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(54) **PHYSIOLOGICAL MEASUREMENT DEVICE
OR WEARABLE DEVICE INTERFACE
SIMULATOR AND METHOD OF USE**

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USPC **600/301**; 600/587; 600/595

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(57)

ABSTRACT

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15, 2011.

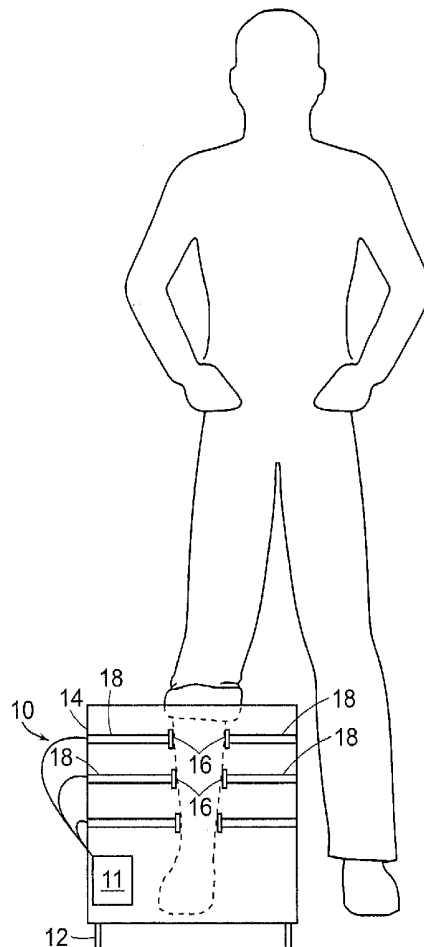
Publication Classification

(51) **Int. Cl.**

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A physiological measurement device or wearable device simulator includes a frame and a plurality of surfaces distributed within the frame. For each surface, a surface actuator links the surface of the frame. At least one of: i) force or position imparted by the surface on a physiological feature of a subject by the surface actuator; and ii) the force imparted by the physiological feature of the subject on the surface, can be employed to modulate the positions of the surfaces relative to each other independently of the forces imparted by or on those surfaces, thereby measuring the physiological feature of the subject or simulating a wearable device interface.



