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(54) **Title**: DEVICE FOR THE DIGITAL INTRAORAL DETECTION OF TEETH AND METHOD THEREFOR

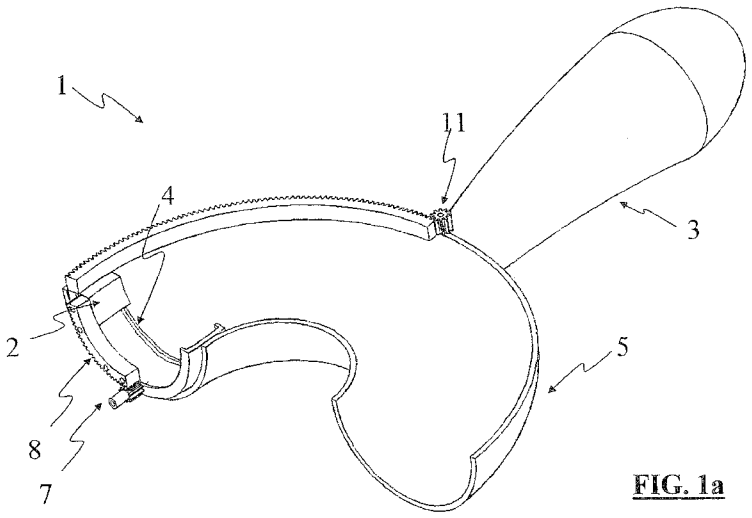


FIG. 1a

(57) **Abstract**: A device (1) for intraoral digital detection of at least one portion of a set of teeth of a person, comprising at least one unit (2) for the acquisition of one or more spatial coordinates (X, Y, I) of at least one point of the at least one portion of the set of teeth and at least one frame (3) for supporting the at least one acquiring unit, characterised in that the at least one acquiring unit (2) is coupled to the at least one frame (3) in a manner that allows translation along at least one direction with respect to the at least one portion of the set of teeth, for the acquisition in space of at least one plurality of points of the at least one portion of the set of teeth.

DESCRIPTION

DEVICE FOR THE DIGITAL INTRAORAL DETECTION OF TEETH AND METHOD THEREFOR

Technical field

The present invention relates to a device and a method for digital intraoral detection of at least one portion of a set of teeth.

Background art

It is known that there are devices used for digital intraoral detection of the geometry of the teeth of a patient, to be used subsequently to provide dental prostheses for restorative dentistry and orthodontic braces.

According to the background art, in particular, various 3D intraoral acquisition sensor types, moved manually by an operator, are used normally in the detection of the geometry of a tooth or of a portion of a set of teeth. These devices are based on one or more operating principles for the digital reconstruction of surfaces that do not entail the use of contact sensors. These are indeed known as contactless acquisition principles. Among the principles used by currently known intraoral scanner sensors, mention is made of confocal microscopy, optical coherence tomography and other interferometric methods, active and passive triangulation.

All these principles provide for the use of CCD sensors to acquire

images and/or of photodiodes to receive light signals. When provisions are made for the projection of light onto the scene to be acquired, contactless acquisition methods are termed 'active'. When instead no light is projected onto the scene, these methods are classified as 'passive'.

Currently known 3D intraoral acquisition sensors, which use a contactless active acquisition principle, use various light sources to project light onto the scene. For example, some use structured light projectors capable of projecting predefined patterns onto the scene, while others use laser diodes that emit in visible light frequencies. Initially, the sensor acquires, in the surrounding space and with a certain predefined resolution, a plurality of profiles of points that as a whole are representative of the body to be detected. During this process, an absolute reference system is not used; a series of relative reference systems, each related to a single acquisition frame, is used instead. For each position assumed by the sensor, held manually by the operator, a single frame is in fact acquired which contains information regarding the geometry of a single portion of the set of teeth. Then, by using known graphic processing methods, known as post-processing methods, the points of all the acquired profiles are interpolated, for example by using NURBS or post-processing methods, to obtain the numeric equation of the detected surface. In this case, ordinary programs in the field of computer drawing are also used which allow to obtain the digital surface and, if appropriate, also the digital volume of the body to be detected. All known intraoral

scanning devices allow the acquisition of small portions of teeth per single scanning frame. In other words, the sensor acquires a specific frame for each position in which it is held by the operator. The individual frames are then used by the dedicated software to reconstruct the virtual model of the set of teeth in real time, so that the operator can view it on a monitor. This process entails the use and implementation of very complex software and certainly introduces many errors due to the operation for matching the individual acquired frames, since it is obviously not possible to refer to an absolute reference system.

Summary of the invention

Therefore, the aim of the present invention is to provide an intraoral acquisition device that can be handled easily by the operator and at the same time allows to acquire a portion of the dental arch of a patient, or the entire dental arch, in a single placement, so as to limit considerably the number of frames to be aligned during post-processing with respect to known devices according to the background art.

An object of the present invention is to provide an acquisition method that does not use complicated algorithms or methods both during acquisition and during post-processing.

This aim, this object and others are achieved by the present device for intraoral digital detection of at least one portion of the set of teeth of a person, comprising at least one acquiring unit for acquiring one or

more spatial coordinates of at least one point of said at least one portion of the set of teeth and at least one frame for supporting said at least one acquiring unit, characterised in that said at least one acquiring unit is coupled to said at least one frame so that it can translate along one or more directions with respect to said at least one portion of the set of teeth for the spatial acquisition of at least one plurality of points of said at least one portion of the set of teeth.

In practice, the fact that said at least one acquiring unit is capable of translating with respect to said at least one set of teeth allows to render almost mutually integral the teeth of the patient and the device itself and therefore avoid the problems linked to time-variant devices, i.e., devices that acquire, for each scan, individual frames associated with small portions of the set of teeth. In these devices of the background art, in fact, the reference systems of each individual acquired frame are mutually distinct and therefore it is necessary to perform subsequent operations for matching the acquired frames in order to reconstruct the complete model of the set of teeth. Moreover, in these devices of the background art even small movements of the patient during acquisition interfere more severely with the total result of the measurement. All this is avoided with the configuration of the device according to the invention.

Moreover, said at least one acquiring unit is capable of translating with respect to the frame in a direction of space and therefore is capable of acquiring a plurality of points along the profile of said at least one portion of a set of teeth, or of translating along an additional

direction of space, and therefore capable of acquiring, in combination with the points acquired along the first spatial direction, a surface of the portion of the set of teeth.

In detail, and advantageously, said acquiring unit is of the laser type and utilises time-of-flight or pulsed time-of-flight techniques. The proprietor has in fact tested that the use of this technology is particularly effective in the case of detections of surfaces that are less than 30 mm and preferably less than 20 mm from the laser unit used for acquisition. The precision that can be obtained with said laser units that adopt this technique, which currently is used only for the acquisition of points that are spaced from the laser unit used for acquisition by more than a few tens of centimetres, is surprisingly greater than the precision obtainable from known laser apparatuses used in the acquisition of portions of sets of teeth.

