(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
01 March 2018 (01.03.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/037337 A1

(51) International Patent Classification:
A61C 7/08 (2006.01) *A61C 19/045* (2006.01)
A61C 7/36 (2006.01) *A61C 19/05* (2006.01)

(21) International Application Number:
PCT/IB2017/055056

(22) International Filing Date:
22 August 2017 (22.08.2017)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
102016000086724 23 August 2016 (23.08.2016) IT

(72) Inventor; and
(71) Applicant: IZZI, Gian Domenico [IT/IT]; Via Pescasseroli, 29, 66100 Chieti (IT).

(74) Agent: MAIELLO, Helenio Francesco; Corso G. Garibaldi 142, 84123 Salerno (IT).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: DEVICE AND METHOD FOR COMPUTER-AIDED REALIZING AN ODONTOIATRIC CONSTRUCTION BITE

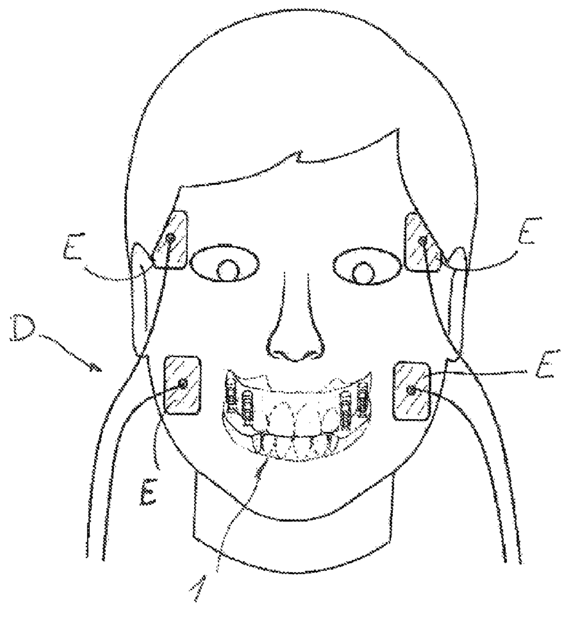

FIG. 1

(57) Abstract: A device for computer-aided realization of a dental construction bite comprises an upper supporting structure (2) and a lower supporting structure (3) adapted to be respectively associated to the upper dental arch (As) and to the lower dental arch (Ai) of a patient to define a pair of reference planes, operating means (4) associated to at least one of the supporting structures (2, 3) to vary the relative position of the reference planes and identify respective occlusal planes, electronic control means adapted to be operatively associated with means for detection (D) of physical parameters of the patient adapted to detect the variation of the parameters as a function of the relative positions of the reference planes, wherein the electric control means are adapted to store the relative positions between the reference planes and to associate to each of them the respective set of detected parameters.

WO 2018/037337 A1

DEVICE AND METHOD FOR COMPUTER-AIDED REALIZING AN ODONTOIATRIC CONSTRUCTION BITE

Description

Technical Field

The present invention finds its application into the field of dental devices and relates to a device and method for the computer-aided realization of an odontoiatric construction bite.

State of the art

As known, the construction bite is a tool designed for use in dentistry in mandibular repositioning operations necessary to correct conditions of incorrect occlusion of the teeth that may oblige the mandible to assume a non-comfortable position for facial and neck muscles and for temporomandibular articulation.

Specifically, the construction bite is designed to be interposed between the upper and lower dental arch so as to record their mutual position following the mandibular repositioning.

Mandibular repositioning is intended to correct the spatial relationship between the upper arch and the lower arch, associating it with a balanced bilateral neuromuscular activity of the chewing muscle and to a non-pathological dynamic function of the temporomandibular articulation.

It has been proven and widely demonstrated in scientific literature by numerous studies how the spatial relationship between the dental arches, and hence the occlusion, are closely related to the posture.

For example, "*Cuccia A., Caradonna C. 2009. The Relationship Between the Stomatognathic System and Body Posture*" shows that variations in the mandibular position induce variations in the postural structure of the person.

Again, in sport activities an incorrect occlusion may affect the athlete's postural attitude, compromising performance and increasing the risk of injury.

As matter of fact, a minimal variation in balance can turn into variations in intensity of strength and coordination skills, as well as causing a state of muscular tension that negatively affects the entire body, decreasing its overall athletic potential.

In such cases, the application of an intraoral device such as the bite, constructed through a valid construction bite, is ultimate.

The common construction techniques for the construction bites comprise the use of a thermosetting or thermoplastic material, such as a piece of wax, undergoing to heat softening and introduced into the mouth of the patient before manually positioning the mandible into a presumed therapeutic position.

In this way, the patient can bite the soft material to imprint the marking of dental arch thereon so that with the cooling of the material the reciprocal position of the arches is consolidated.

This position may be reproduced at any time by simply repositioning the construction bite on the teeth and making the patient to close the mouth in such a manner that the indentations coincide, forcing the jaw to assume that particular position.

A first drawback of this solution is that the effectiveness of the bite thus realized and the consequent position of the mandible can only be verified after the registration of the construction bite, through instrumental tests such as surface electromyography, posture-stabilometric or baro-podometric test or other instrumental exams that provide real-time results.

As matter of fact, instrumental tests generally provide a first step wherein the patient is asked to tighten the teeth without the wax interposed to tighten successively the teeth on the inserted construction bite, so as to assess whether the new position of the mandible after the repositioning gives an effective improvement of the electromyographic and/or posturo-stabilometric and/or baro-podometric parameters compared to the starting position of the patient in the absence of wax.

For this reason, it is often necessary to set more construction bites, usually at least three, corresponding to different positions of the jaw.

These positions are identified through various techniques, often of an empirical nature, and are always based on a manual displacement of the mandible, resulting in results that are not always correct and not repeatable.

The construction bite that is found to be more efficient is sent to the dental technician, which uses it to clog the dental plaster arch models and reproduce faithfully on the final device, which can be an orthodontic device, a prosthesis, a reconstruction or a bite, the same ratio between the arches that was detected with the bite considered to be improved by instrumental exams.

It thus appears evident that such solutions do not allow for predictable and achievable results through an operational protocol defined and validated by the scientific community in order to be effective in all patients.

In addition, it is not possible to identify a neuro-muscular balance position based solely on anatomical and clinical references that are strongly variable from patient to patient. Consequently, the bites so constructed represent only a solution close to the therapeutic one, but not the optimal one because to reach it would be highly unlikely.

A further drawback of these solutions is that the successful outcome of the therapy is strongly related to the operator's expertise as the technique still has a strong manual component, with the consequence that the high degree of craftsmanship of these techniques makes them unrepeatable.