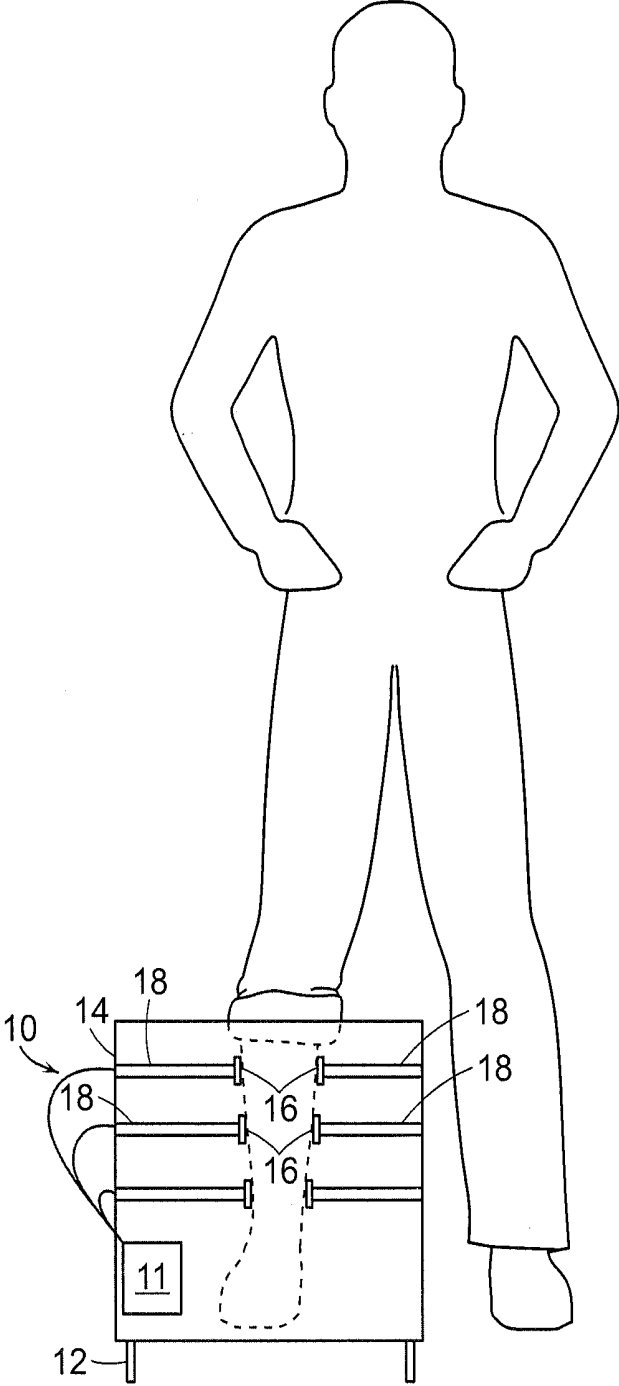


FIG. 1

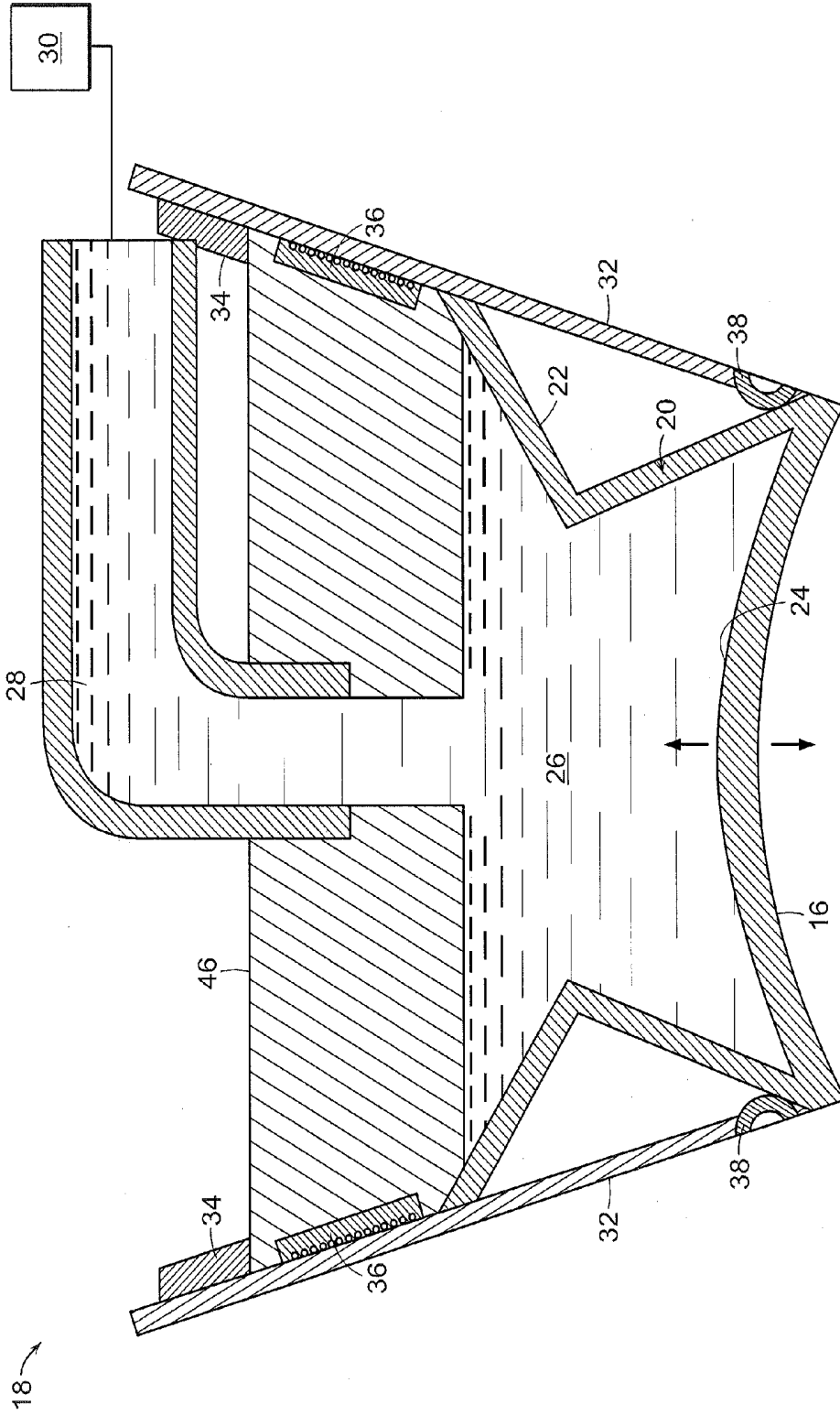


FIG. 2

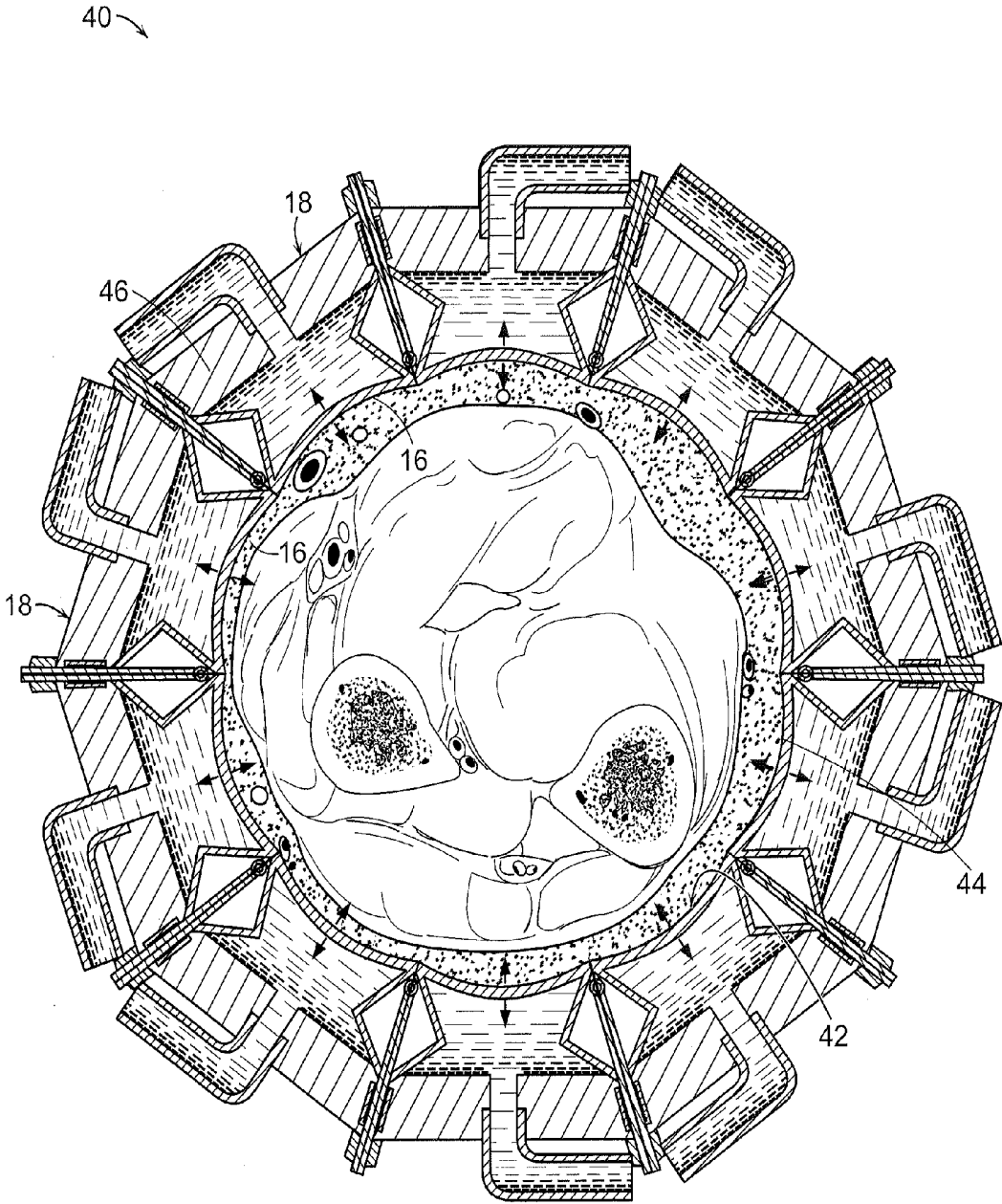