Furthermore, said supporting frame comprises at least one first guide for coupling in a translatable manner said at least one acquisition unit along a first direction with respect to said at least one portion of the set of teeth. Furthermore, said supporting frame comprises at least one second guide for coupling in a translatable manner said at least one acquisition unit along a second direction with respect to said at least one portion of a set of teeth. In a preferred manner, said at least one first guide has a substantially U-shaped profile that is extended along a substantially rectilinear axis. Said at least one second guide also has a U-shaped profile but is extended along an axis that is arc-like, i.e., capable of allowing the movement of said at least one acquiring unit

with respect to at least one portion of a set of teeth, which, as is known, is arc-shaped. In particular, the shape of said arc-like axis substantially duplicates the shape of the dental arch. The shape of the U-shaped profile of the two guides is advantageous because it allows the set of teeth of the patient to access its interior for the acquisition both of the internal surface of said set of teeth and of its external surface.

According to a particular embodiment of the invention, said at least one first guide and said at least one second guide have a semi-circular profile. In particular, however, the profile of said at least one second guide is extended along a semi-circular axis. In an alternative manner, said at least one first guide always has a semi-circular profile, while said at least one second guide has a semi-circular profile which, however, is extended along an axis that is shaped like a circular arc, not like a semicircle, with an angle comprised between 10 and 50° and preferably 30°. In both of the above cited embodiments, said at least one first guide lies, substantially within the U-shaped profile of said at least one second guide so as to allow the acquiring unit to perform acquisition both transversely to the portion of the set of teeth and in a longitudinal direction. In fact, as described in one embodiment of the invention, said at least one first guide is restrained so that it can slide with respect to said at least one second guide.

According to a particular embodiment of the invention, if said at least one second guide has a profile with an extension comprised between 10 and 50° and in any case smaller than 180°, then said at least one

second guide can rotate with respect to said frame. In this embodiment, the device comprises means for retaining in a stable position said at least one second guide in at least two positions with respect to said frame. In this manner it is possible to acquire the points of the set of teeth by rotating said at least one second guide between two positions that are preferably mutually spaced by 90°. Preferably, the positions in which said second guide remains stable are three and are angularly spaced with respect to each other by 90°.

According to an embodiment that is distinct from the one described previously, said at least one second guide, which is extended through 180°, is integral, i.e., coupled in a fixed manner, to said supporting frame.

In practice, in both of the embodiments cited above said at least one first guide slides along the second guide, entraining with itself said at least one acquiring unit.

According to the invention, the device comprises first means for the movement of said at least one acquiring unit along said at least one first guide. In detail, said means for the movement of said at least one acquiring unit along said at least one first guide comprise at least one rack that is coupled so that it can slide along said at least one first guide, at least one electric motor or piezoelectric motor or motor of another kind, which is coupled integrally to said at least one first guide and at least one gearwheel which is coupled integrally to said motor and can mesh with said rack. In this embodiment, said at least one acquiring unit is integral with said rack, which, as anticipated above,

slides with respect to the first guide and thus slides the first acquiring unit with respect to the portion of the set of teeth to be acquired.

Moreover, said device comprises second means for the movement of said at least one first guide with respect to said at least one second guide. In particular, said second means for moving said at least one first guide with respect to said second guide comprise at least one second rack, which is coupled so that it can slide along said at least one second guide, at least one motor coupled integrally to said at least one second guide, and at least one gearwheel which is coupled integrally with said motor and can mesh with said rack. In this configuration, said at least one first guide is coupled integrally to said at least one second rack and therefore moves and slides with respect to the portion of the set of teeth to be acquired when the second rack slides with respect to said second guide.

In a preferred manner, said device comprises at least one second acquiring unit, which is coupled to said at least one first guide and is spaced angularly with respect to said at least one acquiring unit. Preferably, said first and second acquiring units are arranged at approximately 90° to each other. In this manner, the first rack only has to perform a 90° translation in order to be able to acquire the transverse profile of a portion of a set of teeth.

The invention allows to achieve the above cited aim and object also by means of a method for the digital detection of at least one portion of a set of teeth of a person by means of a device according to one or more of claims 1 to 17, comprising the step a) of positioning said

device inside the mouth of the patient so that the set of teeth of the patient lies within the U-shaped profile of said at least one first guide and of said at least one second guide, the step b) of acquiring, by means of said at least one acquiring unit, one or more spatial coordinates of at least one point of said at least one portion of the set of teeth, and the step c) of translating said at least one acquiring unit with respect to said frame along at least one first direction for the spatial acquisition of a plurality of points of said at least one portion of the set of teeth. Advantageously, said at least one acquiring unit is of the laser type and said step b) of the method comprises the step of acquiring one or more spatial coordinates of at least one point of said at least one portion of the set of teeth by virtue of techniques of the time-of-flight or pulsed time-of-flight type.

Moreover, the method, according to a further embodiment of the invention, comprises the additional step d) of translating said at least one acquiring unit along at least one second spatial direction with respect to said at least one portion of the set of teeth, at least when said plurality of points of said at least one portion of the set of teeth has been acquired during said step c) of the method. In practice, often a plurality of points has been acquired along a first direction, during said step c) of the method, the first guide is moved along a second direction, so that said step c) of the method can be repeated again, In practice, steps c) and d) are repeated iteratively until a number of points sufficient to cover said at least one portion of the set of teeth is acquired. In a subsequent post-processing step, a surface is

created by means of the mathematical interpolation of the set of points acquired during said steps c) and d) of the method.

Brief description of drawings

Multiple particular embodiments of the present invention are now described, merely by way of non-limiting example, with reference to the accompanying figures, wherein:

- Figures 1a, 1b and 1c are multiple perspective views of a first embodiment of the digital detection device according to the invention, in which the acquiring unit is translated along the first guide and the first guide is translated with respect to said second guide;
- Figures 2a to 2d are perspective views of the device according to the invention, comprising a first guide and an additional first guide, each provided with two acquiring units;
- Figures 3a to 3f are perspective views of an additional embodiment of the invention, in which the acquisition units are translated along the respective first guide, the first guides are translated with respect to said second guide and the second guide is rotated with respect to the frame in three distinct positions.

Detailed description of preferred embodiments of the invention

With particular reference to the figures cited above, the reference numeral 1 designates the digital detection device according to the invention.