Manual mandibular repositioning is guided solely by the hands of the operator with the consequent inevitable inaccuracies and the inability to control the slightest changes in the mandibular position which can lead to a non-negligible variation in the results of the instrumental tests.

Further errors may also be due to erroneous perceptions of distances, which may significantly affect the position that the operator will have to take on the jaw.

Another drawback is that these solutions allow for the detection of a limited number of interocclusal positions, generally not more than three, especially since such techniques take a long time for both recording and performing the subsequent instrumental tests adapted to evaluate their effectiveness.

In addition, the construction bites of thermoplastic material, then malleable at room temperature, may accidentally deform or break, even because of the reduced thickness.

Last but not least, instrumental tests cannot be carried out simultaneously with the registration of the bite, but only after the wax solidification, because the execution of such tests involves tightening the mandible on the construction bite, that must be solid in order to resist to a certain reaction and not to deform.

A further known technique for realizing a construction bite is the use of mandibular kinesiography associated with transcutaneous electrical neural stimulation (T.E.N.S.).

This technique, although valid only in certain clinical situations, is uncommon and low used, unlike the classic registration of the construction bite, due to a series of limitations. Specifically, this technique requires long operational times and has difficulty in its executing due to the complex mechanisms that require some operator experience.

Moreover, the devices required for this technique are particularly expensive.

Last but not least, this technique always suffers from inaccuracies linked to a negligible manual rate and from the possible alteration of the result due to anatomical variables that kinesiography does not take into account.

In addition, with this technique, only the rest position of the mandible, with the teeth that are not in contact, and the ideal trajectory that it needs to accomplish, are precisely identified, as they are determined by the patient's muscles that have been relaxed.

On the contrary, the complete lack of precision in determining the correct vertical dimension, fundamental for realizing a valid construction bite, results in low precision in determining the correct therapeutic position, since this technique, for the detection of the vertical dimension, is based only on average measures, unsuitable for all patients.

Therefore, all known techniques have in common that they performing first the mandibular repositioning and only after the instrumental analysis for verifying the obtained result, so resulting in little efficiency.

US2013/280672 discloses a tool for defining and measuring anatomical features of a patient for realizing dentures comprising all of the features of the preamble of claim 1, and in particular a lower structure and an upper structure that define reference planes and operating means for varying the relative position of such plans.

However, this tool does not allow these physical parameters to be determined by varying the relative orientation between these reference plans.

Scope of the invention

The object of the present invention is to overcome the above mentioned drawbacks by providing a device and method for the computer-aided manufacturing of a construction bite that is particularly effective and economical.

A particular object is to provide a device and method for the computer-aided manufacturing of a dental construction bite that allows to determine mandibular displacement in a mechanical and accurate manner, to obtain repeatable, predictable results, free from errors due to the greater or lesser ability of the operator.

Yet another object is to provide a device and method for the computer-aided realization of a dental construction bite which, in contrast to the known techniques, allow to realize the bite starting from instrumental analysis to carry out, consequently, an optimal mandibular repositioning in an extremely fast and automated manner until the achieving of the desired result.

Yet another object is to provide a device and a method for the computer-aided realization of a dental construction bite that are particularly quick and do not require the construction of more bites.

A further object is to provide a device and a method for the computer-aided construction of a dental construction bite not affected by inaccuracies due to small variations in the mandibular position during manual repositioning or due to error of perception of the operator.

Lastly, it is to provide a device and method for the computer-aided realization of a dental construction bite allowing the detection of a large number of interocclusal positions in order to detect the real therapeutic positioning of the mandible.

Such objects, as well as others that will become apparent hereinafter, are obtained by a computer-aided device for realizing a dental construction bite which, according to claim 1, comprises an upper supporting structure and a lower supporting structure to be associated respectively with the upper dental arch and lower dental arch of a patient to define a pair of reference planes, operating means associated with at least one of said supporting structures to vary the relative position of said reference planes and identify respective occlusal planes, electronic control means adapted to be operatively associated with means for detection of physical parameters of the patient adapted to detect the variation of said parameters in relation to the relative positions of said reference planes, said electronic control means being adapted to store the relative positions between said reference planes and to associate each of them with the respective set of detected parameters.

The device thus made will allow to perform a continuous repositioning of the mandible according to the results obtained in real time through the simultaneous instrumental analysis.

Specifically, the device will perform a series of displacements corresponding to respective occlusion conditions up to detect the therapeutic mandibular positioning.

The use of mechanical systems will also allow to stably lock the detected therapeutic position, avoiding any slight deviations therefrom at any subsequent stage and up to the manufacturing of the bite, which will be extremely precise and reliable.

The use of automated systems will make the whole operation repeatable and free from errors related to the greater or minor expertise of the operator.

Last but not least, it will not be necessary to manufacturing more test bites but a single bite will generally be sufficient which will correspond to the actual therapeutic position of the mandible for the specific patient.

According to a further aspect of the invention there is provided a method for the computer-aided realization of a dental construction bite according to claim 12.

Advantageous embodiments of the invention are obtained according to the dependent claims.

Brief disclosure of the drawings

Further features and advantages of the invention will become more apparent in the light of the detailed description of some preferred but non-limiting embodiments of the device and of the method according to the present invention, described and illustrated by way of non-limiting example with the aid of the attached drawings, wherein:

FIG. 1 is a schematic view of a device applied to a patient;

FIG. 2 is an exploded front of a device according to the invention;

FIG. 3 is a front view of the device according to the invention in a first working condition;

FIG. 4 is a front view of the device of Fig. 3 in a second working condition;

FIG. 5 is a side view of the device of Fig. 3;

FIG. 6 is a side view of the device of Fig. 4;

FIG. 7 is a side view of a detail of the device according to the invention in a first working condition;

FIG. 8 is a side view of the detail of Fig. 7 in a second working condition;

FIG. 9 is a front view of the device in a second embodiment and in a first working condition;

FIG. 10 is a front view of the device of Fig. 9 in a second working condition;

FIG. 11 is a side view of the device according to the invention wherein further details are visible;

FIG. 12 is a schematic view of the screen of the monitor of a computer during a step of the method in a first working condition;

FIG. 13 is a schematic view of the screen of Fig. 12 in a second working condition.

Best modes of carrying out the invention

Referring to the figures, some preferred but not exclusive embodiments of a device for the computer-aided realization of a dental construction bite are shown.

Fig. 1 schematically shows the device, indicated generically by **1**, inserted during operation within a patient's mouth and associated with detecting means **D** of the patient's physical parameters to detect the variation of the parameters according to the position taken instantaneously from the mandible and the consequent relative position between the dental arches.

