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(71) Applicant: **HEADWAY LTD.** [IL/IL]; 17 Sky (Tchelet)
St.; Misgav Venture Accelerator, 20174 Misgav Industrial
Park (IL).

(72) Inventors: **LEVITAL, Tamir**; 8 Yehezkel St., 52245
Ramat Gan (IL). **ZAK, Shoham**; St' Hagalil 35, 23800
Givat Ela (IL). **GRINBOIM, Aviv**; Habrush 13, 4050000
Even Yehuda (IL).

(74) Agents: **Dr. Eyal Bressler LTD.** et al.; 11 Tuval Street,
Lazrom House, 52522 Ramat Gan (IL).

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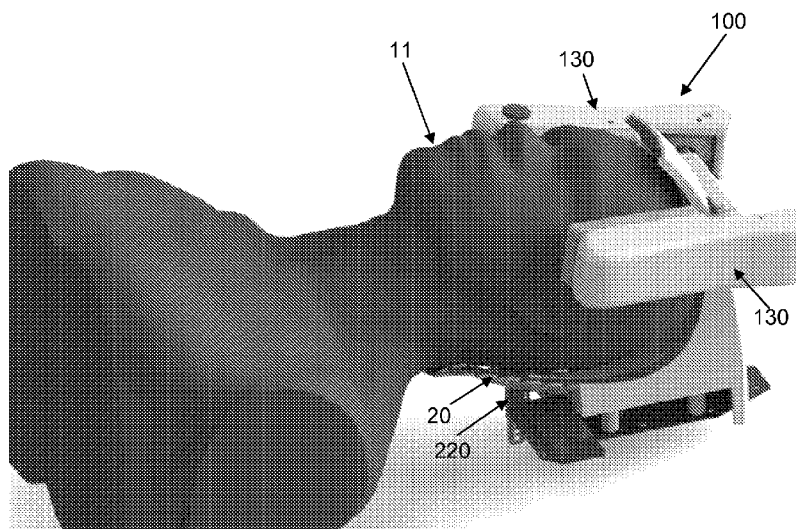


Fig. 15d

(57) Abstract: An apparatus is disclosed for treating a patient by controllably and supportably maneuvering the patient's body or part thereof. The apparatus comprises a cradle and at least one flexible supporting element physically connected to said cradle, said flexible supporting element characterized by a retracted configuration in which said body or part thereof is supported by application of force by said flexible supporting elements onto said treated body or part thereof and a one relaxed configuration, in which no force is applied by said flexible supporting elements onto said body or part thereof. In the particular case of treatment of neck pain, seven flexible supporting elements are provided, each one adapted to support a cervical vertebra.



A SUPPORTIVE CRADLE FOR PHYSIOTHERAPEUTIC APPLICATIONS

FIELD OF THE INVENTION

The present invention generally relates to means (namely, an ergonomic cradle) for controlling physiotherapy devices, in particular, for supporting and maneuvering the head and neck of a patient to treat, control, or prevent skeletal or musculoskeletal pain.

BACKGROUND OF THE INVENTION

Muscle dysfunction is commonly associated with chronic head and neck pain. Whatever the origin of the pain (trauma, pathology of the cervical spine, etc.), patients frequently develop lateral, anterior and posterior neck muscle activation imbalance, muscle fatigue, muscle shortening, and over-contraction of agonist and antagonist muscles. Subsequently, muscle hyperalgesia and reduced neck range of motion is induced. The hyperalgesia and muscle dysfunction become a vicious cycle. For some patients, mobilization and/or physical therapy are effective, while for other patients, biofeedback relaxation techniques are helpful. In many cases, the therapeutic protocol involves a set of motions that are repeated cyclically. A number of devices have been developed that are designed to provide at least some degree of automation to the therapeutic protocol.

PCT publication no. WO1995007669 titled "*inflatable cervical traction/stretch device*" discloses an inflatable cervical traction/stretch cradle which comprises a hollow inflatable body made of an elastically expandable material; said body including a shoulder portion, a head portion and a bellows portion; said bellows portion, said shoulder portion and said head portion having aligned U-shaped openings therein adapted to receive and support a user's neck; means, connected to said body, for pumping air into said body and for relieving or releasing air out of said body; and said head portion, said bellows portion and said shoulder portion having an un-inflated condition, a first inflated condition and a second inflated condition where said bellows portion is expanded and acts against and between said head portion and said shoulder portion.

Another prior art is US patent no. US5752927 titled an "*Inflatable cervical traction device*" discloses again an inflatable cervical traction device comprising (a) a C-

shaped multi-ribbed inflatable hollow collar having four separate chambers, in which two of said chambers are located at rear right and left locations of said collar, while other two of said chambers are located at front right and left locations of said collar; (b) means for securing two opposite front ends of said collar together in a releasable manner to hold said collar about a neck of a person; (c) means for pumping air into said four chambers of said collar, to inflate each of said four chambers at various pressurized amounts, so that said collar can properly support the neck of the person; (d) means for releasing air from said four chambers of said collar, so that said collar can deflate to be easily removed from the neck of the person; (e) a V-shaped mandibular cup; and (f) two sets of hook and loop fasteners for securing said mandibular cup onto two top front edges of said collar in a releasable manner for an increased positive contact with the chin of the person.

Yet another prior art is US patent no.5916185 titled a "*Inflatable cervical traction or stretch device*" discloses a cervical traction or stretch device comprising: an inflatable and expandable bladder or bellows having an undulating or pleated wall and a central U-shaped space so that said bladder or bellows can extend at least part way around the neck of a user with said undulating or pleated wall extending transversely of the user's neck; and a pumping mechanism coupled to said bladder or bellows and operable by a user for pumping air into said bladder or bellows for expanding same; said bladder or bellows having an upper side and a lower side; said lower side being constructed and arranged to be positioned adjacent a user's shoulders and exert pressure there against when said bladder or bellows is inflated and expanded; and said upper side being constructed and arranged to engage and exert pressure against the base of a user's head when said bladder or bellows is inflated and expanded.

All of the above mentioned prior art cervical device are based on the adjustment of the cradle to the patient's head by means of the inflation and deflation of balloons. Furthermore, the movement of the cervical device and thus, the treatment provided is also based on the inflation and deflation of the balloons.

There remains, however, a long-felt need for a cervical device (i.e., a cradle) that would ergonomically fit the patient.

Furthermore, there still remains a long-felt need for a cervical device (i.e., a cradle) that would enable a simple mechanical mechanism to provide the required treatment to the patients.

SUMMARY OF THE INVENTION

It is one object of the present invention to provide an apparatus for treating all or part of the body of a patient by controllably and supportably maneuvering the treated body or part thereof, the apparatus comprising:

- a cradle adapted for holding the treated body or part thereof stably and comfortably; and,

- at least one flexible supporting element physically connected to the cradle, the at least one supporting element adapted to support at least a portion of the treated body or part thereof and characterized by at least one retracted configuration, in which the body or part thereof is supported by application of force by the at least one flexible supporting element onto the treated body or part thereof;

- wherein each of the flexible supporting elements is adapted, in a retracted configuration, to apply force and to support at least a portion of the treated body or part thereof according to a support function $F(\alpha)$, $F(\alpha)$ being characterized by a form chosen from a group consisting of (a) $F(\alpha)$ decreases as the bending angle α of the body or part thereof decreases; and (b) $F(\alpha)$ is substantially independent of α .

It is another object of the present invention to provide the apparatus as defined above, additionally comprising at least one relaxed configuration, in which no force is applied by the flexible supporting elements onto the body or part thereof.

It is another object of the present invention to provide the apparatus as defined above, wherein the body part is selected from a group consisting of neck, head and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, wherein the at least one flexible element is selected from a group consisting of a spring-like element, a balloon-like element, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, comprising seven flexible supporting elements, each of which is adapted to support at least one cervical vertebra.

It is another object of the present invention to provide the apparatus as defined above, wherein $F(\alpha)$ differs between at least two of the flexible supporting elements.

It is another object of the present invention to provide the apparatus as defined above, wherein $F(\alpha)$ is substantially identical for all of the flexible supporting elements.

It is another object of the present invention to provide the apparatus as defined above, wherein at least two flexible supporting elements are connected together.

It is another object of the present invention to provide the apparatus as defined above, wherein the curvature of the flexible supporting element is adjustable.

It is another object of the present invention to provide the apparatus as defined above, wherein the adjustment of the curvature of the flexible supporting member is via a screw mechanism.

It is another object of the present invention to provide the apparatus as defined above, wherein the angle of the flexible supporting element with respect to the horizontal is adjustable.

It is another object of the present invention to provide the apparatus as defined above, wherein the distance between at least two of the flexible supporting elements is adjustable, so as to adjust to different lengths of the part of the body.

It is another object of the present invention to provide the apparatus as defined above, wherein the adjustment of the distance between the at least two the flexible supporting elements is via a screw mechanism.

It is another object of the present invention to provide the apparatus as defined above, wherein at least one the balloon-like element is adapted to transition between at least one inflated state and at least one deflated state.

It is another object of the present invention to provide the apparatus as defined above, wherein the means of the inflation is selected from a group consisting of a hand pump, a mechanical pump, compressed gas, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, additionally comprising at least one arm adapted to be positioned adjacent to at least some portion of at least one side of the body part.

It is another object of the present invention to provide the apparatus as defined above, additionally comprising a locking mechanism adapted to lock the at least one the arm in position.

It is another object of the present invention to provide the apparatus as defined above, wherein the distance between at least two of the arms is adjustable.

It is another object of the present invention to provide the apparatus as defined above, wherein the adjustment of the distance between at least two the arms is selected from a group consisting of a slide mechanism, a screw mechanism, an inflatable balloon-like mechanism, a ball joint, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, wherein the at least one arm comprises at least one sensor.

It is another object of the present invention to provide the apparatus as defined above, wherein the sensor is selected from a group consisting of a position sensor, a pressure sensor, an accelerometer, a motion sensor, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, wherein the sensor is selected from a group consisting of a gyroscope, an inclinometer, an accelerometer, an ultrasound sensor, a camera-based detector, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, wherein the sensor is adapted such that a user can determine therefrom parameters of the at least one arm selected from a group consisting of: the arm is in an open position, the arm is in a closed position, the arm is locked in position, the distance between at least two arms, the height of the arm, the angle of the arm with respect to the horizontal, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, additionally comprising at least one detecting means; wherein the detecting means is feedback interconnected with the arm.

It is another object of the present invention to provide the apparatus as defined above, wherein output of the detecting means is used to alter at least one of the adjustable parameters.

It is another object of the present invention to provide the apparatus as defined above, additionally comprising at least one maneuverable platform interconnected with at least one of the cradle and at least one of the at least one arms, the maneuverable platform comprising maneuvering means adapted to maneuver the platform in a

predetermined pattern for a predetermined duration in at least one plane chosen from a group consisting of the sagittal plane, the coronal plane, and the horizontal plane.

It is another object of the present invention to provide the apparatus as defined above, wherein the maneuvering of the body or part thereof is characterized by parameters selected from allowed movements, the duration of the motion is in the range from 0 to about 10 minutes.

It is another object of the present invention to provide the apparatus as defined above, wherein the allowed movements are selected from a group consisting of: Sagittal flexion in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to about $(70^{\circ}, 0^{\circ}, 0^{\circ})$; Sagittal return in a range from about $(70^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Coronal tilt right in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 45^{\circ}, 0^{\circ})$; Coronal return right in a range from about $(0^{\circ}, 45^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Coronal tilt left in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, -45^{\circ}, 0^{\circ})$; Coronal return left in a range from about $(0^{\circ}, -45^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Horizontal rotation right in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 60^{\circ})$; Horizontal return right in a range from about $(0^{\circ}, 0^{\circ}, 60^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Horizontal rotation left in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, -60^{\circ})$; and Horizontal return left in a range from about $(0^{\circ}, 0^{\circ}, -60^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$.

It is another object of the present invention to provide the apparatus as defined above, wherein the predetermined pattern is a lobular three dimensional pattern.

It is another object of the present invention to provide the apparatus as defined above, wherein the predetermined pattern is characterized by adjustable parameters.

It is another object of the present invention to provide the apparatus as defined above, additionally comprising at least one detecting means; wherein the detecting means is feedback interconnected with the maneuverable platform.

It is another object of the present invention to provide the apparatus as defined above, wherein output of the detecting means is used to alter at least one of the adjustable parameters.

It is another object of the present invention to provide the apparatus as defined above, wherein the detecting means comprises a sensor.

It is another object of the present invention to provide the apparatus as defined above, wherein the sensor is selected from a group consisting of a position sensor, a pressure sensor, an accelerometer, a motion sensor, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, wherein the sensor is selected from a group consisting of a gyroscope, an

inclinometer, an accelerometer, an ultrasound sensor, a camera-based detector, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, wherein the sensor is integrated into at least one of the cradle and the at least one arm and the sensor is adapted to track movement of at least one of the at least one of the cradle and the at least one arm for the purpose of regulation of the movement.

It is another object of the present invention to provide the apparatus as defined above, further comprising means for at least one of measuring and reporting at least one parameter related to at least one of a group consisting of the medical, physiological, and emotional condition of the patient.

It is another object of the present invention to provide the apparatus as defined above, further comprising means selected from a group consisting of mechanical, software and hardware for limiting by a predetermined amount at least one motion of the cradle.

It is another object of the present invention to provide the apparatus as defined above, wherein the motions are selected from the allowed movements.

It is another object of the present invention to provide the apparatus as defined above, wherein the cradle additionally comprises pressure sensors to measure at least one of the pressure and force the body part is applying in any direction on the interior of the cradle.

It is another object of the present invention to provide the apparatus as defined above, wherein the measurement of at least one of pressure and force is used for passive-assisted treatment, where the patient is instructed to follow actively the maneuvering of the cradle.

It is another object of the present invention to provide the apparatus as defined above, wherein the patient is instructed, using bio-feedback instrument, to follow actively the maneuvering of the cradle.

It is another object of the present invention to provide the apparatus as defined above, wherein the maneuvers are selected according to parameters characterizing the patient, the parameters selected from a group consisting of physiological movements in the sagittal plane, physiological movements in the coronal plane, physiological movements in the horizontal plane and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, additionally comprising a sensor unit adapted to establish the position of the body part.

It is another object of the present invention to provide the apparatus as defined above, wherein the sensor unit is held to the body part by a restraining means.

It is another object of the present invention to provide the apparatus as defined above, wherein the restraining means is at least one strap.

It is another object of the present invention to provide the apparatus as defined above, wherein the at least one strap is adjustable and is lockable in position by means of a member of a group consisting of: elasticity in the strap, a ratchet, a pull strap locked by a friction buckle, a pull strap locked by means of a buckle with a tang, a spring-like member, and any combination thereof.

It is another object of the present invention to provide the apparatus as defined above, wherein the apparatus is adapted to treat at least one condition selected from a group consisting of migraine, tension type headaches, post traumatic headaches, cervicogenic headaches, myofascial headaches, neck pain, post whiplash injury, muscle over-contraction, sleep disorders, cervical disc herniation, and cervical disc protrusion.

It is another object of the present invention to provide a method for treating the body of a patient or a part thereof, comprising steps of:

- obtaining an apparatus as defined above;
 - placing the body or part thereof on the cradle;
 - controllably maneuvering the cradle; and,
 - supporting the body or part thereof in the retracted configuration by at least one flexible supporting element;
- thereby applying force to and supporting at least a portion of the treated body or part thereof according to a support function $F(\alpha)$, $F(\alpha)$ being characterized by a form chosen from a group consisting of (a) $F(\alpha)$ decreases as the bending angle α of the body or part thereof decreases; and (b) $F(\alpha)$ is substantially independent of α .

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing at least one relaxed configuration, in

which no force is applied by the flexible supporting elements onto the body or part thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of characterizing the maneuvering by parameters selected from a predetermined set of allowed movements.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the body part from a group consisting of head, neck and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting at least one flexible element from a group consisting of a spring-like element, a balloon-like element, and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing seven flexible supporting elements, each of which is adapted to support at least one cervical vertebra.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing the support function $F(\alpha)$ differing between at least two of the flexible supporting elements.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing the support function $F(\alpha)$ substantially identical for all of the flexible supporting elements.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of connecting together at least two of the flexible supporting elements.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of adjusting the curvature of the flexible supporting element.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing the adjustment of the flexible supporting element via a screw mechanism.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of adjusting the angle of the flexible supporting element with respect to the horizontal.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of adjusting the distance between at least two of the flexible supporting elements, so as to adjust to different lengths of the part of the body.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of adjusting the distance between at least two flexible supporting elements via a screw mechanism.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of transitioning the balloon-like element between at least one inflated state and at least one deflated state.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the means of inflation from a group consisting of a hand pump, a mechanical pump, compressed gas, and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing the apparatus additionally comprising at least one arm adapted to be positioned adjacent to at least some portion of at least one side of the body part.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of locking at least one of the at least one arms in position.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of adjusting the distance between at least two of the arms.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the means of adjustment of the distance between at least two arms from a group consisting of a slide mechanism, a screw mechanism, an inflatable balloon-like mechanism, a ball joint, and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing at least one arm comprising at least one sensor.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the sensor from a group consisting of a

position sensor, a pressure sensor, an accelerometer, a motion sensor, and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the sensor from a group consisting of a gyroscope, an inclinometer, an accelerometer, an ultrasound sensor, a camera-based detector and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of adapting the sensor such that a user can determine therefrom parameters of at least one arm selected from a group consisting of: the arm is in an open position, the arm is in a closed position, the arm is locked in position, the distance between at least two arms, the height of the arm, the angle of the arm with respect to the horizontal, and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing at least one detecting means; wherein the detecting means is feedback interconnected with the arm.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of altering at least one of the adjustable parameters based on output of the detecting means.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing at least one maneuverable platform interconnected with at least one of the cradle and at least one of the at least one arms, the maneuverable platform comprising maneuvering means adapted to maneuver the platform in a predetermined pattern for a predetermined duration in at least one plane chosen from a group consisting of the sagittal plane, the coronal plane, and the horizontal plane.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of characterizing the maneuvering by parameters selected from allowed movements, the duration of the motion is in the range of 0 to about 10 minutes.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the allowed movements from a group consisting of: Sagittal flexion in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to about $(70^{\circ}, 0^{\circ}, 0^{\circ})$; Sagittal return in a range from about $(70^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Coronal tilt right in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 45^{\circ}, 0^{\circ})$; Coronal return right in a range from about

(0°,45°,0°) to (0°,0°,0°); Coronal tilt left in a range from about (0°,0°,0°) to (0°,-45°,0°); Coronal return left in a range from about (0°, 45°,0°) to (0°,0°,0°); Horizontal rotation right in a range from about (0°,0°,0°) to (0°,0°,60°); Horizontal return right in a range from about (0°,0°,60°) to (0°,0°,0°); Horizontal rotation left in a range from about (0°,0°,0°) to, (0°,0°, 60°); and Horizontal return left in a range from about (0°, 0°,-60°) to (0°,0°,0°).