FIG. 3

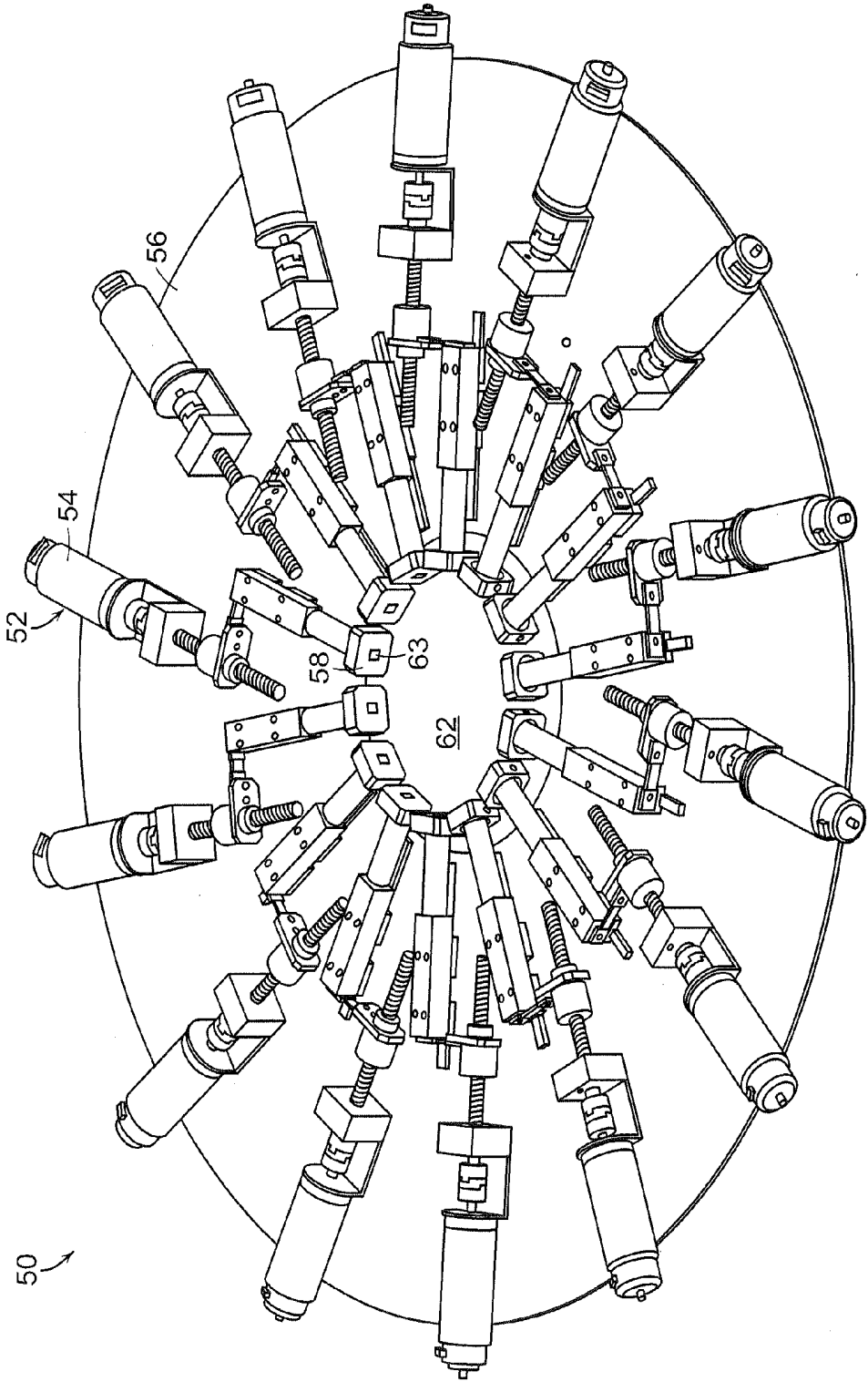


FIG. 4

FIG. 5A

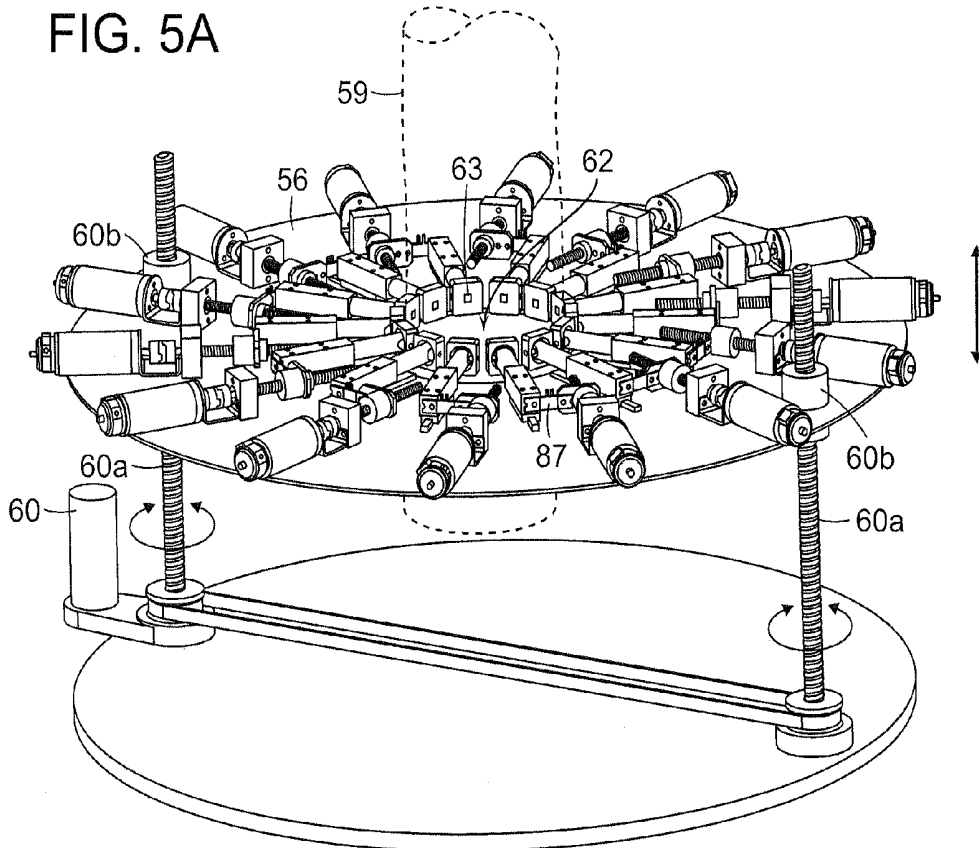
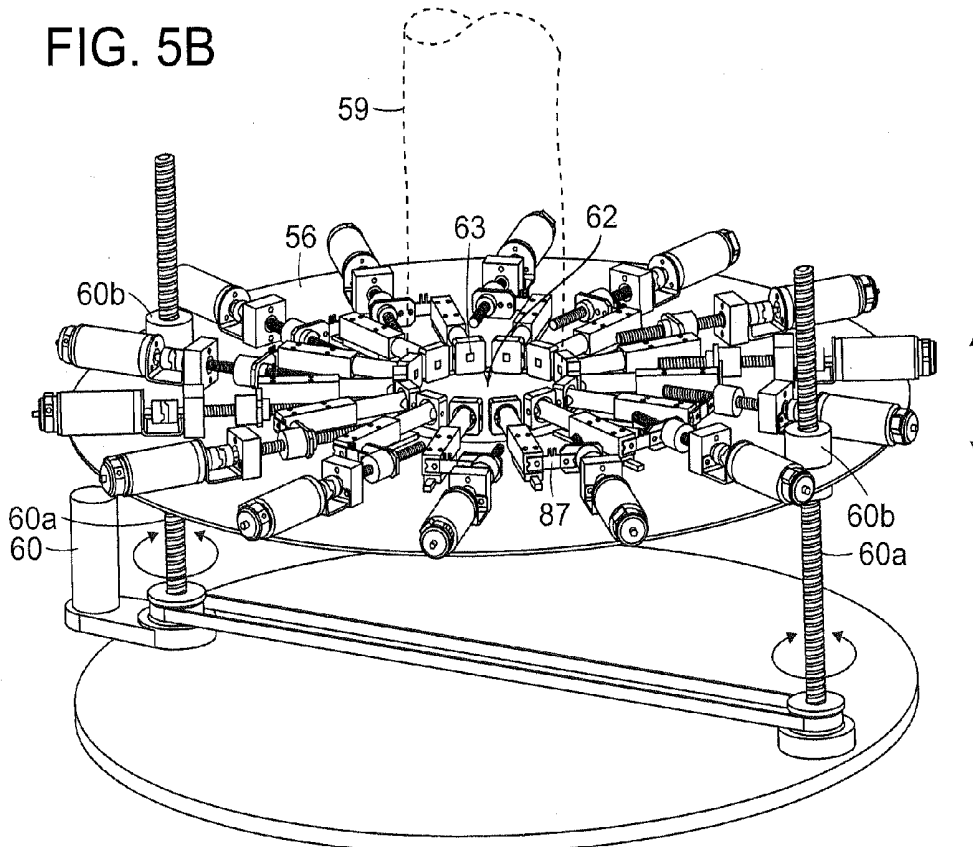