More specifically, in such a configuration the detection means **D** comprise a plurality of electromyography electrode **E** of a known type and therefore not described in more detail below.

According to alternative configurations, not shown, the device **1** may be connected to different detection tools, such as known instruments for carrying out a baro-podometric examination or a posture-stabilometric examination.

As can be more clearly seen from **Fig. 2**, the device **1** comprises an upper supporting structure **2** and a lower supporting structure **3** which are associated respectively with the upper dental arch **As** and with the lower dental arch **Ai** of the patient to define a pair of reference plans.

In the illustrated configuration, the two supporting structures **2**, **3** are structurally similar to the common templates used in orthodontics as containment device according to the prior art and in particular are obtained by thermoforming starting from a thermoplastic or thermosetting material applied to the dental arches **As**, **Ai** to define respectively an upper mask **2** and a lower mask **3** having the negative shape respectively of the upper and lower dental arches **As**, **Ai**.

Preferably, the masks **2**, **3** will be hot molded and made on the plaster model of the upper **As** and lower dental arch **Ai** of the patient, so as to precisely follow the shape thereof and covering all the exposed surfaces of the teeth and partly also a portion of the surrounding gum, with an extension just enough to secure the additional elements of the device **1**.

However, according to not shown variants, the supporting structures **2**, **3** may also have a different shape and, for example, may be made of simple plates in a material of adequate strength or be completely absent.

Moreover, their extension may vary depending on the position of the teeth and the morphology of tissues of the single patient. Their thickness will preferably be within half a millimeter, so that they have the minimum interocclusal encumbrance.

The device **1** also comprises operating means **4** associated with at least one of the supporting structures, such as the upper structure **2**, to operate thereon or, in the absence of them, directly on the arches **As**, **Ai**, varying the relative position of the reference planes along at least three mutually orthogonal directions.

In this way, at each relative position of the reference planes, and hence of the dental arches **As**, **Ai**, it will be possible to identify a specific occlusal plane.

There are also electronic control means, not visible in the figure, which will be operatively associated with said detection means **D** of the physical parameters and will detect the variation of the physical parameters in function of the relative positions of the reference planes following the action produced from the operating means **4**, which, by varying the relative position of the dental arches **As**, **Ai** and hence of the mandible, will bring to a new condition of the musculature which will be detected by the control means according to their typology.

The control means will store the relative positions taken each time from the reference planes to associate the respective set of detected parameters to each of them, enabling the operator to accurately estimate the optimal position of the reference planes which corresponds to the actual therapeutic position of the mandible.

According to the preferred but not exclusive configuration of the figures, the operating means **4** comprise a plurality of linear driving elements **6** integral with one of the supporting structures, preferably the upper **2**, to move it with respect to the other supporting structure **3** along respective movement directions in both directions.

In this way, through the combined movement of the driving elements **6** along the respective directions, it will be possible to obtain a complex movement of the reference planes and thus a rototranslation displacement of the mandible in the space.

The driving elements **6** may be of mechanical, hydraulic, pneumatic, oleodynamic or similar type, without any particular limitations.

In the configuration of the figures four actuators **6** are provided, two on the left and two on the right of the patient's sagittal plane, in symmetrical positions relative thereto and located at the molars and canines, but their number and position may vary without particular theoretical limitations.

In this configuration, the driving elements **6** comprise a single-acting piston **7** sliding inside a cylinder **8** integral with the outer surface of the upper supporting structure **2**.

The piston **7** is associated with a spring **9** or other elastic element allowing it to return to the starting position.

The outer ends **10** of the pistons **7** will act on respective lateral guide slots **11** of the lower structure **3** to define a thrust surface for the linear driving elements **6** against which the latter may exercise their strength and cause the relative movements between the supporting structures **2**, **3** and the resulting vertical displacement of the mandible.

In the illustrated configuration, the lower structure **3** comprises two side guide planes **11** symmetrical with respect of the sagittal plane of the patient.

The two guide planes **11** are, in use, horizontal surfaces perpendicular to the outer surface of the lower supporting structure **3** and extend from the canine to the molars, both on the right and the left side.

The independent movement of the driving elements **6** will allow the inclination of the occlusal plane on two or more planes of the space, in an extremely precise and controlled manner.

Figs. 3 and **4** show two different positions of the reference planes corresponding to two different inclinations of the occlusal plane obtained by moving only the left driving element **6**.

Figs. 5 and **6** illustrate the same positions taken by the two arches **As**, **Ai** but from a side view.

As schematically illustrated in **Fig. 7**, the operating means **4** comprise, for each driving element **6**, a corresponding transmission element **12** adapted to be disposed, during use, outside the patient's oral cavity and operatively connected to motor means **13** to transfer its motion to the corresponding driving element **6** and produce the movement along its respective direction of movement **X**, in both directions.

In the illustrated configuration, the transmission elements **12** are electrically driven oleodynamic elements with linear motion but may be selected between traction mechanical elements, fluid-dynamic elements, compressed air, electric or equivalent means.

In the illustrated configuration, as can be seen from the comparison of **Figs. 7** and **8**, the transmission elements **12** are connected to a stepper motor **13** having a screw **14** for rotating clockwise or counterclockwise to move a slider **15** up or down, promoting the input of a fluid inside the cylinder **8** of the driving element 6 through a duct **16** and

obtaining the corresponding linear movement of the piston **7** which it is connected to.
By placing the slider **15** in the initial position, at least partial emptying of the cylinder **8** will be obtained and the piston **7** will be pushed toward the initial position by the elastic element **9** present in the cylinder **8**.
Figs. 9 and **10** illustrate the previously described device **1** wherein each driving element **6** is connected to a respective transmission element **12** which can be controlled independently of the others.
According to a further particularly advantageous aspect, there will be first sensor means, not visible from the figures, adapted to detect the pressure exerted by each of the driving elements **6** on the respective thrust surface **11**.
For example, the first sensor means will comprise for each driving elements **6** a pressure sensor for detecting the pressure inside the duct **16** or a sensor operatively associated with the transmission element **12**.
Since each mechanical driving element **6** positioned at the mouth is connected to the respective transmission element **12** located out of the mouth, it results that the pressure detected by each sensor will be directly proportional to that exerted in the oral cavity by the relative driving element **6** relative to the guide plane **11** of the lower supporting structure **3**.
The pressure detection will allow it to be checked uniformly on the arch points where the driving elements **6** are positioned.
Further, as can be seen from **Fig. 2**, supporting structures **2**, **3** will comprise second sensor means for geometrically detecting the position of the lower supporting structure **3** on the occlusal plane relative to a fixed reference system associated with the upper supporting structure **2**.
Preferably, the second sensor means will be of the Hall effect type and comprise at least one pair of position sensors **17** associated with the upper supporting structure **2** and at least one magnet **18**, for example of a permanent type, associated with the lower supporting structure **3**.
The second sensor means will allow to measure the distance between the position sensors **17** and the magnet **18** by exploiting the intensity of the magnetic field that the latter causes on the position sensors **17**, which will generate a voltage proportional to the distance.
The two position sensors **17** will be placed symmetrically on the outer surface of the upper

supporting structure **2**, for convenience at the premolars.