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting for the predetermined pattern a lobular three dimensional pattern.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of characterizing the predetermined pattern by adjustable parameters.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing at least one detecting means; wherein the detecting means is feedback interconnected with the maneuverable platform.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of using output of the detecting means to alter at least one of the adjustable parameters.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing the detecting means comprising a sensor.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the sensor from a group consisting of a position sensor, a pressure sensor, an accelerometer, a motion sensor, and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the sensor from a group consisting of a gyroscope, an inclinometer, an accelerometer, an ultrasound sensor, a camera-based detector and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of integrating the sensor into at least one of the cradle and at least one arm and the sensor is adapted to track movement of at least one of the cradle and at least one arm for the purpose of regulation of the movement.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of at least one of measuring and reporting at least one

parameter related to at least one of a group consisting of the medical, physiological, and emotional condition of the patient.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of limiting by a predetermined amount at least one motion of the cradle by means chosen from a group consisting of mechanical means, software means, and hardware means.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the motions from the allowed movements.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing the cradle with pressure sensors to measure at least one of the pressure and force the body part is applying in any direction on the interior of the cradle.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of using the measurements of at least one of the pressure and force for passive-assisted treatment, where the patient is instructed to follow actively the maneuvering of the cradle.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of instructing the patient, using bio-feedback instrument, to follow actively the maneuvering of the cradle.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the maneuvers according to parameters characterizing the patient, the parameters selected from a group consisting of physiological movements in the sagittal plane, physiological movements in the coronal plane, physiological movements in the horizontal plane and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing a treatment selected from a group consisting of (a) improvement of neck muscle function; (b) treatment for at least one sleep disorder; (c) increasing neck muscle bulk; (d) improving ROM; and (e) rehabilitating movement of at least one affected body part following an injury.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of providing the apparatus with a sensor unit adapted to establish the position of the body part.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of holding the sensor unit to the body part by a restraining means.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of selecting the restraining means to be at least one strap.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of adjusting the at least one strap and locking the at least one strap in position by means of a member of a group consisting of: elasticity in the strap, a ratchet, a pull strap locked by a friction buckle, a pull strap locked by means of a buckle with a tang, a spring-like member, and any combination thereof.

It is another object of the present invention to provide the method as defined above, additionally comprising a step of adapting the method to treat at least one condition selected from a group consisting of migraine, tension type headaches, post traumatic headaches, cervicogenic headaches, myofascial headaches, neck pain, post whiplash injury, muscle over-contraction, over-tension of the neck muscles, neck movement disorders, sleep disorders, cervical disc herniation, and cervical disc protrusion.

BRIEF DESCRIPTION OF THE FIGURES

In order to understand the invention and to see how it may be implemented in practice, a plurality of embodiments is adapted to now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which

FIGs. 1 to 5 present views of embodiments of the present invention;

FIGs 6 to 10 present views of embodiments of the flexible supporting element of the present invention;

FIG. 11 present views of an embodiments of the arms of the present invention;

FIG. 12 presents a view of a ball joint in the arm of the present invention;

FIG. 13A-D presents views of an embodiment of a head restraint; the figures illustrate means for establishing the position of the head in real time during treatment;

FIG. 14A-C presents views of an embodiment of a balloon;

FIG. 15A-D presents a view of a preferred embodiment of the present invention;

FIG. 16 schematically presents various possible rotations of the head about the sagittal, coronal, and horizontal planes;

FIG. 17 presents a view of the effect of bending motion on an embodiment of the present invention;

FIG. 18A-F illustrates, not to scale, various lobular two and three dimensional maneuvers according to a set of possible embodiment of the present invention; and,

FIG. 19A-D illustrates the force (in kg) applied by the flexible supporting elements as a function of the bending angle, α .

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following description, various aspects of the invention will be described. For the purposes of explanation, specific details are set forth in order to provide a thorough understanding of the invention. It will be apparent to one skilled in the art that there are other embodiments of the invention that differ in details without affecting the essential nature thereof. Therefore the invention is not limited by that which is illustrated in the figures and described in the specification, but only as indicated in the accompanying claims, with the proper scope determined only by the broadest interpretation of said claims.

As used herein, the term **"physical therapy session"** refers to a period of time during which a physical therapy device as defined above is in operation (i.e. performing a physical manipulation on the body of an individual or part thereof.)

As used herein, the term **"motion of a physical therapy device"** refers to the motions of said device that enable or cause manipulation of the patient's body or body part of interest during the physical therapy, and not necessarily to gross motions of the device itself. Similarly, as used herein, terms such as "increase" or "decrease" of the motion of a physical therapy device can refer to changes in the amplitude, velocity, or acceleration of the motions leading to the manipulation of the body or body part of interest. That is, when the context requires it, it is understood in what follows that the motions of the manipulated body or body part are discussed in terms of the motions of the physical therapy device that lead to such manipulations.

As used herein, the term "**about**" or "**approximately**" refers to a value within $\pm 25\%$ of the defined measure.

As used herein, the term "**cradle**" refers to a supporting means for the body of a patient or a part thereof.

The present invention provides an apparatus for treating a patient's body or a part thereof, by controllably and supportably maneuvering said treated body or part thereof, said apparatus comprising

a cradle adapted for holding said treated body or part thereof stably and comfortably; and,

n flexible supporting elements in communication with said cradle adapted to support at least a portion of said treated body or part thereof; n is an integer greater than or equal to 1; each of said n flexible supporting elements is characterized by at least one retracted configuration, in which force is applied by said n flexible supporting elements onto said at least a portion of the said treated body or part thereof so as to support the same; and at least one relaxed configuration, in which no force is applied by said n flexible supporting elements onto said at least a portion of the said treated body or part thereof;

wherein each one of said flexible supporting elements is adapted, in said retracted configuration, to apply force and to support at least a portion of said treated body or part thereof according to a support function F ; said F is a function of the bending angle, α of said body or part thereof, $F(\alpha)$; said $F(\alpha)$ represented by at least one of the following:

- a. $F(\alpha)$ is substantially constant for each angle α ;
- b. $F(\alpha)$ decreases as angle α increases;
- c. any combination thereof

According to a preferred embodiment of the present invention n equals 7.

According to a preferred embodiment, the flexible element is a spring-like element, a balloon-like element or any combination thereof.

According to another preferred embodiment of the present invention, the treated body or part thereof is the neck or the head of the patient.

One of the main goals of the present invention is to provide a dynamic cradle useful for the treatment of range of motion (ROM) reduction, by increasing patient's cervical ROM and neck muscle flexibility, and, as a result, reducing pain; rehabilitation and relaxation of shoulder and cervical muscle over-contraction, e.g., after sport activity and/or injuries, and whole body relaxation. An additional benefit of the present invention is that the action of opposing the movement of the cradle enables the patient to increase his or her cervical muscle bulk and strength.

Reference is now made to FIG. 1, which illustrates an embodiment of the apparatus for treating the body of a patient or part thereof with the present invention.

In the embodiment illustrated in FIG. 1, the apparatus **100** comprises (a) a cradle **10** for holding said treated body or part thereof stably and comfortably; (b) at least one spring-like supporting element **20** physically connected to said cradle adapted to support at least a portion of the treated body or part thereof. In preferred embodiments of the invention, each of the supporting elements is capable of motion independent of the others.

As described, each of the spring-like supporting elements comprises a spring or spring-like member and is characterized by at least one retracted configuration, in which force is applied by the spring-like supporting elements onto said at least a portion of the treated body or part thereof, thereby providing support to it; and at least one relaxed configuration, in which the spring-like supporting elements do not provide any force to the treated body or part thereof (e.g. the neck).

According to preferred embodiments, at least one spring-like member is characterized by being adjustable, such that the amount of force applied by the spring-like supporting elements to the treated body part can be varied. In preferred embodiments, this force can be varied by changing at least one of the height of the spring-like supporting member, its angle to the horizontal, its length, the distance between spring-like members, and any combination thereof..

According to a preferred embodiment of the present invention the cradle **10** is adapted to hold the head of the patient and the spring-like supporting elements **20** are adapted to support the neck of the patient.

Reference is now made to FIG. 2a which illustrates the cradle of the present invention holding the head 11 of the patient and the spring-like supporting elements supporting the neck 21 of the patient.

It should be emphasized that according to the core concept behind the present invention, each one of said spring-like supporting elements 20 is adapted to apply force and to support (in the retracted configuration) at least a portion of said neck according to a support function $F(\alpha)$. In some embodiments, $F(\alpha)$ is a function $F(\alpha)$ of the bending angle α of said body or part thereof. In preferred embodiments, $F(\alpha)$ decreases as angle α increases, and the apparatus thus provides maximal support when no bending occurs. In other embodiments, $F(\alpha)$ is substantially independent of α .

According to one preferred embodiment of the present invention, the cradle comprises seven spring-like supporting elements, each of which is adapted to support one of the seven neck vertebrae. According to another embodiment of the present invention, each one of said spring-like supporting elements support at least a portion of said body or part thereof in a substantially different support function $F(\alpha)$.

According to another embodiment of the present invention, all of said spring-like supporting elements support at least a portion of said body or part thereof in a substantially equal support function $F(\alpha)$.

In the figure the patient is seen lying down. In this position the bending angle α is substantially 0, and the spring-like supporting elements are fully retracted. In one embodiment of the invention, the support function $F(\alpha)$ is at its maximum, and the spring-like supporting elements are applying the maximum support to the vertebrae of the neck. In another embodiment, the support applies a constant predetermined force that is substantially independent of the bending angle, α .

As will be described hereinafter as the bending angle α increases, the spring-like supporting elements are partially retracted and partially relaxed; and the support $F(\alpha)$ is:

- (a) according to one embodiment, decreasing (i.e., the force and support applied by spring-like supporting elements to the vertebrae of the neck decreases) or,
- (b) according to another embodiment, the support $F(\alpha)$ apply a constant predetermined support force, regardless of the bending angle, α .

Reference is now made to FIG. **2b**, which illustrates two situations. One, denoted by a dashed line, is a situation in which the body part is not bent, and the spring-like supporting elements are fully retracted. In the other, denoted by the solid line the body part is bent, and the spring-like supporting elements are partially retracted. The two situations are shown superimposed one on the other in order to illustrate the reaction of the apparatus to the movement of the patient.

Reference is now made to FIG. **3a** which illustrates the cradle of the present invention in front view. The arrows represent an option to adjust the distance between the ear-like “arms” (130) ergonomically, comfortably to each patient’s needs, using slides which can be locked in any physiological position. In a preferred embodiment, the width can be adjusted for each arm individually, adjusting one ear at a time. In another embodiment, the adjustment means moves both “arms” synchronically. In yet another embodiment, coarse adjustment is made for both arms synchronically, while fine adjustment is made for each ear individually,

In some embodiments, both arms are locked in position during treatment, providing a force which holds the patient's head firmly but comfortably in a fixed position relative to the cradle at all times during treatment; the patient's head is constrained to move according to the movements of the cradle. In other embodiments, only one arm is locked in position so that only one side of the patient's head is constrained. In these embodiments, the patient's head is constrained to move by a arm locked in position only when said arm is moving toward the patient's head. If said arm is moving away from the head, the patient's head will remain in contact with the arm only if the patient actively moves his head.

Reference is now made to FIG. **3b** which illustrates a fine-tuning adjustment around the cheeks achieved via inflatable pillows, located within the “arms” (130), which can be inflated and deflated by the caregiver or by the patient. In a preferred embodiment, inflation and deflation of the pillows is carried out for each pillow individually. In another embodiment, inflation of both pillows is done simultaneously. In yet another embodiment, coarse adjustment is made for both pillows synchronically, while fine adjustment is made for each pillow individually, Inflation of the pillows provides a force which holds the patient's head firmly but comfortably in a fixed position relative to the cradle at all times during treatment; the patient's head is constrained to move according to the movements of the cradle.

Adjustment can be made by means not limited to at least one slide, at least one ratchet, at least one screw, at least one pillow, and any combination of the above.

Reference is now made to FIG. 4, which illustrates the cradle in position surrounding the head of a patient, with the arms cradling the sides of the face. The arms (130), the rails along which the adjustment slides ride (120) and the support plate(s) (150) to which the arms are attached are clearly seen.

In addition to the ability to adjust the distance between the ear-like arms, it is also possible to rotate the arms about a vertical axis, thereby ensuring that the neck is in a physiological position even for an asymmetrical head.

Reference is now made to FIG. 5, which illustrates the cradle without a patient, showing the slide mechanism and the rotation mechanism. FIG. 5a illustrates a perspective view, FIG. 5b illustrates a view from the front, looking upwards, and FIG. 5c illustrates the device from behind. In FIG. 5, a support plate (150) is attached to the arms (130). The support plate (150) is connected to a bar (140), pivoted in its center, thereby enabling the arms to rotate around an axis through the pivot synchronically.

The arms (130) are connected both to the slide rails (120) and the rotation synchronizing bar (140). The support plate (150) is most easily seen in FIGs. 5b and 5c. FIG. 5c also shows a spring-like support (20) which supports the neck. In other embodiments, a balloon-like support replaces the spring-like support.

Because the lordosis of the human neck varies, adjustment of the height of the springs is desirable in order to ensure proper support of the neck vertebrae. One embodiment of a means of adjusting the spring height, a screw mechanism (170), is illustrated in FIG. 6. In this embodiment, the opposite ends of the mechanism are attached to opposite ends of the spring mechanism and, as the screw mechanism is tightened, the distance between the ends is shortened, thereby raising the center of the spring. FIG. 6a illustrates the screw mechanism (170) in its untightened state, with the spring mechanism (20) only slightly raised in the center, while FIG. 6b illustrates the screw mechanism (170) in the tightened state, with the spring mechanism (20) significantly raised in the center.

In reference to FIG. 7, there is illustrated another embodiment of a method of supporting the neck vertebrae. In this embodiment, at least one inflatable pillow (21),

preferably with at least seven separately-inflatable sections, supports the neck, and especially the cervical lordosis. The pillow section or the pillows (21) can be inflated by hand (shown) or via compressed air or a mechanical pump (not illustrated). The pillows (21) can be inflated individually, jointly, and any combination thereof.

In reference to FIG. 8, another embodiment is illustrated, in which the springs (20) are used for coarse adjustment of the neck support, while at least one inflatable pillow (21) is used for the fine adjustment. The spring can have adjustment means such as the example illustrated in FIG. 6, and, in a preferred embodiment, the at least one inflatable pillow (21) has at least seven separately-inflatable sections.

In reference to FIG. 9, another embodiment is illustrated, in which springs or spring-like elements 20 comprise a neck support. The neck support is flexibly connected at its proximal end to the cradle and comprises a vertical adjustment mechanism 220. In FIG. 9a, the vertical adjustment mechanism is in a lowered position, with the neck support and the springs 20 close to horizontal. In FIG. 9b, the vertical adjustment mechanism 220 has been raised, causing the free, distal, end of the neck support to rise and the neck support to be at a larger angle to the horizontal than in FIG. 9a. By this means, the neck support can be made to follow the angle of the neck, such that the springs 20 provide a substantially similar force on all of the cervical vertebrae.

In reference to FIG. 10, another embodiment is illustrated, in which springs or spring-like elements 20 comprise a neck support. The neck support is connected at its proximal and distal ends to a screw mechanism 170. In FIG. 10a, the screw mechanism 170 is in a more-open position; the spring-like elements 20 are relatively far apart, in a position suitable to support the vertebrae in a person with a longer neck, such as a tall adult. In FIG. 10b, the screw mechanism 170 has been tightened; the spring-like elements 20 have been brought closer together to accommodate a person with a shorter neck, such as a child or a short person, where the vertebrae are closer together.

In reference to FIG. 11, an embodiment of the cradle is shown in which adjustment of the arms 130 is illustrated. In the embodiment of FIG. 11, the arms form narrow wands on either side of the face, thereby enabling the head to be retrained without covering the ears. In FIG. 11a, the arms are in contact with the cheeks, in front of the

ears, while, in FIG. **11b**, the arms **130** are in contact with the rear part of the skull, beneath the ears.

In reference to FIGs. **11c** and **11d**, another adjustment of the arms **130** is shown. In FIG. **11c**, the arms are shown in an open position, where the arms **130** are not in contact with the patient's head. In the position shown in FIG **11c**, the patient's head can easily be lowered into or raised from the cradle **10**. In FIG. **11d**, the arms are shown in a closed position, where the arms **130** are in contact with the patient's head, thus restraining the patient's head. It can be clearly seen that the position of the arms in the closed position can be easily adjusted to accommodate different patient head sizes.

The arms **130** are adapted to move in at least the two directions, towards-away from the head, and forward-back parallel to the head, shown in FIG. **11**. The arms **130** are independently adjustable; each arm can be moved to its desired position, without affecting the position of the other arm.

The arms **130** preferably comprise a latching or locking mechanism, or other such means, such that, if the locking or latching mechanism is in an "open" position, the arms **130** can move freely, whereas, if the locking or latching mechanism is in a "closed" position, the arms **130** do not move, thereby laterally restraining the head. In preferred embodiments, each arm **130** is independently lockable or latchable so that each arm **130** can be independently positioned and independently locked or latched into place.

In reference to FIG. **12**, an embodiment of a ball joint **1210** enabling such movement is illustrated. In the embodiment of Fig. **12**, each arm **130** comprises a ball joint **1210**. The ball joint **1210** comprises a ball **1220** fitting smoothly and rotatably within a socket in arm **130** and a pin **1230** connectable to the main body of cradle **10**. This ball joint enables the arm **130** to be oriented in any desired angular direction, with limits to radial motion towards and away from the center of rotation of the arm **130** being the points at which the pin **1230** contacts the arm **130**. The ease with which the arm **130** is moved can be set by, for example, selecting an appropriate tightness of fit between ball **1220** and the socket. Other means of affecting ease of motion include selecting appropriate roughnesses for the ball **1220** and socket and altering or adjusting the the or amount of lubrication in the joint.