FIG. 5B



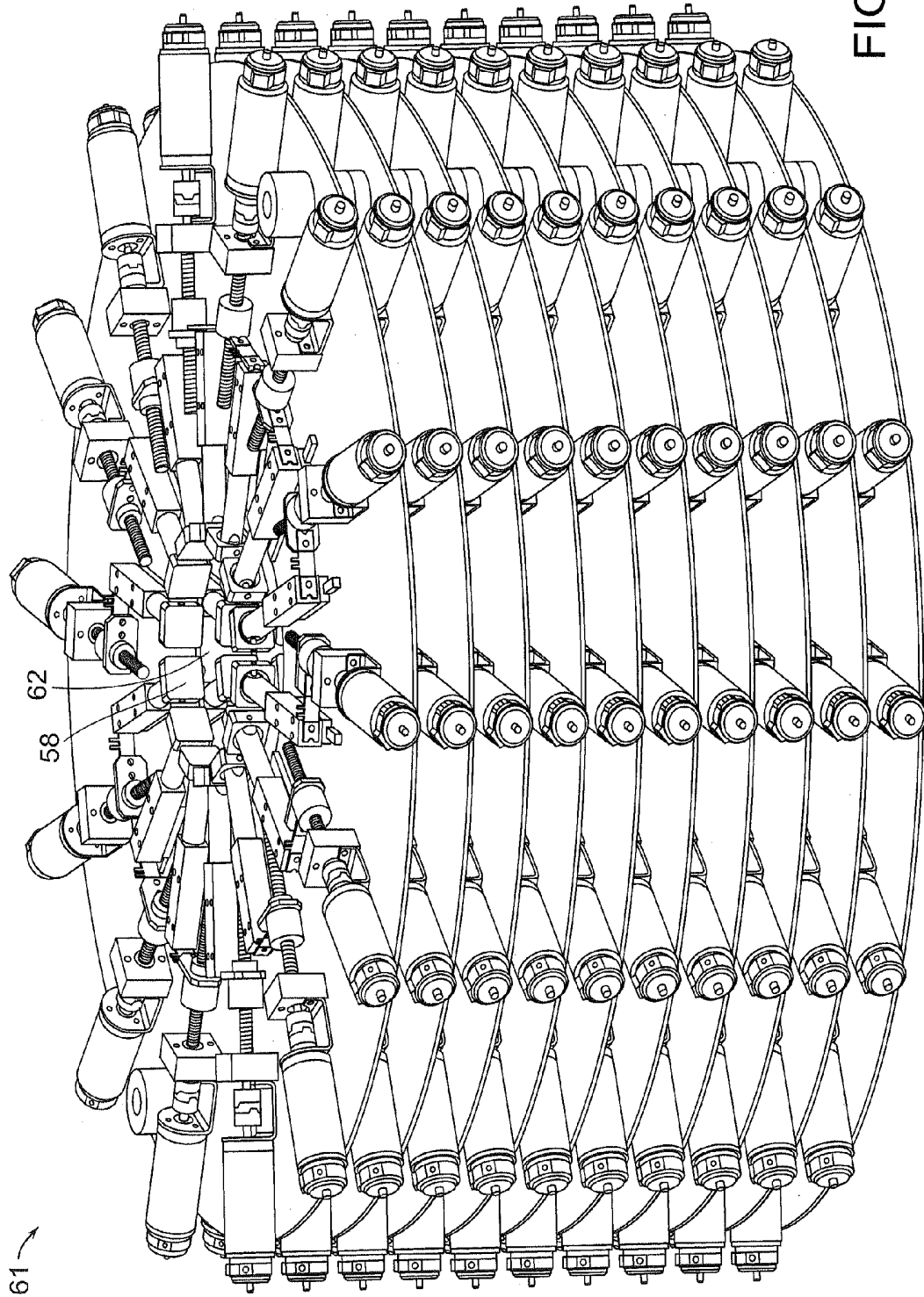


FIG. 6

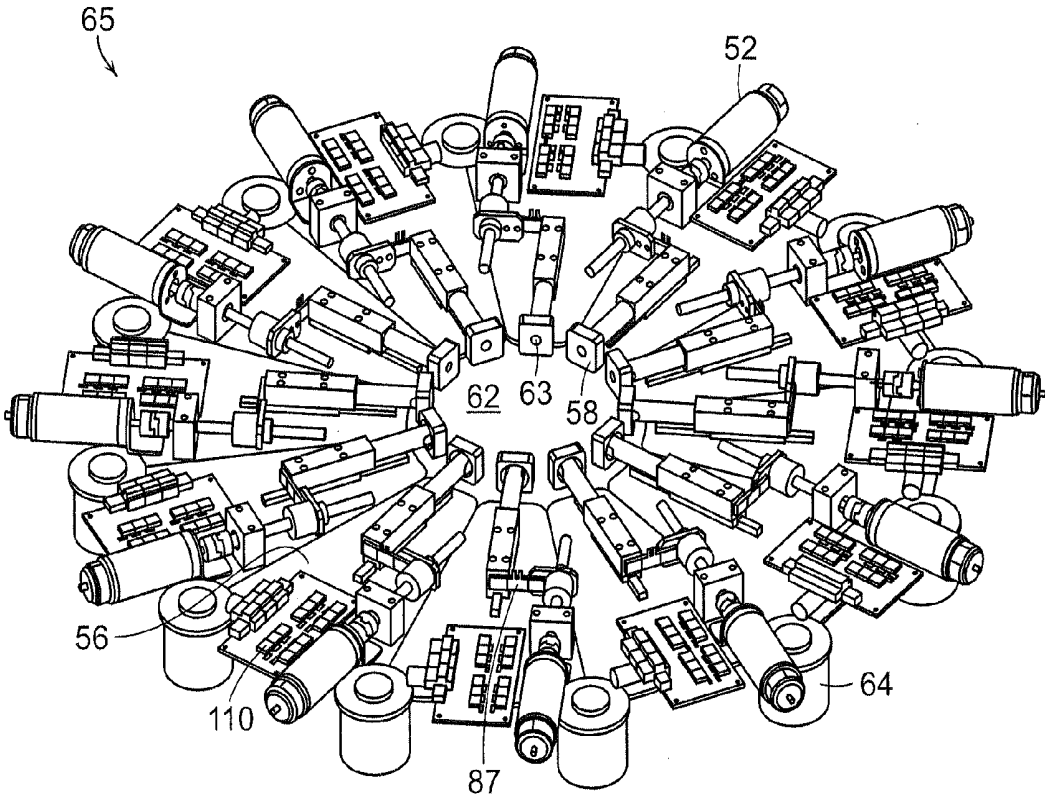


FIG. 7A

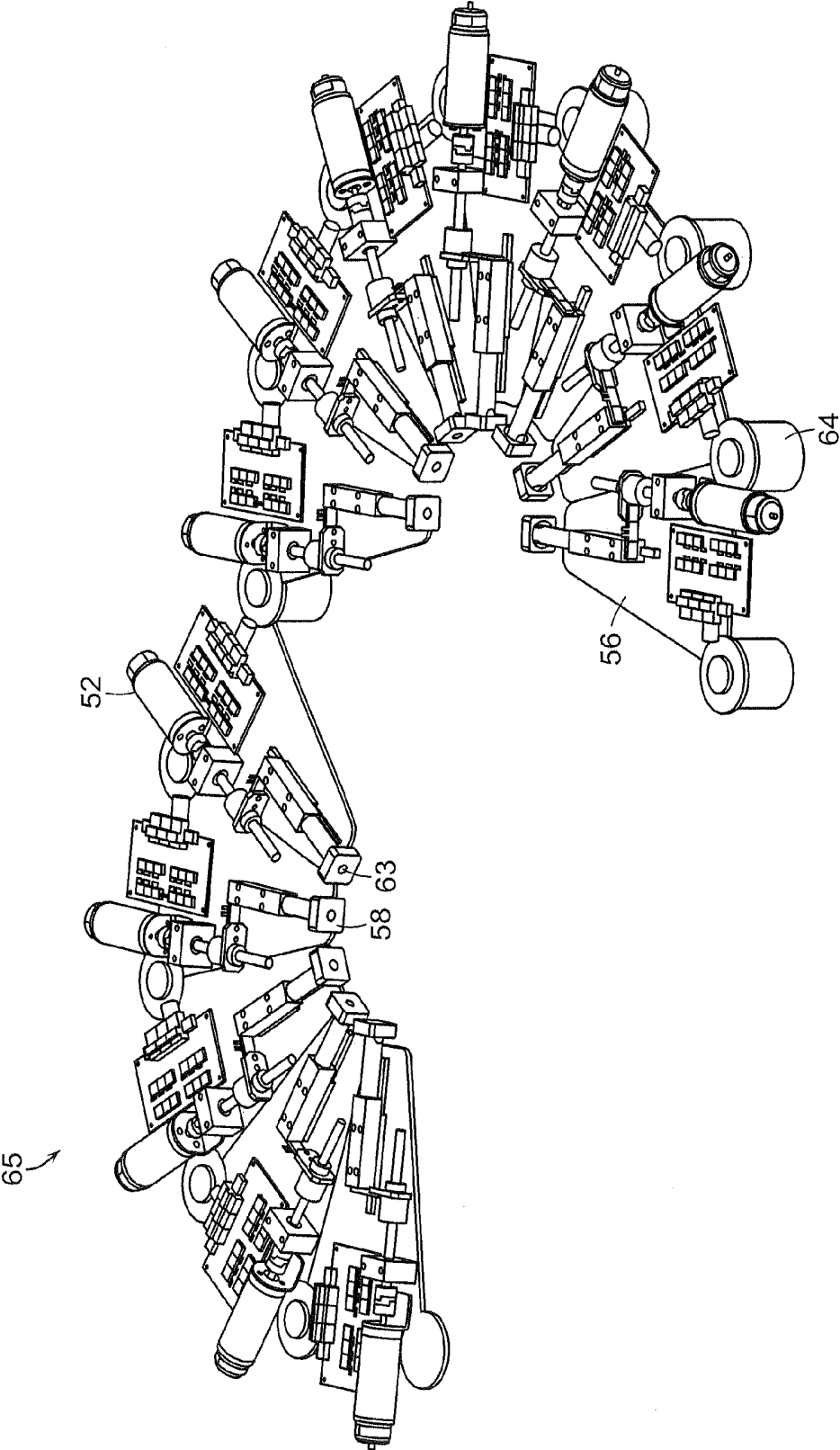


FIG. 7B

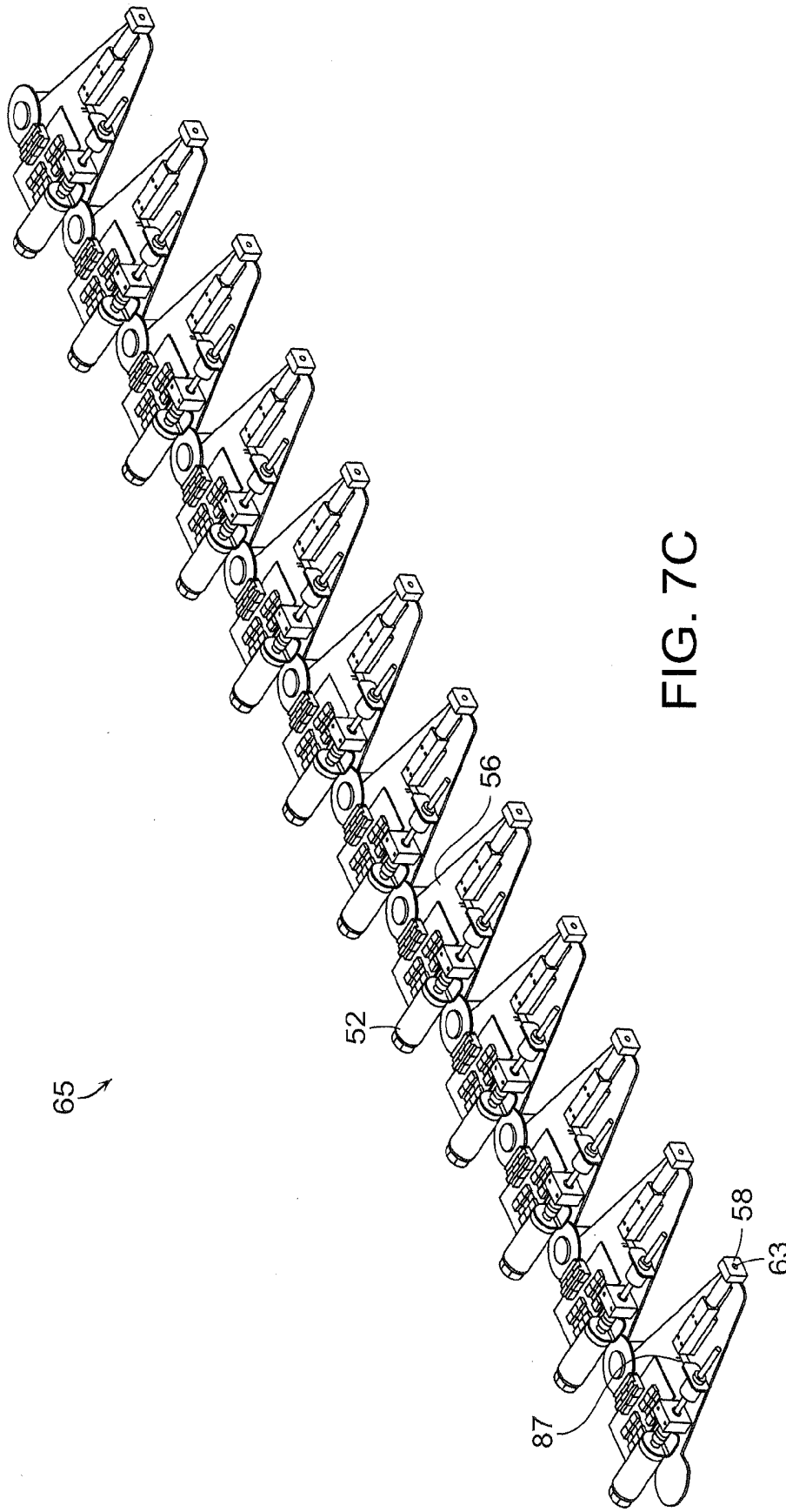


FIG. 7C

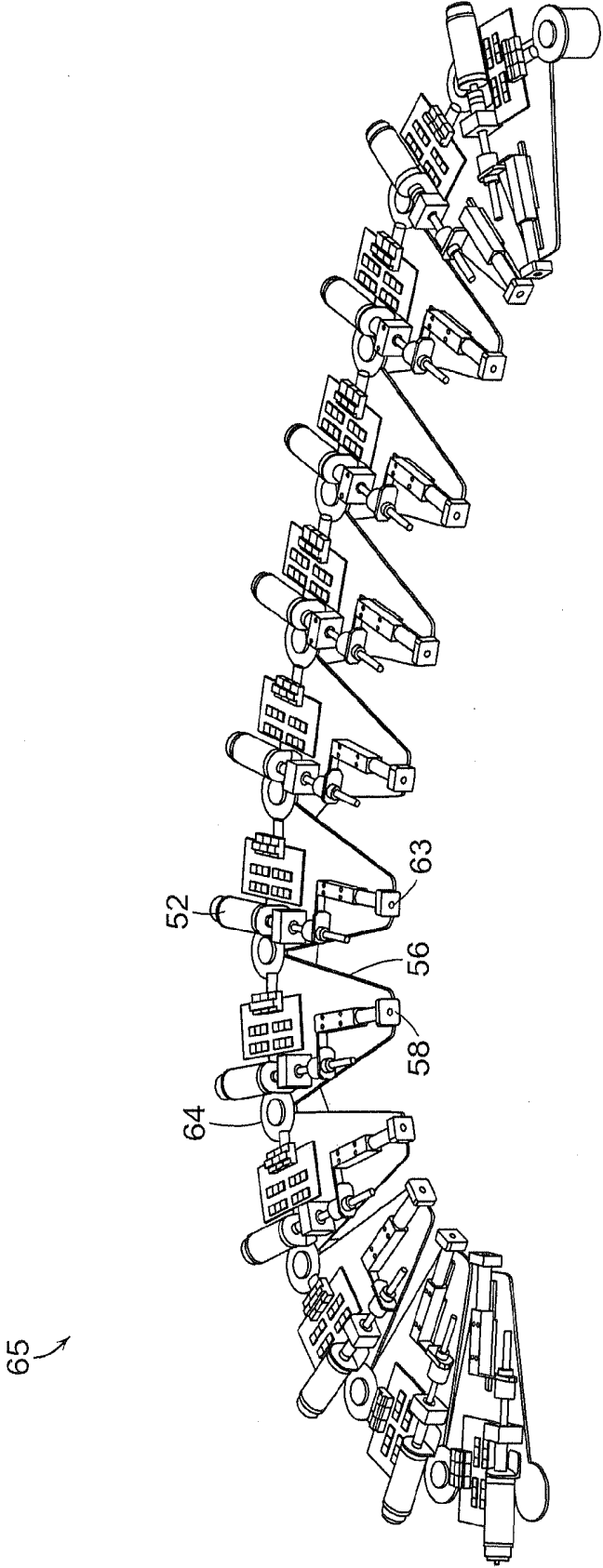


FIG. 7D

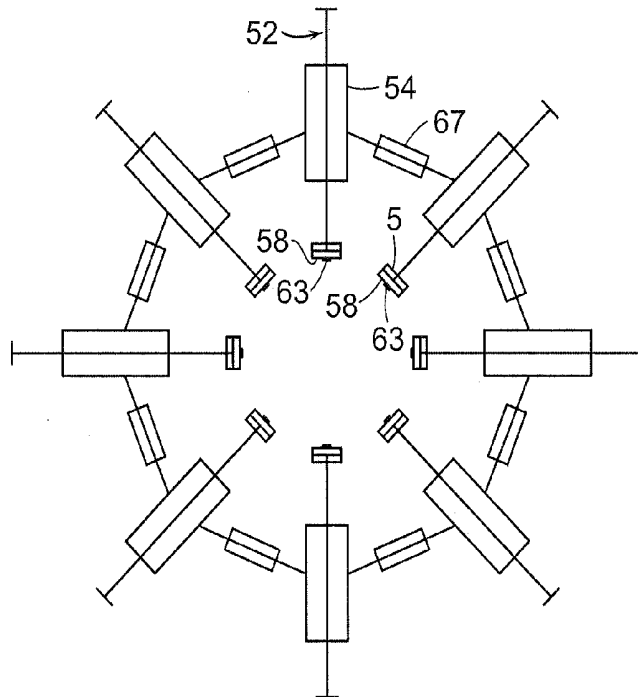


FIG. 8A

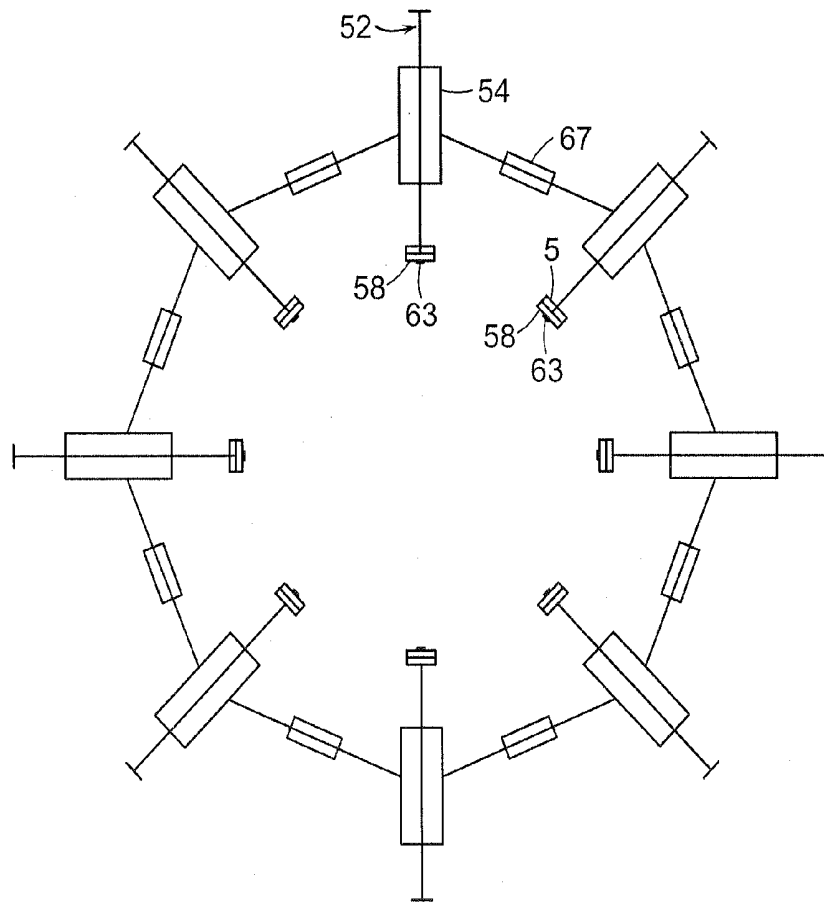


FIG. 8B

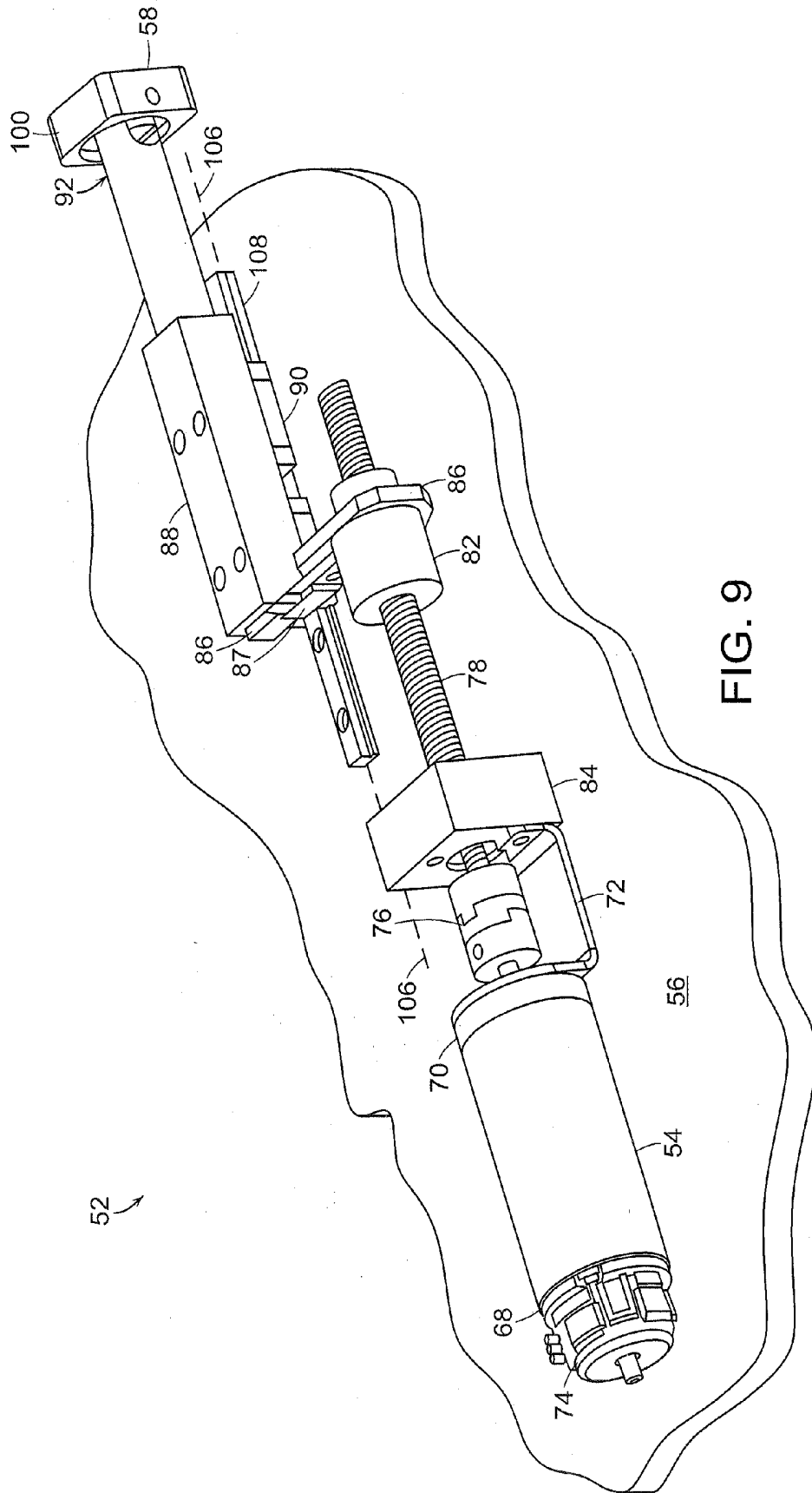


FIG. 9

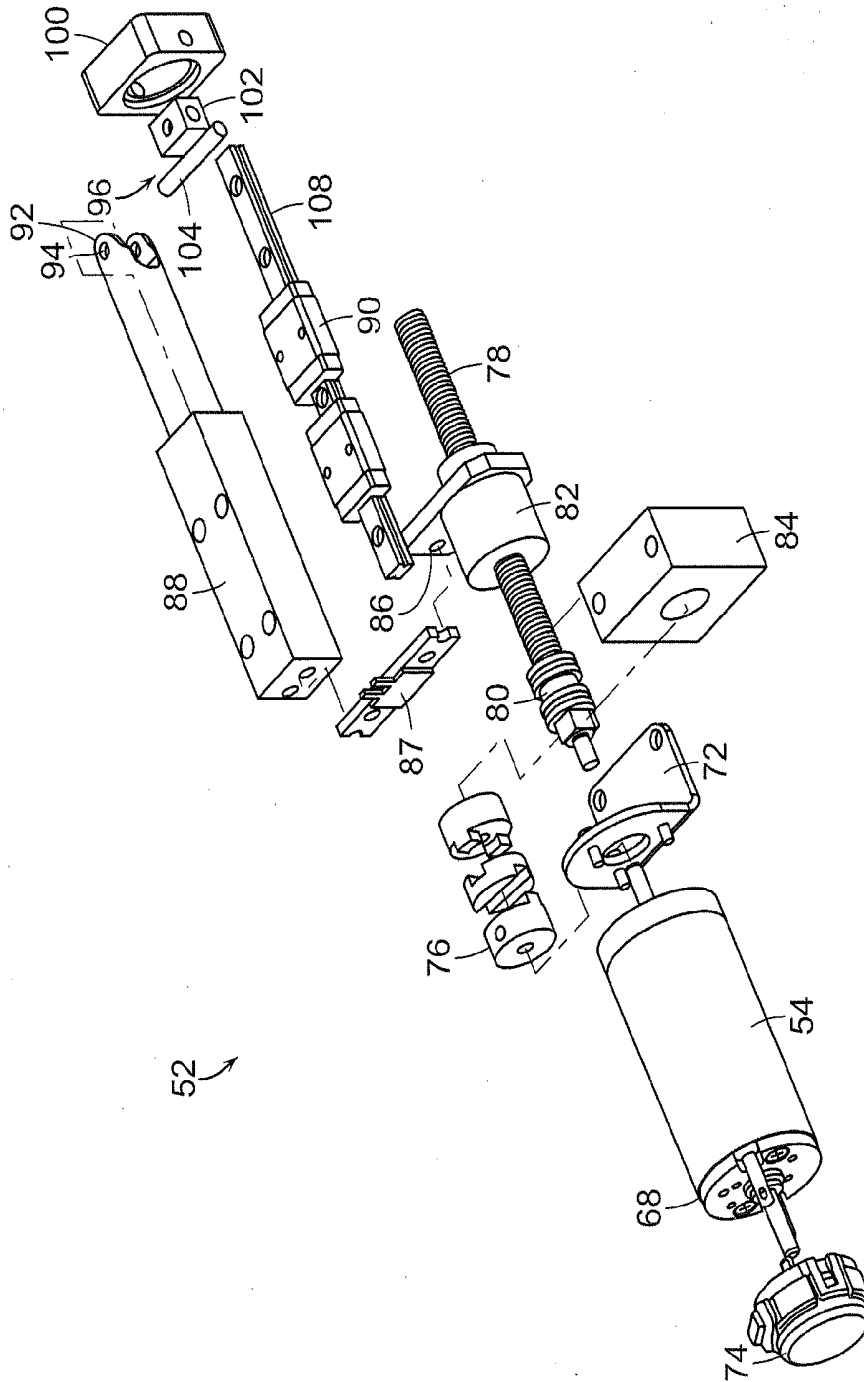


FIG. 10

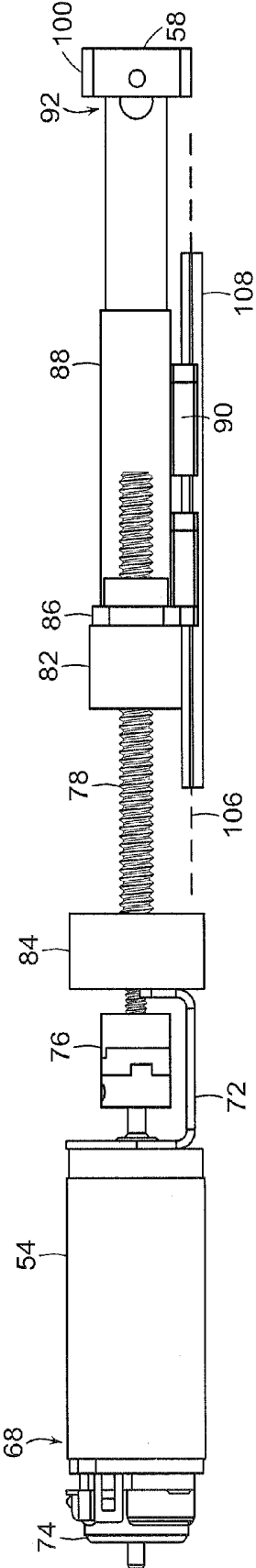


FIG. 11A

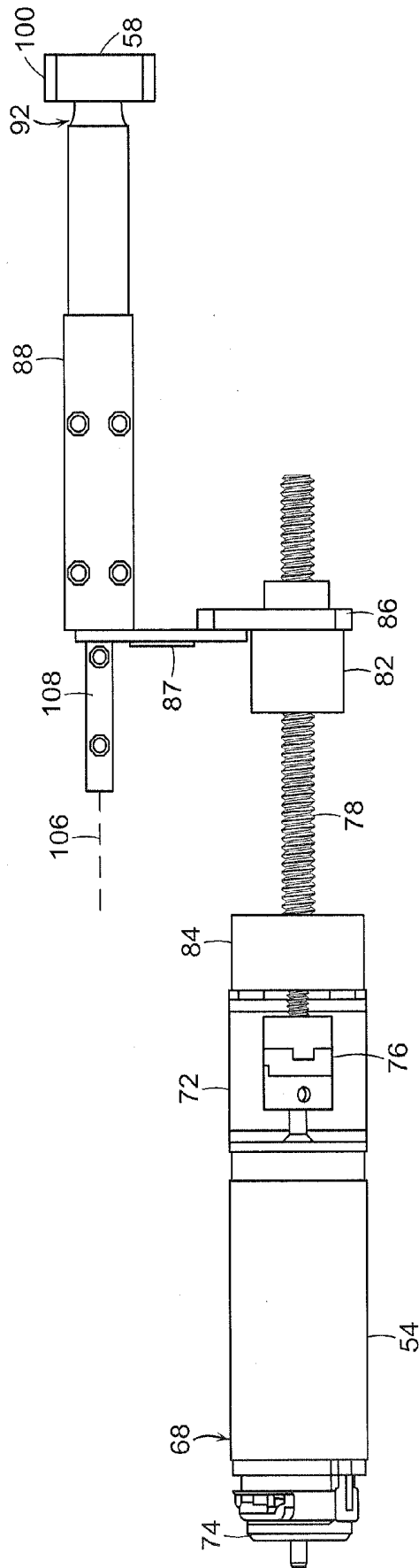


FIG. 11B

**PHYSIOLOGICAL MEASUREMENT DEVICE
OR WEARABLE DEVICE INTERFACE
SIMULATOR AND METHOD OF USE**

RELATED APPLICATION(S)

[0001] This application claims the benefit of U.S. Provisional Application No. 61/576,275, filed on Dec. 15, 2011.

[0002] The entire teachings of the above application are incorporated herein by reference.

GOVERNMENT SUPPORT

[0003] This invention was made with government support under VA118-12-C-0040 from United States Department of Veterans Affairs. The government has certain rights in the invention.

BACKGROUND OF THE INVENTION

[0004] Body-attachable devices employed to support a subject at, for example, a limb or the terminal end of a residual limb, often cause significant problems consequent to uneven distribution of force at surface areas of the subject in contact with the supporting orthosis or prosthesis. Although orthoses and prostheses typically are fitted by forming a material to the contours of the area of contact with the subject, soft tissue tends to move under use conditions consequent to linear and non-linear changes and differences in load, impedance and stiffness across the interface between the orthosis or prosthesis and the subject. Such changes of the soft tissue underlying the interface redistributes force across the area of the orthosis or prosthesis contacting the subject and can, as a consequence, deleteriously