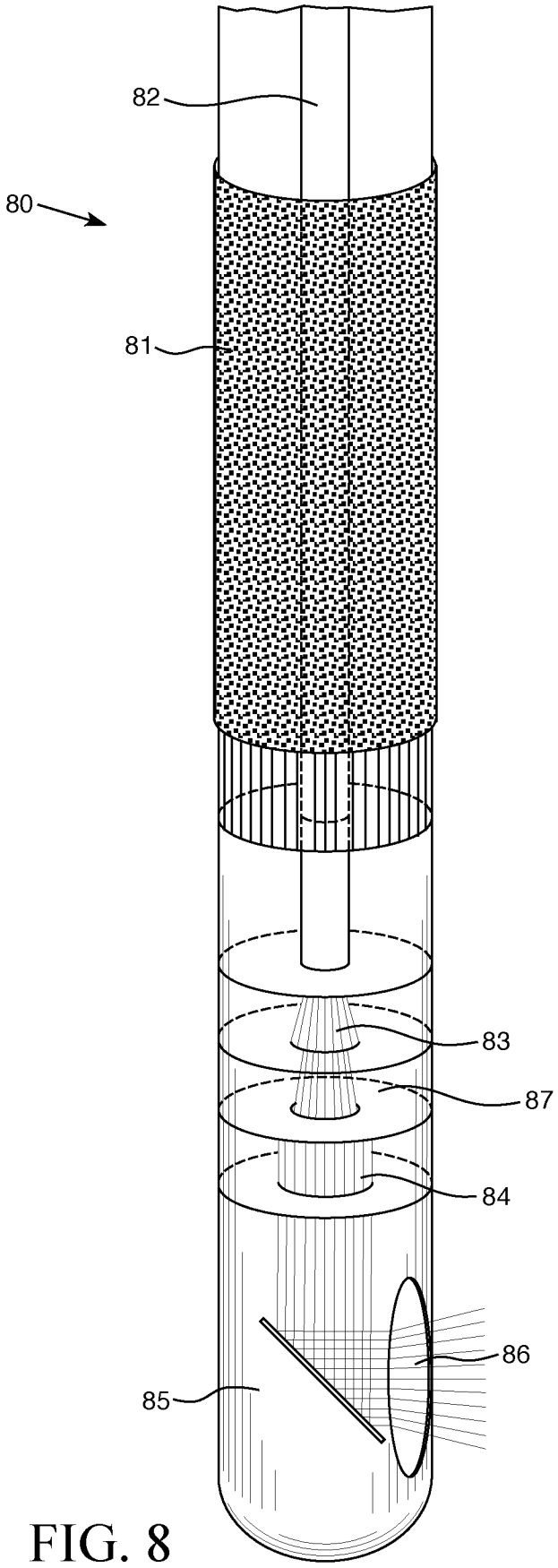

FIG. 8

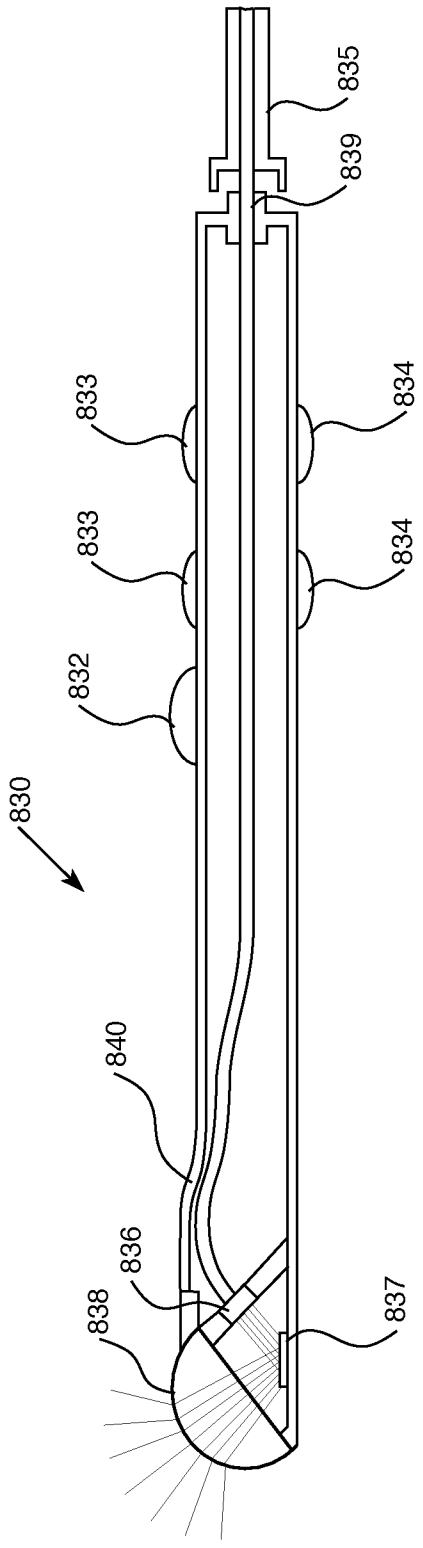

FIG. 8A

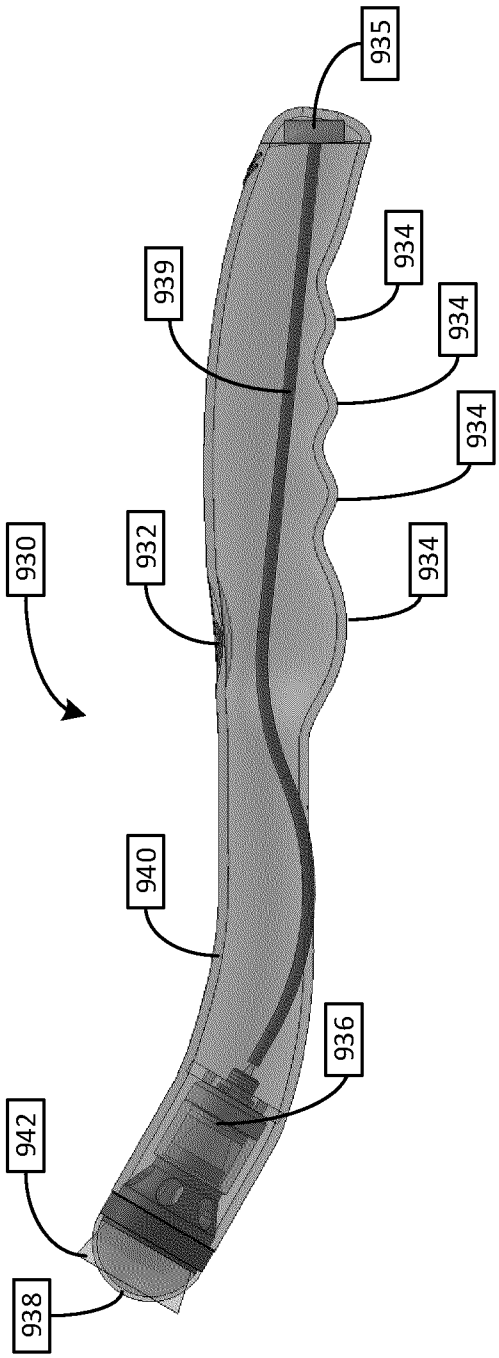

FIG. 8B

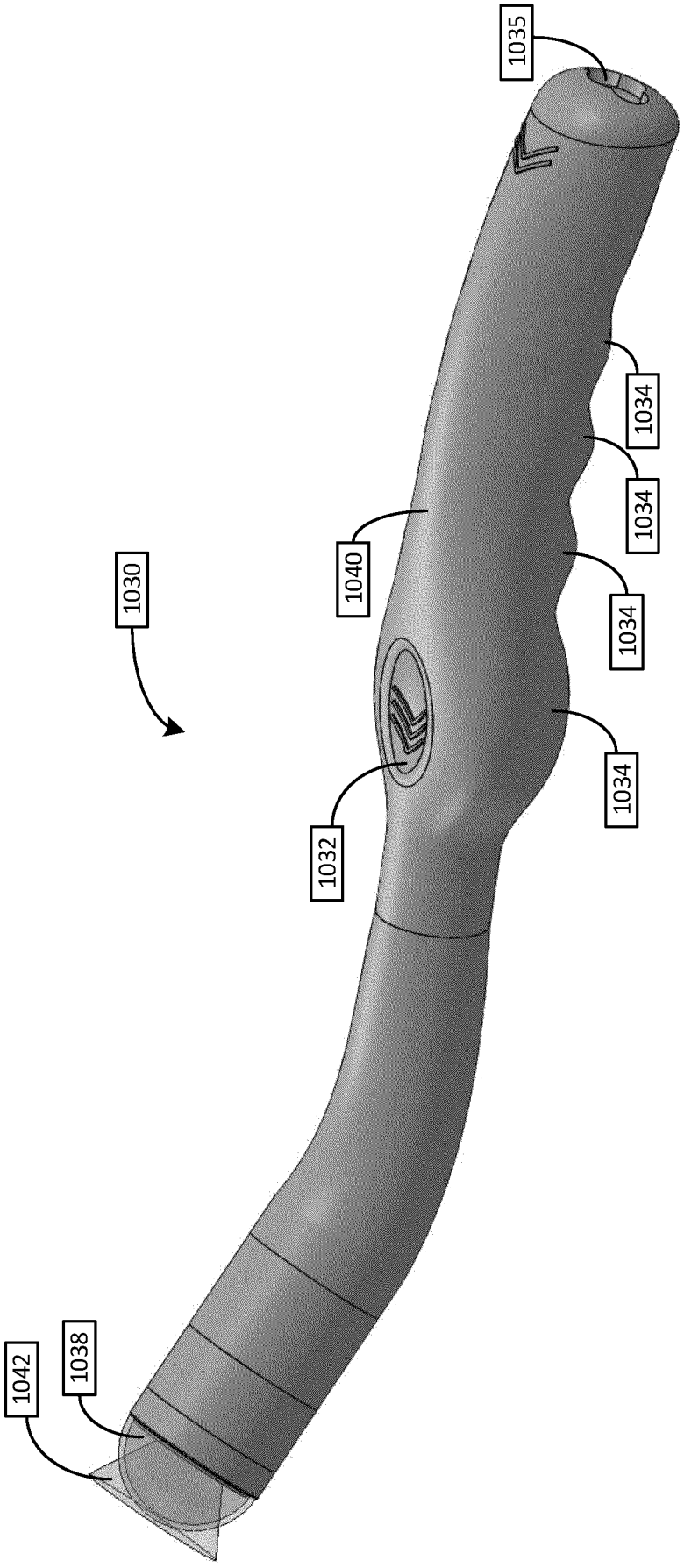

FIG. 8C