In some embodiments, the amount of restraint of the head is set by the ease of adjustment of the arms **130**. In other embodiments, latches or catches, either independent of the ball joint **1210** or, preferably, in conjunction with it, set the amount of restraint of the head. A non-limiting example of a latching mechanism in conjunction with the ball joint **1210** is a section of the socket adapted, when open, to allow free movement of the ball **1220** and adapted, when closed, to rest firmly against the ball **1220** so as to prevent the ball **1220** from moving. During adjustment of the device, the latch will be open; once the arms **130** are in a comfortable position for the patient, resting firmly and comfortably against the patient's head, the latch is closed, thereby restraining the patient's head during treatment. At the end of the treatment, the latch is again opened, freeing the patient's head from the device.

In reference to FIG. **13**, in another embodiment, the system additionally comprises a sensor unit (**180**). Fig. **13a** illustrates the sensor unit (**180**), while Fig. **13b** illustrates the sensor unit (**180**) in position on a human head. The sensor unit (**180**) comprises sensors to establish the position of the head in real time during treatment. The sensors can be accelerometers, gyroscopic, ultrasound sensors, a camera-based detector (as will be disclosed in Figs. **13c-13d**) or any combination thereof. In one embodiment, the position of the head is communicated to display means, recording means and any combination thereof. In another embodiment, the position of the head is communicated relative to its position at some previous time.

The sensor unit (**180**) is held firmly but comfortably to the head by a restraining means, preferably at least one strap, which is adjustable, in a non-limiting manner, by means of one of a group consisting of elasticity in at least one portion of the strap, a ratchet, a pull adjustment locked by means of a friction buckle a pull adjustment locked by means of a buckle with a tang, and any combination thereof. A single strap will preferably surround the head in the transverse plane. A pair of straps may surround the head with one tilted upward from the transverse plane from the sensor unit (**180**) to near the crown of the head, with the other tilted downward from the transverse plane from the sensor unit (**180**) to near the base of the head. In another embodiment, there is a transverse strap and a spring-like portion fitting over the head in the sagittal plane.

Reference is now made to Figs. 13c-13d which illustrates another embodiment of image-processing based method for establishing the position of the head in real time during treatment.

According to this embodiment, instead of accelerometers, gyroscopic, ultrasound sensors – the sensor is a camera-based detector. In other words, the sensor unit 180 will comprise at least one camera-based detector 1811. In this embodiment, the system will comprise at least one camera 1812 (see Fig. 13d) that will be able, by means of image processing, to detect the head's position during treatment.

It should be noted that according to another embodiment of the present invention, there could be more than one camera (e.g. stereo-camera to allow binocular vision) so as to provide the user with higher resolution of the head (or other treated organ) location, to prevent view-blocks and provide a more accurate three-dimension record .

According to this embodiment, the camera (or the stereo-camera) will detect the camera-based detector (or detectors) 1811 and will, by conventional known algorithms, locate the 3D position of the treated organ (e.g., head).

In reference to FIG. 14, a support pillow (190) is illustrated, inflatable independently on the two sides thereof. FIG. 14a illustrates the support pillow (190) from above, FIG. 14b illustrates a perspective view of the support pillow (190) in the inflated state, and FIG. 14c illustrates a side view of the support pillow (190) in the inflated state.

In reference to FIG. 15, an embodiment of the present device is shown. FIG. 15A shows the device with the arms 130 in an open position, adapted to allow easy insertion of a head into the cradle 10 as well as easy removal of the head aside from the cradle. An embodiment of vertical adjustment mechanism 220 is shown, with the spring-like members 20 held at a desired angle by the vertical adjustment mechanism 220.

Figs. 15B and 15C show, from two different angles, the above embodiment of the present device in a position typical of that attained when the device is being used. In use, the arms 130 are substantially horizontal, resting against the face and restraining lateral movements of the head. The body 10 of the cradle of the cradle is shown, as are the vertical adjustment mechanism 220 and the spring-like members 20.

FIG. 15d shows the above embodiment of the present device **100** in a position for use, with a head **11** in position, with the back of the skull resting comfortably in the body of the cradle, the arms **130** substantially horizontal and laterally restraining the head, and the spring-like members **20** supporting the neck, held at an appropriate height and at the appropriate angle by the vertical adjustment mechanism **220**.

In a preferred embodiment, the cradle retains three rotational degrees of freedom (i.e. freedom to rotate independently in the sagittal (**101**), coronal (**102**), and horizontal planes (**103**); these planes of motion are illustrated in **FIG. 16** relative to the motion manipulator portion. In a second preferred embodiment, the cradle retains these three rotational degrees of freedom along with three linear degrees of freedom (i.e. freedom to move independently along the axis parallel to the motion manipulator part's primary axis of the motion manipulator and the two axes in the plane perpendicular to the motion manipulator part's primary axis).

In reference to **FIG. 17**, there is illustrated the effect on the springs (**20**) of a rotation in the coronal plane. **FIG. 17a** illustrates the cradle (**10**) and the springs (**20**) before the coronal rotation, and **FIG. 17b** illustrates the cradle (**10**) and springs (**20**) after a coronal rotation toward the left.

In other words, each patient is treated with a specific therapy such that each therapy will be suited to the specific patient according to different parameters characterizing said specific patient. Said parameters can be any combination of "allowed movements" as defined in Table 1 below.

The person undergoing treatment rests his or her head within a recess in the cradle while lying down, either prone or supine. In the course of the treatment the head is caused to perform a 3D oscillatory movement at a very slow velocity (e.g., $0.3 - 3^\circ \text{ s}^{-1}$) by means of motors adapted to move a platform on which the cradle rests, in three axes. This slow movement is adapted to lengthen and relax over-contracted neck muscles. It is adapted to gradually abolish abnormal neck muscle contraction patterns.

In one embodiment of the invention this computer provides movement of the head described in the following table, in which the angle of the head is defined by the vector of movement angles in the sagittal, coronal, and horizontal planes, denoted (S, C, H), where S is the sagittal angle in degrees, C is the coronal angle in degrees, and

H is the horizontal angle in degrees, and where in all planes 0° is the position of the un-tilted head:

Table 1 Basic Movement Cycle and Allowable Movements

<i>Step</i>	<i>Allowable Movement</i>	<i>Start Angle</i>	<i>End Angle</i>
1.	Sagittal flexion	$(0^\circ, 0^\circ, 0^\circ)$	(Up to $70^\circ, 0^\circ, 0^\circ$)
2.	Sagittal return	(Up to $70^\circ, 0^\circ, 0^\circ$)	$(0^\circ, 0^\circ, 0^\circ)$
3.	Coronal tilt right	$(0^\circ, 0^\circ, 0^\circ)$	$(0^\circ, \text{Up to } 45^\circ, 0^\circ)$
4.	Coronal return right	$(0^\circ, \text{Up to } 45^\circ, 0^\circ)$	$(0^\circ, 0^\circ, 0^\circ)$
5.	Coronal tilt left	$(0^\circ, 0^\circ, 0^\circ)$	$(0^\circ, \text{Up to } -45^\circ, 0^\circ)$
6.	Coronal return left	$(0^\circ, \text{Up to } -45^\circ, 0^\circ)$	$(0^\circ, 0^\circ, 0^\circ)$
7.	Horizontal rotation right	$(0^\circ, 0^\circ, 0^\circ)$	$(0^\circ, 0^\circ, \text{Up to } 60^\circ)$
8.	Horizontal return right	$(0^\circ, 0^\circ, \text{Up to } 60^\circ)$	$(0^\circ, 0^\circ, 0^\circ)$
9.	Horizontal rotation left	$(0^\circ, 0^\circ, 0^\circ)$	$(0^\circ, 0^\circ, \text{Up to } -60^\circ)$
10.	Horizontal return left	$(0^\circ, 0^\circ, \text{Up to } -60^\circ)$	$(0^\circ, 0^\circ, 0^\circ)$

It is in the scope of the invention wherein the patient's body or an body or part thereof is manipulated in a set of (i) allowed movement, (ii) start angles, and (iii) end angles; Sagittal flexion, $(0^\circ, 0^\circ, 0^\circ)$, (Up to $70^\circ, 0^\circ, 0^\circ$), respectively; Sagittal return (Up to $70^\circ, 0^\circ, 0^\circ$), $(0^\circ, 0^\circ, 0^\circ)$; Coronal tilt right, $(0^\circ, 0^\circ, 0^\circ)$, $(0^\circ, \text{Up to } 45^\circ, 0^\circ)$; Coronal return right, $(0^\circ, \text{Up to } 45^\circ, 0^\circ)$, $(0^\circ, 0^\circ, 0^\circ)$; Coronal tilt left, $(0^\circ, 0^\circ, 0^\circ)$, $(0^\circ, \text{Up to } -45^\circ, 0^\circ)$; Coronal return left, $(0^\circ, \text{Up to } -45^\circ, 0^\circ)$, $(0^\circ, 0^\circ, 0^\circ)$; Horizontal rotation right, $(0^\circ, 0^\circ, 0^\circ)$, $(0^\circ, 0^\circ, \text{Up to } 60^\circ)$; Horizontal return right, $(0^\circ, 0^\circ, \text{Up to } 60^\circ)$, $(0^\circ, 0^\circ, 0^\circ)$; Horizontal rotation left, $(0^\circ, 0^\circ, 0^\circ)$, $(0^\circ, 0^\circ, \text{Up to } -60^\circ)$; Horizontal return left, $(0^\circ, 0^\circ, \text{Up to } -60^\circ)$, $(0^\circ, 0^\circ, 0^\circ)$, respectively, refers in the present invention as "allowed movements".

In '**feedback mode**' the computer receives feedback signals from sensors on the patient, to optimize a personal unique treatment of the head and neck in three dimensional space and time.

Due to the technology used, the patient undergoes a relaxing "**zero gravity**" floating experience, which leads to profound muscle relaxation, including relaxation of neck muscles as well as facial and mastication muscles.

This dynamic cradle is useful for the treatment of pain especially head and neck pain syndromes such as migraine, and other headaches: tension type, post traumatic, cervicogenic, and myofascial headache, as well as neck pain, such as post whiplash injury and muscle over-contraction.

Moreover, this dynamic cradle is useful for the treatment of ROM reduction, by increasing patient's cervical ROM and neck muscle flexibility, and as a result, reducing pain; rehabilitation and relaxation of shoulder and neck muscles over-contraction, e.g., after sport activity and/or other injuries, and whole body relaxation. Besides, while opposing the cradle movement one can increase his or her muscle bulk & strength, optionally by using the active-assisted mode.

According to yet another preferred embodiment of the present invention, a cradle is provided that conforms to the shape of the human head, neck and shoulders.

Reference is now made to FIGs. 18a to 18f, illustrating, not to scale, the direction in which the treated body or part thereof is maneuvered. FIG. 18a illustrates an even figure 8-like track (here, a clockwise direction). This lobular maneuver is provided in a two dimensional and/or a three dimensional manner here a loop-like continuous movement along the sagittal plane. FIG. 18b depicts similar figure 8-like track, here, along a counter-clockwise direction. FIGs. 18c – 18f depict similar figure 8-like continuous movement along various planes. It is acknowledged in this respect that uneven figure 8-like (with one extended lob) continuous movements along all Sagittal, Horizontal, and Coronal planes are possible.

This 2D and/or 3D maneuvers are provided in a continuous or interrupted manner, in a spontaneous, feedbacked and/or predetermined manner. It is in the scope of the invention wherein the aforesaid 3D movement is provided with six degrees of freedom (DFs), especially wherein the motion is characterized by a continuous passive motion in a 6-DFs lobular maneuver.

According to another embodiment of the present invention a variety of embodiment are provided for illustrating the holding and attachment of the patient's head and neck to the treatment table.

Reference is now made to FIGs. 19a-19d, illustrating four examples of the force (in kg) applied by the spring-like supporting elements as a function of the bending angle α . As can be seen from the figure, in the embodiments illustrated in FIGs. 19a and

19b, the support function is essentially constant (at approximately 3 kg (approx. 30 N) in FIG. **19a** and 0.5 kg (approx. 5 N) in FIG. **19b**), independent of the bending angle α . FIGs. **19c** and **19d** illustrate embodiments in which the support function decreases as the bending angle α increases. In the embodiment illustrated in FIG. **19c**, the support function decreases from approximately 3.5 kg to approximately 0.3 kg as α increases from approximately 10° to approximately 65° , while in the embodiment illustrated in FIG. **19d**, support function decreases from approximately 0.5 kg to approximately 0.05 kg over this range in α .

In preferred embodiments of the invention, maximum force applied by at least one of the spring-like supporting elements, for an adult patient, is between 3-4 kg, while the maximum force for a child the force is about 0.5 kg.

In the foregoing description, embodiments of the invention, including preferred embodiments, have been presented for the purpose of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiments were chosen and described to provide the best illustration of the principals of the invention and its practical application, and to enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth they are fairly, legally, and equitably entitled.

CLAIMS

We claim:

1. An apparatus for treating all or part of the body of a patient by controllably and supportably maneuvering said treated body or part thereof, said apparatus comprising:
 - a cradle adapted for holding said treated body or part thereof stably and comfortably; and,
 - at least one flexible supporting element physically connected to said cradle, said at least one supporting element adapted to support at least a portion of the said treated body or part thereof and characterized by at least one retracted configuration; wherein, in said retracted configuration said body or part thereof is supported by application of force by said at least one flexible supporting element onto said treated body or part thereof.
2. The apparatus according to claim 1, wherein each of said flexible supporting elements is adapted, in said retracted configuration, to apply force and to support at least a portion of said treated body or part thereof according to a support function $F(\alpha)$, $F(\alpha)$ being characterized by a form chosen from a group consisting of (a) $F(\alpha)$ decreases as the bending angle α of said body or part thereof decreases; and (b) $F(\alpha)$ is substantially independent of α .
3. The apparatus according to claim 1, additionally comprising at least one relaxed configuration, in which no force is applied by said flexible supporting elements onto said body or part thereof.
4. The apparatus according to claim 1, wherein said body part is selected from a group consisting of neck, head and any combination thereof.
5. The apparatus according to claim 1, wherein said at least one flexible element is selected from a group consisting of a spring-like element, a balloon-like element, and any combination thereof.
6. The apparatus according to claim 1, comprising seven flexible supporting elements, each of which is adapted to support at least one cervical vertebra.
7. The apparatus according to claim 2, wherein $F(\alpha)$ differs between at least two of said flexible supporting elements.

8. The apparatus according to claim 2, wherein $F(\alpha)$ is substantially identical for all of said flexible supporting elements.
9. The apparatus according to claim 1, wherein at least two flexible supporting elements are connected together.
10. The apparatus according to claim 1, wherein the curvature of said flexible supporting element is adjustable.
11. The apparatus according to claim 1, wherein said adjustment of said curvature of said flexible supporting member is via a screw mechanism.
12. The apparatus according to claim 1, wherein the angle of said flexible supporting element with respect to the horizontal is adjustable.
13. The apparatus according to claim 1, wherein the distance between at least two of said flexible supporting elements is adjustable, so as to adjust to different lengths of said part of the body.
14. The apparatus according to claim 13, wherein said adjustment of said distance between said at least two said flexible supporting elements is via a screw mechanism.
15. The apparatus according to claim 4, wherein at least one said balloon-like element is adapted to transition between at least one inflated state and at least one deflated state.
16. The apparatus according to claim 15, wherein the means of said inflation is selected from a group consisting of a hand pump, a mechanical pump, compressed gas, and any combination thereof.
17. The apparatus according to claim 1, additionally comprising at least one arm adapted to be positioned adjacent to at least some portion of at least one side of said body part.
18. The apparatus according to claim 17, additionally comprising a locking mechanism adapted to lock said at least one said arm in position.
19. The apparatus according to claim 17, wherein the distance between at least two of said arms is adjustable.

20. The apparatus according to claim 17, wherein said adjustment of the distance between at least two said arms is selected from a group consisting of a slide mechanism, a screw mechanism, an inflatable balloon-like mechanism, a ball joint, and any combination thereof.
21. The apparatus according to claim 17, wherein said at least one arm comprises at least one sensor.
22. The apparatus according to claim 17, wherein said sensor is selected from a group consisting of a position sensor, a pressure sensor, an accelerometer, a motion sensor, and any combination thereof.
23. The apparatus of claim 17, wherein said sensor is selected from a group consisting of a gyroscope, an inclinometer, an accelerometer, an ultrasound sensor, a camera-based detector, and any combination thereof.
24. The apparatus according to claim 17, wherein said sensor is adapted such that a user can determine therefrom parameters of said at least one arm selected from a group consisting of: the arm is in an open position, the arm is in a closed position, the arm is locked in position, the distance between at least two arms, the height of the arm, the angle of the arm with respect to the horizontal, and any combination thereof.
25. The apparatus as defined in claim 17, additionally comprising at least one detecting means; wherein said detecting means is feedback interconnected with said arm.
26. The apparatus as defined in claim 17, wherein output of said detecting means is used to alter at least one of said adjustable parameters.
27. The apparatus according to claim 17, comprising at least two arms.
28. The apparatus according to claim 27, wherein the movement of said arms is synchronized.
29. The apparatus according to claim 1, additionally comprising at least one maneuverable platform interconnected with at least one of said cradle and at least one of said at least one arm, said maneuverable platform comprising maneuvering means adapted to maneuver said platform in a predetermined

pattern for a predetermined duration in at least one plane chosen from a group consisting of the sagittal plane, the coronal plane, and the horizontal plane.

30. The apparatus according to claim 29, wherein said maneuvering of said body or part thereof is characterized by parameters selected from allowed movements, said duration of said motion is in the range from 0 to about 10 minutes.
31. The apparatus as defined in claim 29, wherein said allowed movements are selected from a group consisting of: Sagittal flexion in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to about $(70^{\circ}, 0^{\circ}, 0^{\circ})$; Sagittal return in a range from about $(70^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Coronal tilt right in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 45^{\circ}, 0^{\circ})$; Coronal return right in a range from about $(0^{\circ}, 45^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Coronal tilt left in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, -45^{\circ}, 0^{\circ})$; Coronal return left in a range from about $(0^{\circ}, -45^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Horizontal rotation right in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 60^{\circ})$; Horizontal return right in a range from about $(0^{\circ}, 0^{\circ}, 60^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Horizontal rotation left in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to, $(0^{\circ}, 0^{\circ}, -60^{\circ})$; and Horizontal return left in a range from about $(0^{\circ}, 0^{\circ}, -60^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$.
32. The apparatus as defined in claim 29, wherein said predetermined pattern is a lobular three dimensional pattern.
33. The apparatus as defined in claim 29, wherein said predetermined pattern is characterized by adjustable parameters.
34. The apparatus as defined in claim 33, additionally comprising at least one detecting means; wherein said detecting means is feedback interconnected with said maneuverable platform.
35. The apparatus as defined in claim 34, wherein output of said detecting means is used to alter at least one of said adjustable parameters.
36. The apparatus as defined in claim 34, wherein said detecting means comprises a sensor.
37. The apparatus as defined in claim 36, wherein said sensor is selected from a group consisting of a position sensor, a pressure sensor, an accelerometer, a motion sensor, and any combination thereof.