affect the subject not only in the area of contact with the prosthesis but, secondarily, as a result of efforts by the subject to minimize discomfort caused by that uneven distribution of force during activity. Previous attempts to minimize uneven distribution of force across the contact area between a subject and a prosthesis have included, for example, bladders that are distributed across the surface area of the prosthesis contacting the subject. However, such attempts generally do not account for differences in load, impedance or stiffness across the interface between an orthosis or prosthesis and a subject and, therefore, cannot be manipulated to correct the types of forces distributed across the interface.

[0005] Therefore, a need exists to overcome or minimize the above-referenced difficulties.

SUMMARY OF THE INVENTION

[0006] The invention generally is directed to a physiological measurement device or wearable device simulator, and to a method for measuring a physiological feature of a subject, or simulating an interface of a wearable device.

[0007] In one embodiment, the invention is a physiological measurement device or wearable device simulator that includes a frame and a plurality of surfaces distributed within the frame. For each surface, a surface actuator links the surface to the frame, whereby i) forces applied by the surfaces to the subject, and ii) the position of the surfaces relative to each other and relative to the subject, can be modulated independently of each other, thereby measuring the physiological feature of the subject or simulating a wearable device interface.

[0008] In another embodiment, the invention is a method for measuring a physiological feature of a subject or simulat-