The magnet **18** will preferably be positioned on the outer surface of the lower structure **3** at the median line, as can be seen in **Fig. 11** or more clearly in **Fig. 2**.

The two sensors **17**, so arranged, form together with the magnet **18** a triangle having a movable vertex represented by the magnet **18** placed on the lower structure **3**, while the base of the triangle is fixed because it is represented by the line connecting the two sensors 17.

With this arrangement, wherein the base of the triangle will be constant while the two sides of the triangle will vary, it will be possible to compute geometrically the position of the mandible at the occlusal plane relative to a fixed reference system represented by the upper jaw, as will be described more clearly later on.

It will be understood that such second sensor means may be replaced by equivalent position detection means.

Suitably, the control means may comprise an electronic board or similar means provided with a microcontroller adapted to handle input and output signals through input/output ports.

The electronic card may also have a USB interface that allows communication with a computer.

Position sensors, pressure sensors, and electromyography sensors or other detection means **D** will be connected to the input ports of the electronic card that may process input information through appropriate software and generate outbound signals to control the motor means **13** through the output ports to which they are connected.

It is understood that the electronic board may be replaced by equivalent means for receiving signals collected from external sensors, processing such signals, and generating outbound signals.

Operatively, it will first be necessary to apply the detection means **D** of the physical parameters to the patient according to the specific instrumental analysis, which may be preferably an electromyography carried out by applying a plurality of electrodes **E** to the patient’s face or a baro-podometric exam or, still, a posture-stabilometric exam, carried out with known type equipment.

Subsequently, the upper **2** and lower supporting structures 3 will be applied to the upper dental arch **As** and to the patient’s lower dental arch **Ai** respectively to define a pair of reference planes.

Optionally, the two supporting structures **2**, **3** may be two thermoplastic templates made by known techniques.

Once the device **1** is inserted into the mouth of the patient, it will be required to swallow it to tighten the teeth, keeping them tight during the procedure.

At this point, the device **1** will be switched on and the linear mechanical driving elements **6** will be operated so that they will stop as soon as they come into contact with the guide plane **11** of the lower structure **3**. The contact will be detected by the pressure sensors described above.

At this point, the control means will read the input signals coming from the first sensor means and elaborate them by means of a special software that generates output commands for the motor means **13**.

The driving elements **6** will cause the relative movement of the reference planes and the consequent mandibular displacements by exerting a force on the respective lower guide planes **11**, which will thus be moved away in each of the contact points with the driving elements **6** independently of each other, so as to handle the mandible movement with wide range of action.

For example, operating only the two front driving elements will result in greater opening or greater distance between upper and lower front teeth, while operating two driving elements positioned on the same side will cause an opening on that side greater than on the other side.

The operation of driving elements **6** may be managed by the software through various preset modes that may selected at the execution of the procedure.

A first mode is the random one, wherein the driving elements **6** are operated so as to test different position combinations that are instantly recorded by the control means that will associate each relative position between the planes to a set of corresponding physical parameters.

At the end of the test, the software will automatically select the best situation by analyzing the numeric values found through instrumental exams and will indicate the coordinates of the position that gave such results.

The coordinates consist of the exact position of the piston **7** of each mechanical driving element **6** that may be indirectly find thorough the software that stores the steps, or the portion of a round, which make each motor **13** to run through the transmission element **12** that connect it to the mechanical driving element **6**.

This process can be initially conducted with a coarse degree of precision so as to speed up the examination, and then become more and more precise as it approaches the therapeutic position.

A second operating mode involves the specific movement of each driving element **6** in a direction until the instrumental analysis values continue to improve.

When the first worse value will occur, the driving element **6** will move in the opposite direction.

As soon as the best position is reached, there will be a very small movement of the driving elements **6**, quick and alternating forward and backward, close to the therapeutic position.

Finally, a third mode is the manual one, even if always assisted by the computer, wherein the single driving elements **6** are controlled by the operator through the computer by making them advance in one direction or the other, guided by the graphic visualization of the examination values, so that it is possible to know if you are approaching or not at the desired position.

As soon as the presumed therapeutic position is reached, identifying the optimal parameter set and detecting the relative position between the reference planes, the position search step will be interrupted to leave the linear driving elements **6** locked at that precise point, so fixing the inclination of the occlusal plane on the sagittal and front plane.

However, in this position, the mandible may occupy several positions on the occlusal plane, for example, more or less advanced or laterally displaced.

Therefore, it will be necessary to trace the exact position that the mandible had at the occlusal plane at the time of the optimal set of physical parameters detected through the specific instrumental examination.

Hence, after the first step of moving the reference planes to determine the optimum inclination of the occlusal plane, it will be necessary to provide a second step of relative movement between the planes along a parallel direction to determine the optimal position of the mandible relative to the upper jaw.

Specifically, you can check the values recorded by the second sensor means at the best performance condition.

At this stage, the patient will still wear the device **1** with the driving elements **6** that will be locked.

The device **1** may be provided with a monitor to graphically display the coordinates of the above point.

For example, as schematically shown in **Figs. 12** and **13**, the optimum point will be represented by a circle locked in the center of the screen, while the instant position appears with a circle of different color.

Moving the mandible of the patient the circle of the instantaneous position will be moved as a consequence, allowing to bring said circle, in an extremely simple manner, exactly at the center of the screen in correspondence of the fixed circle, i.e. where the desired position is reached.

As the desired point is approached, the circles become more large in such a manner to increase the precision in mandibular repositioning.

When the fixed circle at the center will be graphically reached the mandible will be exactly in the optimum position that was recorded during the exam.

At this point, the position of the lower structure **3** may be locked with respect to the upper structure **2**, for example by introducing a quick-release fastening material or a light-curing material. The construction bite will be so ready to be sent to the dental technician.

From above it is apparent that the device and the method according to the invention achieve the intended objects.

In particular, the device of the invention is characterized by high resistance which allows it to be used also in electromyographic and posturostabilometric analysis wherein it is necessary to tighten the teeth, always guaranteeing that displacements will be determined with high precision and resolution.

The presence of position sensors also allows a repositioning not only mechanical, but also physiological, i.e. determined by the swallowing of the patient on the new occlusal plane that has been obtained by previous mechanical movements.