38. The apparatus of claim 1, wherein said sensor is selected from a group consisting of a gyroscope, an inclinometer, an accelerometer, an ultrasound sensor, a camera-based detector, and any combination thereof.
39. The apparatus of claim 38, wherein said sensor is integrated into at least one of said cradle and said at least one arm and said sensor is adapted to track movement of at least one of said cradle and said at least one arm for the purpose of regulation of said movement.
40. The apparatus of claim 1, further comprising means for at least one of measuring and reporting at least one parameter related to at least one of a group consisting of the medical, physiological, and emotional condition of said patient.
41. The apparatus of claim 1, further comprising means selected from a group consisting of mechanical, software and hardware for limiting by a predetermined amount at least one motion of said cradle.
42. The apparatus of claim 41, wherein said motions are selected from said allowed movements.
43. The apparatus of claim 1, wherein said cradle additionally comprises pressure sensors to measure at least one of the pressure and force said body part is applying in any direction on the interior of said cradle.
44. The apparatus of claim 43, wherein said measurement of said at least one of pressure and force is used for passive-assisted treatment, where said patient is instructed to follow actively said maneuvering of said cradle.
45. The apparatus of claim 29, wherein said patient is instructed, using bio-feedback instrument, to follow actively said maneuvering of said cradle.
46. The apparatus of claim 29, wherein said maneuvers are selected according to parameters characterizing said patient, said parameters selected from a group consisting of physiological movements in the sagittal plane, physiological movements in the coronal plane, physiological movements in the horizontal plane and any combination thereof.
47. The apparatus of claim 1, additionally comprising a sensor unit (180) adapted to establish the position of said body part.

48. The apparatus of claim 47, wherein said sensor unit (180) is held to said body part by a restraining means.
49. The apparatus of claim 47, wherein said restraining means is at least one strap.
50. The apparatus of claim 47, wherein said at least one strap is adjustable and is lockable in position by means of a member of a group consisting of: elasticity in said strap, a ratchet, a pull strap locked by a friction buckle, a pull strap locked by means of a buckle with a tang, a spring-like member, and any combination thereof.
51. The apparatus as defined in claim 1, wherein said apparatus is adapted to treat at least one condition selected from a group consisting of migraine, tension type headaches, post traumatic headaches, cervicogenic headaches, myofascial headaches, neck pain, post whiplash injury, muscle over-contraction, sleep disorders, cervical disc herniation, and cervical disc protrusion.
52. A method for treating the body of a patient or a part thereof, comprising steps of:
obtaining an apparatus according to claim 1;
placing said body or part thereof on said cradle;
controllably maneuvering said cradle; and,
supporting said body or part thereof in said retracted configuration by said at least one flexible supporting element;
thereby applying force to and supporting at least a portion of said treated body or part thereof.
53. The method according to claim 52, wherein said step of applying force is in accordance to a support function $F(\alpha)$, $F(\alpha)$ being characterized by a form chosen from a group consisting of (a) $F(\alpha)$ decreases as the bending angle α of said body or part thereof decreases; and (b) $F(\alpha)$ is substantially independent of α .
54. The method according to claim 52, additionally comprising a step of providing at least one relaxed configuration, in which no force is applied by said flexible supporting elements onto said body or part thereof.

55. The method according to claim 52, additionally comprising a step of characterizing said maneuvering by parameters selected from a predetermined set of allowed movements.
56. The method according to claim 52, additionally comprising a step of selecting said body part from a group consisting of head, neck and any combination thereof.
57. The method according to claim 52, additionally comprising a step of selecting at least one flexible element from a group consisting of a spring-like element, a balloon-like element, and any combination thereof.
58. The method according to claim 52, additionally comprising a step of providing seven flexible supporting elements, each of which is adapted to support at least one cervical vertebra.
59. The method according to claim 53, additionally comprising a step of providing said support function $F(\alpha)$ differing between at least two of said flexible supporting elements.
60. The method according to claim 53, additionally comprising a step of providing said support function $F(\alpha)$ substantially identical for all of said flexible supporting elements.
61. The method according to claim 52, additionally comprising a step of connecting together at least two of said flexible supporting elements.
62. The method according to claim 52, additionally comprising a step of adjusting the curvature of said flexible supporting element.
63. The apparatus according to claim 52, additionally comprising a step of providing said adjustment of said flexible supporting element via a screw mechanism.
64. The apparatus according to claim 52, additionally comprising a step of adjusting the angle of said flexible supporting element with respect to the horizontal.
65. The apparatus according to claim 52, additionally comprising a step of adjusting the distance between at least two of said flexible supporting elements, so as to adjust to different lengths of said part of the body.

66. The apparatus according to claim 52, additionally comprising a step of adjusting said distance between said at least two said flexible supporting elements via a screw mechanism.
67. The method according to claim 57, additionally comprising a step of transitioning said balloon-like element between at least one inflated state and at least one deflated state.
68. The method according to claim 67, additionally comprising a step of selecting the means of said inflation from a group consisting of a hand pump, a mechanical pump, compressed gas, and any combination thereof.
69. The method according to claim 52, additionally comprising a step of providing said apparatus additionally comprising at least one arm adapted to be positioned adjacent to at least some portion of at least one side of said body part.
70. The method according to claim 52, additionally comprising a step of locking at least one said at least one arm in position.
71. The method according to claim 70, additionally comprising a step of adjusting the distance between at least two of said arms.
72. The method according to claim 69, additionally comprising a step of selecting the means of adjustment of the distance between at least two said arms from a group consisting of a slide mechanism, a screw mechanism, an inflatable balloon-like mechanism, a ball joint, and any combination thereof.
73. The method according to claim 69, additionally comprising a step of selecting said sensor from a group consisting of a position sensor, a pressure sensor, an accelerometer, a motion sensor, and any combination thereof.
74. The method according to claim 69, additionally comprising a step of selecting said sensor from a group consisting of a gyroscope, an inclinometer, an accelerometer, an ultrasound sensor, a camera-based detector and any combination thereof.
75. The method according to claim 69, additionally comprising a step of adapting said sensor such that a user can determine therefrom parameters of said at least one arm selected from a group consisting of: the arm is in an open position, the arm is in a closed position, the arm is locked in position, the distance between at

least two arms, the height of the arm, the angle of the arm with respect to the horizontal, and any combination thereof.

76. The method according to claim 69, additionally comprising a step of providing at least one detecting means; wherein said detecting means is feedback interconnected with said arm.
77. The method according to claim 69, additionally comprising a step of altering at least one of said adjustable parameters based on output of said detecting means.
78. The apparatus according to claim 77, comprising at least two arms.
79. The apparatus according to claim 78, wherein the movement of said arms is synchronized.
80. The method according to claim 52, additionally comprising a step of providing at least one maneuverable platform interconnected with at least one of said cradle and at least one of said at least one arm, said maneuverable platform comprising maneuvering means adapted to maneuver said platform in a predetermined pattern for a predetermined duration in at least one plane chosen from a group consisting of the sagittal plane, the coronal plane, and the horizontal plane.
81. The method according to claim 80, additionally comprising a step of characterizing said maneuvering by parameters selected from allowed movements, said duration of said motion is in the range of 0 to about 10 minutes.
82. The method according to claim 80, additionally comprising a step of selecting said allowed movements from a group consisting of: Sagittal flexion in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to about $(70^{\circ}, 0^{\circ}, 0^{\circ})$; Sagittal return in a range from about $(70^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Coronal tilt right in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 45^{\circ}, 0^{\circ})$; Coronal return right in a range from about $(0^{\circ}, 45^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Coronal tilt left in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, -45^{\circ}, 0^{\circ})$; Coronal return left in a range from about $(0^{\circ}, -45^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Horizontal rotation right in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to $(0^{\circ}, 0^{\circ}, 60^{\circ})$; Horizontal return right in a range from about $(0^{\circ}, 0^{\circ}, 60^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$; Horizontal rotation left in a range from about $(0^{\circ}, 0^{\circ}, 0^{\circ})$ to, $(0^{\circ}, 0^{\circ}, -60^{\circ})$; and Horizontal return left in a range from about $(0^{\circ}, 0^{\circ}, -60^{\circ})$ to $(0^{\circ}, 0^{\circ}, 0^{\circ})$.

83. The method according to claim 80, additionally comprising a step of selecting for said predetermined pattern a lobular three dimensional pattern.
84. The method according to claim 80, additionally comprising a step of characterizing said predetermined pattern by adjustable parameters.
85. The method according to claim 84, additionally comprising a step of providing at least one detecting means; wherein said detecting means is feedback interconnected with said maneuverable platform.
86. The method according to claim 85, additionally comprising a step of using output of said detecting means to alter at least one of said adjustable parameters.
87. The method according to claim 85, additionally comprising a step of providing said detecting means comprising a sensor.
88. The method according to claim 87, additionally comprising a step of selecting said sensor from a group consisting of a position sensor, a pressure sensor, an accelerometer, a motion sensor, and any combination thereof.
89. The method according to claim 52, additionally comprising a step of selecting said sensor from a group consisting of a gyroscope, an inclinometer, an accelerometer, an ultrasound sensor, a camera-based detector and any combination thereof.
90. The method according to claim 89, additionally comprising a step of integrating said sensor into at least one of said cradle and said at least one arm and said sensor is adapted to track movement of at least one of said cradle and said at least one arm for the purpose of regulation of said movement.
91. The method according to claim 52, additionally comprising a step of at least one of measuring and reporting at least one parameter related to at least one of a group consisting of the medical, physiological, and emotional condition of said patient.
92. The method according to claim 52, additionally comprising a step of limiting by a predetermined amount at least one motion of said cradle by means chosen from a group consisting of mechanical means, software means, and hardware means.

93. The method according to claim 92, additionally comprising a step of selecting said motions from said allowed movements.
94. The method according to claim 52, additionally comprising a step of providing said cradle with pressure sensors to measure at least one of the pressure and force said body part is applying in any direction on the interior of said cradle.
95. The method according to claim 94, additionally comprising a step of using said measurements of at least one of the pressure and force for passive-assisted treatment, where said patient is instructed to follow actively said maneuvering of said cradle.
96. The device of claim 80, additionally comprising a step of instructing said patient, using bio-feedback instrument, to follow actively said maneuvering of said cradle.
97. The method according to claim 80, additionally comprising a step of selecting said maneuvers according to parameters characterizing said patient, said parameters selected from a group consisting of physiological movements in the sagittal plane, physiological movements in the coronal plane, physiological movements in the horizontal plane and any combination thereof.
98. The method according to claim 52, additionally comprising a step of providing a treatment selected from a group consisting of (a) improvement of neck muscle function; (b) treatment for at least one sleep disorder; (c) increasing neck muscle bulk; (d) improving ROM; and (e) rehabilitating movement of at least one affected body part following an injury.
99. The method according to claim 52, additionally comprising a step of providing said apparatus with a sensor unit (180) adapted to establish the position of said body part.
100. The method according to claim 99, additionally comprising a step of holding said sensor unit (180) to said body part by a restraining means.
101. The method according to claim 99, additionally comprising a step of selecting said restraining means to be at least one strap.
102. The method according to claim 99, additionally comprising a step of adjusting said at least one strap and locking said at least one strap in position by means of

a member of a group consisting of: elasticity in said strap, a ratchet, a pull strap locked by a friction buckle, a pull strap locked by means of a buckle with a tang, a spring-like member, and any combination thereof.

- 103.** The method according to claim 52, additionally comprising a step of adapting said method to treat at least one condition selected from a group consisting of migraine, tension type headaches, post traumatic headaches, cervicogenic headaches, myofascial headaches, neck pain, post whiplash injury, muscle over-contraction, over-tension of the neck muscles, neck movement disorders, sleep disorders, cervical disc herniation, and cervical disc protrusion.

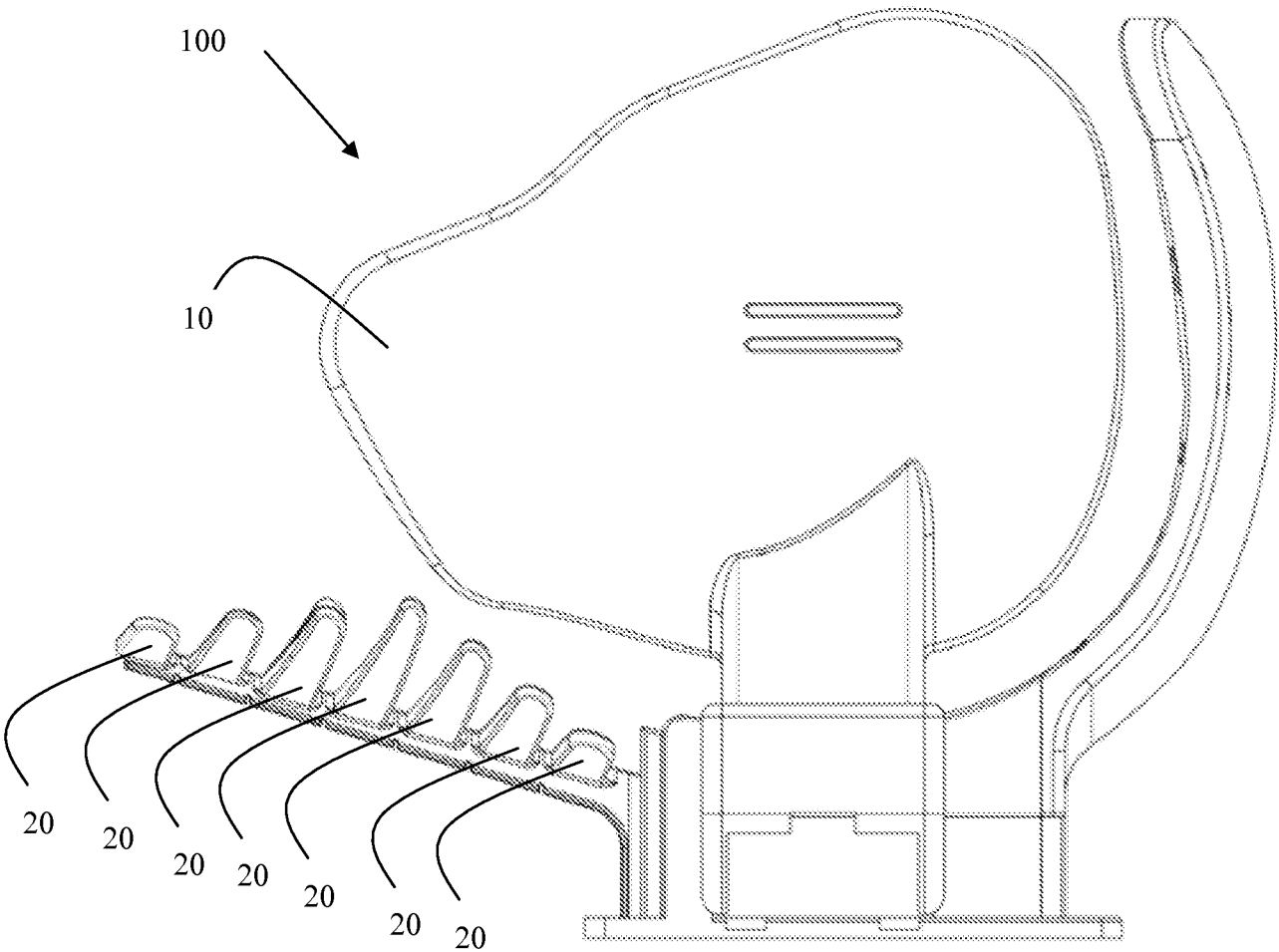


Fig. 1

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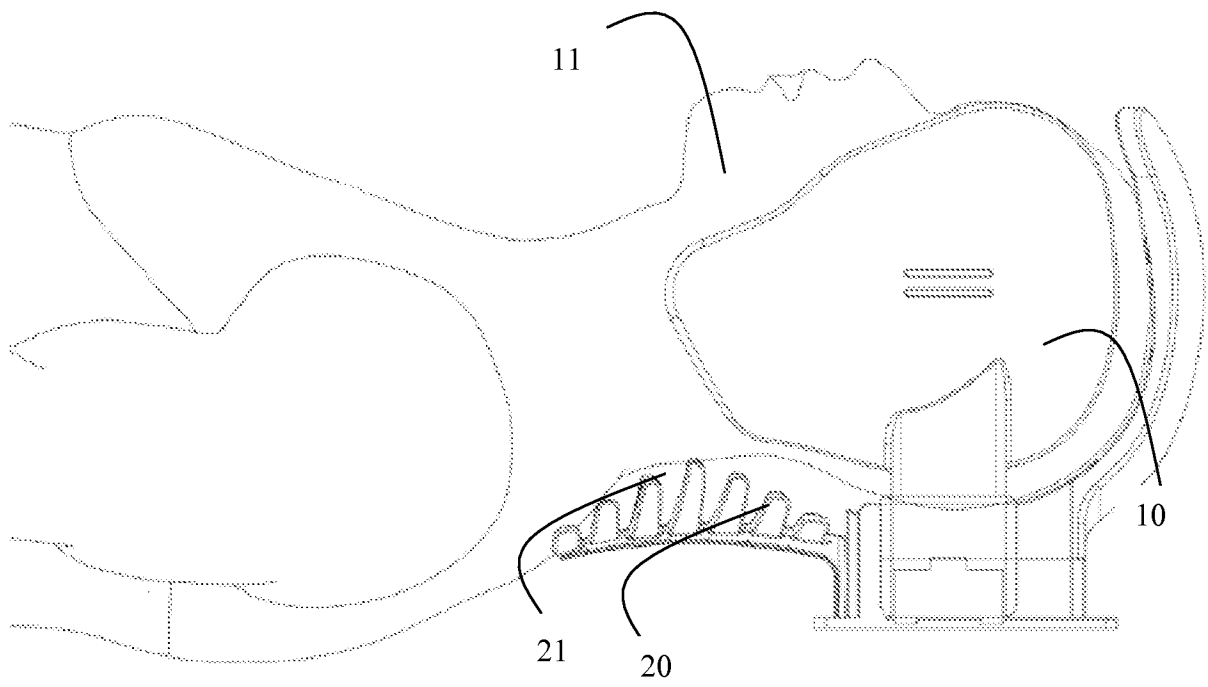