ing an interface of a wearable device, including the steps of placing a plurality of surfaces against a subject, at least a portion of the surfaces being linked to a frame by an actuator, and modulating independently of each other at least one of: i) the forces applied by the surfaces to the subject; and ii) the position of the surfaces relative to each other and relative to the subject, thereby measuring the physiological feature of the subject or simulating an interface of a wearable device.

[0009] This invention has many advantages. For example, by fixing the position of at least a portion of the surfaces, independently of the forces applied by or to the surface, a physiological feature of the subject at the surface can be modeled or measured, and the interface between a wearable device, such as an orthosis or a prosthesis, and the subject, can be simulated with increased accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a representation of one embodiment of the invention while it is fixed in space relative to a subject.

[0011] FIG. 2 is a cross-sectional view of one embodiment of an actuator suitable for use in the invention.

[0012] FIG. 3 is a cross-sectional view of one embodiment of the invention, including an array of actuators of the type shown in FIG. 2.

[0013] FIG. 4 is a plan view of another embodiment of the invention, including a two-dimensional array of actuators, each of which employs a motor.

[0014] FIGS. 5 and 5B are perspective views of another embodiment of the invention, wherein the array of actuators shown in FIG. 4 can be moved along a subject by use of at least one frame actuator.

[0015] FIG. 6 is a perspective view of another embodiment of the invention employing a three-dimensional array of the actuators shown in FIG. 4.

[0016] FIGS. 7A-7D are perspective views of an embodiment of the invention employing interstitial actuators.

[0017] FIGS. 8A and 8B are schematic representations of another embodiment of the invention employing interstitial actuators, wherein the diameter of a socket defined by the surface actuators can be made wider by use of the interstitial actuators.