Figure 1a shows the device 1 for digital detection of the set of teeth of

a person and comprises a laser unit 2, which contains all the optical elements required for the acquisition of the Z coordinate in space of a point of said set of teeth, and a frame 3, which is shaped like a handle, for supporting the laser acquiring unit 2. It should be noted that the X and Y coordinates of the generic point of the set of teeth to be acquired are already known by the device, because the acquiring unit 2 moves, as will be described later, along guides 4 and 5 the geometry of which is known. In practice, therefore, the only coordinate to be identified is the one related to the distance between the laser unit 2 and the generic point of the set of teeth impinged on by the laser. The optical elements contained within the acquiring unit 2 are constituted preferably by arrays of laser diodes, PIN photodiodes, APD (avalanche photodiodes) or SPAD (single photon avalanche photodiodes), beam splitters, optical attenuators, collimators and lenses that allow transmission and reception of the optical signal after reflection on the target. It should be noted that advantageously said laser acquiring unit 2 utilises time-of-flight or pulsed time-of-flight techniques.

Of course, although it is not described herein, an embodiment that uses a laser unit or a structured light unit that employs another acquisition technique of the contactless type is still within the protective scope of the present invention. The handle of the frame 3 can be used advantageously to accommodate all the electronic components that allow the operation of the measurement system.

As an alternative, said electronic components can be

accommodated in a small dedicated box and located in a remote position with respect to the frame 3.

Advantageously, the acquisition unit 2 is coupled to said frame 3 so that it can translate along one direction with respect to said set of teeth for the spatial acquisition of a plurality of points of said set of teeth. In particular, the supporting frame 3 comprises a first guide 4 for coupling in a translatable manner said first laser unit 2 along a first direction with respect to said set of teeth, specifically in a transverse direction.

Furthermore, said supporting frame 3 comprises a second guide 5 for coupling indirectly and in a translatable manner said first laser unit 2 along a second direction with respect to the set of teeth, specifically in a direction that is substantially parallel to the set of teeth or to a portion thereof.

Moreover, the first guide 4 and the second guide 5 have a transverse profile that is shaped like an arc of a circle, preferably – as shown in Figures 1a, 1b and 1c – of a semicircle; moreover, said first guide 4 lies substantially within the profile of said second guide 5. In particular, the first guide 4 is extended along a rectilinear axis, while the shape of the second guide 5 is the shape of a half torus obtained from the revolution through 180° of a semicircle, which is none other than the profile of said second guide 5 that has substantially the same dimensions as the transverse profile of said first guide 4. As a consequence of this shape, it is evident that when the device is placed inside the mouth of the patient the portion of the set of teeth is

located in practice inside the second guide 5, i.e., inside the half-torus surface shown in the accompanying figures.

In practice, although it is not described here, in other embodiments said first guide 4 can have, however, a substantially U-shaped profile and so can said second guide 5, but said first guide 4 has a profile that is extended along a rectilinear axis while said second guide 5 has a profile that is extended along an arc-like axis. Such a solution is within the protective scope of the present invention.

According to the embodiment described herein, the first guide 4 is coupled so that it can slide with respect to the second guide 5, which in turn is integral with said supporting frame 3. In this manner, the laser acquiring unit 2 can slide both transversely and longitudinally with respect to a portion of the set of teeth and thus can acquire completely the surface thereof.

Furthermore, the device 1 comprises first means 7 for the movement of said first unit 2 along said guide 4. Figure 1b shows the first unit 2 displaced by 90° with respect to its initial position shown in Figure 1a. In particular, said first means 7 for the movement of said first unit 2 along said first guide 4 comprise a rack 8, which is coupled so that it can slide along said first guide 4, an electric motor 9, which is coupled integrally with said first guide 4, and a gearwheel 10, which is coupled integrally with said motor, in particular to the driving shaft, and can mesh with said rack 8. In practice, the laser unit 2, which is integral with said rack 8, is moved with respect to the guide 4 when the electric motor 9 moves the rack 8 by means of the gearwheel 10. Therefore,

the rack 8 moves through 90° and thus moves the laser acquiring unit 2. It should be noted that the motor according to the representative embodiment described here is of the electric type, but a motor of the piezoelectric type or of another similar type is still within the protective scope of the present invention.

Moreover, said device 1 comprises second means 11 for the movement of the first guide 4 with respect to said second guide 5. In detail, said second movement means 11 of said first guide 4 comprise a second rack 12, which is coupled so that it can slide along said second guide 5, an electric motor 13, or a piezoelectric motor in an alternative embodiment, which is coupled integrally to said second guide 5, and a gearwheel 14, which is coupled integrally to said electric motor 13 and can mesh with said second rack 12. Ultimately, the first guide 4, which is integral with said second rack 12, is moved with respect to the second guide 5 when the electric motor 13 moves the second rack 12 along the second guide 5 by means of the gearwheel 14. This solution, therefore, allows to move the laser acquiring unit 2 also in a direction that is substantially parallel to the portion of the set of teeth to be acquired. The embodiment described herein, therefore, allows the acquisition of one half of the portion of the set of teeth of the person subjected to this operation.

According to a further embodiment shown in Figures 2a to 2d, the device 1, in addition to the elements described above (which have the same reference numerals), comprises furthermore a second laser unit 15, which is coupled to said first guide 4 and is angularly spaced

with respect to said first laser unit 2 by approximately 90°. In this manner, the simple movement of the first rack 8 by 90° entails the acquisition of the entire profile of transverse points of said set of teeth. The embodiment presented here shows furthermore the presence of an additional first guide 40, which is provided with two additional laser acquiring units 20 and 150 that are arranged at 90° to each other and has the same operation as said first guide 4. Said additional first guide 40, which in turn is arranged at 90° with respect to said first guide 4 and is integral with said second rack 12, is moved by the second rack 12 in the same manner described above for the first guide 4 (compare Figures 2a and 2c). In this manner, the simple movement of the second rack 12 through 90°, obtained by the rotation of the electric motor 13, entails the acquisition of the entire longitudinal profile of points of said set of teeth. It is clear that in this embodiment also the laser units 2, 15, 20 and 150 translate respectively along the first guide 4 and the additional first guide 40. In particular, the additional first guide 40 also is provided with additional first means 70 for the movement of said additional first unit 20 along said additional first guide 40. Figure 2b shows the acquisition units 2, 15, 20 and 150, shifted by 90° with respect to their initial position, which is shown in Figure 2a. In particular, said additional first means 70 for the movement of the laser units 20 and 150 comprise a rack 80, which is coupled so that it can slide along said additional first guide 40, an electric motor 90, which is coupled integrally to said additional first guide 40, and a gearwheel 100, which is coupled integrally to said motor 90, in

particular to the driving shaft, and can mesh with said rack 80.

Figures 3a to 3f show a further embodiment of the device 1. In particular, in the illustrated case, said second guide 5 has a U-shaped profile, particularly a semi-circular profile, which is extended along an axis that is shaped like an arc of a circle with an angular extension of 30°. In practice, differently from the preceding case (see Figures 1 and 2), said second guide 5 substantially has the shape of a torus that has a semi-circular profile and an extension through an angle of 30°.