Fig. 2a

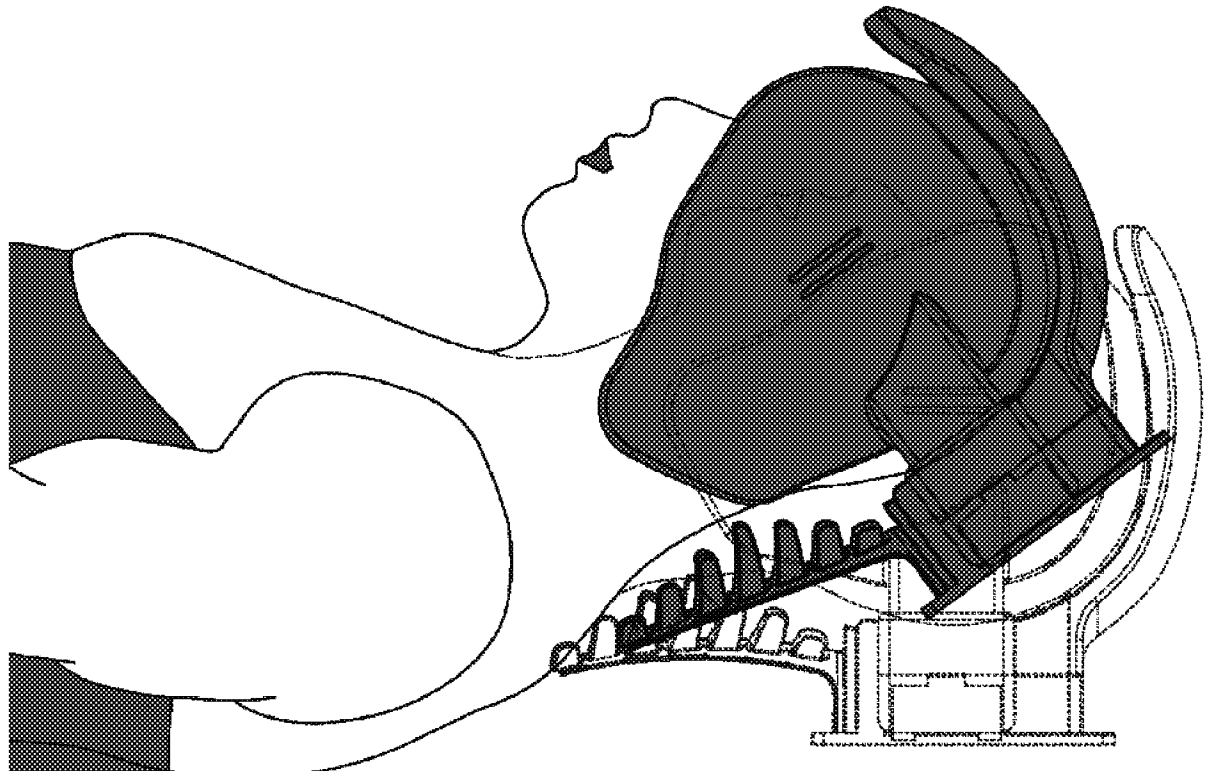


Fig. 2b

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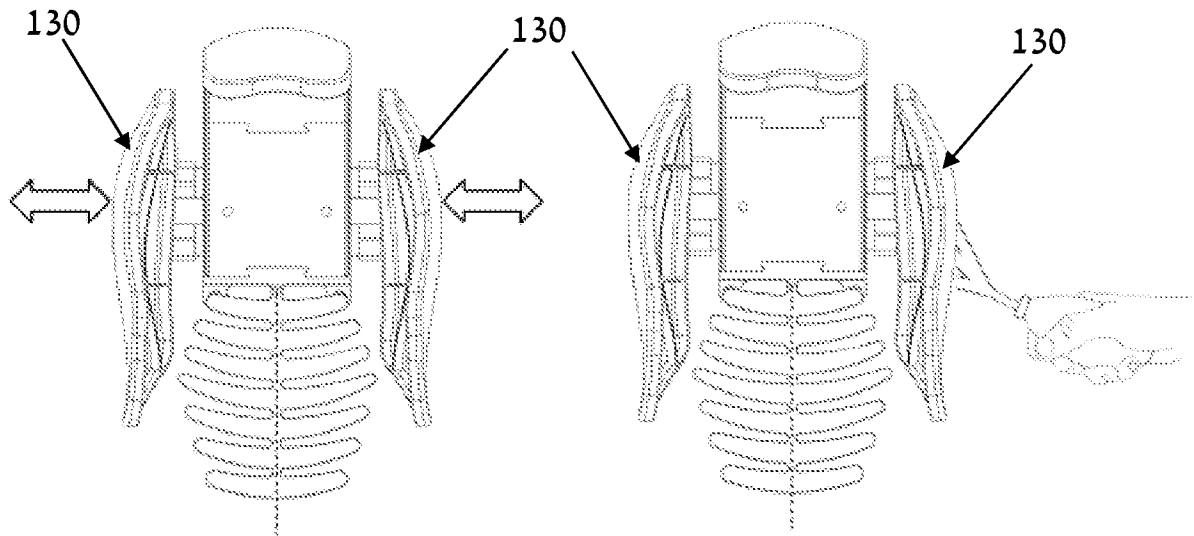


Fig. 3a

Fig. 3b

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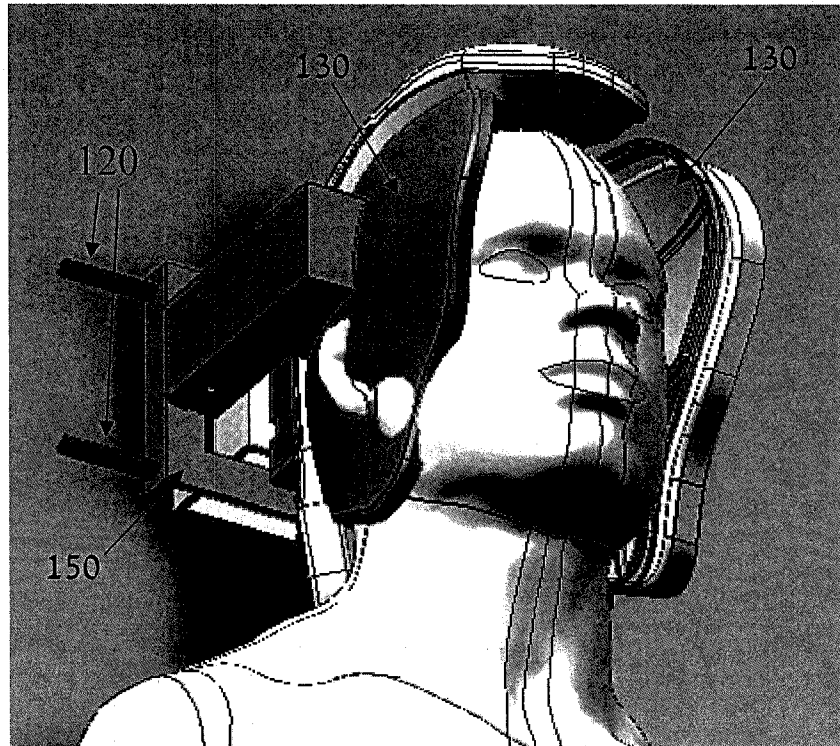


Fig. 4

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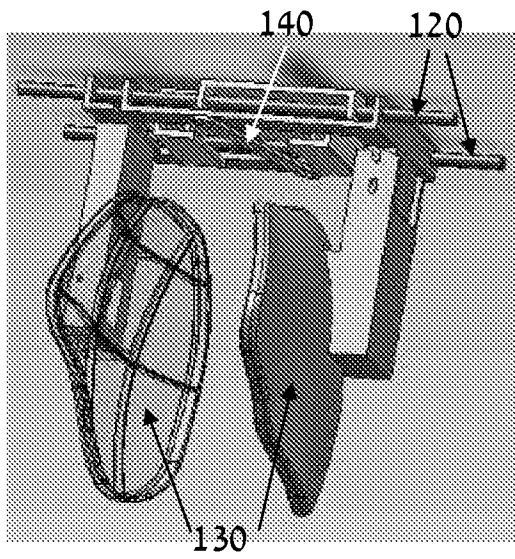


Fig. 5a

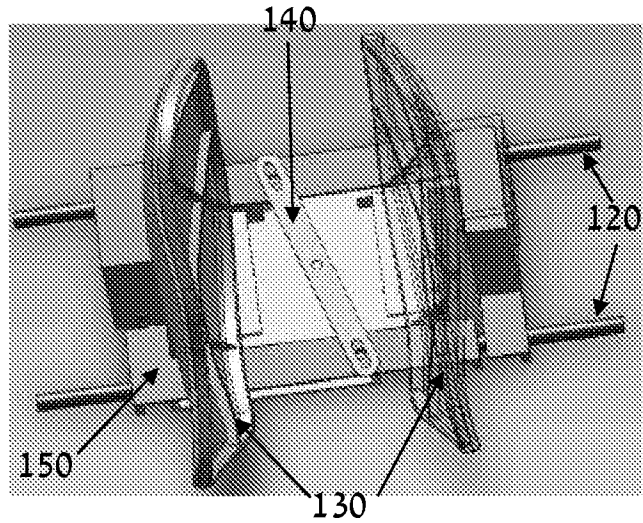


Fig. 5b

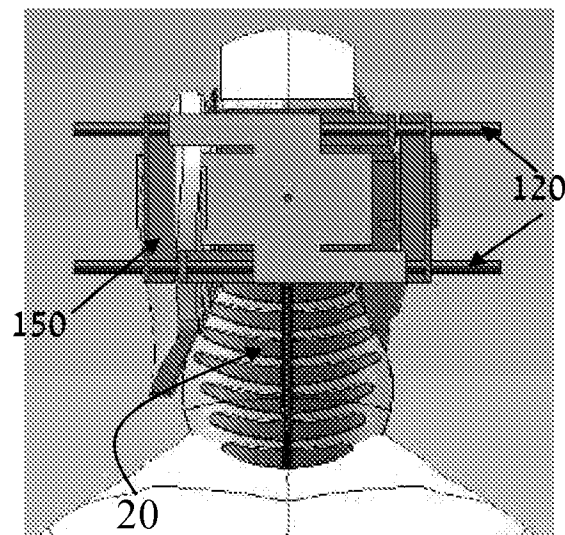
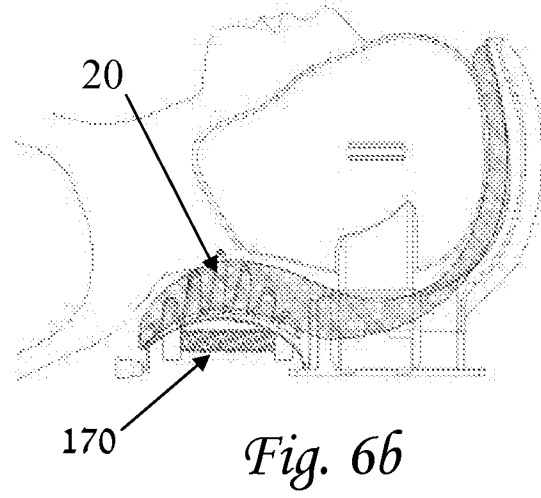
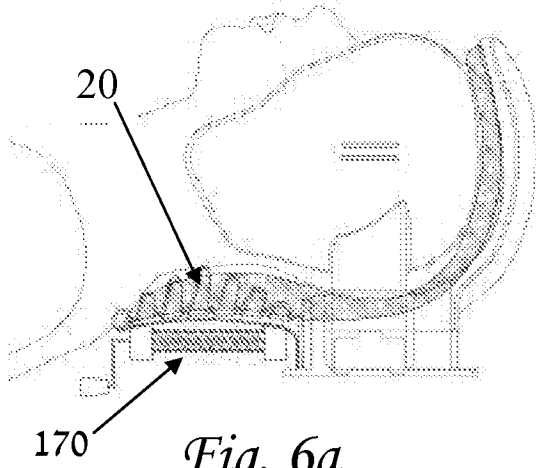
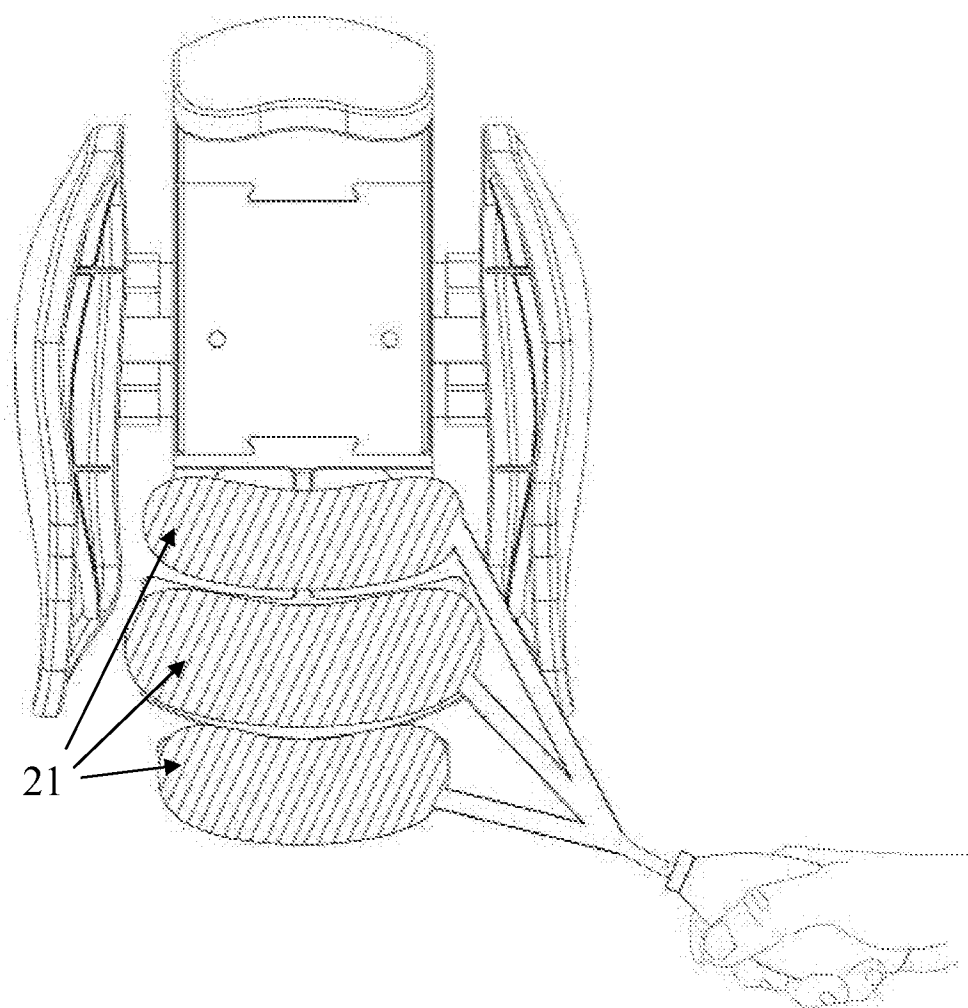


Fig. 5c

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*Fig. 7*

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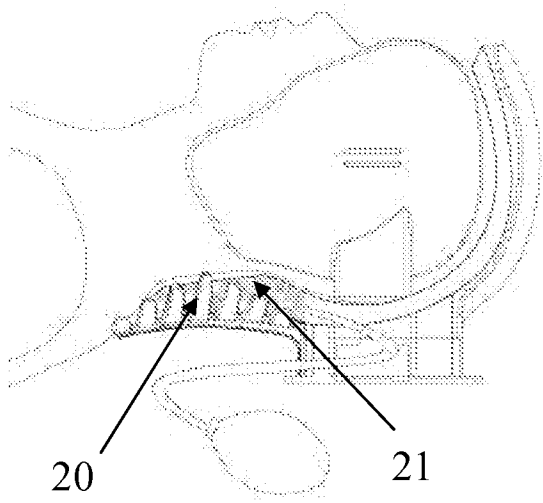


Fig. 8a

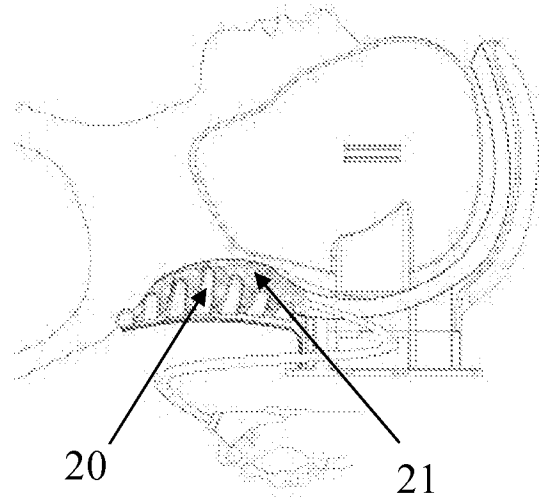


Fig. 8b

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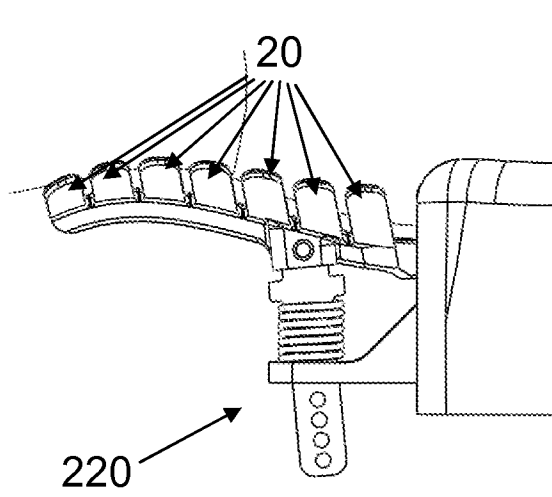