This movement step may also be carried out by the same patient by moving the mandible in multiple random directions on said already fixed plane, always simultaneously with the position and electromyographic records, as the device creates a new occlusal plane which to freely occlude on, without holding the mandible tied.

The device thus conceived, amongst the various applications, would allow the manufacturing of construction bites also during the physical activity of the subject (treadmill or sports training) without being bound by fixed and heavy external supports, obtaining advantages in making construction bites functionalized in relation to the sport activity of the patient.

Furthermore, the device can move the two reference planes directly from the inside of the oral cavity, avoiding significant flexions on the structure that would drastically affect precision and reproducibility, allowing clamping on durable and stable guide planes for executing a EMG test, allows to precisely move each quadrant of the dental arch, allow to control instantly the pressures exerted on each quadrant (on each driving element) and correlate them to instrumental tests.

Still, the device has minimal interocclusal encumbrance, essential for the manufacturing of effective construction bites, respecting the oral functions and vertical occlusion size.

Last but not least, the device is extremely versatile since the construction bite made therethrough is at the basis of multiple dental procedures, for example within the gnatological, orthodontic, prosthetic, restorative branch.

The device and the method according to the invention are susceptible of numerous modifications and variations, all of which are within the inventive concept expressed in the appended claims. All details may be replaced by other technically equivalent elements, and the materials and tools may be different according to the needs without departing from the scope of the present invention.

Although the device and method have been described with particular reference to the attached figures, the reference numbers used in the description and claims are used to improve the intelligence of the invention and do not constitute any limitation to the claimed scope.

Claims

1. A device for computer-aided realization of a dental construction bite, comprising:

- an upper supporting structure (**2**) and a lower supporting structure (**3**) adapted to be respectively associated to the upper dental arch (**As**) and to the lower dental arch (**Ai**) of a patient to define a pair of reference planes;
- operating means (**4**) associated to at least one of said supporting structures (**2**, **3**) to vary the relative position of said reference planes adapted to identify respective occlusal planes;

characterized by comprising electronic control means adapted to be operatively associated with means for detection (**D**) of physical parameters of the patient adapted to detect the variation of said parameters as a function of the relative positions of said reference planes;

and in that said electric control means are adapted to store the relative positions between said reference planes and to associate to each of them the respective set of detected parameters.

2. Device as claimed in claim 1, characterized in that said upper (**2**) and lower (**3**) supporting structure are obtained by thermoforming starting from a thermoplastic or thermosetting material applied to the dental arches (**As**, **Ai**) to define respectively an upper mask and a lower mask having a negative shape of the dental arches.

3. Device as claimed in claim 1 or 2, characterized in that said operating means (**4**) comprise a plurality of linear driving elements (**6**) integral with said upper supporting structure (**2**) to move it with respect to said lower support structure (**3**) along respective movement directions (**X**).

4. Device as claimed in claim 3, characterized in that said operating means (**4**) comprise two pairs of linear driving elements (**6**) integral with the outer surface of said upper supporting structure (**2**) in symmetrical positions, in use, with respect to the sagittal plane of the patient.

5. Device as claimed in claim 3 or 4, characterized in that said operating means (**4**) comprise, for each of said driving elements (**6**), a corresponding transmission element (**12**) adapted to be placed in use externally to the oral cavity of the patient and operatively connected to motor means (**13**) to transfer the motion thereof to the corresponding driving elements (**6**) and cause its the movement along the respective movement direction (**X**).

6. Device as claimed in claim 5, characterized in that said transmission elements (**12**) are of the linear motion type.

7. Device as claimed in any claim from 3 to 6, characterized in that said lower supporting structure (**3**) comprises lateral guide means for said driving elements (**6**).

8. Device as claimed in claim 7, characterized in that said guide means comprise a pair of horizontal thrust planes (**11**) symmetric in use with respect to the sagittal plane of the patient and adapted to define a thrust surface for said linear driving elements (**6**) so as to promote the relative movements between said supporting structures (**2**, **3**).

9. Device as claimed in claim 8, characterized by comprising first sensor means adapted to detect the pressure exerted by each of said driving elements (**6**) on the respective thrust surface (**11**).

10. Device as claimed in any preceding claim, characterized in that said supporting structures (**2**, **3**) comprise second sensor means adapted to detect geometrically the position of said lower support structure (**3**) on the occlusal plane with respect to a fixed reference system associated with said upper supporting structure (**2**).

11. Device as claimed in claim 10, characterized in that said second sensor means are of the Hall-effect type and comprise at least one pair of position sensors (**17**) firmly associated with said upper supporting structure (**2**) and at least one magnet or electromagnet (**18**) associated with said lower supporting structure (**3**).

12. A method for computer-aided realization of a dental construction bite, comprising:

a) applying an upper supporting structure and a lower supporting structure respectively to the upper dental arch and to the lower dental arch of a patient to define a pair of reference planes;

b) moving said reference planes mutually with each other;

c) detecting a corresponding set of patient's physical parameters at each relative position between said planes;

d) identifying the optimum set of parameters and detecting the corresponding relative position between said reference planes;

e) repositioning and locking said reference planes in the position corresponding to the optimal set of physical parameters;

f) introducing a hardening material between said support structures for manufacturing the dental bite;

wherein said steps e) and f) are carried put operating from the outside of the patient's mouth.

13. Method as claimed in claim 12, characterized in that said detecting step c) is carried out by applying a plurality of electrodes to the patient's body to carry out an electromyography.

14. Method as claimed in claim 12, characterized in that said detecting step c) is an instrumental examination such as electromyography, baropodometric-stabilometric analysis or an instrumental analysis providing real time results.

15. Method as claimed in any claim from 12 to 14, characterized in that said moving step b) comprises a first step of relative movement between said reference planes along one or more directions to define the optimal inclination of the occlusal plane and a second step of relative movement between said planes along a direction parallel thereto to define the optimal position of the mandible with respect to the upper jaw.