In this case also, said first guide 4 and said additional first guide 40 are coupled so that they can slide with respect to said second guide 5. Both said first guide 4 and said additional first guide 40 each move two laser acquiring units 4, 15 and 20, 150. Furthermore, according to the particular embodiment of the invention described here, and differently from the two embodiments described illustrated previously, said second guide 5 can rotate with respect to said frame 3 about the pivot 50. In practice, the second guide 5 can assume different positions with respect to the frame 3 so as to facilitate the placement of the device in the mouth of the patient to acquire three parts of the portion of the set of teeth, i.e., the two lateral parts and the central part. This embodiment is unquestionably more compact from the point of view of space occupation, although its operation, at least on each part of the set of teeth that is acquired, is substantially identical to the one described previously, at least as regards the operation of the first guide 4 and of the additional first guide 40. Furthermore, the particular shape of the guides allows the device to adapt to all possible dental

arch dimensions. According to this embodiment, the device comprises means (not visible here) for retaining in a stable position said second guide 5 in three distinct stable positions with respect to said frame which are angularly spaced by 90°. Reference should be made in this regard to Figures 3d, 3e and 3f, which show the second guide 5 in a position that is substantially perpendicular to the frame 3 and in two opposite positions in which the second guide 5 is substantially parallel to the frame 3.

It should be noted that although the embodiment described here illustrates the presence of two first guides 4 and 40, an embodiment that has a single first guide 4 is still within the protective scope of the present invention. Moreover, an embodiment that comprises retention means that make available only two stable positions is also still within the scope of the present embodiment of the invention. In this case, more preferably but not exclusively, the shape of said second guide 5 is substantially rectilinear.

The invention also provides a method for digital detection of a set of teeth of a person by means of the device 1 described above. In particular, said method comprises the step a) of placing said device 1 inside the mouth of the patient so that the set of teeth of the patient is located within the U-shaped profile of said at least one first guide 4 and of said at least one second guide 5, the step b) of acquiring, by means of said acquiring unit 2, the Z spatial coordinate of a point of said set of teeth, and the step c) of translating said laser unit 2 with respect to said frame 3 along a first direction for the spatial acquisition

of a plurality of points of said portion of the set of teeth. In this manner, as can be seen in Figures 1a and 1b, the acquiring unit 2 is capable of acquiring a series of points so as to form a profile of the set of teeth, albeit a partial one, in a direction that is transverse to said set of teeth. The translation of said acquiring unit 2 occurs along a first guide 4 that is coupled to said frame 3. The movement of the acquiring unit 2 depends on the dimensions of the generic tooth of the first rack 8. In practice, the spatial resolution of acquisition along said first direction, i.e., along a transverse profile of the portion of the set of teeth, depends on the dimensions of the generic tooth of said first rack 8.

It should be noted that said step b) comprises the step of acquiring by means of at least one laser unit that uses acquisition techniques of the time-of-flight or pulsed time-of-flight type.

Furthermore, the method also comprises the step d) of translating said acquiring unit 2 along a second spatial direction with respect to said set of teeth, at least when said plurality of points of said set of teeth has been acquired during said step c) of the method. In the case being considered, although not shown, the extent of the movement of the laser acquiring unit 2 along a second direction depends on the dimensions of the generic tooth of the second rack 5. Said movement in fact occurs only after the step c) of the method has ended and an additional transverse profile of the set of teeth has to be acquired. Therefore, the resolution between points that belong to distinct and adjacent transverse profiles depends on the dimensions of the generic tooth of the second rack 12. Finally, steps c) and d) are repeated

iteratively. In practice, therefore, with reference for example to the embodiment described in Figures 1a to 1c, the first guide 4, at the end of the method, reaches the position shown in Figure 1c, thus having acquired half of the portion of the set of teeth to be acquired.

In the case of the embodiment shown in Figures 2a to 2c, acquisition is performed on the entire set of teeth, both externally, i.e., on the part of the set of teeth that is visible, and internally, i.e., on the portion of the set of teeth that is not visible.

Finally, in the case of said third embodiment, shown in Figures 3a to 3f, or if the second guide 5 has a reduced angular extension with respect to the first embodiment, the method also comprises the step e) of rotating said second guide 5 with respect to said frame and the step f) of retaining in a further stable position said second guide 5 with respect to said frame 3. In practice, steps e) and f) are repeated cyclically after steps c) and d) are performed. Therefore, once a part of the portion of the set of teeth to be analysed has been acquired, the second guide is rotated into a further stable position for the subsequent acquisition of a second part of the portion of the set of teeth. In the case of three stable positions there are three stable placements of the second guide 5 with respect to the frame 3.

CLAIMS

1) A device (1) for the digital intraoral detection of at least one portion of a set of teeth of a person, comprising at least one unit (2) for acquiring one or more spatial coordinates (X, Y, Z) of at least one point of said at least one portion of the set of teeth and at least one frame (3) for supporting said at least one acquiring unit, characterised in that said at least one acquiring unit (2) is coupled to said at least one frame (3) in a translatable manner along at least one direction with respect to said at least one portion of the set of teeth, in order to acquire the space at least one plurality of points of said at least one portion of the set of teeth.

2) The device (1) according to claim 1, characterised in that said at least one acquiring unit comprises a laser unit of the time-of-flight or pulsed time-of-flight type.

3) The device according to claim 1 or 2, characterised in that said supporting frame (3) comprises at least one first guide (4) for coupling in a translatable manner said at least one acquiring unit (2) along a first direction with respect to said at least one portion of the set of teeth.

4) The device according to one or more of the preceding claims, characterised in that said supporting frame comprises at least one second guide (5) for coupling directly or indirectly, in a translatable manner, said at least one acquiring unit along a second direction with respect to said at least one portion of the set of teeth.

5) The device according to claim 4, characterised in that said at

least one first guide is coupled so that it can slide with respect to said at least one second guide.

6) The device according to claims 3 or 4 or 5, characterised in that said at least one first guide and/or said at least one second guide has/have a U-shaped profile, said at least one first guide being arranged substantially inside the U-shaped profile of said at least one second guide.

7) The device according to claim 6, characterised in that said at least one first guide has a substantially circular arc-shaped profile and in that said at least one second guide has a substantially circular arc-shaped profile.

8) The device according to one or more of claims 4 to 7, characterised in that said at least one second guide can rotate with respect to said frame.

9) The device according to claim 8, characterised in that said at least one second guide has an arc-like axis and in that the profile of said at least one second guide is extended along said arc-like axis through a circular arc comprised between 10 and 50°.

10) The device according to claim 8 or 9, characterised in that it comprises means for retaining in a stable position said at least one second guide in at least two stable positions with respect to said frame.