Fig. 9a

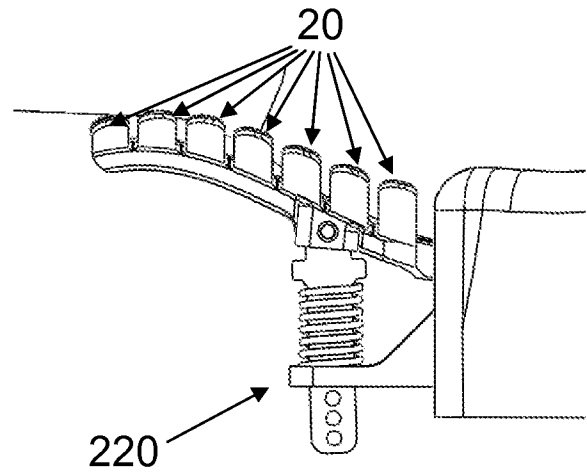


Fig. 9b

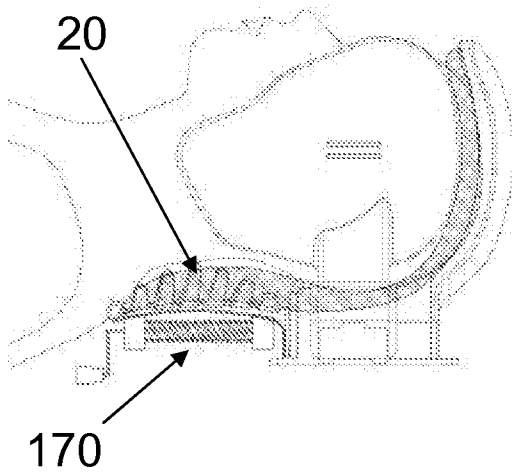


Fig. 10a

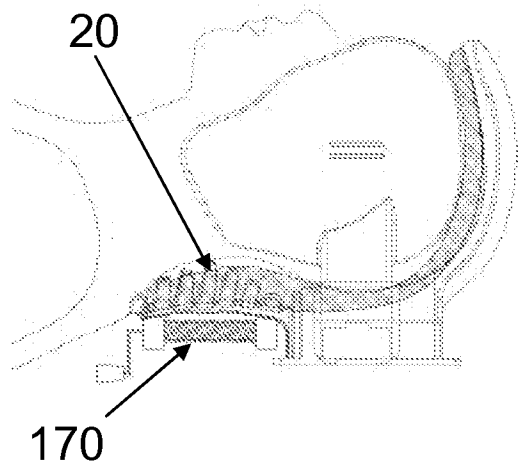


Fig. 10b

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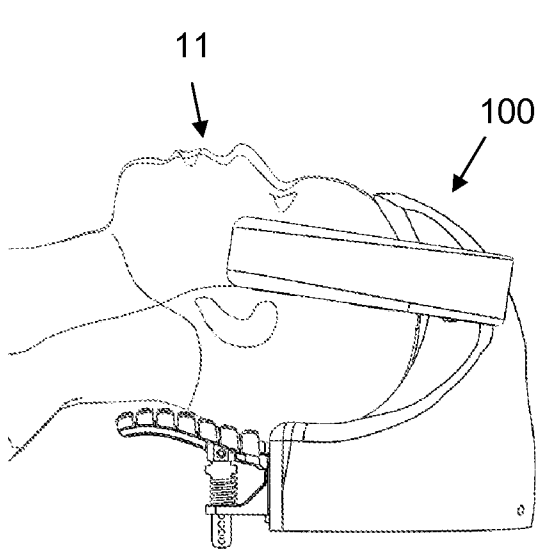


Fig. 11a

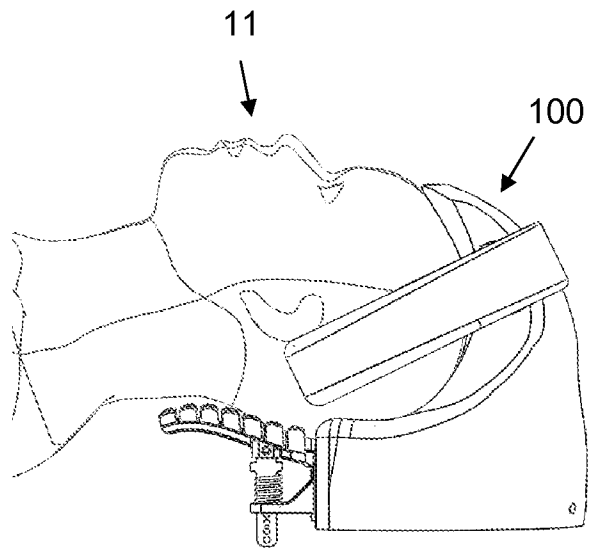


Fig. 11b

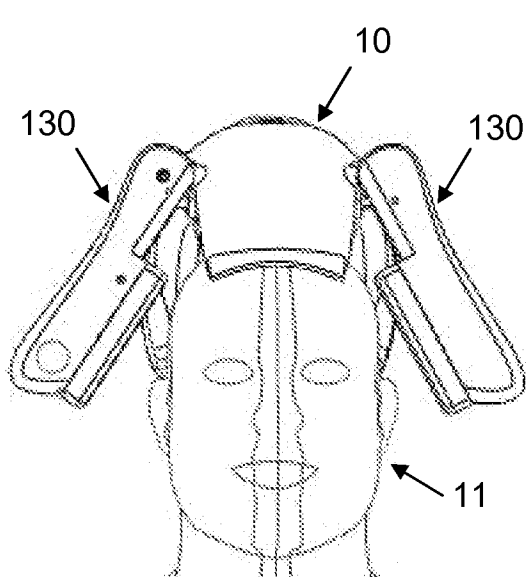


Fig. 11c

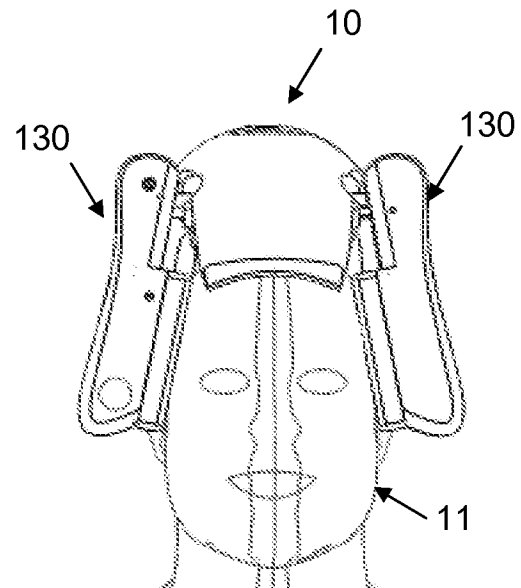


Fig. 11d

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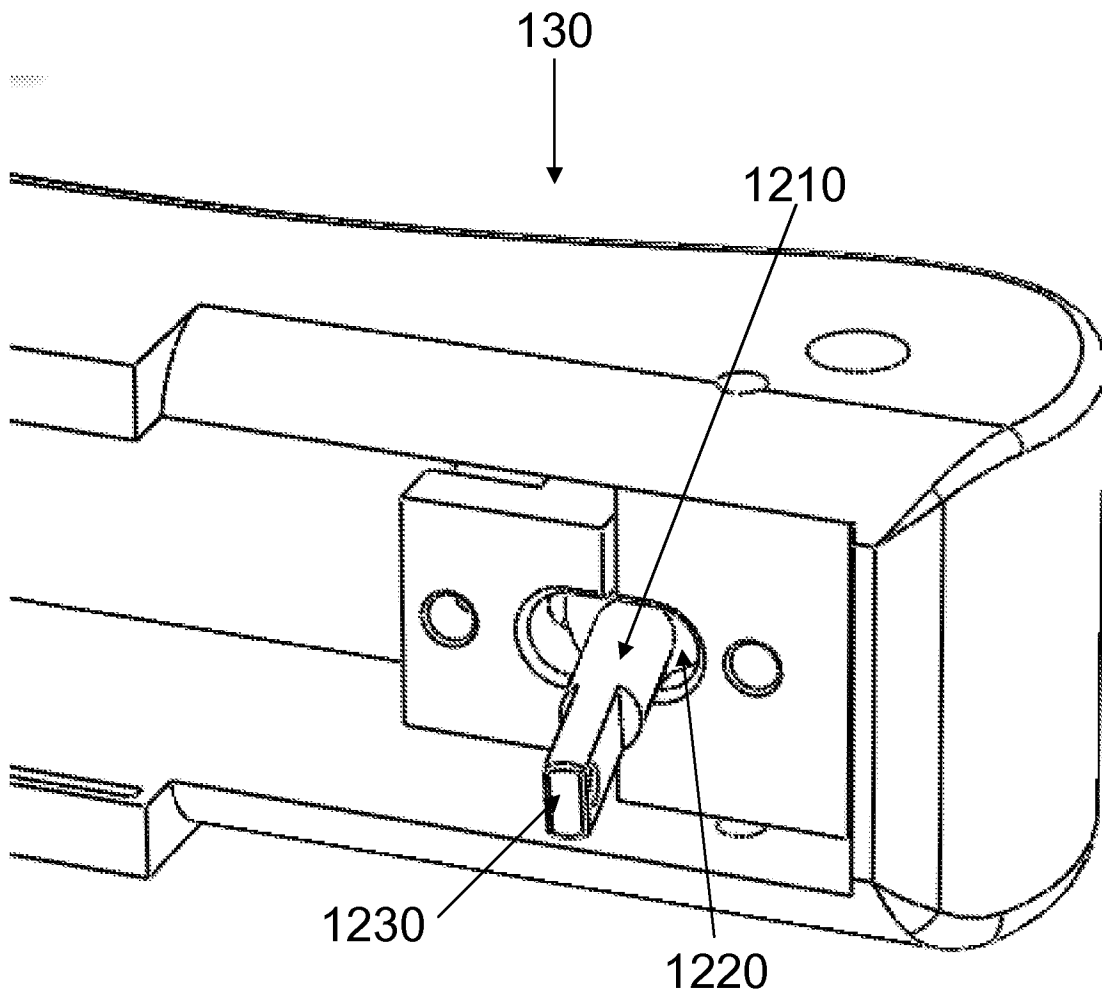


Fig. 12

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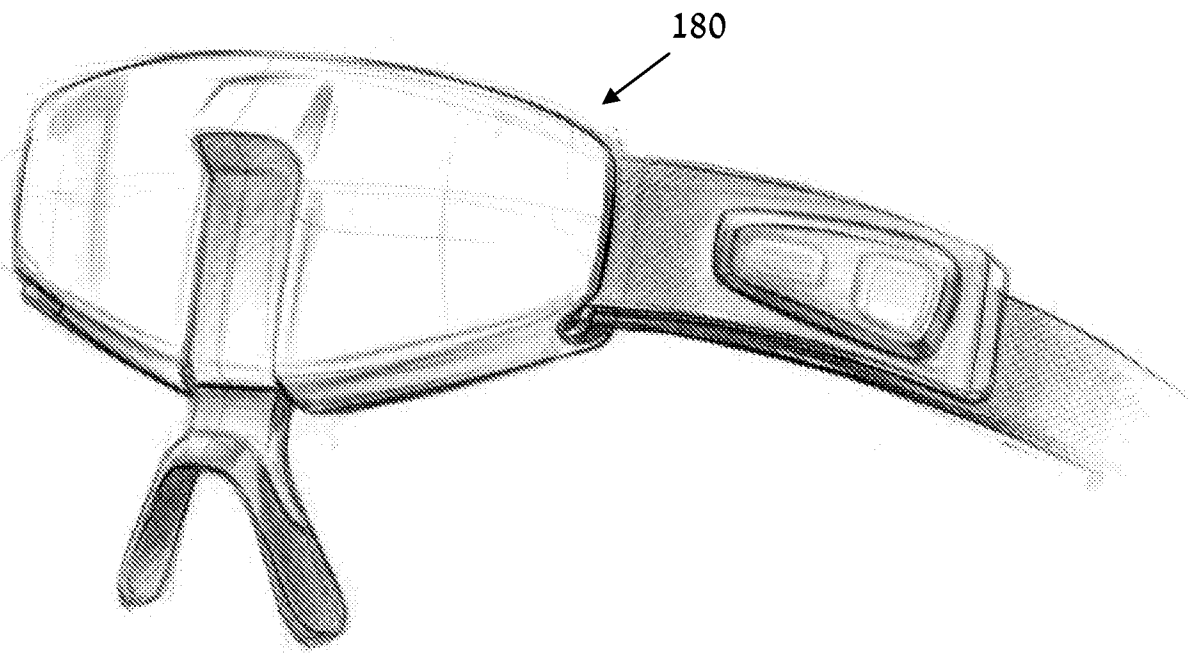


Fig. 13a

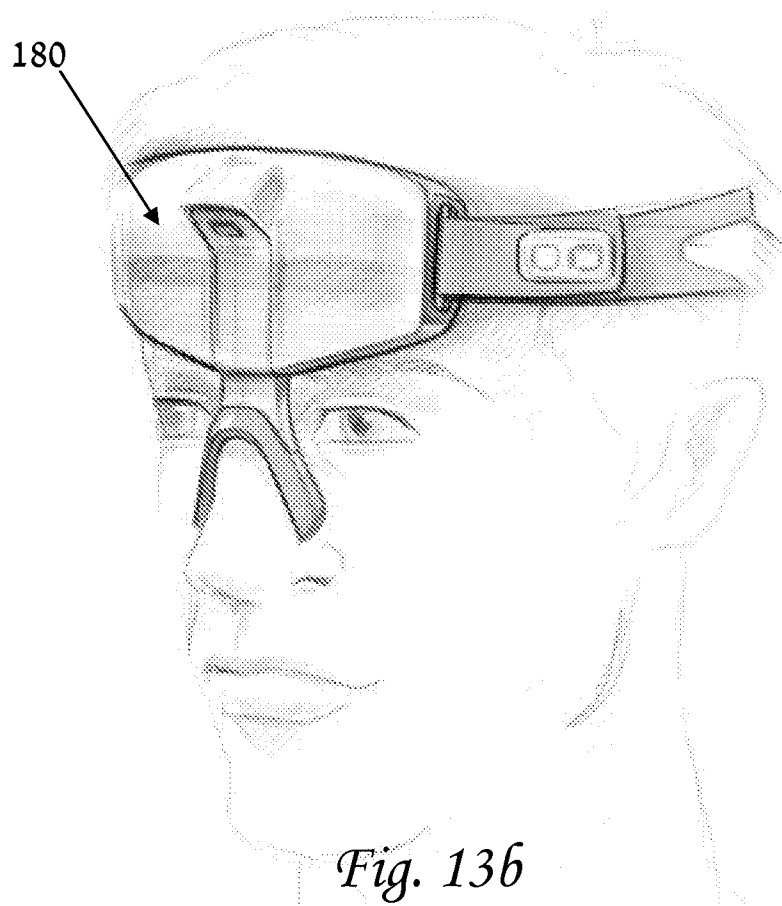


Fig. 13b

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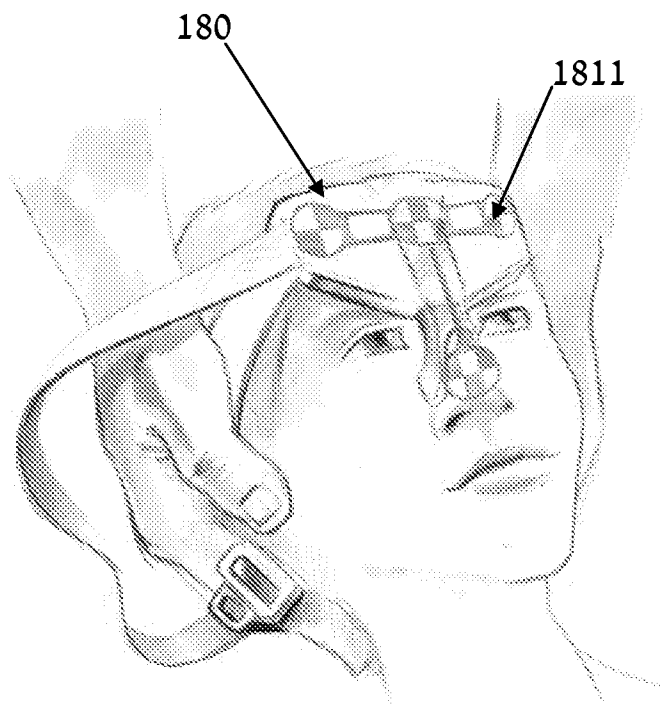