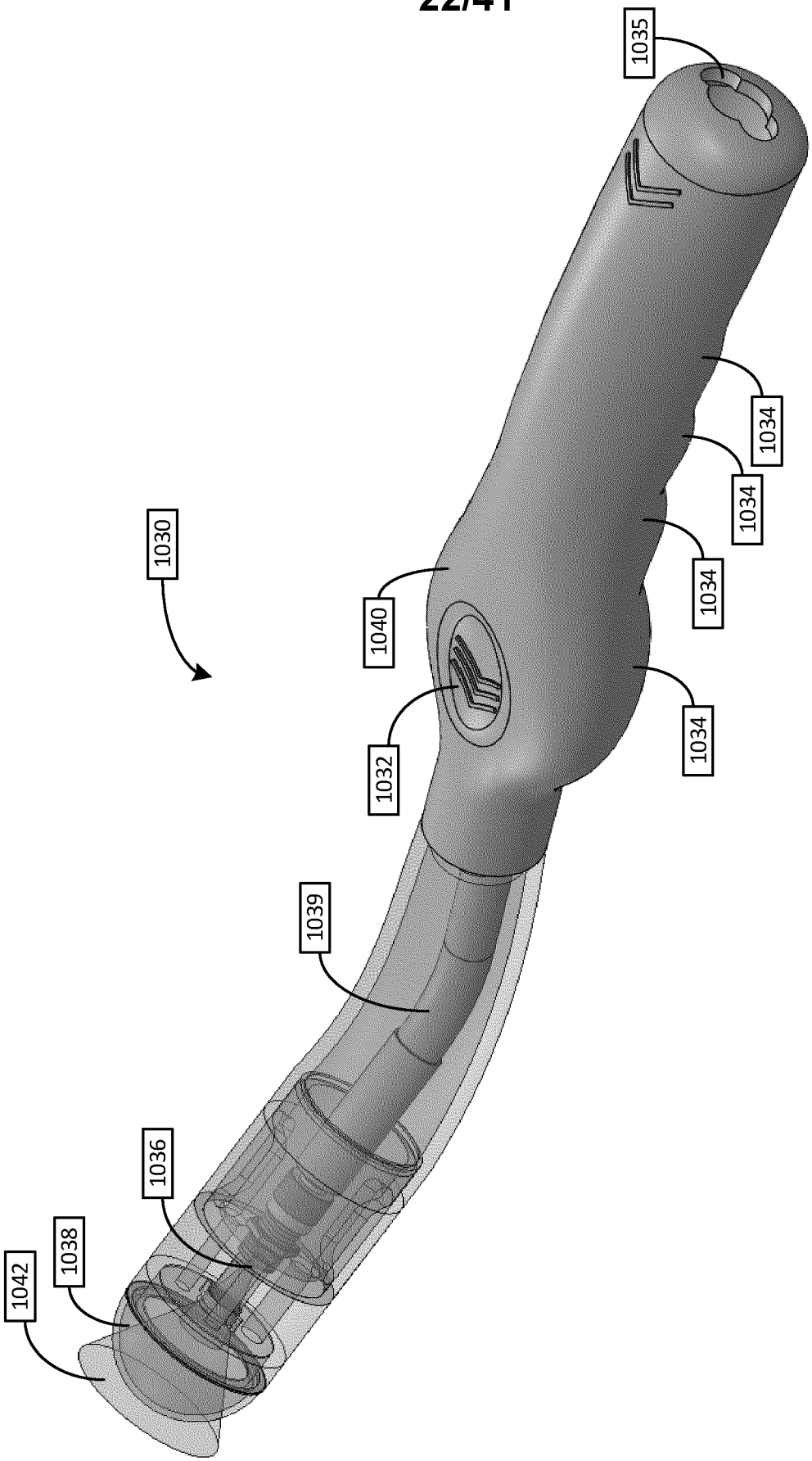

FIG. 8D

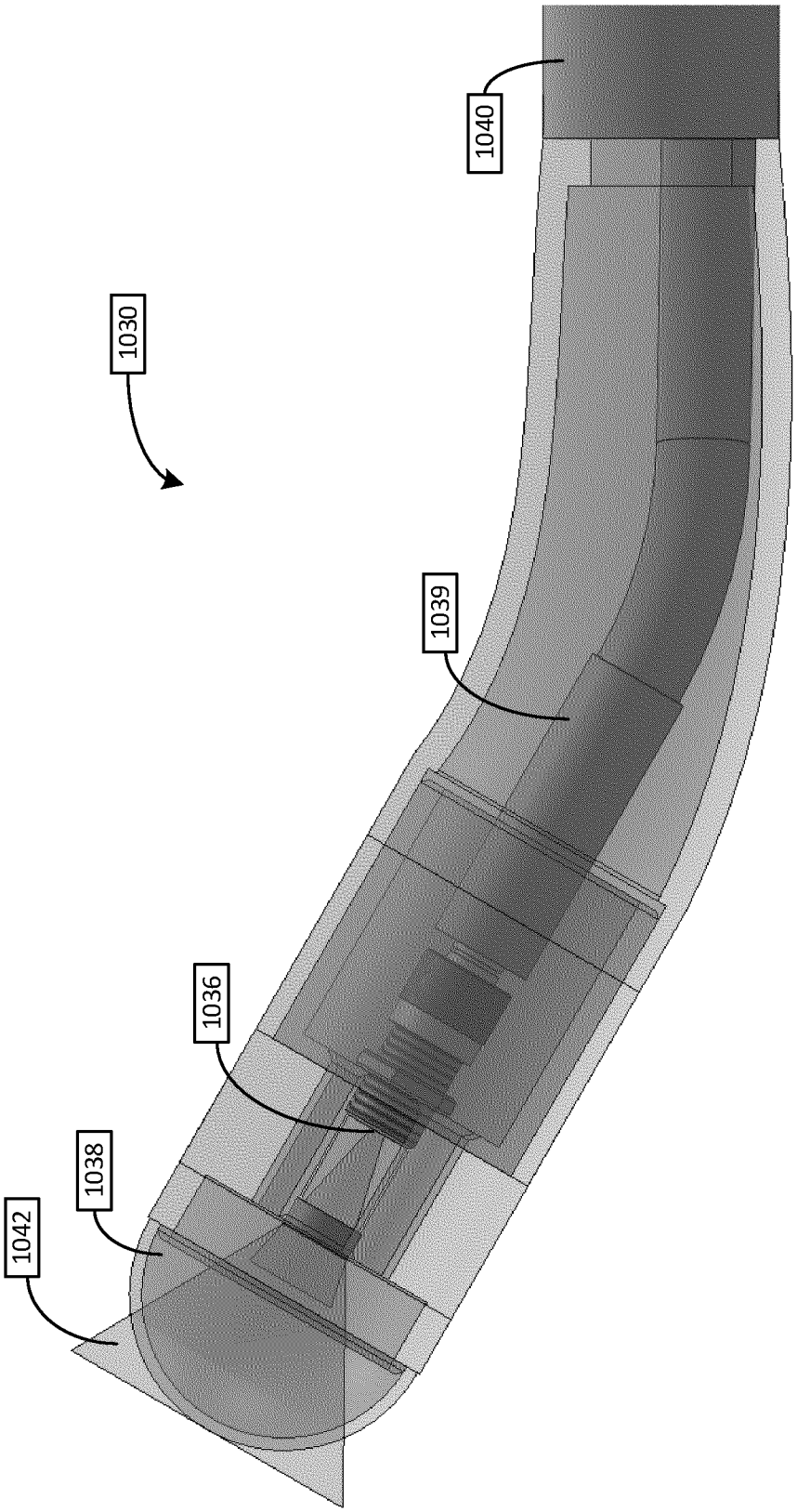

FIG. 8E

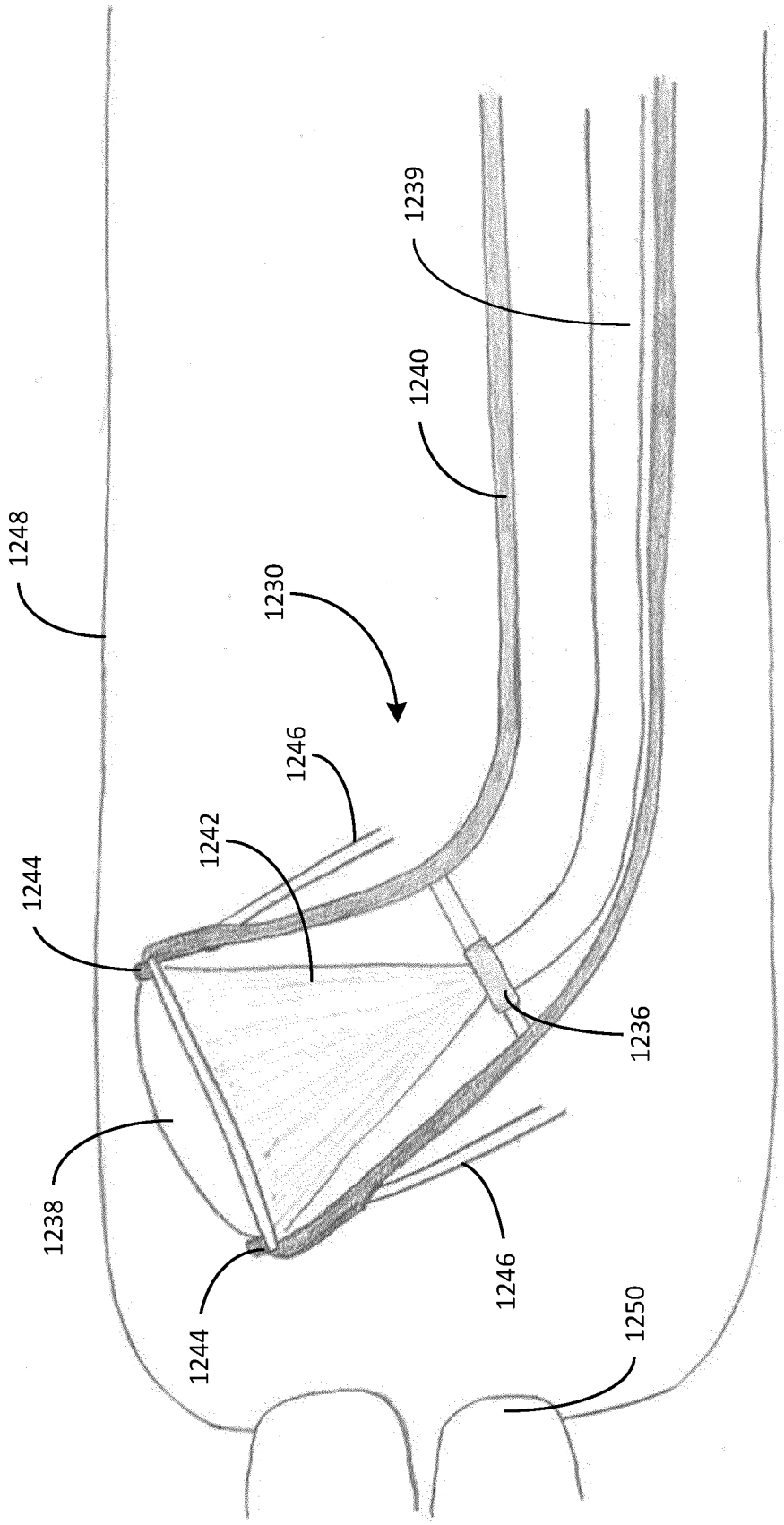

FIG. 8F

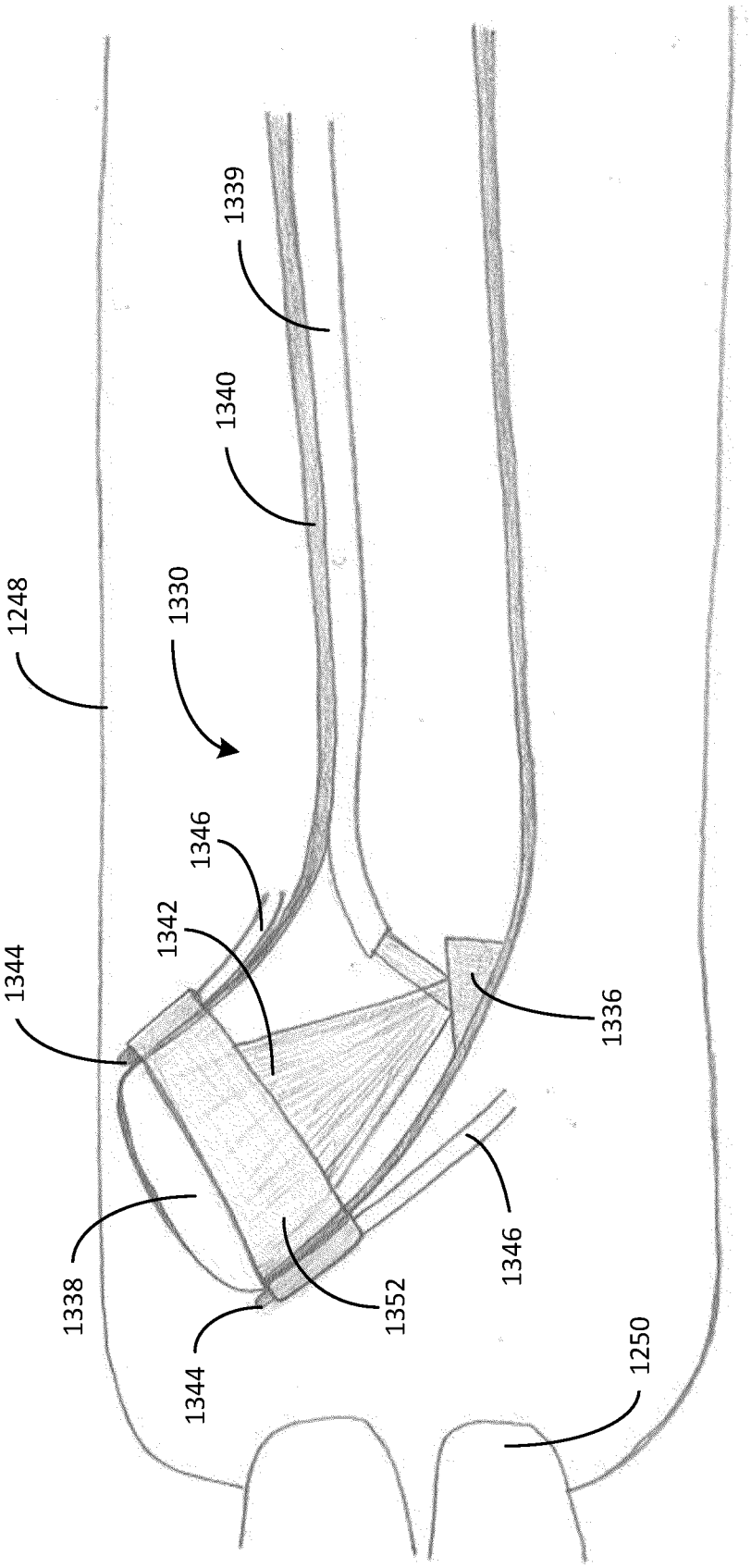
1339
1340
1248
1330
1346
1342
1344
1336
1338