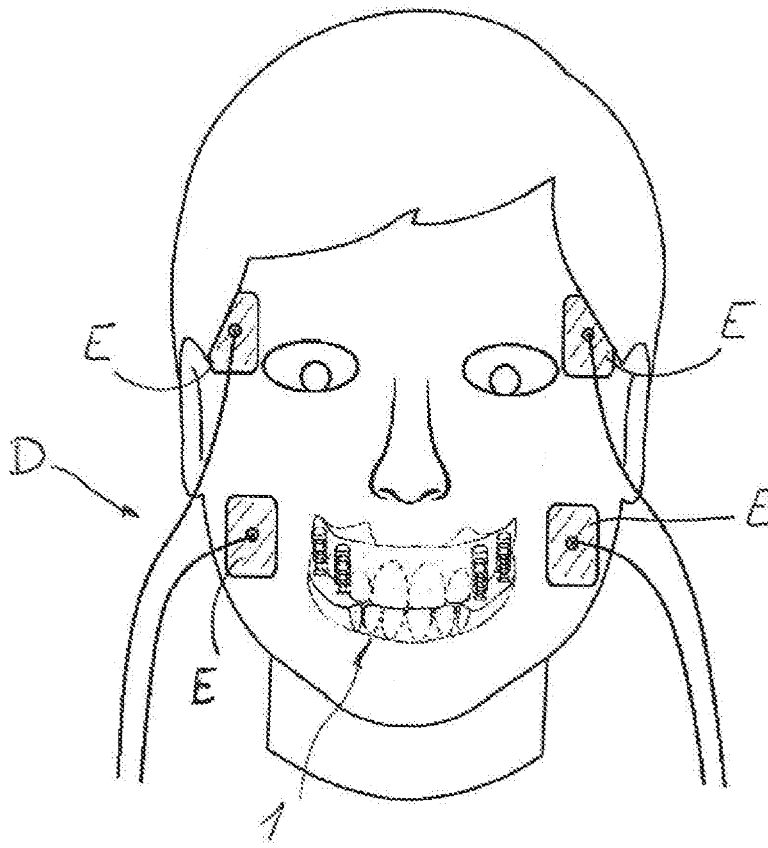

FIG. 1

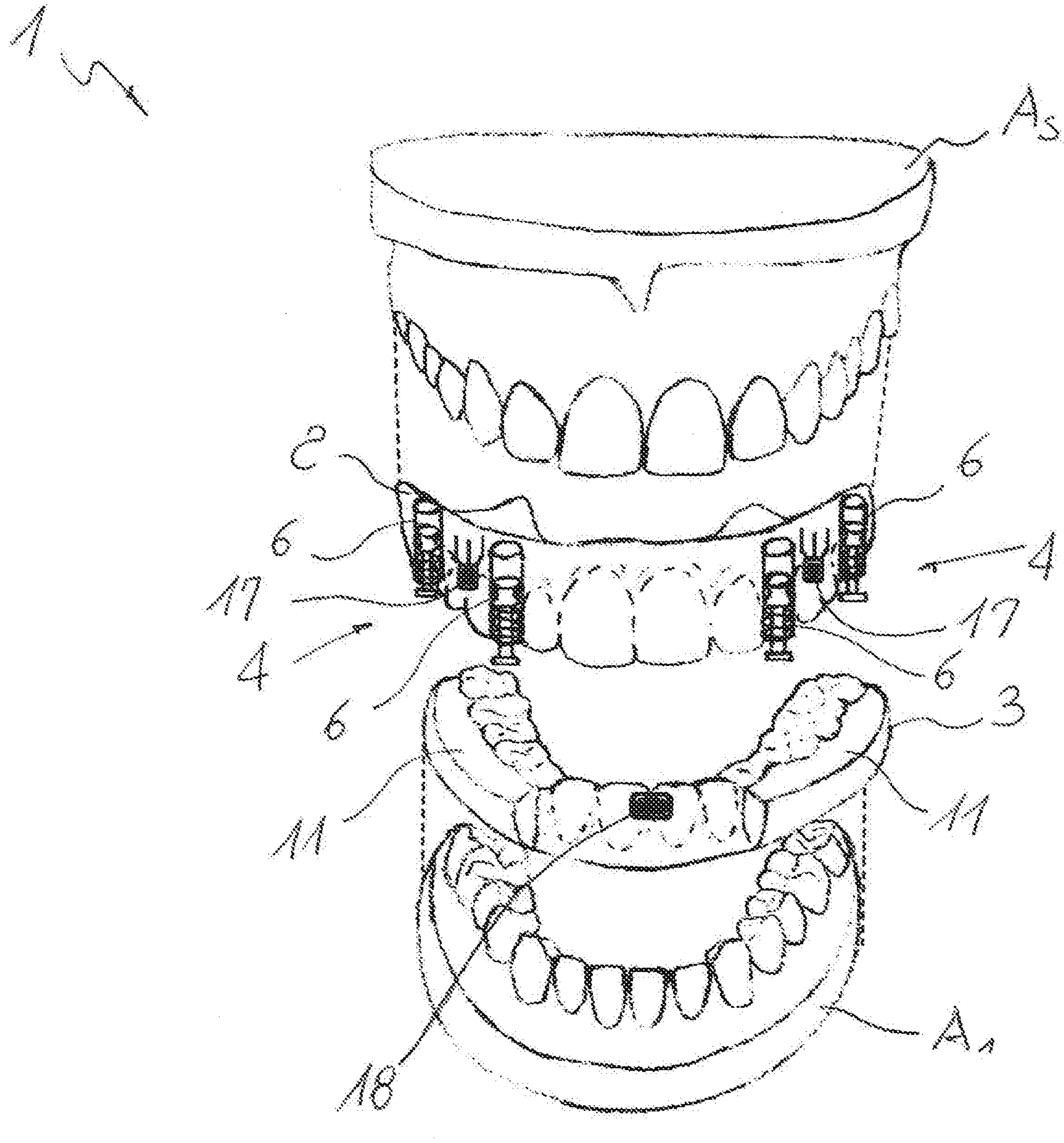

FIG. 2

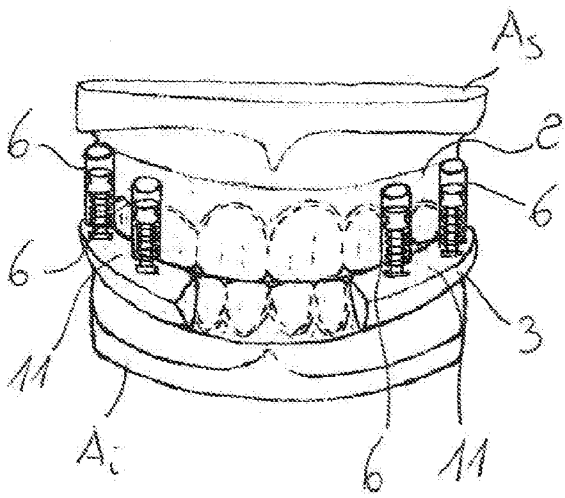

FIG. 3

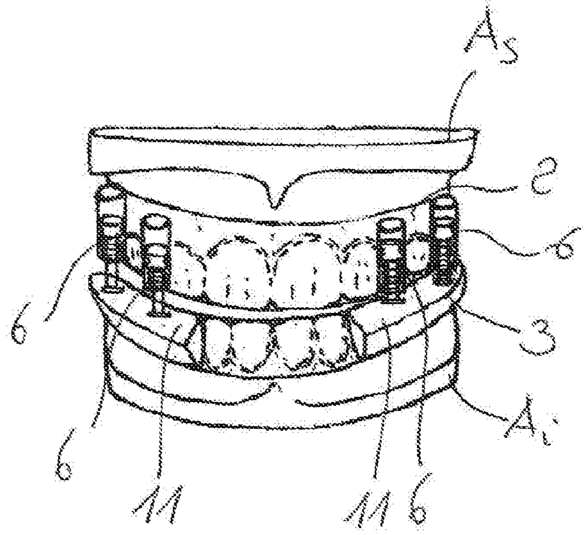

FIG. 4

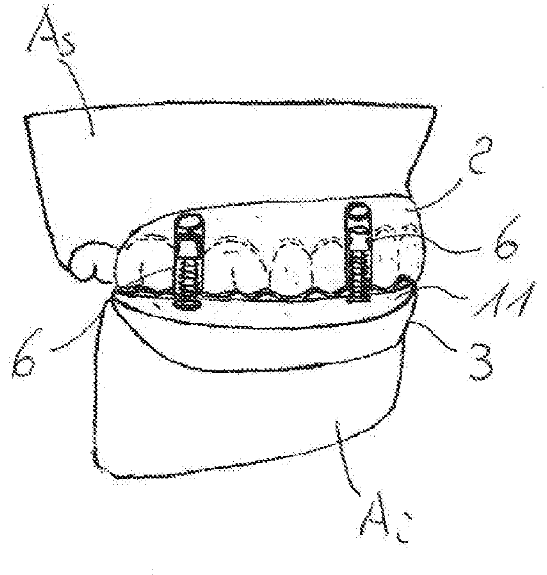

FIG. 5

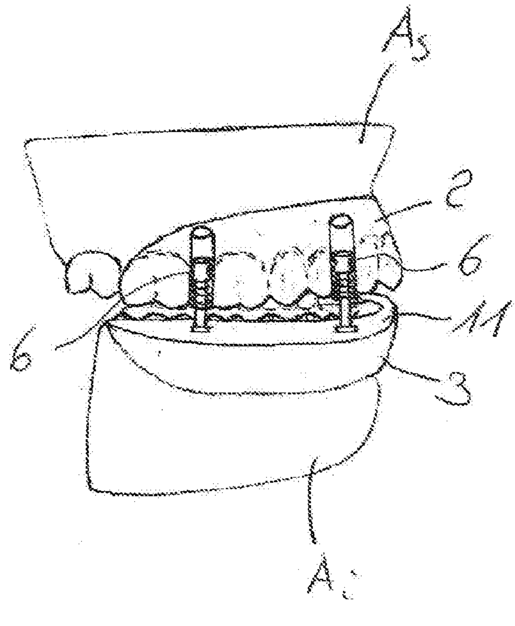

FIG. 6

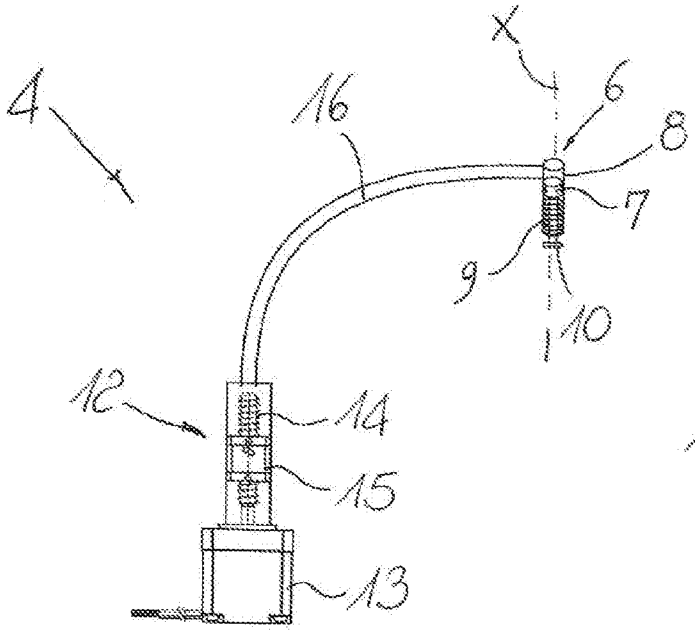

FIG. 7

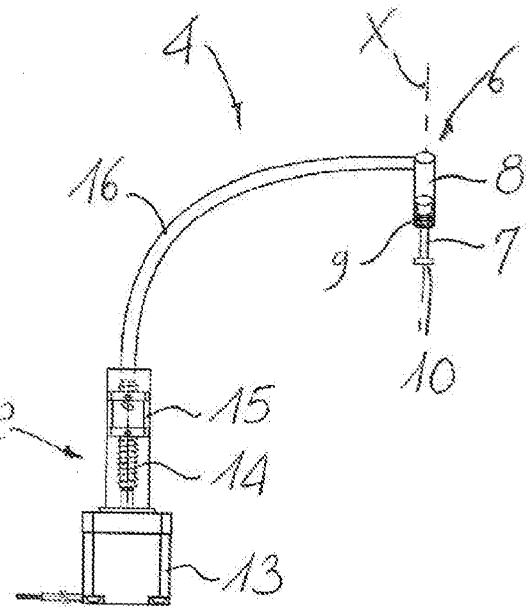

FIG. 8

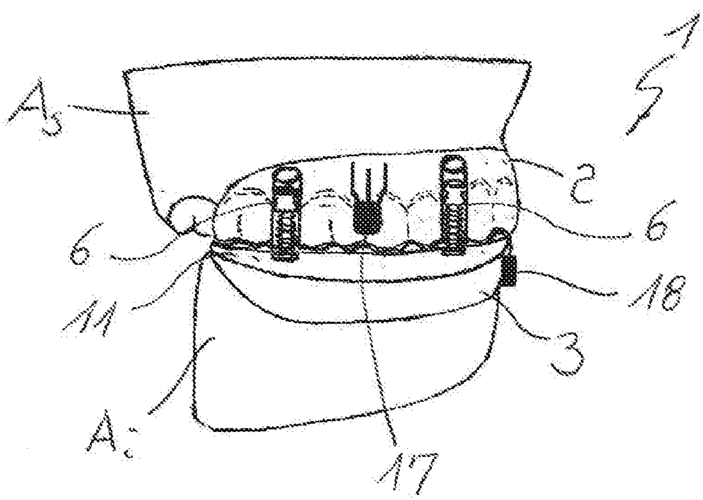

FIG. 11

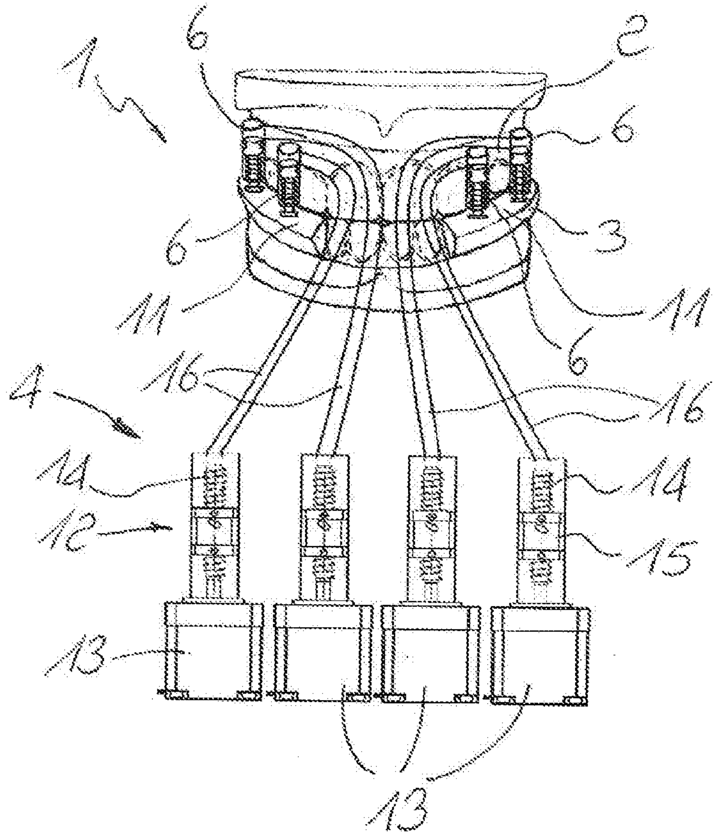
1
6
2
6
6
3
11
11
6
16
4
16
14
14
12
15
13
13

FIG. 9

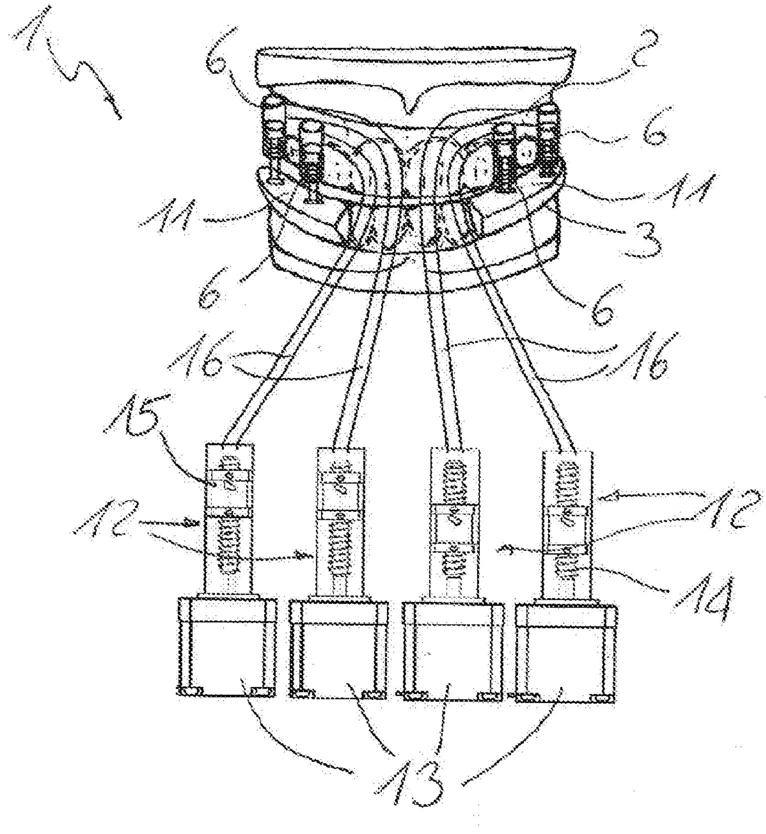
1
6
2
6
11
11
3
6
6
16
16
15
12
12
14
13

FIG. 10

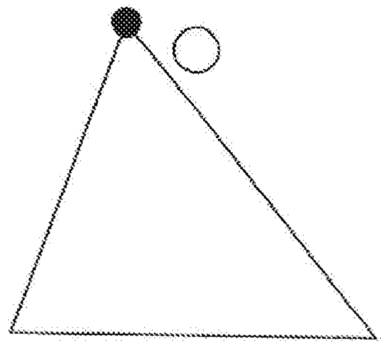