Fig. 13c

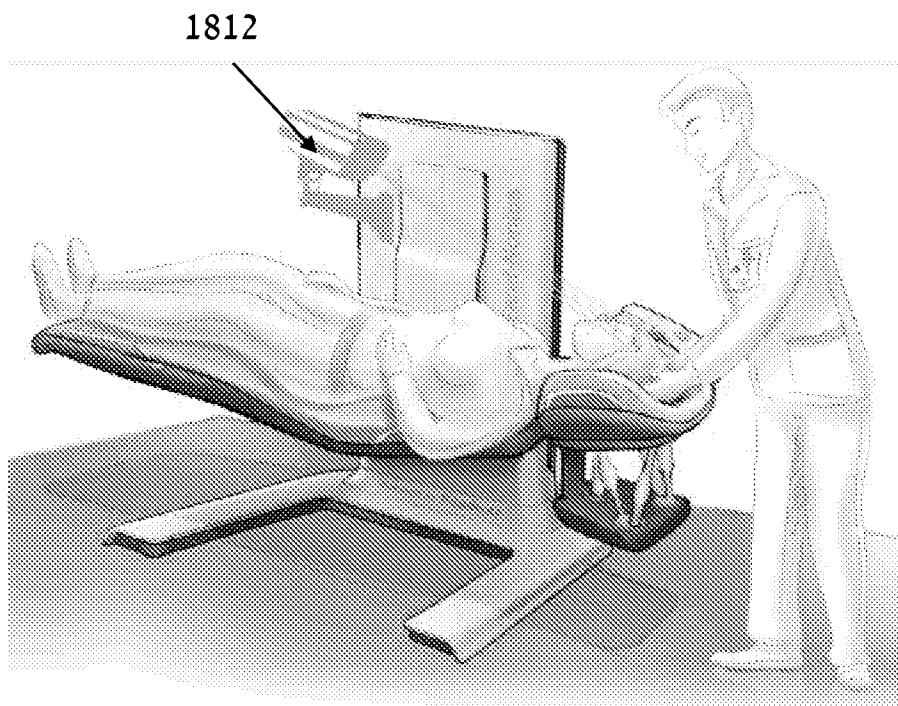


Fig. 13d

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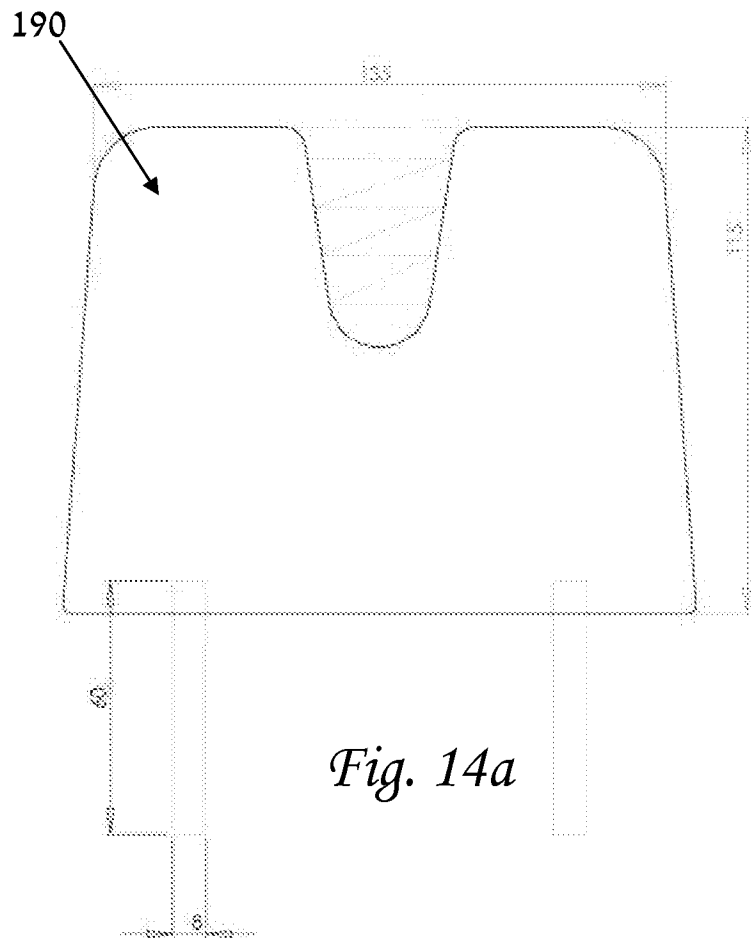


Fig. 14b

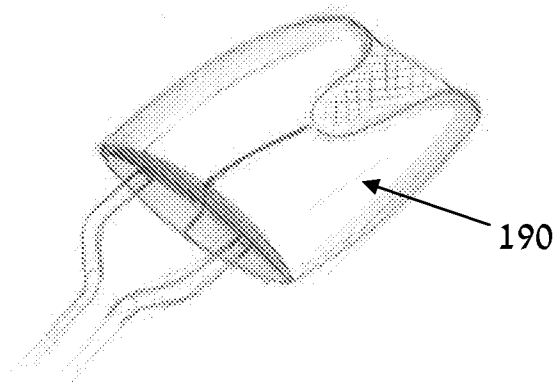
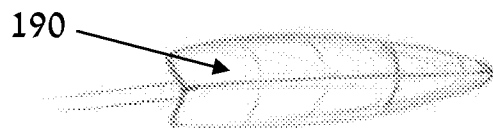
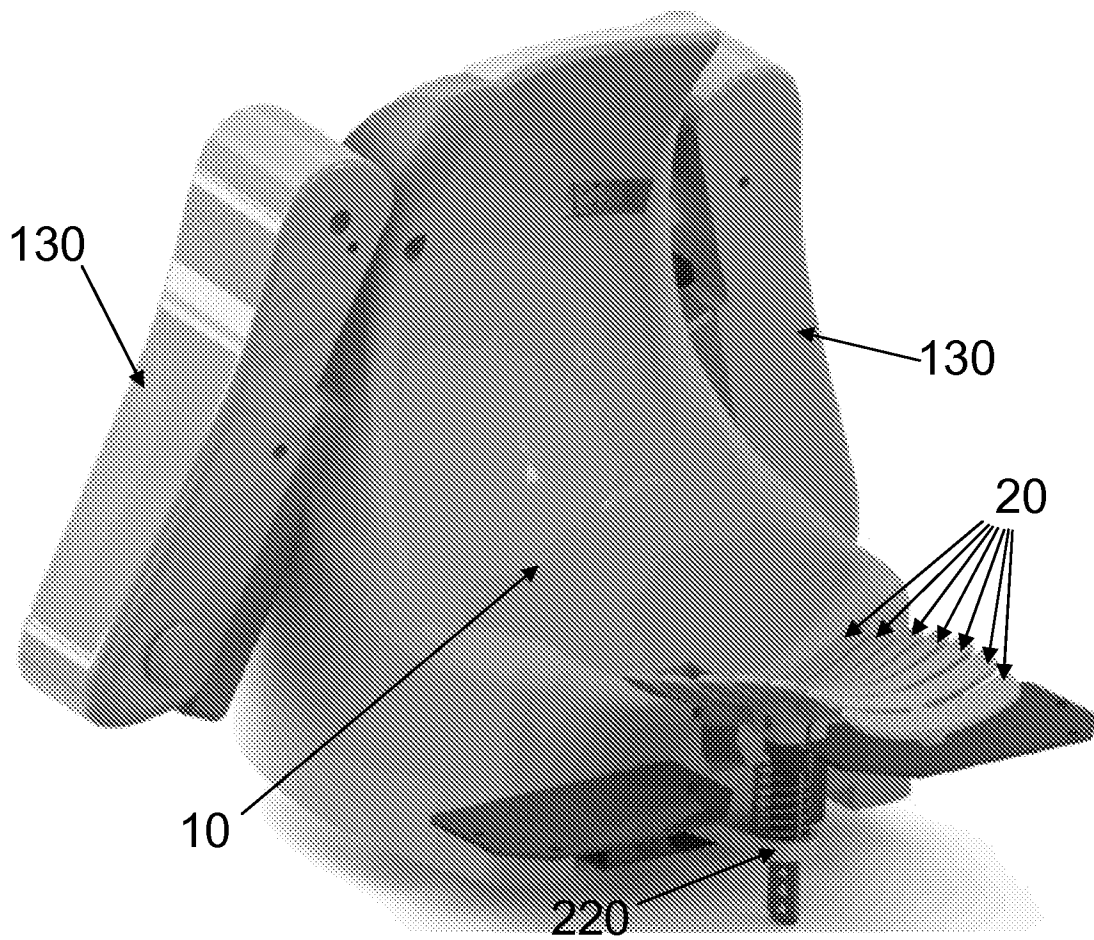


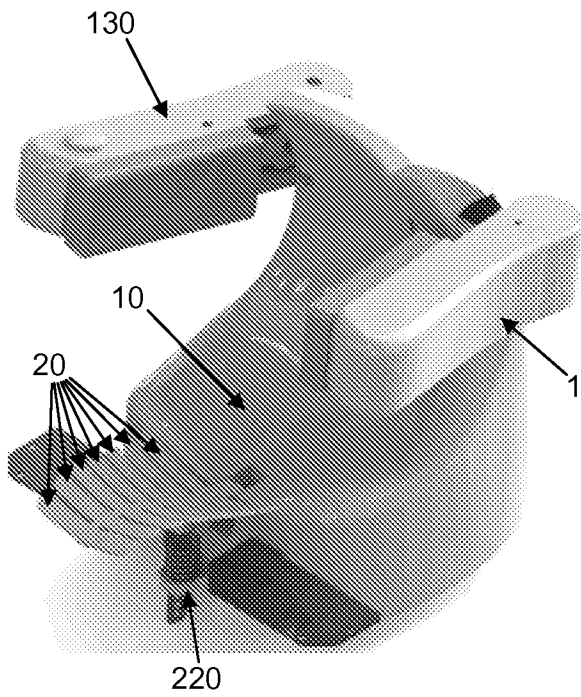
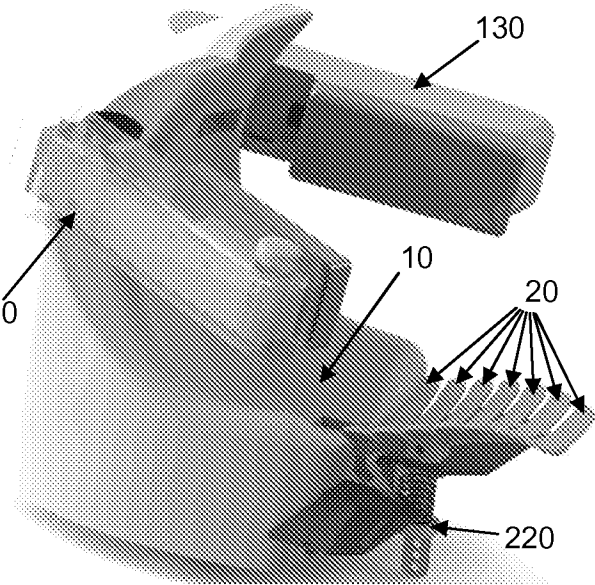
Fig. 14c



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*Fig. 15a*

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*Fig. 15b**Fig. 15c*

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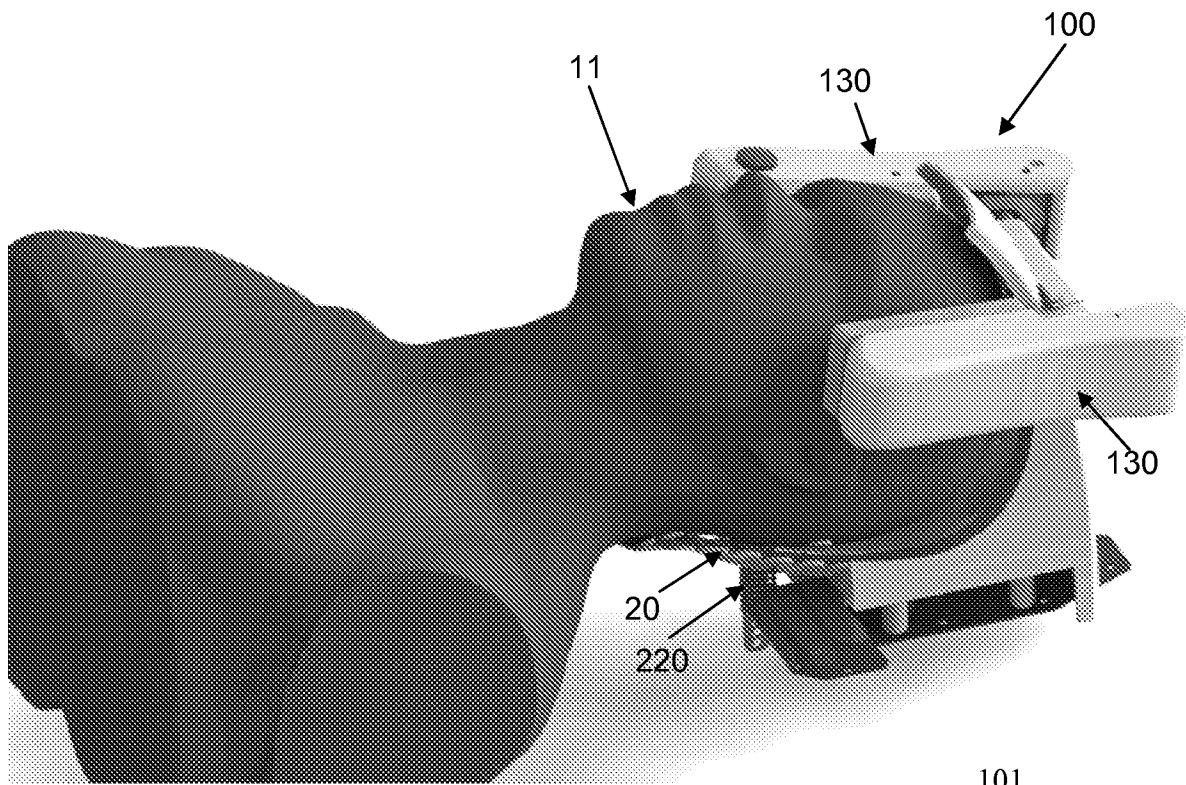


Fig. 15d

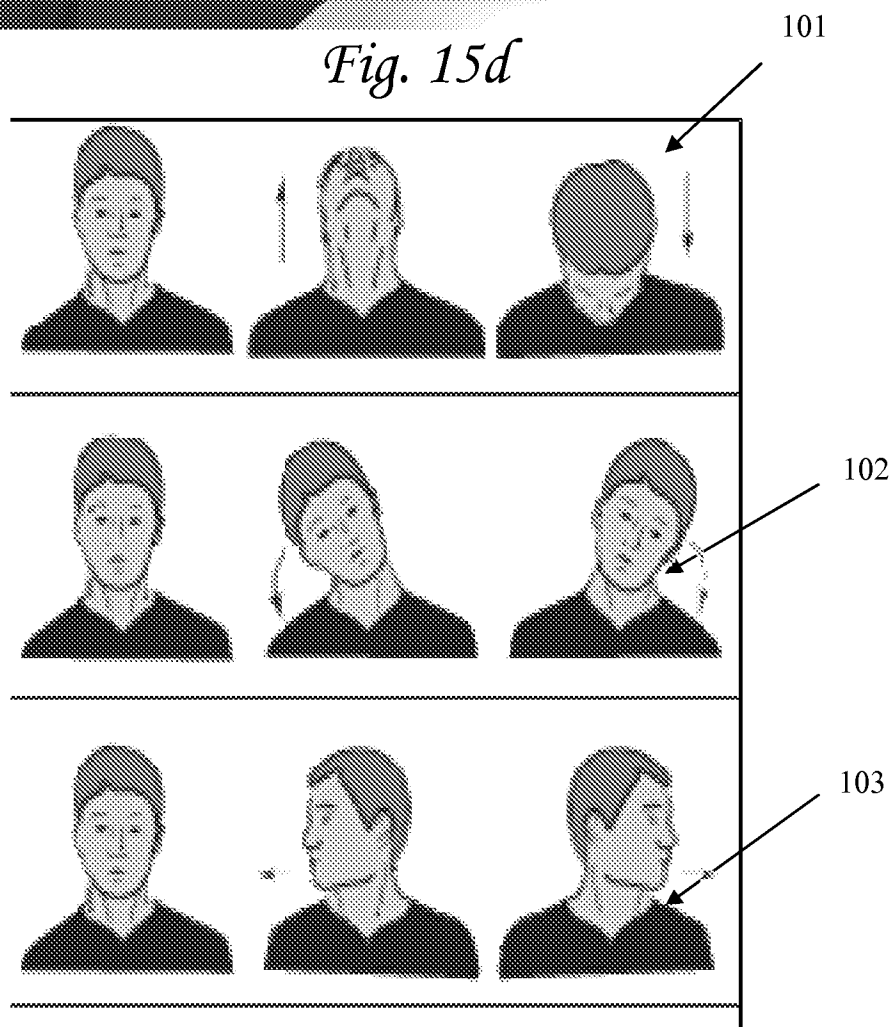


Fig. 16

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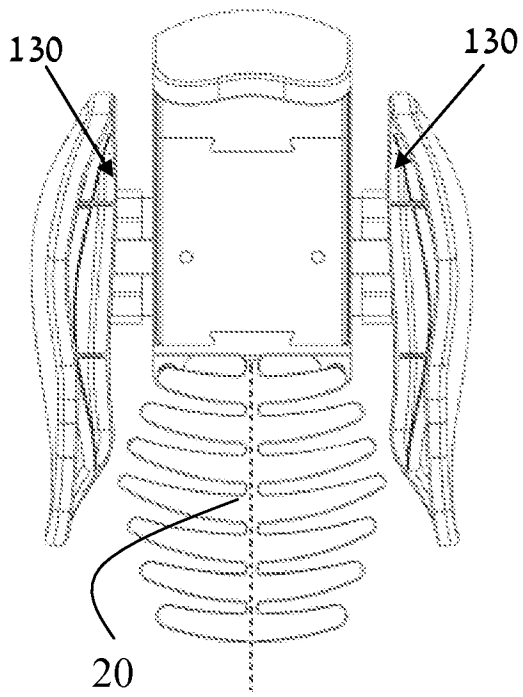