1352
1346
1344
1250

FIG. 8G

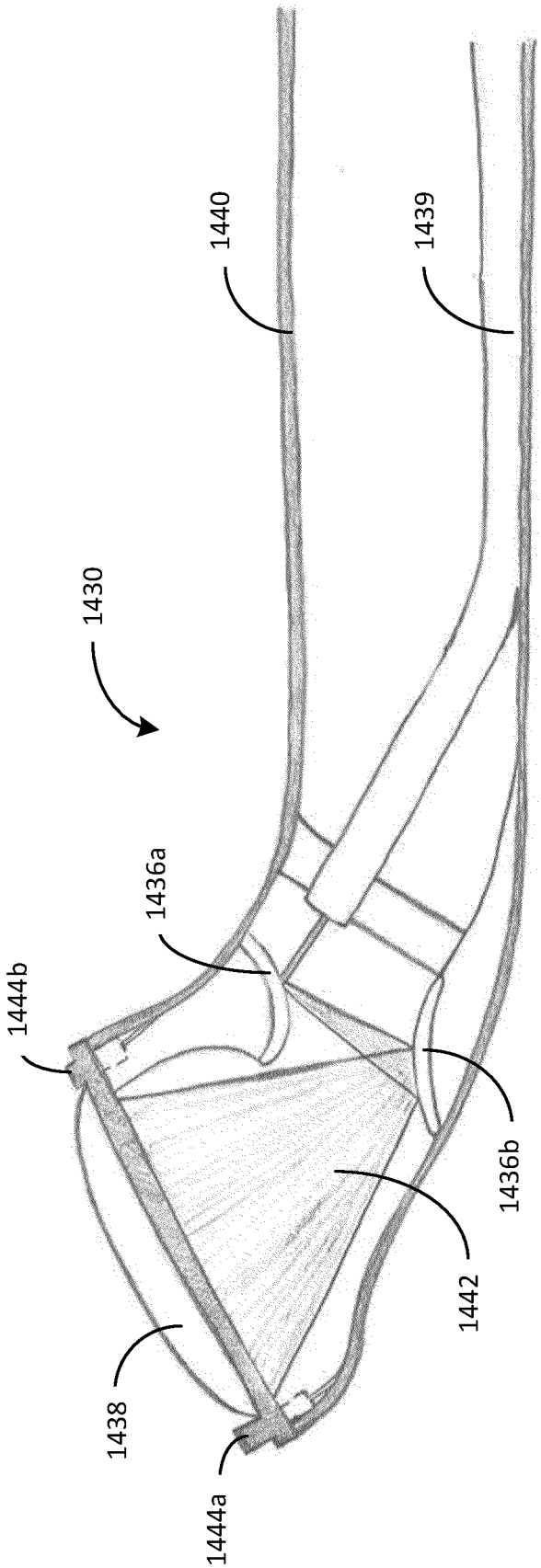

FIG. 8H

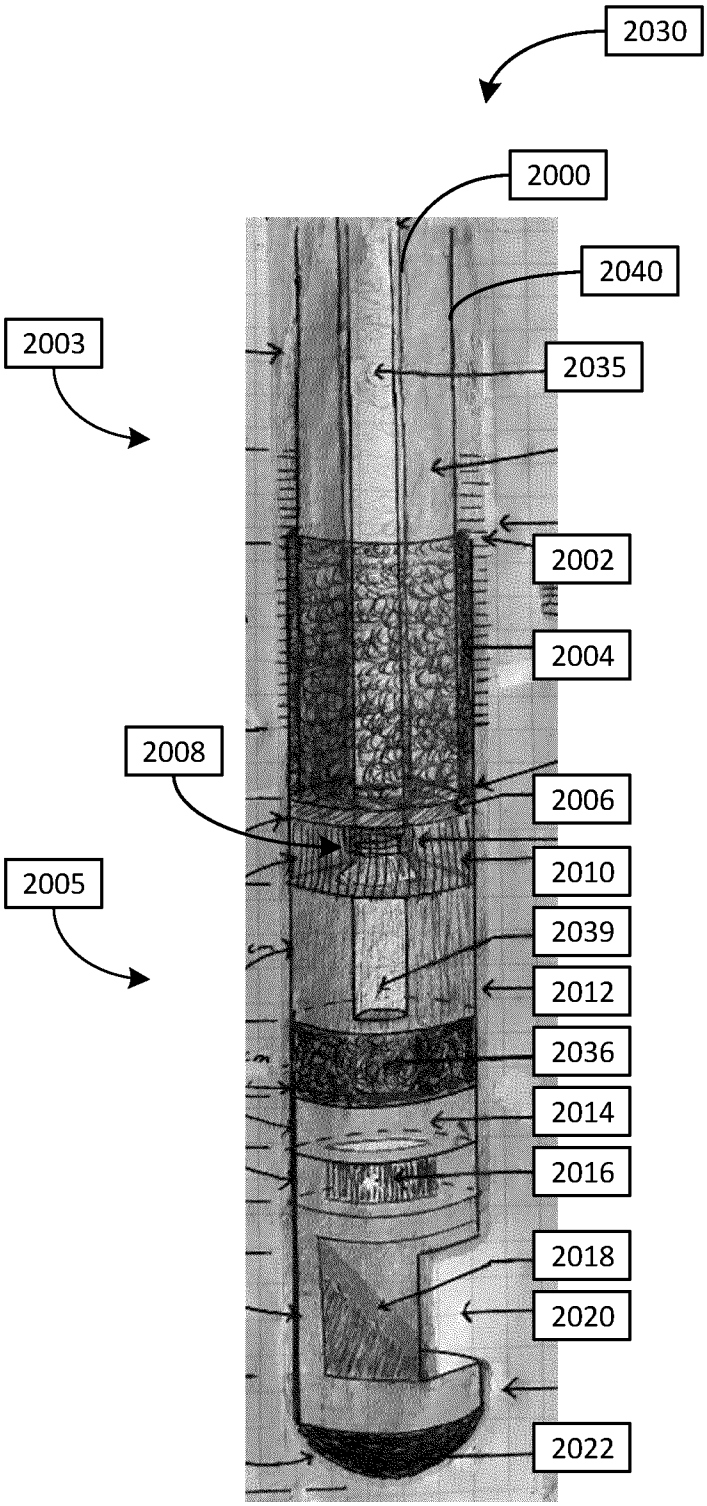
2030
2000
2040
2003
2035
2002
2004
2008
2006
2005
2010
2039
2012
2036
2014
2016
2018
2020
2022