[0018] FIG. 9 is a perspective view of a surface actuator employable in the embodiment of the invention represented in FIG. 4.

[0019] FIG. 10 is an exploded view of the surface actuator shown in FIG. 9.

[0020] FIG. 11A is a side view of the surface actuator shown in FIG. 9.

[0021] FIG. 11B is a plan view of the surface actuator shown in FIG. 9.

DETAILED DESCRIPTION OF THE INVENTION

[0022] A description of example embodiments of the invention follows. The invention generally is directed to a physiological measurement device or wearable device interface simulator. The invention is also directed generally to a method for measuring a physiological feature of a subject or simulating an interface of a wearable device.

[0023] In one embodiment of the invention, shown in FIG. 1, physiological measurement device or wearable device interface simulator 10 includes support component 12 that fixes frame 14 relative to any or all of: i) a fixed point in space; ii) a skeletal feature of a subject proximate to a surface of the

subject to be simulated or measured, and iii) the surface of the subject to be simulated or measured. Typically, support component will include rods and straps, as necessary, to minimize relative movement between frame and the physiological feature of the subject to be simulated or measured. A plurality of surfaces 16 are distributed within frame 14. Surface actuator 18 links each surface to frame 14. Surfaces 16 can be separated from each other, contiguous with each other, or overlap with each other. Controller 11 is linked to surface actuators 18 and can be employed to coordinate modulation of surface actuators, either independently or in response to sensors, such as sensors at surfaces 16, or as more completely described below.

[0024] One embodiment of a suitable surface actuator is shown in FIG. 2. As shown therein, bladder 20 of surface actuator 18 includes bellows 22, diaphragm 24 and frame 46 that define chamber 26. Surface 16 is defined by diaphragm 24. Conduit 28 extends from chamber 26 to fluid source 30. Chamber 26 is filled with a fluid, such as an incompressible liquid, a gas, a gel, or a combination of such fluids. Bellows 22 is supported at a periphery of diaphragm 24 by at least one rod 32 linking the periphery of diaphragm 24 to potentiometer 34 mounted remotely from diaphragm 24. Linear bearing 36 interposed between rod 32 and bellows 22 provides support for rod 32 without interfering with readings by potentiometer 34. Gasket 38 is interposed between diaphragm 24 and rod 32 to ensure flexibility of surface 16 at diaphragm 24 in conforming with a physiological feature of a subject to be simulated or measured.

[0025] In operation, the volume of chamber 26 of bladder 20 can be changed by force applied by a subject contacting surface 16 of diaphragm 24 or can be modulated in response to feedback from surface actuator 18, such as in response to readings of potentiometer 34. "Modulation," as that term is defined herein, means control or monitoring of a feature, such as pressure, force or position. The volume of chamber 26 can be modulated by changing the volume of liquid within chamber 26 through conduit 28. The conduits extending from the bladders of surface actuators 18 are connected through a closed loop control system, whereby the position of surface 16 can be precisely monitored, and, independently, the position of surface 16 can be modulated by modulating the volume of chamber 26 to control the position of surface 16.

[0026] Optionally, or alternatively, sensors other than potentiometer 34 can be employed in surface actuator 18. Examples of such sensors include series elastic actuators, ultrasound sensors capacitive sensors, temperature sensors, infrared optical sensors, linear actuators, visible spectrum optical sensors, fluid pressure sensors, reed switch sensors, inductive sensors and electromyographic sensors, and can be located relative to surface 16 as appropriate.

[0027] In another embodiment, shown in FIG. 3, array 40 of surface actuators 18 define socket 42 at surfaces 16. Surfaces 16 are contiguous and define socket 42 into which residual limb 44 or other appendage or surface of the subject may be inserted for physiological simulation and measurement of the surface of the subject. Surface actuators 18 are supported by frame 46, which can be integral to individual surface actuators 18 and can support other surface actuators 18 by virtue of surface actuators 18 being linked together, as shown in FIG. 3. Alternatively, the frame can be a superstructure (not shown) to which surface actuators 18 are mounted.

[0028] Arrays of surface actuators 18 can take different forms. For example, surface actuators 18 can be distributed in

a plane and around a periphery of an appendage of the subject, as shown in FIG. 3. As previously stated, an array of surface actuators 18 can define, at least in part, a socket or shape into which a residual limb, appendage or subject surface is inserted or applied for physiological simulation and measurement. Optionally, more than one layer of surface actuators 18 are mounted to thereby form a three-dimensional array of sensors, wherein each sensor is associated with a surface actuator, as shown in FIG. 1, and whereby the surfaces define a shape such that the surfaces make contact with a subject's body.

[0029] Although shown as contiguous surfaces in FIG. 3, surface actuators 18 can be separated from each other and still linked by a single frame to which they are mounted. Frame 46, as stated above, can be mounted by suitable support components to a subject to thereby substantially prevent movement of the support proximate to the surface or physiological feature of the subject to be simulated or measured, or relative to a physiological skeletal feature of the subject. In another embodiment, while surface actuators 18 are fixed to frame 46, the shape of frame 46 can be modulated to change the distribution of surface actuators 18 relative to each other, either as a consequence of manual control by an operator of the physiological simulation and measurement device, or by operation of other actuators between surface actuators 18 or between the frame and surface actuators in response to feedback from physiological features measured or sensed by sensors at surface actuators 18.

[0030] Further, modulation of frame 46 and surface actuators 18, either separately or in combination, can be conducted essentially in real-time, either by actions of the operator of the device of the invention, or in response to feedback from sensors at surface actuators 18. Such modulation can be conducted while the subject remains motionless, or in response to changes in the surface of the subject contacting surfaces at surface actuators 18 while the subject is modulating his position, such as by walking or running, or in response to spontaneous muscle contraction proximate to the surfaces contacting surfaces of surface actuators 18. The data collected as a consequence of feedback from sensors at the surface actuators 18 can be compiled to simulate changes in a surface of a subject, either while the subject is motionless, or during normal activity of the subject, to thereby permit fabrication of, for example, a socket or shape of an orthosis or prosthesis for the subject that minimizes trauma at the orthosis or prosthesis, thereby maximizing the comfort of the subject while wearing the orthosis or prosthesis.

[0031] Surface actuators employed in the device of the invention can take many forms. For example, as an alternative to the bladders discussed above with reference to FIGS. 2 and 3, another type of surface actuator can employ a rotary motor to modulate a surface. In one embodiment, shown in FIG. 4, two-dimensional array 50 includes surface actuators 52 based on rotary motors 54. In this embodiment, a two-dimensional image can be constructed by use of surface actuators 52 fixed to frame 56 and that support surfaces 58. Sensors 63 can be located at surfaces 58, or elsewhere, depending on the type of sensor to be employed. Moving the plane of surface actuators 52 and surfaces 58 along an axis substantially normal to the plane of actuators 52 and surfaces 58 can create a three-dimensional image or simulation of an interface between a wearable device and subject 59. Such movement can be conducted by frame actuator 60, as shown in FIGS. 5A and 5B. As can be seen by comparison of FIGS. 5A and 5B, actuation

of frame actuator 60 causes rotation of threaded support 60a within blocks 60b to thereby raise or lower frame 56. Alternatively, a plurality of such two-dimensional arrays can be stacked to form a three-dimensional array 61 of surfaces 58 defining socket 62, as shown in FIG. 6. It is to be noted that a two-dimensional array, as shown in FIGS. 4 and 5, would also define socket 62.

[0032] Surface actuators 52 of another embodiment of the invention, array 65, shown in FIGS. 7A-7D, are fixed to frame 56. In one embodiment, surface actuators 52 form a virtual frame by being linked to another, either directly or through interstitial actuators 64 that are configured to move surface actuators 52 relative to each other, as shown in FIGS. 7A through 7D. In this embodiment, frame 56 can be modulated to change the distribution of position of surfaces 58 relative to each other, either as a result of manual control by the operator of the physiological simulation measurement device invention, or as a result of feedback from sensors 64 at surfaces 58, or from another sensor, such as strain gauge 87, at, or supported by, surface actuators 52. Surface actuators 52 can be controlled by circuits 110. Circuits 110 can be collectively controlled by linking them together, such as through a controller, as shown in FIG. 1.

[0033] Another embodiment of the invention is shown in FIGS. 8A and 8B. As shown therein, surface actuators 52 are separated by interstitial actuators 67. Actuation of interstitial actuators 67 causes the distance between surface actuators 52 to change, thereby causing the distance between surfaces 58 to change, as shown in the transition between FIGS. 8A-8B. The diameter of a socket defined by surfaces 58 can thereby be manipulated beyond the range of motion of surfaces 58 of individual surface actuators 52 when an arrangement of surface actuators 52 are fixed in position relative to each other. Optionally surface actuators 52 can be linked to interstitial actuators 67 by a hinge at the intersection of surface actuators 52 and interstitial actuators 67 shown in FIGS. 8A and 8B.

[0034] One embodiment of surface actuator 52 suitable for use as an actuator of the physiological simulation measurement device of the invention is shown in FIGS. 9-11B. As shown therein, rotary motor 54 includes distal end 68 and proximal end 70, and is mounted at proximal end 70 to mounting bracket 72 that is, in turn, fixed to frame 56 (FIG. 4). Rotary encoder 74 at distal end 68 of rotary motor 54 and controls actuation of rotary motor 54. Shaft coupler 76 couples rotary motor 54 to ball screw 78 through bearing assembly 80. Bearing assembly 80 is fitted within bearing assembly block 84. Ball screw 78 is threaded onto ball nut 82 and is linked to linear thrust block 88 by coupling 86. Strain gauge force sensor 87 is located at coupling 86, and detects the amount of force applied to or by end-effector plate 100. Strain gauge force sensor 87 can be mounted on a single coupling or can span two coupling components, as is known in the art. Linear thrust block 88 is mounted to linear bearing 90. Linear bearing 90 is fixed directly or indirectly to frame 56. Distal end 92 of linear thrust block 88 is fitted onto vertical axis pivots 94 of two-axis joint 96. Two-axis joint 96 prevents interference between linear thrust block 88 and end-effector plate 100. Cube 102 is fitted over two-axis joint 96. End-effector plate 100 is fitted over horizontal pivot pin 104 of two-axis joint 96. End-effector plate 100 defines or supports surface 58 contacting a physiological feature of the subject for modeling or simulation.