FIG. 12

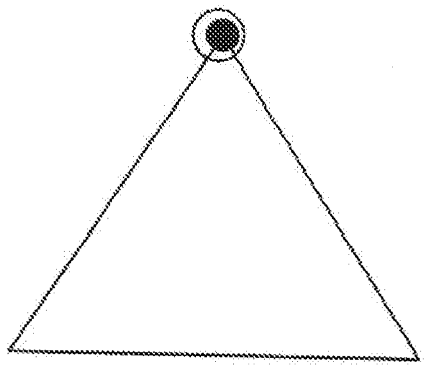

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/055056

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61C7/08 A61C7/36 A61C19/045 A61C19/05
ADD.

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)
A61C

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/280672 A1 (THOMPSON TIMOTHY C [US]) 24 October 2013 (2013-10-24)	1-15
A	US 2016/106525 A1 (KIM JONG HWA [KR] ET AL) 21 April 2016 (2016-04-21)	1-15
A	US 2008/072915 A1 (NELISSEN JOZEF F [BE]) 27 March 2008 (2008-03-27)	1,12
A	US 2015/282900 A1 (LEE SUNG-WAN [KR]) 8 October 2015 (2015-10-08)	1,12

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

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 November 2017	06/12/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Salvatore, Claudio

3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2017/055056

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013280672 A1	24-10-2013	NONE	
US 2016106525 A1	21-04-2016	CN 105208966 A	30-12-2015
		EP 2997928 A1	23-03-2016
		KR 101302702 B1	03-09-2013
		US 2016106525 A1	21-04-2016
		WO 2014185622 A1	20-11-2014
US 2008072915 A1	27-03-2008	NONE	
US 2015282900 A1	08-10-2015	CN 105555223 A	04-05-2016
		KR 101485555 B1	23-01-2015
		US 2015282900 A1	08-10-2015
		WO 2015072738 A1	21-05-2015