FIG. 8I

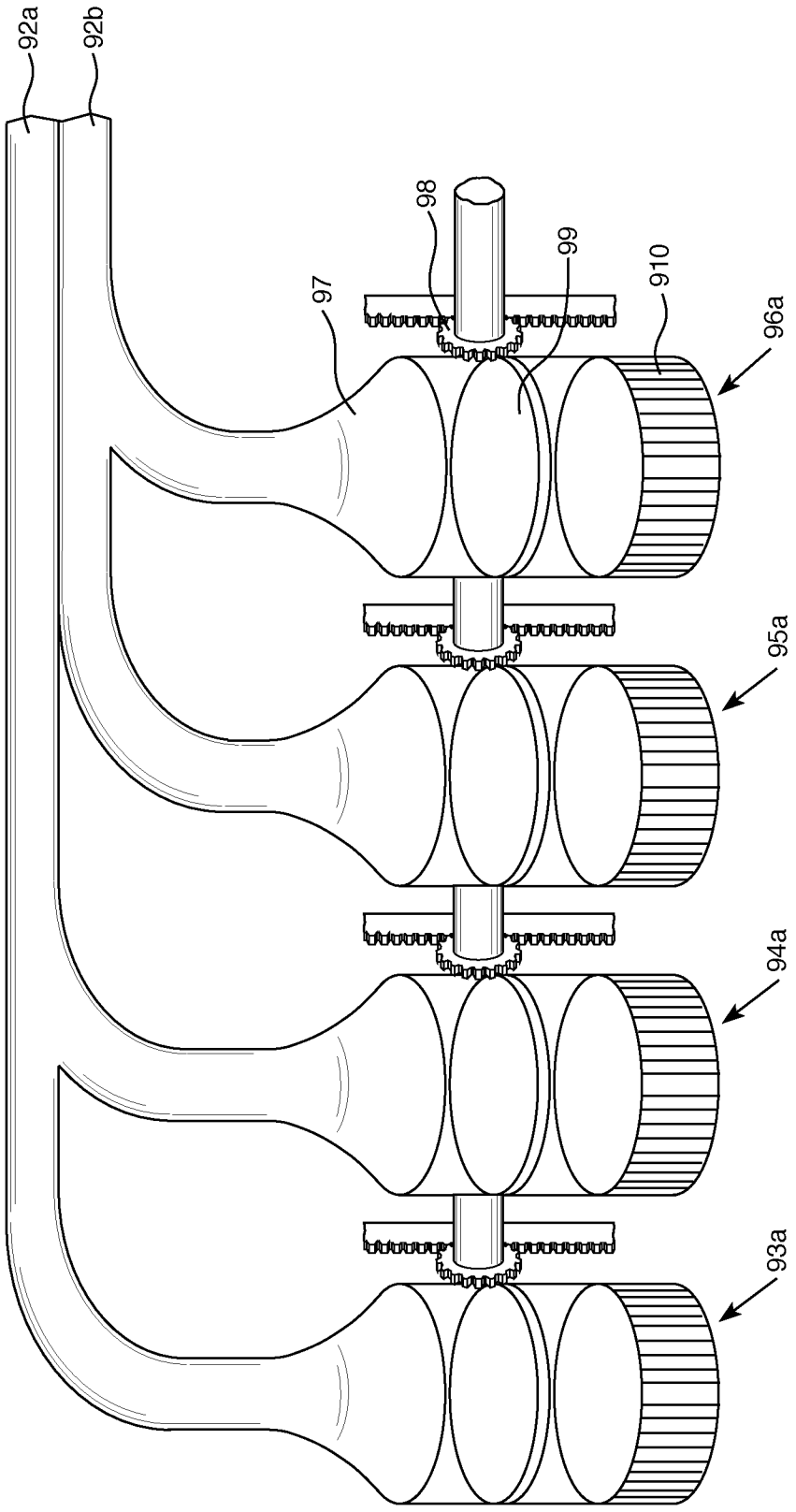

FIG. 9

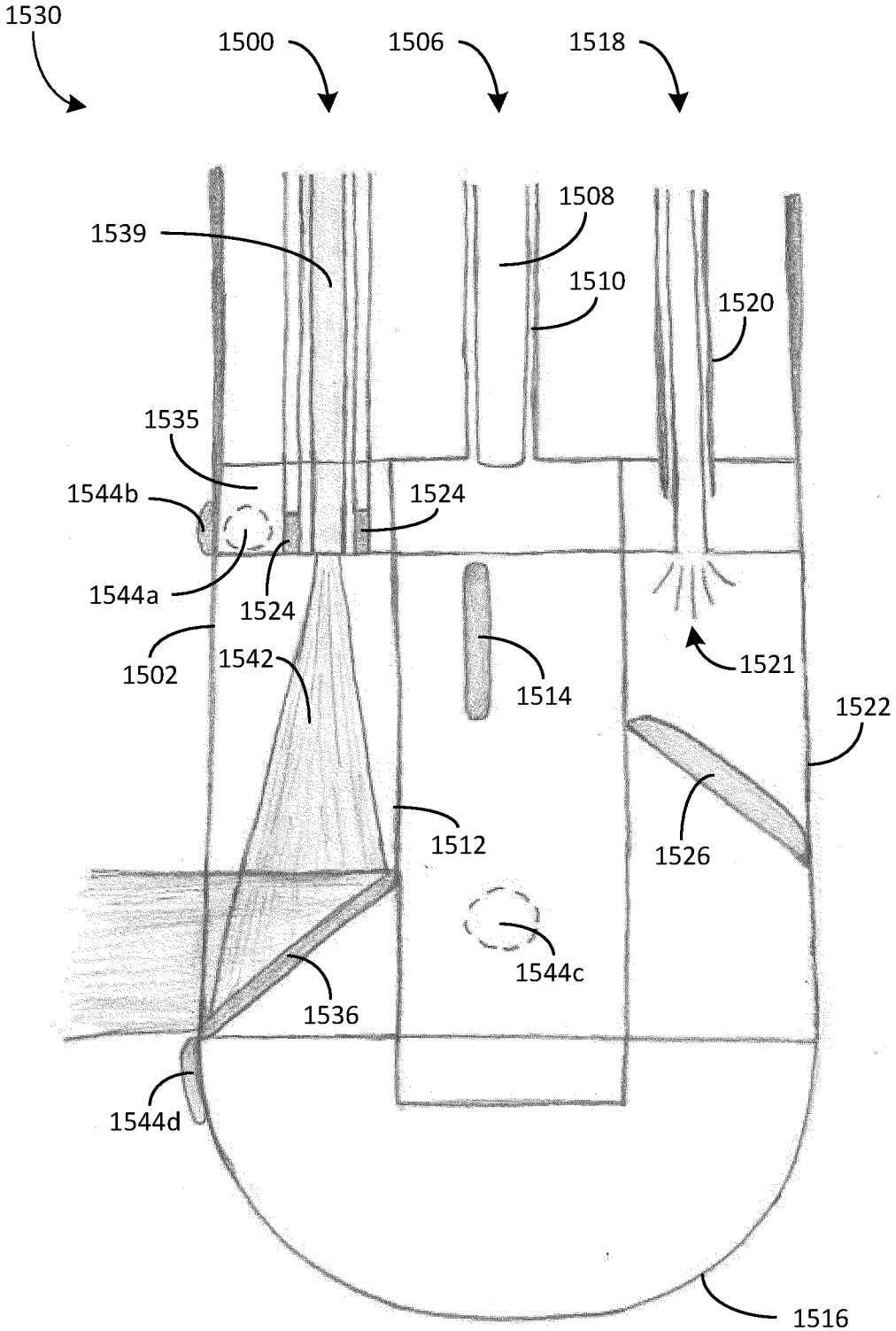
1530
1500
1506
1518
1539
1508
1510
1520
1535
1544b
1524
1544a
1524
1502
1542
1514
1521
1522
1512
1526
1544c
1536
1544d
1516

FIG. 10

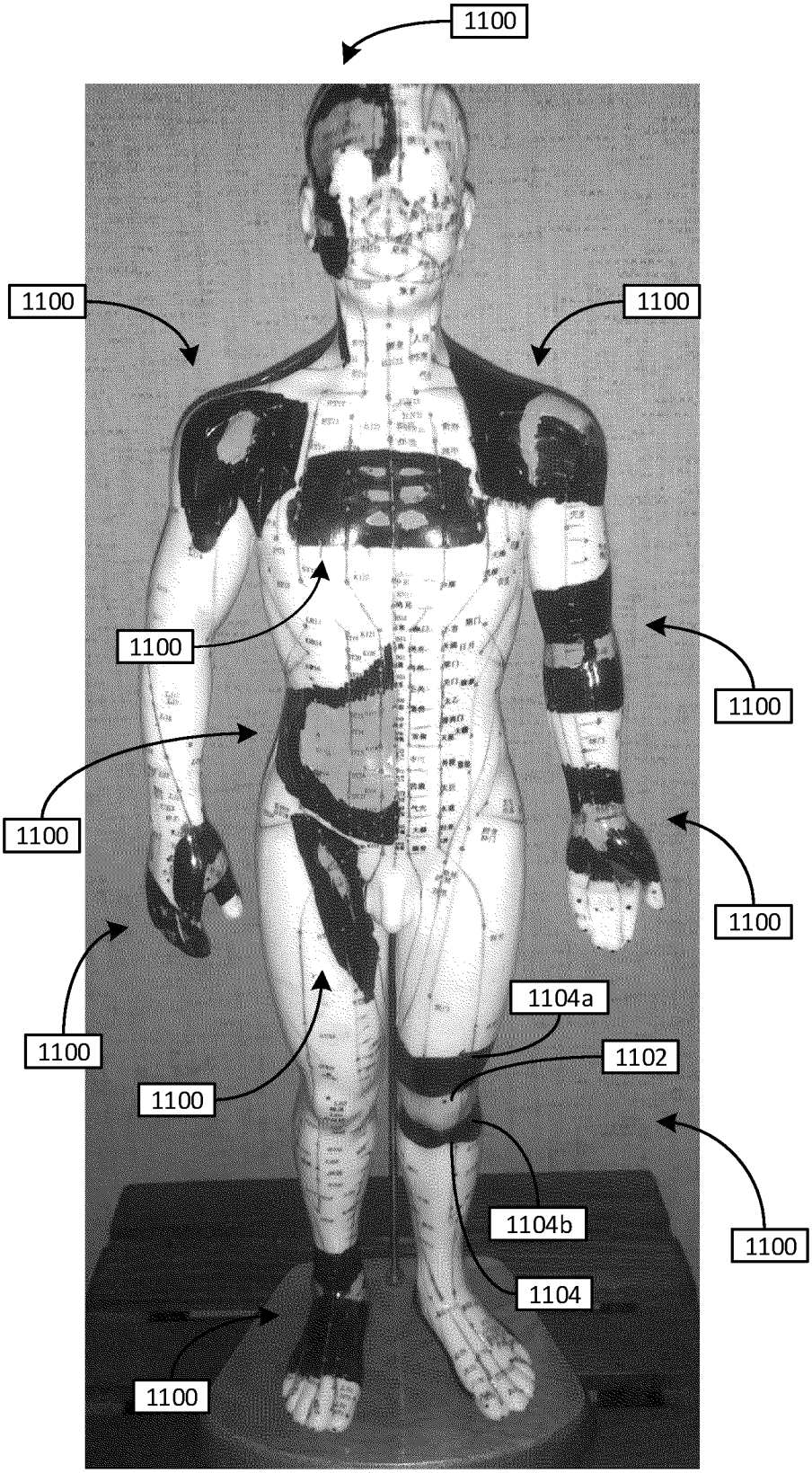
1100
1100
1100
1100
1100
1100
1100
1100
1100
1104a
1102
1104b
1104
1100
1100