Fig. 17a

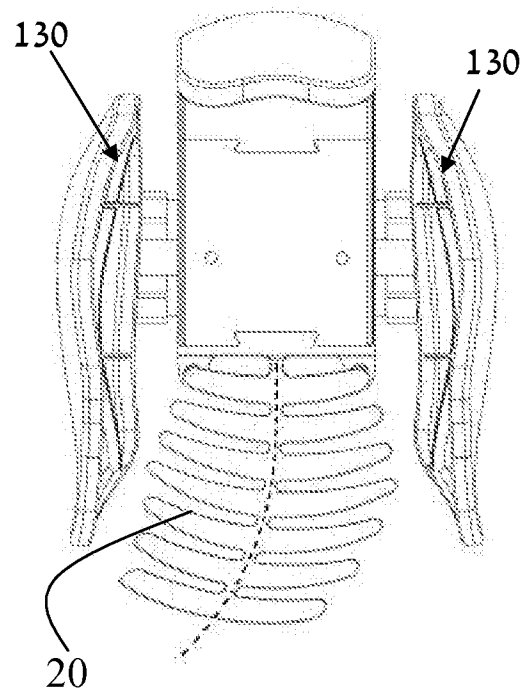
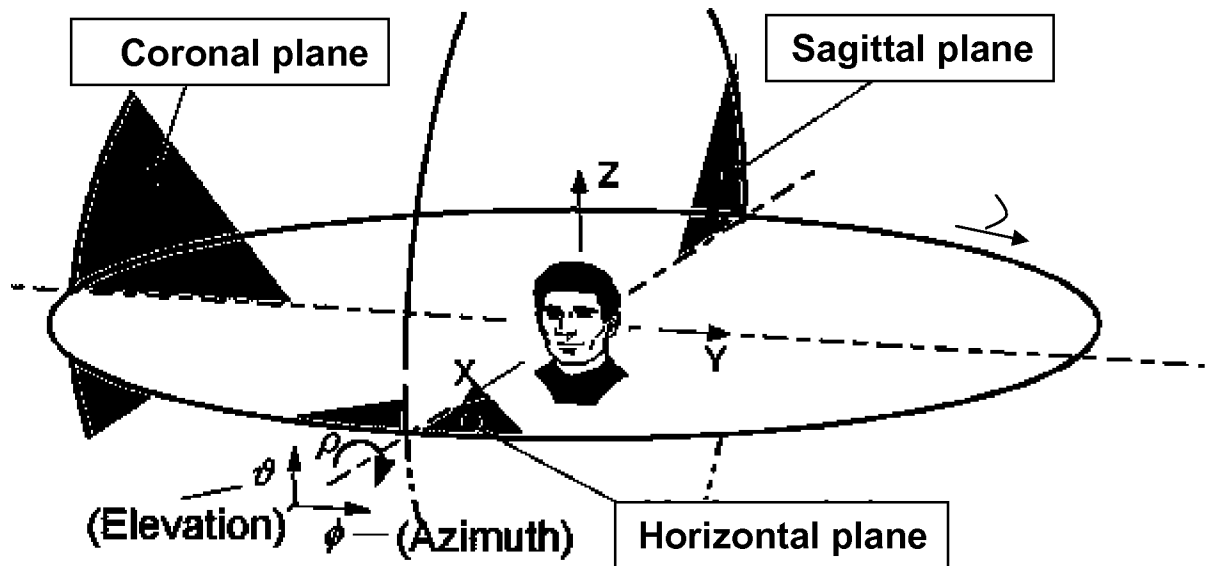
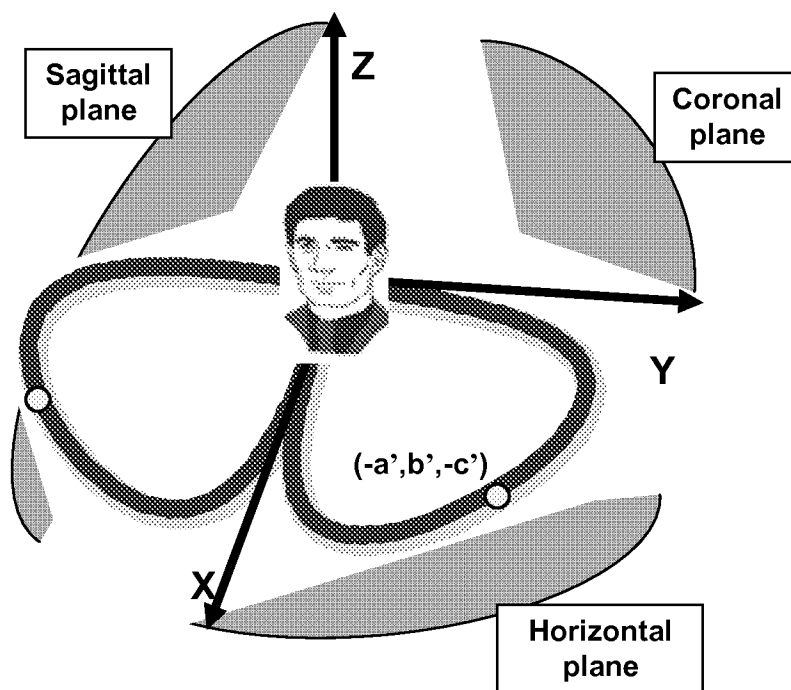
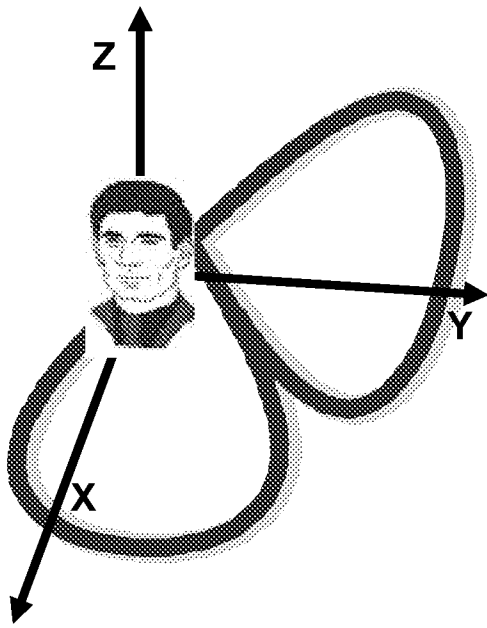
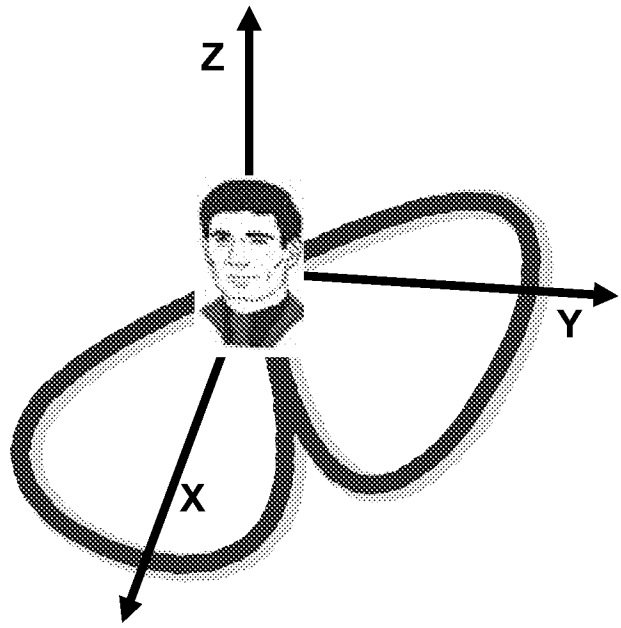
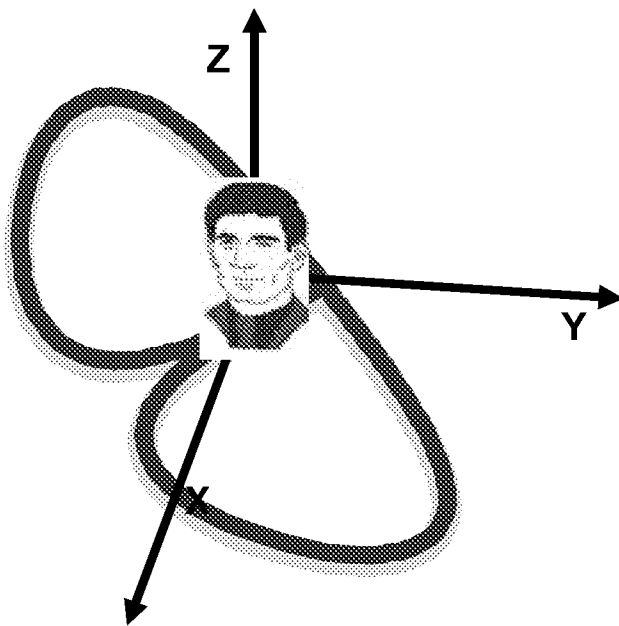
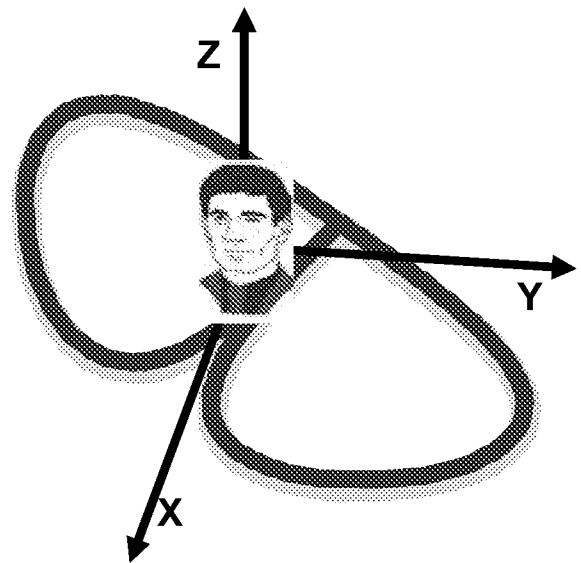


Fig. 17b

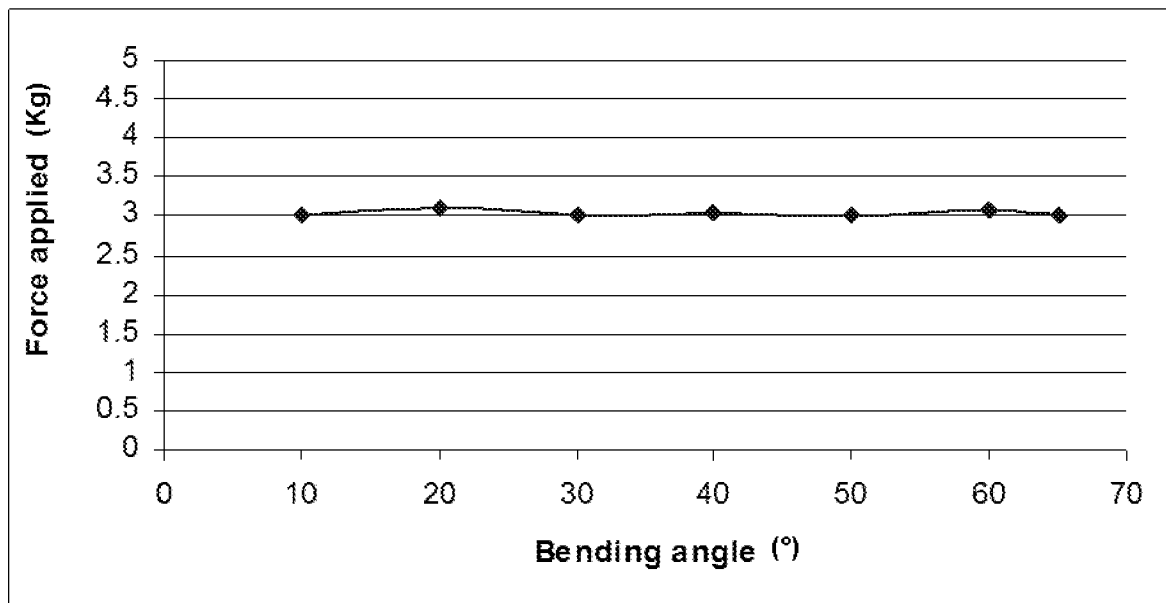
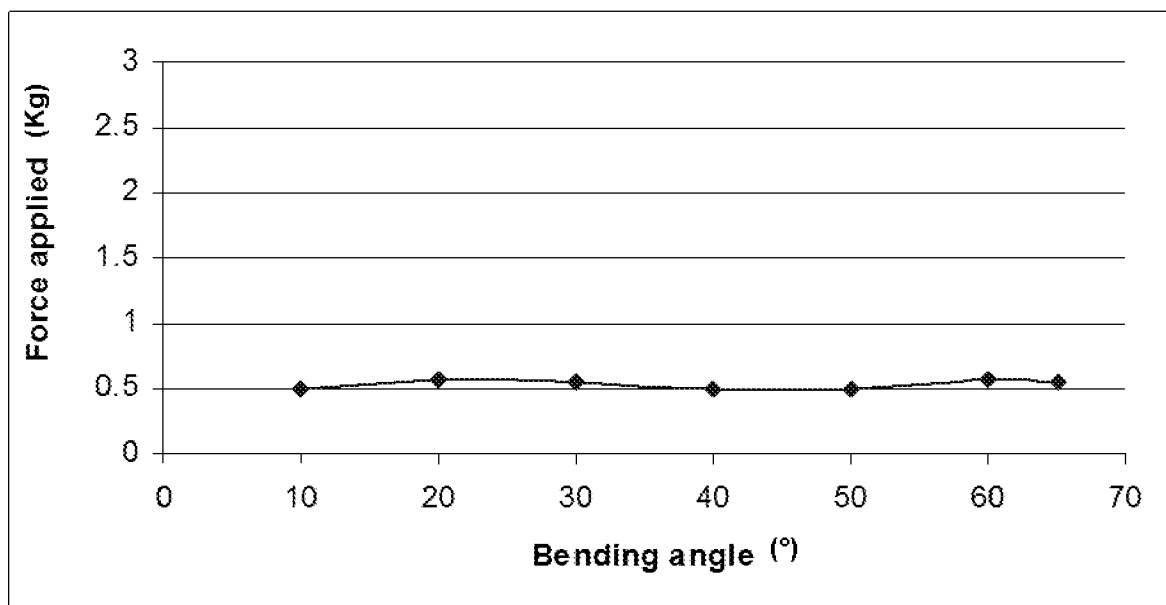
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*Fig. 18a**Fig. 18b*

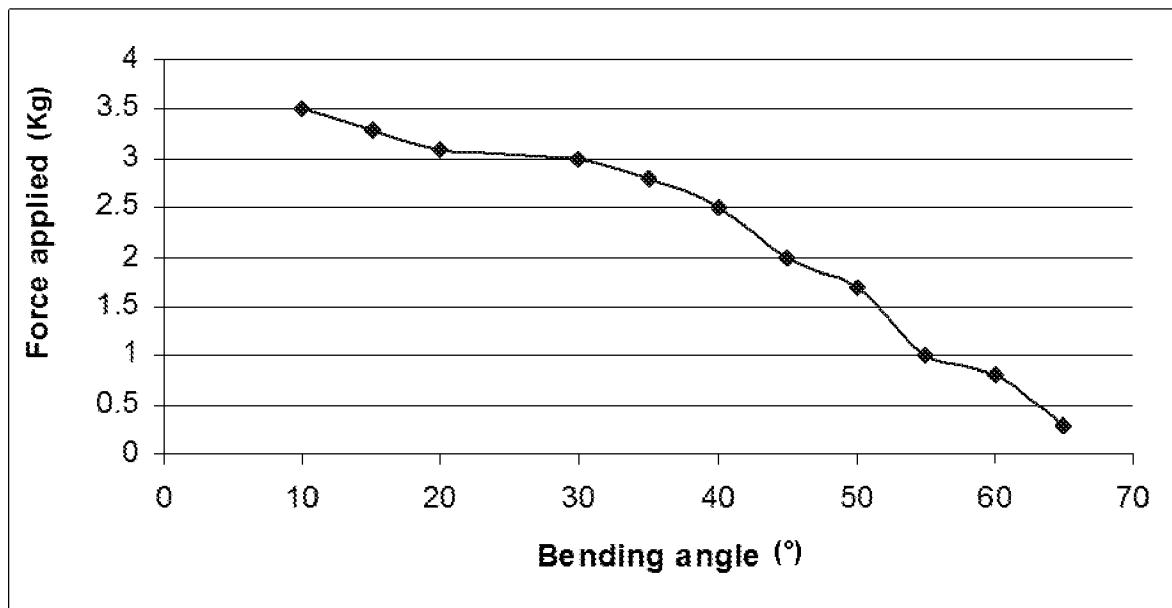
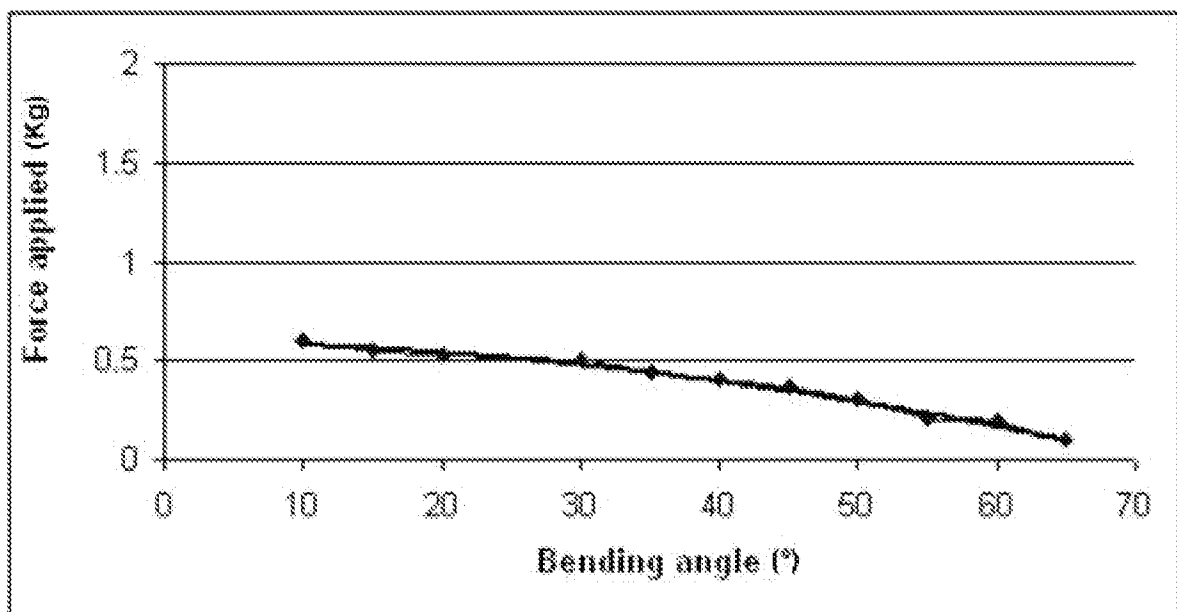
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*Fig. 18c**Fig. 18d**Fig. 18e**Fig. 18f*

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*Fig. 19a**Fig. 19b*

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*Fig. 19c**Fig. 19d*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL2013/050264

A. CLASSIFICATION OF SUBJECT MATTER

IPC (2013.01) A61H 1/02

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)

IPC (2013.01) A61H 1/00

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

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

Databases consulted: THOMSON INNOVATION, FamPat database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/0049228 A1 (LOPE L. P.) 11 Mar 2004 (2004/03/11) paragraphs [0001], [0007], [0021]-[0024], [0027]-[0030], [0033]; figures 1-3, 5-9	1,3,4,6,10-14,17-20, 25-28,45-52,54-56,58, 61-66,69-72,78,79,96-103
Y		21-24,29-44,73-75, 80-95,99
X	US 5713841 A (GRAHAM A. R.) 03 Feb 1998 (1998/02/03) Abstract, column 4, lines 15-30, 60-66; column 5, lines 12-30, 45-50; figures 1-4	1,3-5,9,13,15,16,52, 54-56,61,65,67,68
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Y	WO 2011/101846 A1 (LEVITAL T. ET AL.) 25 Aug 2011 (2011/08/25) page 2, line 30-page 3, line 9; page 11, line 9-page 12, line 22; page 15, lines 7-21	29-37,80-88

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

☒ See patent family annex.

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Date of the actual completion of the international search

10 Jul 2013

Date of mailing of the international search report

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Name and mailing address of the ISA:

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Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel

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Authorized officer

SEGAL Liviu

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL2013/050264

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2008/059497 A2 (RIVER Y. M. ET AL.) 22 May 2008 (2008/05/22) the whole document	1-103

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/IL2013/050264

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