11) The device according to claim 6 or 7, characterised in that said at least one second guide has a substantially semi-circular arc-like axis and the profile of said at least one second guide is extended along

said substantially semi-circular arc-like axis, said at least one second guide being coupled to said supporting frame in a fixed manner.

12) The device according to one or more of the preceding claims, characterised by comprising first means (7) for moving said at least one unit along said at least one first guide.

13) The device according to claim 12, characterised in that said means (7) for moving said at least one unit along said at least one first guide comprise at least one rack (8) that is coupled so that it can slide along said at least one first guide, at least one electric motor (9) integrally coupled to said at least one first guide and at least one gear wheel (10) that is integrally coupled to said motor and can mesh with said rack, said at least one laser unit being integral with said rack.

14) The device according to one or more of claims 3 to 13, characterised in that it comprises second means (11) for moving said at least one first guide with respect to said at least one second guide.

15) The device according to claim 14, characterised in that said second means for moving said at least one first guide with respect to said at least one second guide comprise at least one second rack (12), which is coupled so that it can slide along said at least one second guide, at least one electric motor (13) integrally coupled to said at least one second guide, and at least one gear wheel (14) that is integrally coupled to said motor and can mesh with said rack, said at least one first guide being integrally coupled to said at least one second rack.

16) The device according to one or more of the preceding claims,

characterised in that it comprises at least one second acquiring unit (15) that is coupled to said at least one first guide and is angularly spaced with respect to said at least one laser unit.

17) The device according to claim 16, characterised in that said first and second acquiring units are arranged approximately at 90° to each other.

18) A method for digitally detecting at least one portion of a set of teeth of a person by means of a device according to one or more of claims 1 to 17, comprising the step a) of positioning said device inside the mouth of the patient so that said at least one second guide and said at least one first guide are arranged at said at least one set of teeth of said person, the step b) of acquiring, by means of said at least one acquiring unit (2), one or more spatial coordinates (X, Y, Z) of at least one point (P) of said at least one portion of the set of teeth (1) and the step c) of translating said at least one acquiring unit (2) with respect to said frame along at least one first direction in order to acquire in space a plurality of points of said at least one portion of the set of teeth.

19) The method according to claim 18, characterised in that said step b) comprises the step of acquiring by means of at least one laser unit of the time-of-flight or pulsed time-of-flight type.

20) The method according to claim 18 or 19, characterised in that it comprises the step d) of translating said at least one acquiring unit (2) along at least one second spatial direction with respect to said at least one portion of the set of teeth, at least when said plurality of

points of said at least one portion of the set of teeth has been acquired during said step c) of the method.

21) The method according to one or more of claims 18 to 20, characterised in that steps c) and d) are repeated iteratively.

22) The method according to claim 21, characterised in that it comprises furthermore the step e) of rotating said at least one second guide with respect to said frame and the step f) of retaining said at least one second guide 5 in at least one additional stable position, said steps e) and f) being repeated iteratively at the end of said steps c) and d).

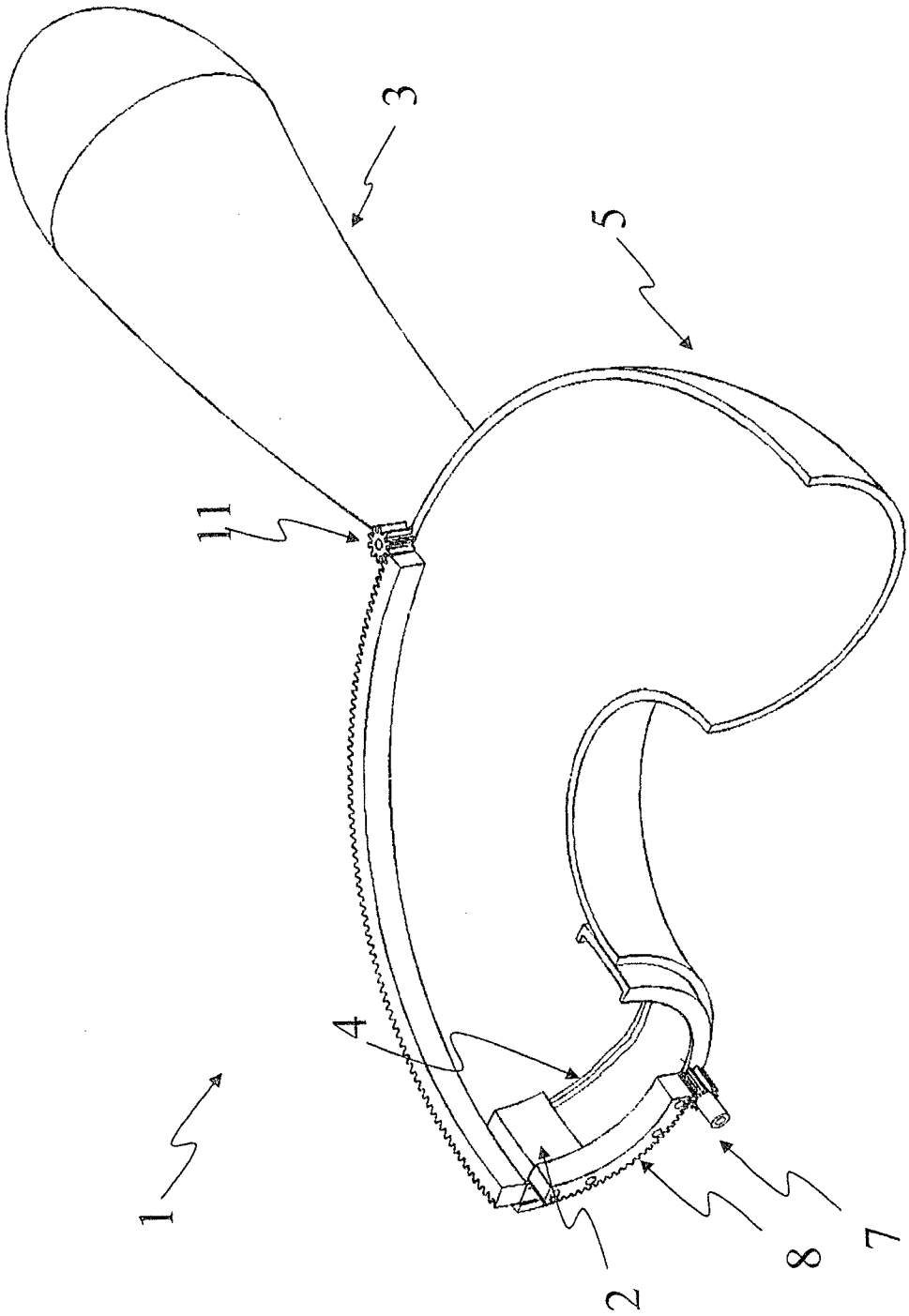
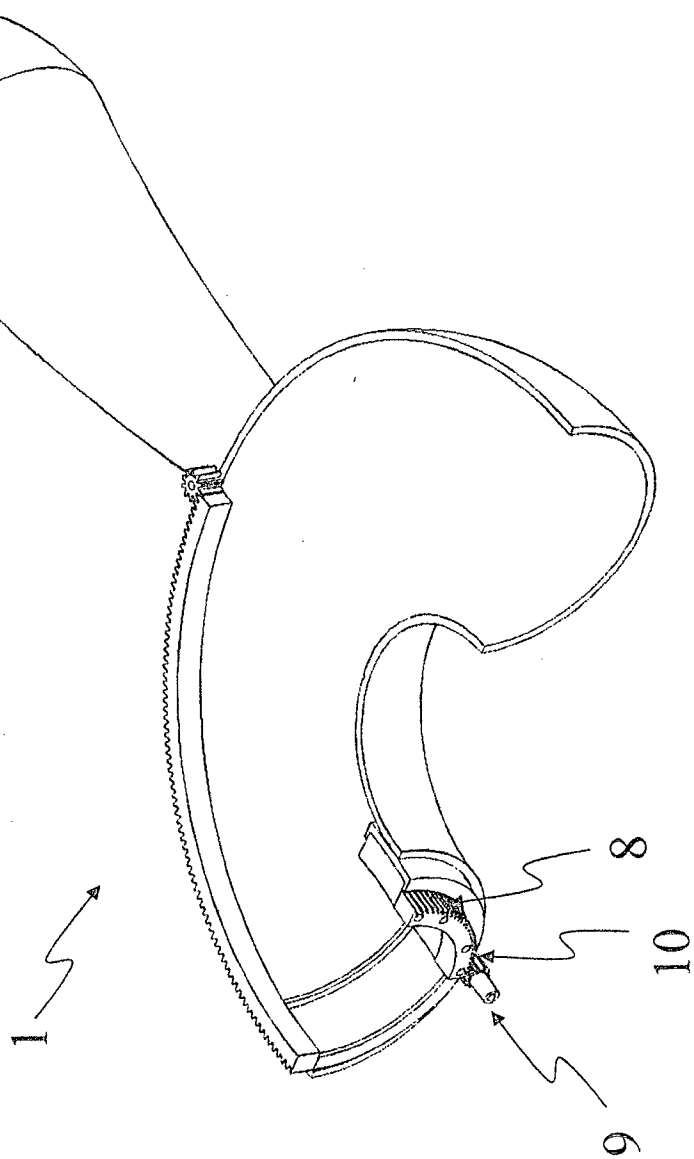