FIG. 11

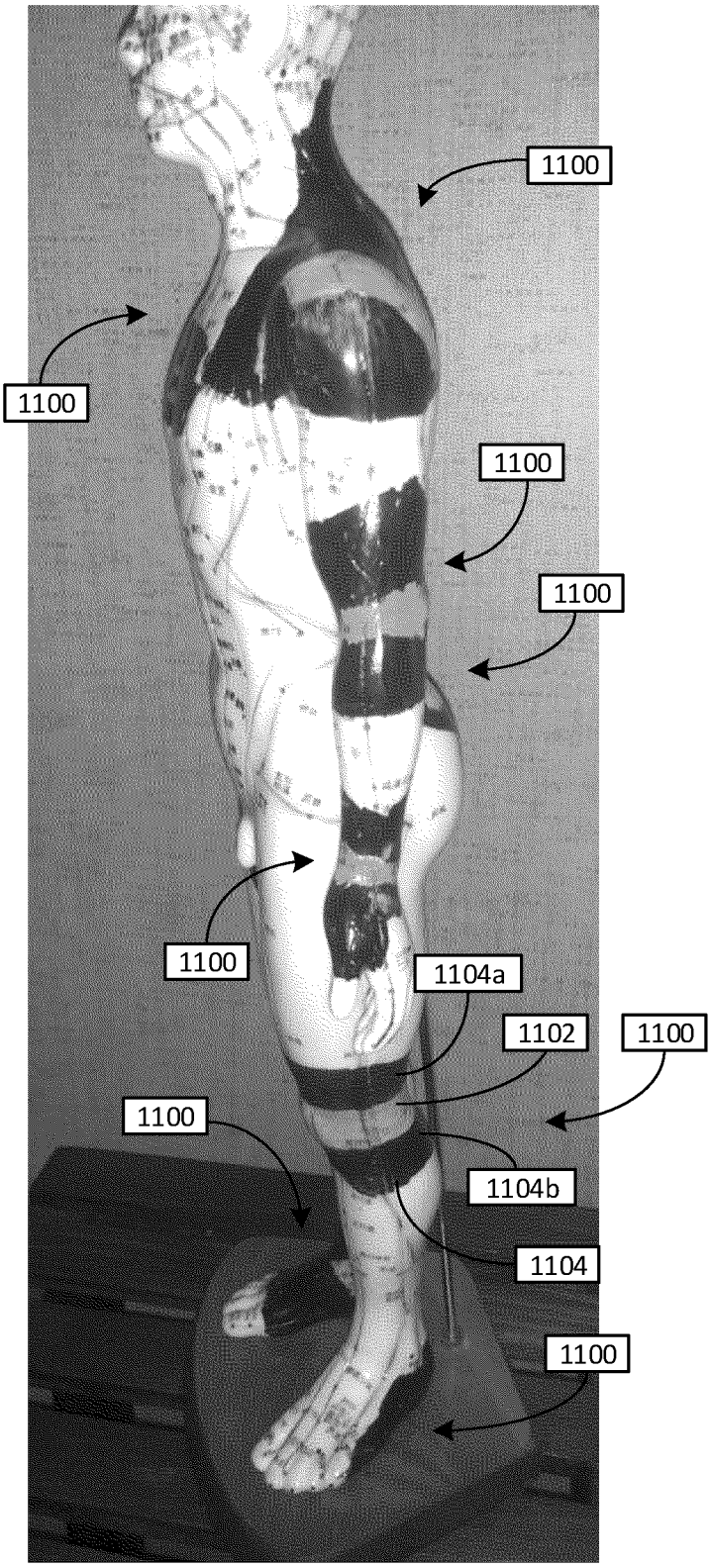
1100
1100
1100
1100
1100
1104a
1102
1100
1100
1104b
1104
1100

FIG. 12

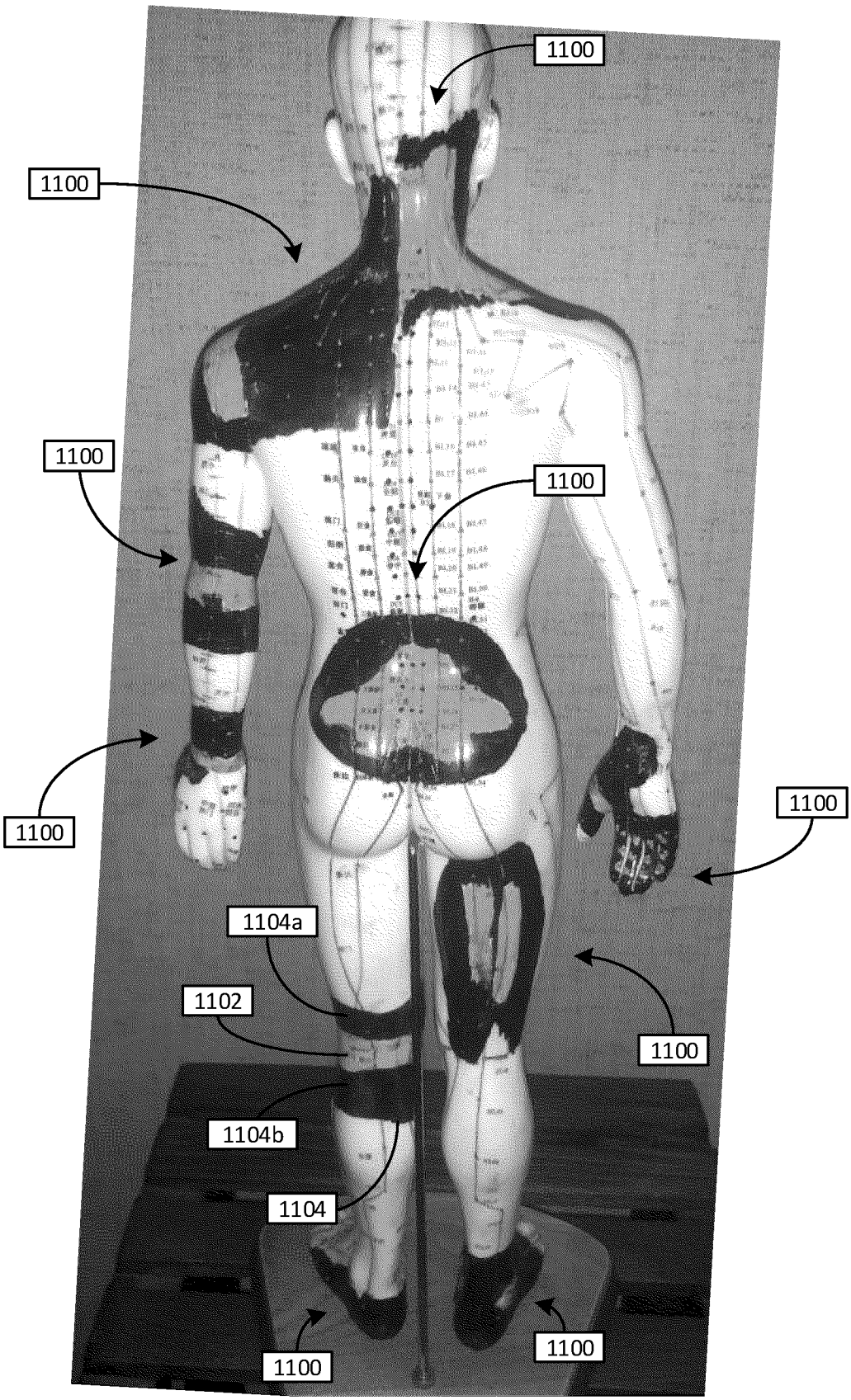
1100
1100
1100
1100
1100
1100
1104a
1102
1100
1104b
1104
1100
1100