[0035] Actuation of rotary motor 54 causes rotation of ball screw 78 and consequent longitudinal motion of linear thrust

bearing 88 on linear bearing 90 along major longitudinal axis 106 of rail 108, thereby causing longitudinal motion of two-axis joint 96 on rail 108 and of end-effector plate 100 along major longitudinal axis 106 of rail 108. Optionally, a temperature sensor or another type of sensor can be placed at end-effector plates 100 in order to measure a physiological feature at the subject. End-effector plates 100 of surface actuators 52 can be contiguous, separated from each other, or overlap. In another embodiment, multiple surface actuators 52 can be linked to a single surface contacting end-effector plate 100 of each surface actuator 52. As described above, surface actuators 52 are linked to a processor or controller 11 (FIG. 1) by a suitable means, such as through circuit 110, shown in FIG. 4, mounted on frame 56. Controller 11 and circuits 110 modulate surface actuators 52 and thereby modulate the position at surfaces at surface actuators 52 relative to the physiological feature of the subject to be measured or simulated. The processor may also, or alternatively, modulate frame actuators (FIG. 5) and interstitial actuators (FIGS. 7A-7D and 8). Surface actuators 52, through the processor, can modulate the position or force applied by each surface actuator to a surface of the subject, and can measure at least one of impedance, force and stiffness of tissue of the subject at the surface of each surface actuator. Further, modulation of the surface actuators can be conducted in response to sensors either at the surface actuators or remote from them, or both, such as sensors employed to detect body temperature, blood pressure, heart rate of the subject, or position of the sensors. The sensors can also be employed at the surface actuator to detect temperature of the surface of the subject at the end-effector plate or bladder surface of the surface actuator employed. Also, alternative types of actuators can be employed, such as actuators that include springs, such as linear or non-linear springs, as are known in the art.

[0036] Such modulation can be by virtue of the arrangement of surface actuators of the device of the invention, and by control of the invention, either manually or automatically, in response to feedback from sensors employed in combination with the array of surface actuators. Further, the invention allows independent control of the shape of a test socket or shape at the surface of the subject in real time. For example, a multi-surface system of the invention can be modulated to determine the ideal socket or surface shape and characteristics for a particular user with the aid of data generated in real time. The device can be capable of determining both the socket shape under load in real time due to physical interaction at the interface between the subject's tissue and the simulated wearable device surface of the invention. For example, shape and pressure data allow the stiffness and impedance of residual limb tissue to be calculated directly.

[0037] Typically, about two hundred individually-controlled surface actuators will be distributed across the surface of a patient to be fitted with an orthotic or prosthetic device. In the case of bladders, at least a portion of the surfaces of the bladders of the surface actuators are flexible. Surfaces in contact with a subject generally will move in a direction that is about normal to a surface of the subject, while restricting tangential movement. The number of surface actuators per actuation surface can range, for example, between about 0.25 and about 3 surface actuators per actuation surface. Feedback from sensors at the surface actuators can be employed to form a three-dimensional image of the surface with which the actuators are in direct or indirect contact. Further, changes in the image can be portrayed in real-time and can reflect not

only changes in position of the surface, but distribution of forces at the points of the surface and distribution of temperature at different points of the surface. Equivalents

[0038] While this invention has been particularly shown and described with references to example embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

[0039] The relevant teachings of all references cited are incorporated herein by reference in their entirety.

What is claimed is:

1. A physiological measurement device or wearable device interface simulator, comprising:

- a) a frame;
- b) a plurality of surfaces distributed within the frame; and
- c) for each surface, a surface actuator linking the surface to the frame, whereby
 - i) forces applied by the surfaces to the subject, and
 - ii) the position of the surfaces relative to each other and relative to the subject

can be modulated independently of each other, thereby measuring a physiological feature of the subject or simulating a wearable device interface.

2. The device or simulator of claim 1, further including a sensor at at least a portion of the surfaces, whereby feedback from the sensor can be employed to modulate the relative positions of the surfaces.

3. The device or simulator of claim 2, wherein the sensor is a pressure sensor.

4. The device or simulator of claim 2, wherein the sensor is a temperature sensor.

5. The device or simulator of claim 2, wherein the sensor is a position sensor.

6. The device or simulator of claim 2, wherein the modulation of force imparted by at least one of the surfaces is in response to at least one of a) a force applied to the sensor by the subject, and b) a change in position of at least a portion of the surfaces relative to each other, the frame, or relative to the subject.

7. The device or simulator of claim 1, further including at least one frame actuator, wherein position of the frame relative to the subject can be modulated by activating the frame actuator.

8. The device or simulator of claim 1, further including at least one interstitial actuator linking the surface actuators **18**, wherein positions of the surface actuators **18** relative to each other are modulated by activation of the interstitial actuator.

9. The device or simulator of claim 1, wherein the position of the frame is configured to be modulated relative to a physiologic skeletal feature of the subject proximate to the physiological feature of the subject to be measured or simulated.

10. The device or simulator of claim 1, wherein the actuator is configured to modulate the resistive force of the subject.

11. The device or simulator of claim 1, wherein the modulation of position of the surfaces is in response to a force upon at least a portion of the surfaces by the subject.

12. The device or simulator of claim 1, wherein the device is further configured to modulate the force imparted by at least a portion of the surfaces on the subject.

13. The device or simulator of claim 12, wherein the modulation of force is at least one member selected from the group consisting of stiffness, damping and impedance.

14. The device or simulator of claim 1, further including a controller that relates the force and positions of each surface to each surface actuator.

15. The device or simulator of claim 14, wherein the controller modulates at least one of the relative positions of the surfaces and the resistive forces applied by the surfaces on the subject.

16. The device or simulator of claim 15, wherein the modulation is of a combination of the relative position of the surfaces, and the resistive forces applied by the surfaces on the subject.

17. The device or simulator of claim 16, wherein the controller simulates the interface between the surfaces and the physiological subject contacting the surfaces by mapping at least one of the position, force and temperature measured by the sensors contacting the physiological subject.

18. The device or simulator of claim 1, wherein the actuator includes a bladder supporting each surface and a potentiometer, wherein the bladder is filled with a gas or an incompressible fluid, and wherein the force imparted by each surface is modulated by modulating the volume of gas or incompressible fluid within the bladder.

19. The device or simulator of claim 1, wherein the actuator includes a motor that is linked to the surface by a screw drive, and at least one of a) a position sensor at the motor to detect the position of the surface, b) a force sensor at the surface or linked to the surface, and c) a temperature sensor at the surface.

20. The device or simulator of claim 1, wherein the surfaces are arrayed in a plane, wherein each surface is normal to the plane, and the surfaces collectively define an opening into which the subject can be placed.

21. The device or simulator of claim 1, wherein the surfaces are arranged three-dimensionally and define a shape such that the surfaces make contact with a subject's body.

22. A method for measuring a physiological feature of a subject or simulating an interface of a wearable device, comprising the steps of:

- a) placing a plurality of surfaces against a subject, at least a portion of the surfaces each being linked to a frame by a surface actuator; and
- b) modulating independently of each other the
 - i) forces applied by the surfaces to the subject, and
 - ii) the position of the surfaces relative to each other and relative to the subject, to thereby measure a physiological feature of the subject or simulate an interface of a wearable device.

23. The method of claim 22, wherein the surfaces are arrayed in a plane, wherein each surface is normal to the plane, and the surfaces collectively define an opening into which the subject can be placed.

24. The method of claim 22, wherein the surfaces are arranged three-dimensionally and define a shape such that the surfaces make contact with a subject's body.

25. The method of claim 22, wherein the support includes a frame actuator, and further including the step of activating the frame actuator to modulate the position of the frame relative to the subject.

26. The method of claim 22, wherein the support includes at least one interstitial actuator linking the surface actuators, and further including the step of actuating at least one interstitial actuator to thereby modulate the positions of the surface actuators relative to each other.

27. The method of claim **22**, wherein at least a portion of the surfaces each include a sensor, and further including the step of independently modulating the relative position of, or force applied by, the surfaces in response to feedback from the sensors.

28. The method of claim **27**, wherein the sensor is a pressure sensor.

29. The method of claim **27**, wherein the sensor is a thermometer.

30. The method of claim **27**, wherein the sensor is a position sensor.

31. The method of claim **27**, wherein the modulation includes activating at least a portion of the surface actuators.

32. The method of claim **27**, wherein the modulation includes activating at least one frame actuator changing the position of the frame relative to the subject.

33. The method of claim **27**, wherein the modulation includes activating at least one interstitial actuator linking surface actuators, thereby modulating the position of the surface actuators relative to each other.

34. The method of claim **22**, further including the step of modulating the position of the frame relative to a physiological skeletal feature of the subject.

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专利名称(译)	生理测量装置或可穿戴设备接口模拟器和使用方法		
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摘要(译)

生理测量装置或可穿戴装置模拟器包括框架和分布在框架内的多个表面。对于每个表面，表面致动器连接框架的表面。以下中的至少一个：
 i) 由表面致动器对受试者的生理特征施加的力或位置；和ii) 受试者的生理特征在表面上施加的力可以用于调节表面相对于彼此的位置，而与由这些表面施加的力或在这些表面上施加的力无关，从而测量受试者的生理特征或模拟可穿戴设备接口。