FIG. 1a

FIG. 1b



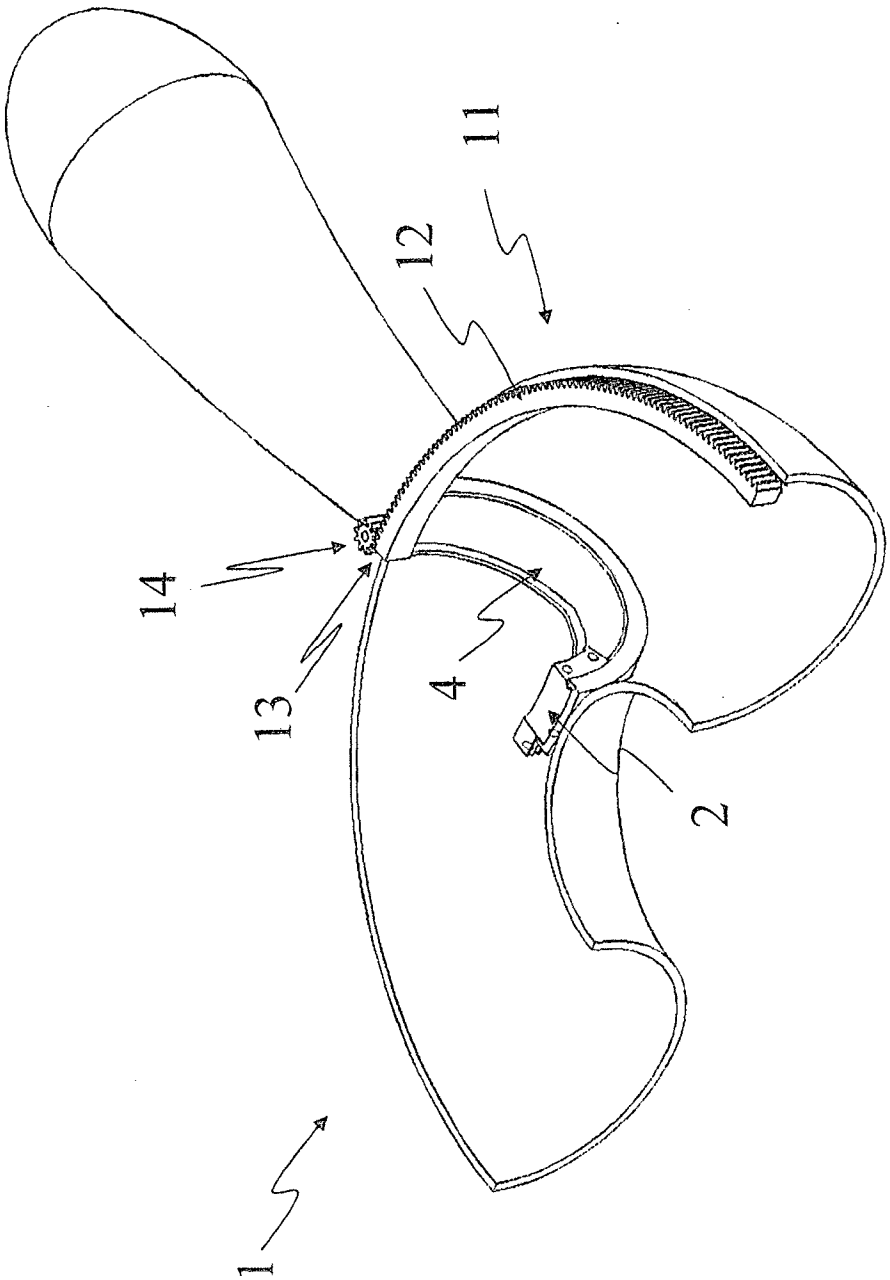
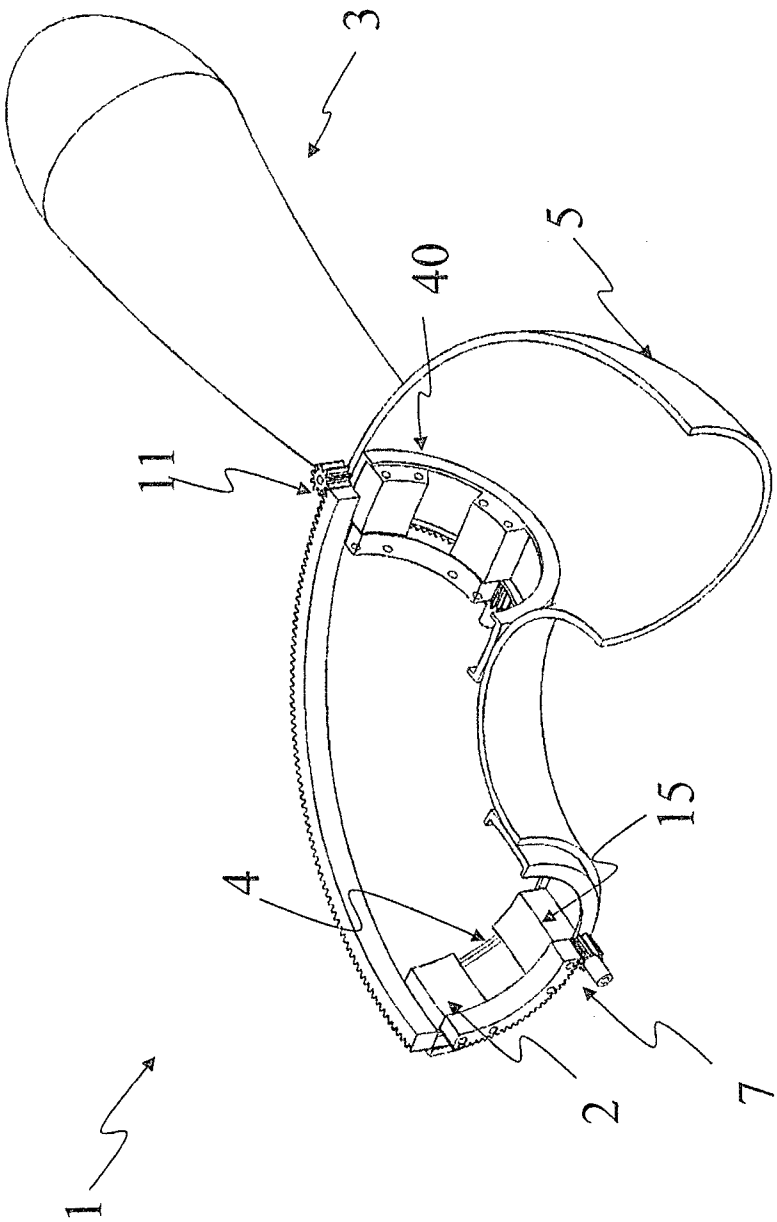