FIG. 13

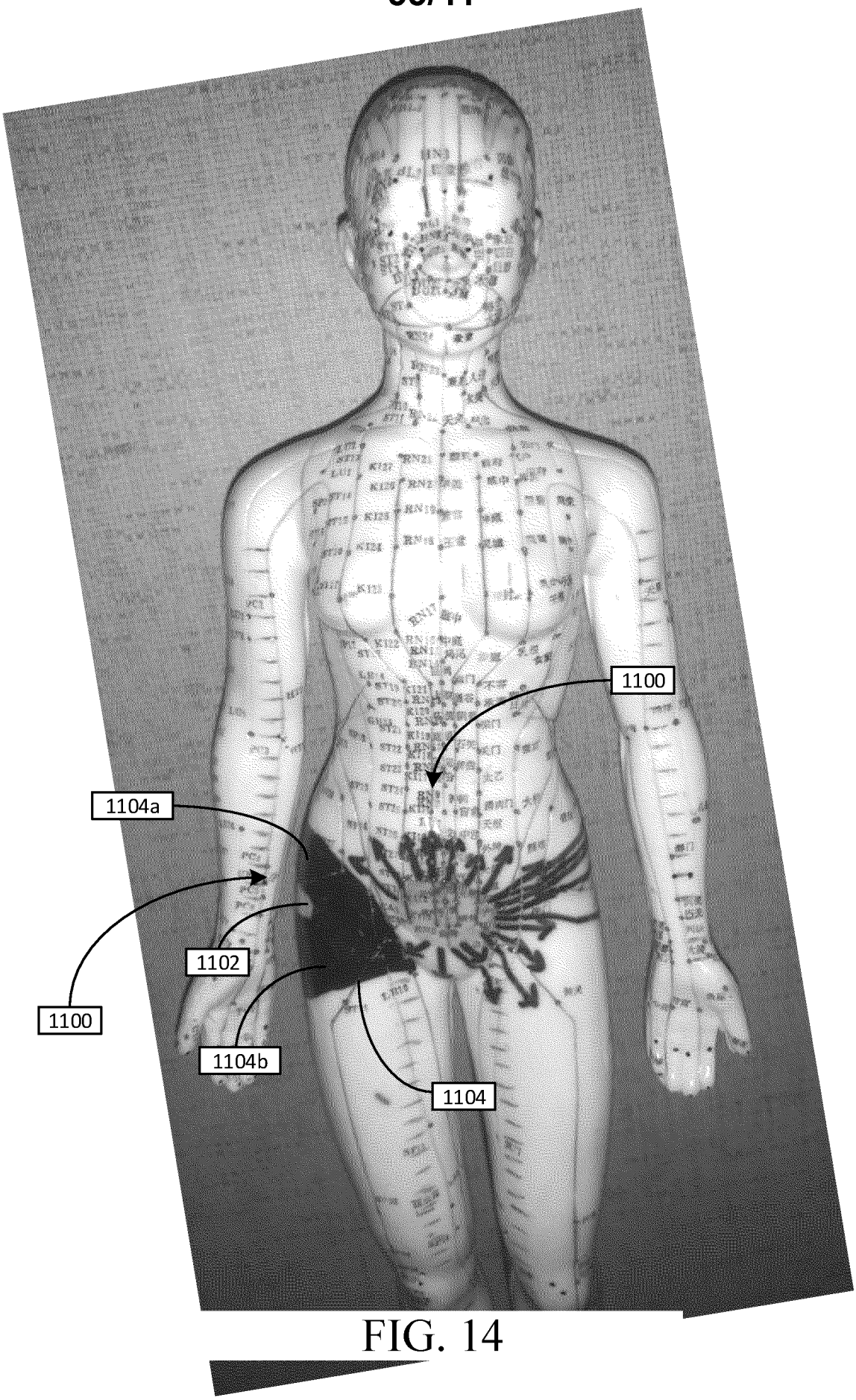

FIG. 14

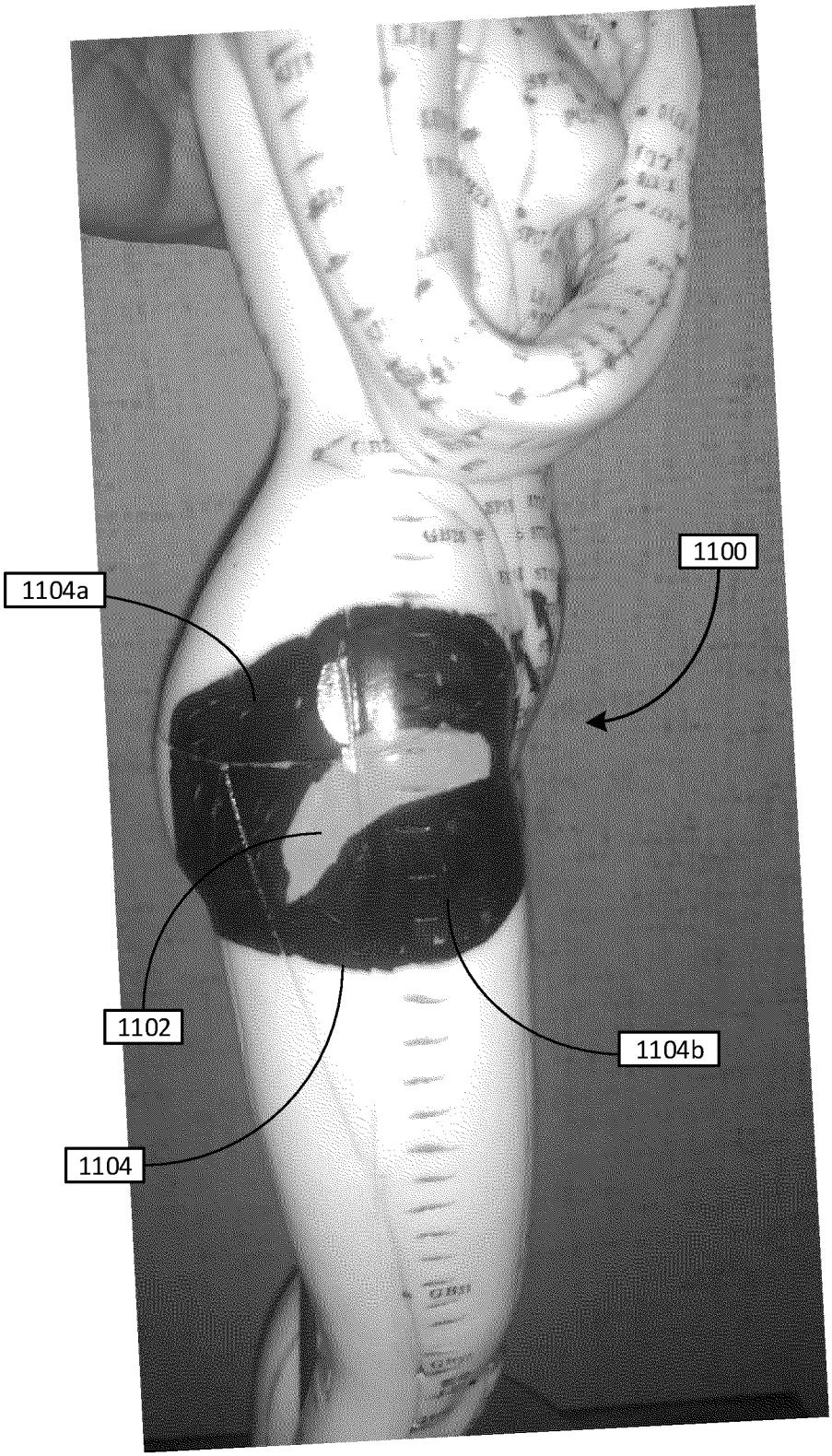

FIG. 15

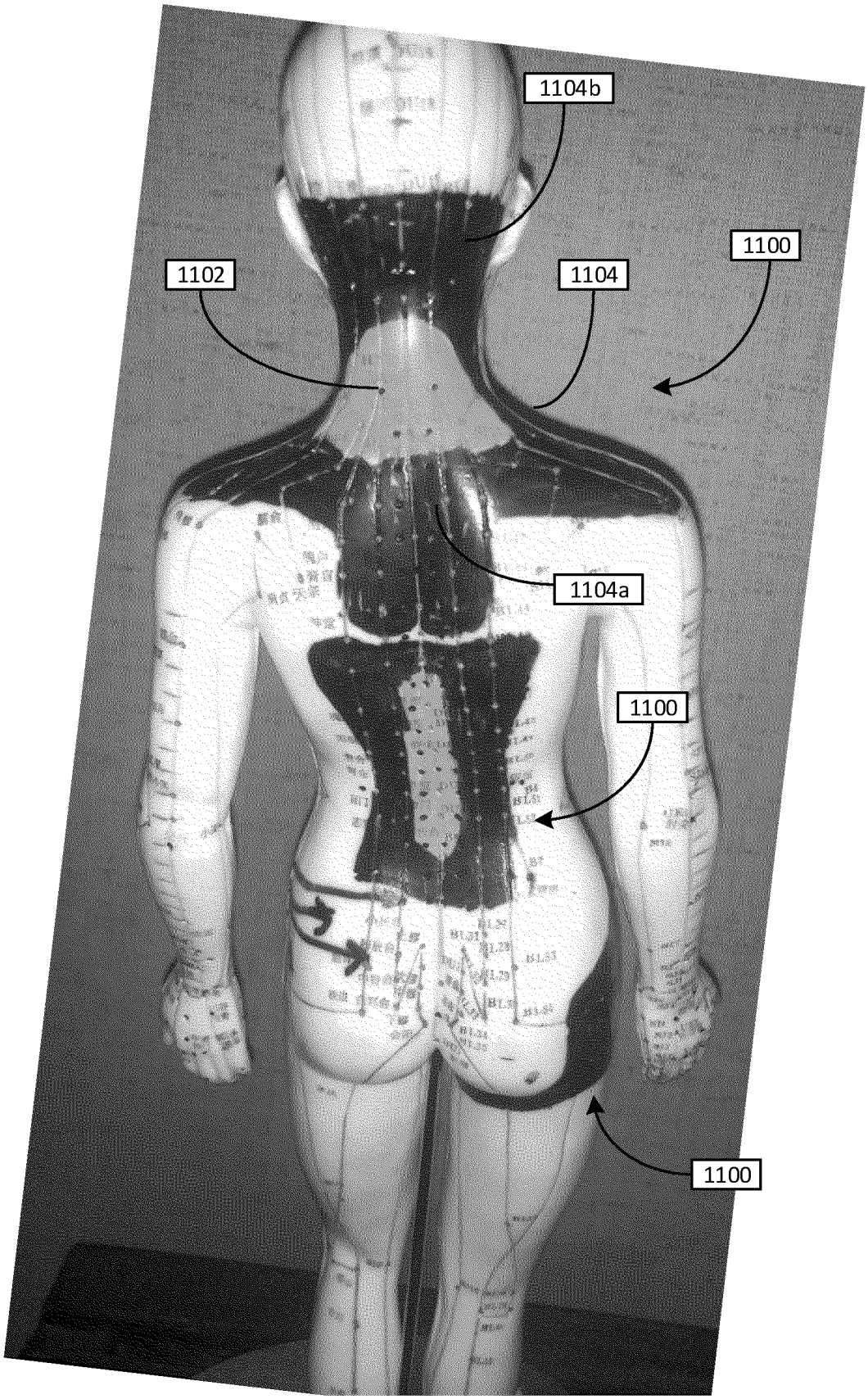

FIG. 16

FIG. 17

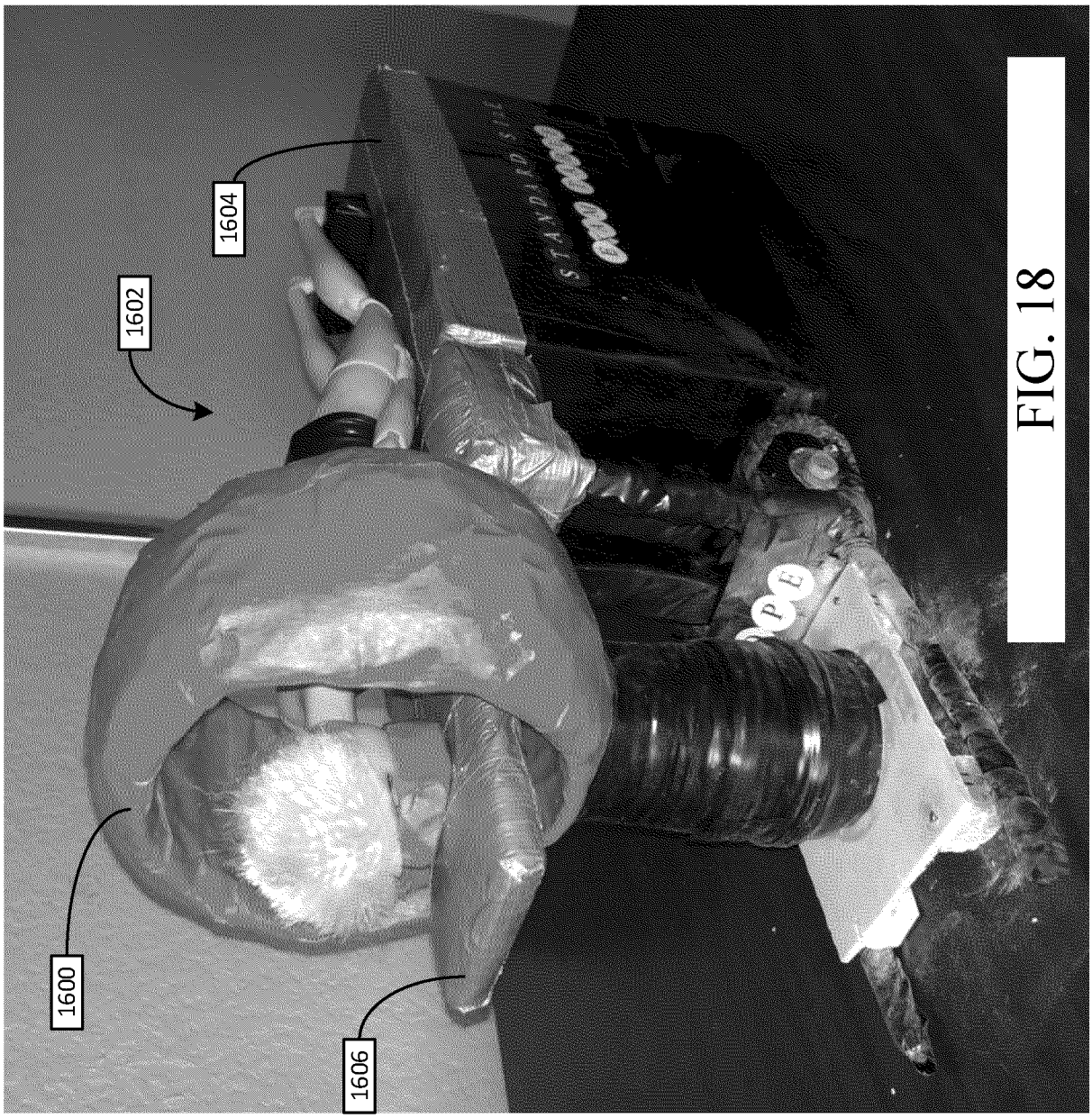

FIG. 18

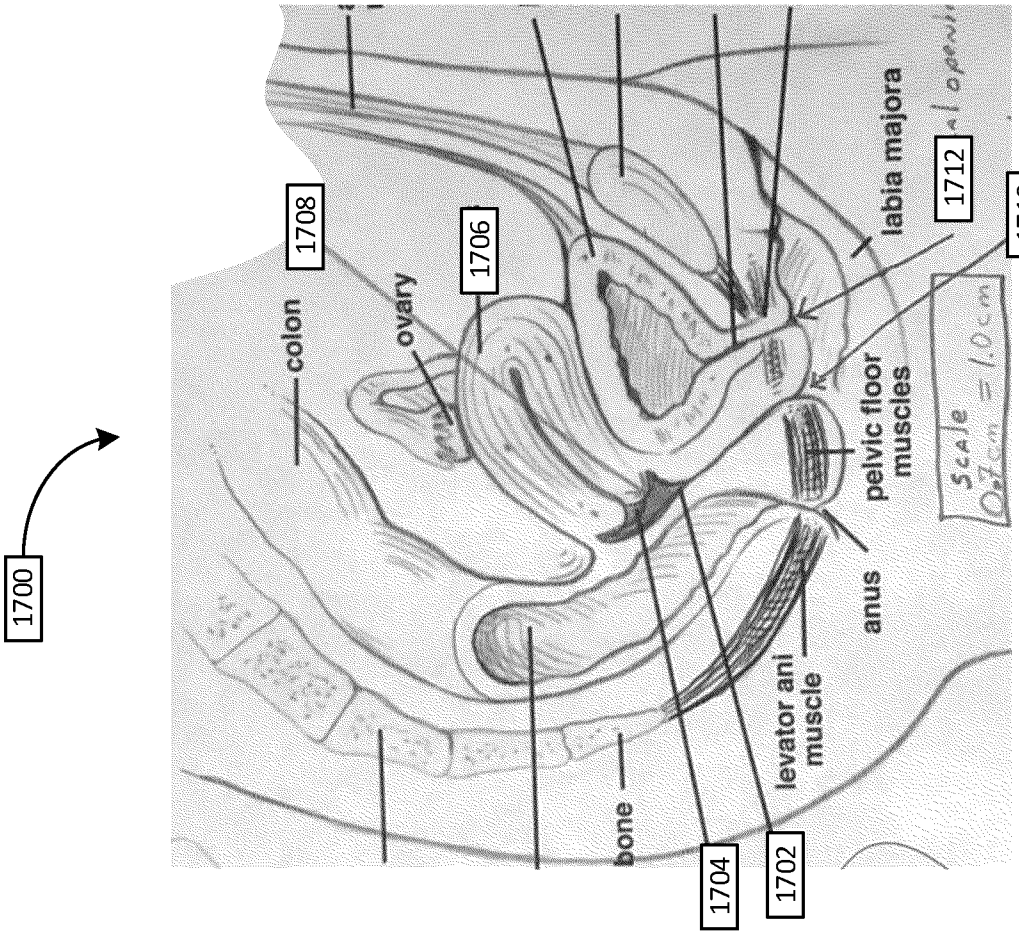
1700
1708
colon
ovary
1706
labia majora
1712
1710
pelvic floor muscles
anus
levator ani muscle
bone
1704
1702

FIG. 20

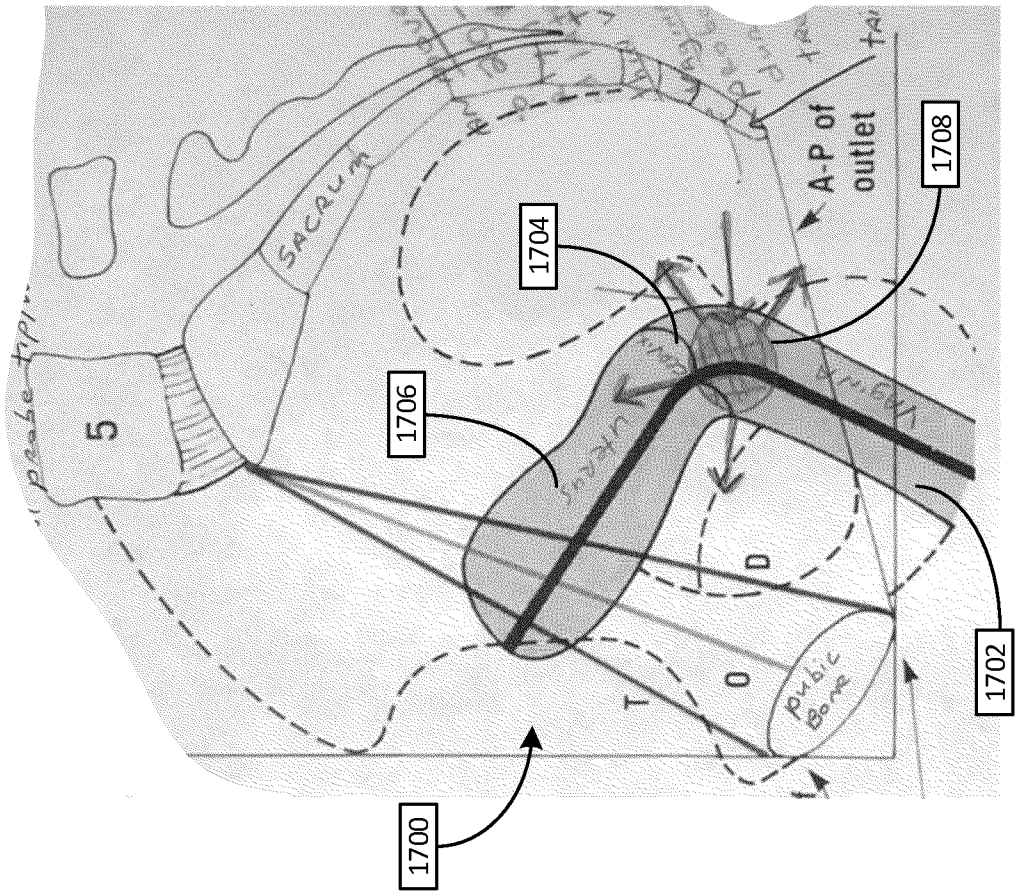
1700
1704
1706
1708
A-P of outlet
1702
SACRUM
5
T
D
0
pubic bone

FIG. 19

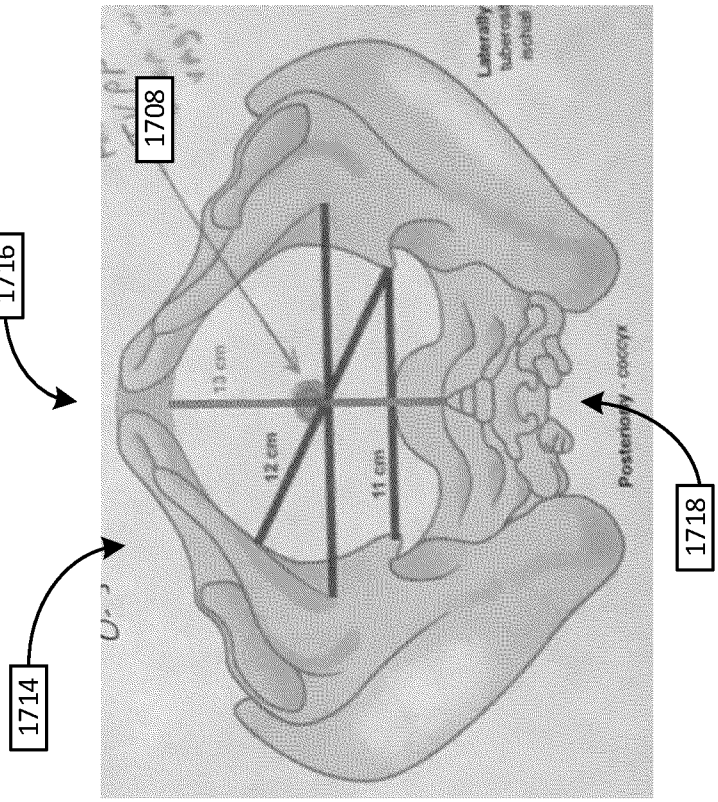

FIG. 21

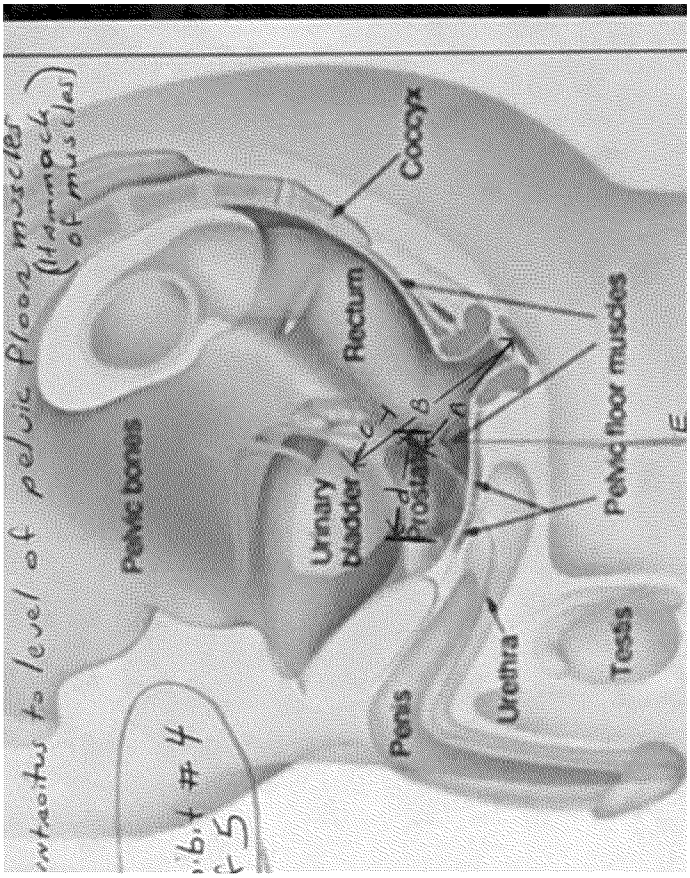
Pelvic bones
Urinary bladder
Rectum
Coccyx
Penis
Urethra
Pelvic floor muscles
Testis