FIG. 1c

FIG. 2a



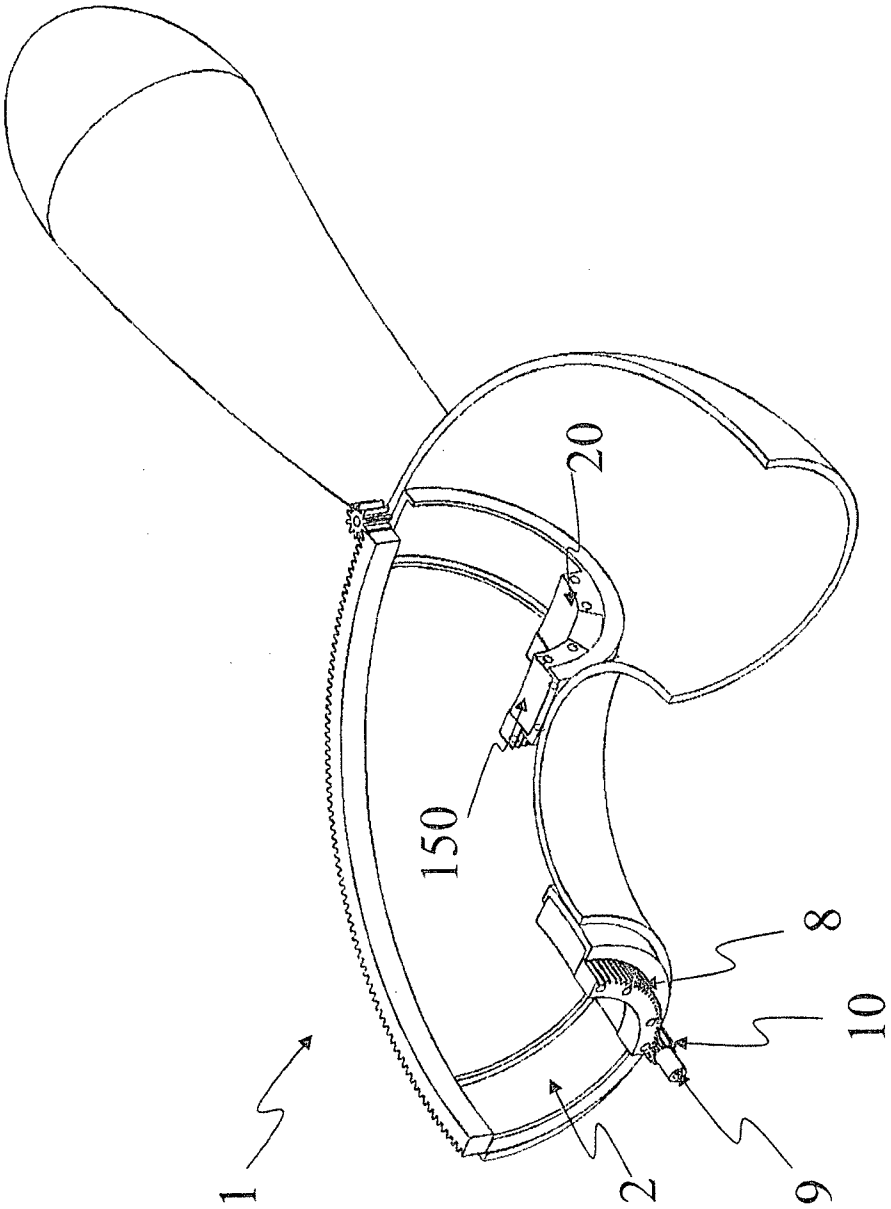


FIG. 2b