FIG. 23

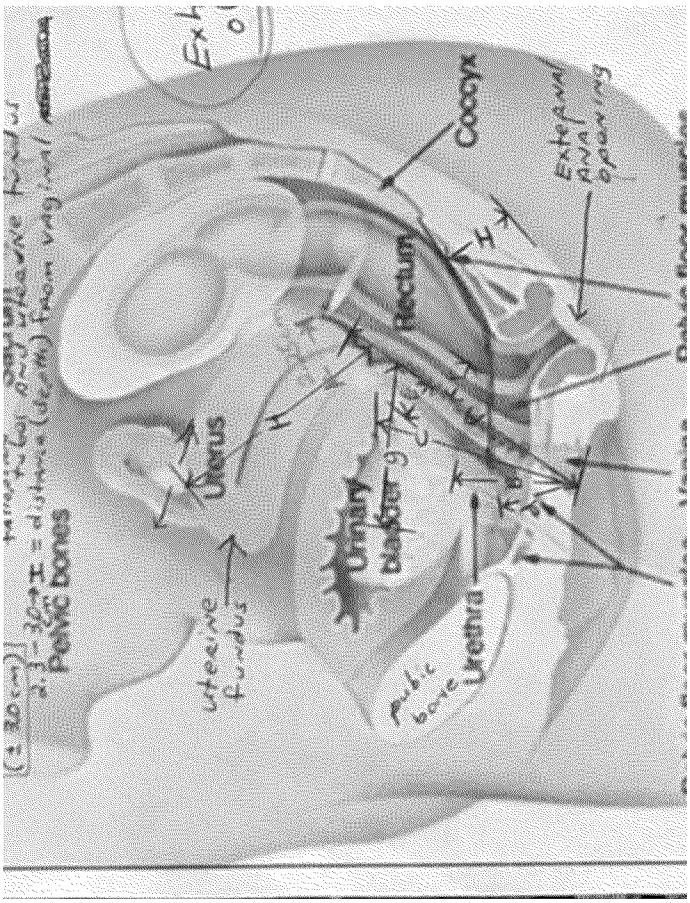
Pelvic bones
Uterus
Urinary bladder
Rectum
Coccyx
Urethra
External anal opening

FIG. 22

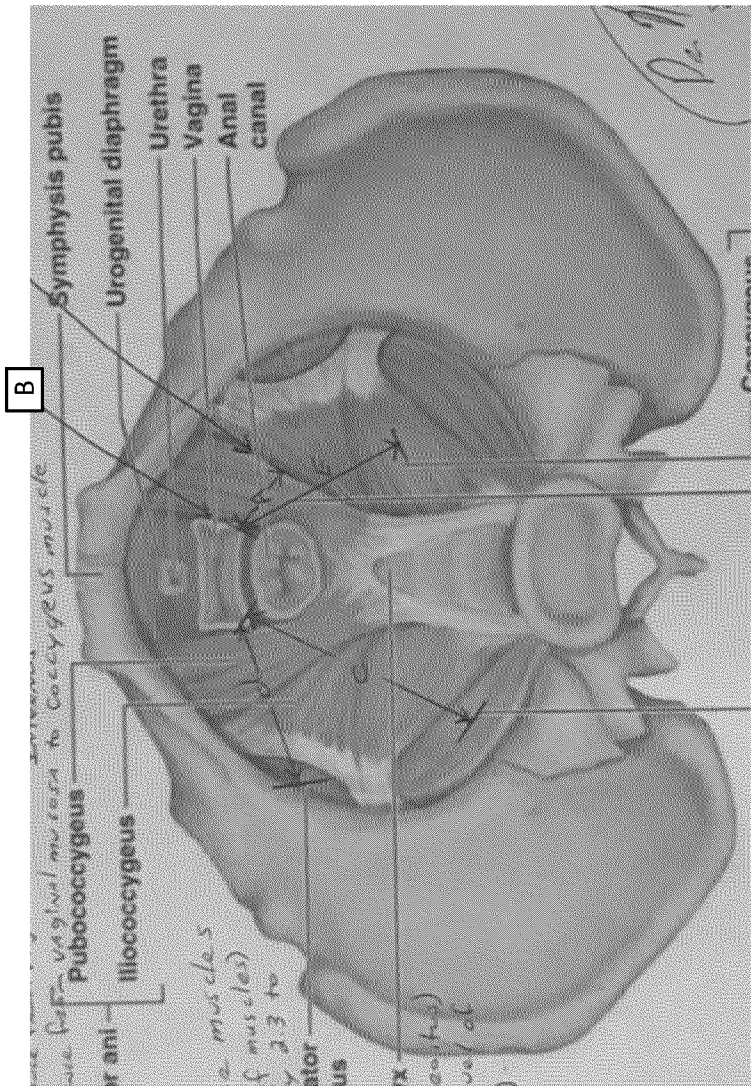
B
Symphysis pubis
Urogenital diaphragm
Urethra
Vagina
Anal canal
Pubococcygeus
Iliococcygeus

FIG. 24

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US19/19286

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A61B 18/20 5/01, 5/02, 5/04, 5/06, 5/067, 5/073, 5/08, 5/10 (2019.01)

CPC - A61B 5/0059, 18/04, A61N 5/0616, 5/0625, 5/0625

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

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

See Search History document

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- A	US 2011/0172746 A1 (Porter, R.) 14 July 2011, abstract, Fig. 1-4, 7, para. [0024], [0035]-[0051], [0055], [0058]-[0063]	119-123 --- 1-118
A	US 2008/0033412 A1 (Whelan, H. et al.) 07 February 2008, abstract, Fig. 1-5, para. [0032]-[0038], [0043]-[0045]	1-123
A	WO 2016/154664 A1 (Rogers, M) 06 October 2016, abstract, Fig. 4, para. [0018]-[0021], [0038], [0043], [0045], [0049]-[0052]	1-123
A	US 2012/0041521 A1 (Oron, U. et al.) 16 February 2012, abstract, Fig. 1, para. [0042]-[0048], [0062]	1-123
A	US 2013/0030249 A1 (EndoClear LLC) 31 January 2013, Fig. 1, para. [0095]-[0100], [0109]-[0113]	1-123
A	US 2006/0167531 A1 (Gertner, M. et al.) 27 July 2006, Fig. 1, 2, 5A, para. [0097], [0100], [0128], [0145]-[0147], [0157]-[0159], [0169]-[0173]	1-123

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

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 June 2019 (04.06.2019)	25 June 2019 (25.06.2019)
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US19/19286

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-39, 50-98, and 109-123 are directed towards a device for administering phototherapy, comprising: a hollow structure and closed tip.

Group II: Claims Group II: Claims 40-49 and 99-108 are directed towards a method for administering phototherapy, comprising: delivering, by the cooling structure, a coolant to at least one of a portion of the handheld probe or a portion of anatomy of the patient.

-***-Continued Within Extra Sheet (below)-***-

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

-***-Continued from Box No. III Observations where unity of invention is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-39, 50-98, and 109-123 are directed towards a device for administering phototherapy, comprising: a hollow structure and closed tip.

Group II: Claims Group II: Claims 40-49 and 99-108 are directed towards a method for administering phototherapy, comprising: delivering, by the cooling structure, a coolant to at least one of a portion of the handheld probe or a portion of anatomy of the patient.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I are at least wherein one or more coherent light generators are mounted to a hollow structure, wherein the hollow structure comprises a first open end through which the hollow structure receives at least a portion of patient anatomy comprising a targeted treatment site, wherein the hollow structure further comprises a rotatable member configured to rotate around at least one rotary axis, and wherein each of the one or more coherent light generators is optically connected to one or more lenses or mirrors mounted to the hollow structure, the one or more lenses or mirrors configured to alter at least one aspect of the beam of coherent light generated by the coherent light generator, and wherein the handheld probe comprises a closed tip from which coherent light is emitted after the beam of coherent light is received, which are not present in Group II.

The special technical features of Group II are at least generating a beam of coherent light of at least 10 W; wherein a handheld probe further comprises a cooling structure; and delivering, by the cooling structure, a coolant to at least one of a portion of the handheld probe or a portion of anatomy of the patient, which are not present in Group I.

The common technical features of Groups I and II are a method for administering phototherapy, comprising: optically connecting a handheld probe to a coherent light generator configured to generate a beam of coherent light, wherein the handheld probe is configured to receive the beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received; accepting an input from an operator; and generating one or more beams of coherent light via one or more coherent light generators and/or the coherent light generator optically connected to the handheld probe, the one or more beams generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient.

However, these common features are previously disclosed by US 2012/0041521 A1 to Oron, U. et al. (hereinafter Oron). Oron discloses: a method for administering phototherapy (a method for administering phototherapy, abstract), comprising: optically connecting a handheld probe to a coherent light generator configured to generate a beam of coherent light (optically connecting a handheld laser probe 12 to a coherent light source configured to generate a beam of coherent light, Fig. 1, para. [0042], [0048]), wherein the handheld probe is configured to receive the beam of coherent light from the coherent light generator and emit the coherent light from the handheld probe after the beam of coherent light is received (wherein the handheld laser probe 12 is configured to receive the beam of coherent light from the coherent light source, via fiberoptic cable 50, and emit the coherent light from the handheld laser probe 12 after the beam of coherent light is received, Fig. 1, para. [0042], [0048]); accepting an input from an operator; and generating one or more beams of coherent light via one or more coherent light generators and/or the coherent light generator optically connected to the handheld probe (accepting an input from an operator; and generating one or more beams of coherent light via one or more coherent light sources and/or the coherent light generator optically connected to the handheld laser probe12, via fiberoptic calbe 50, para. [0042], [0048]), the one or more beams generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient (the one or more beams generated according to a plurality of settings configured to produce a therapeutic effect at a targeted treatment site on a patient, para. [0042], [0054], [0062]).

Since the common technical features are previously disclosed by the Oron reference, these common features are not special and so Groups I-II lack unity.