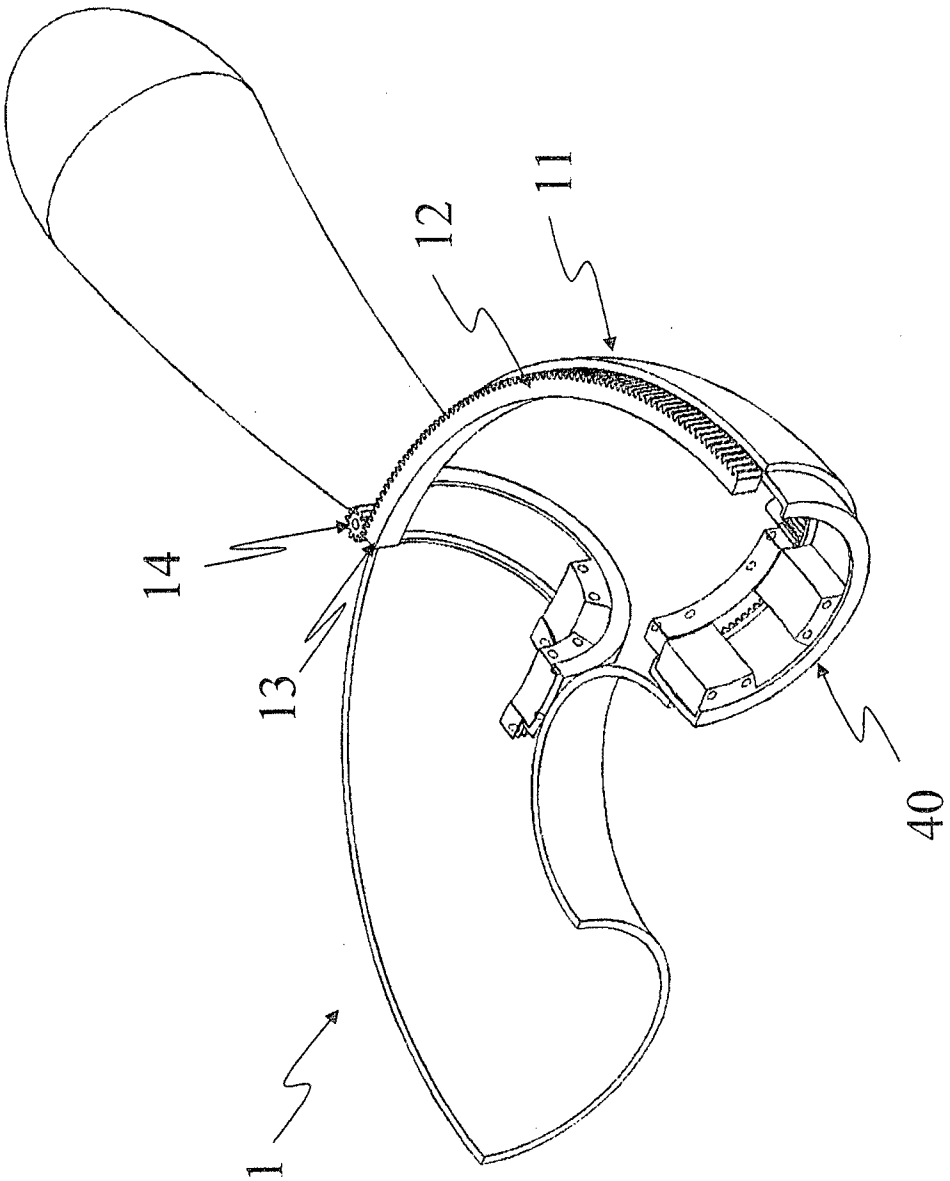


FIG. 2c

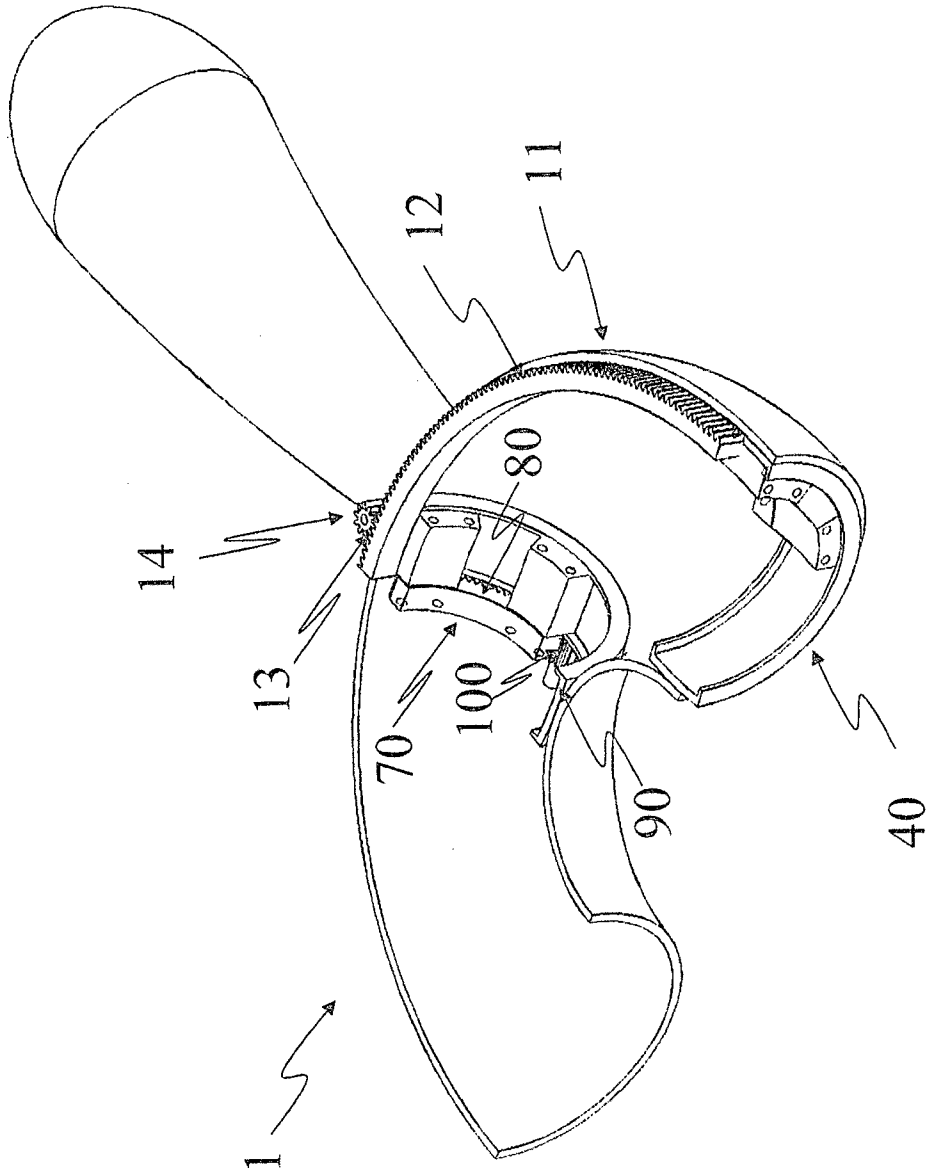
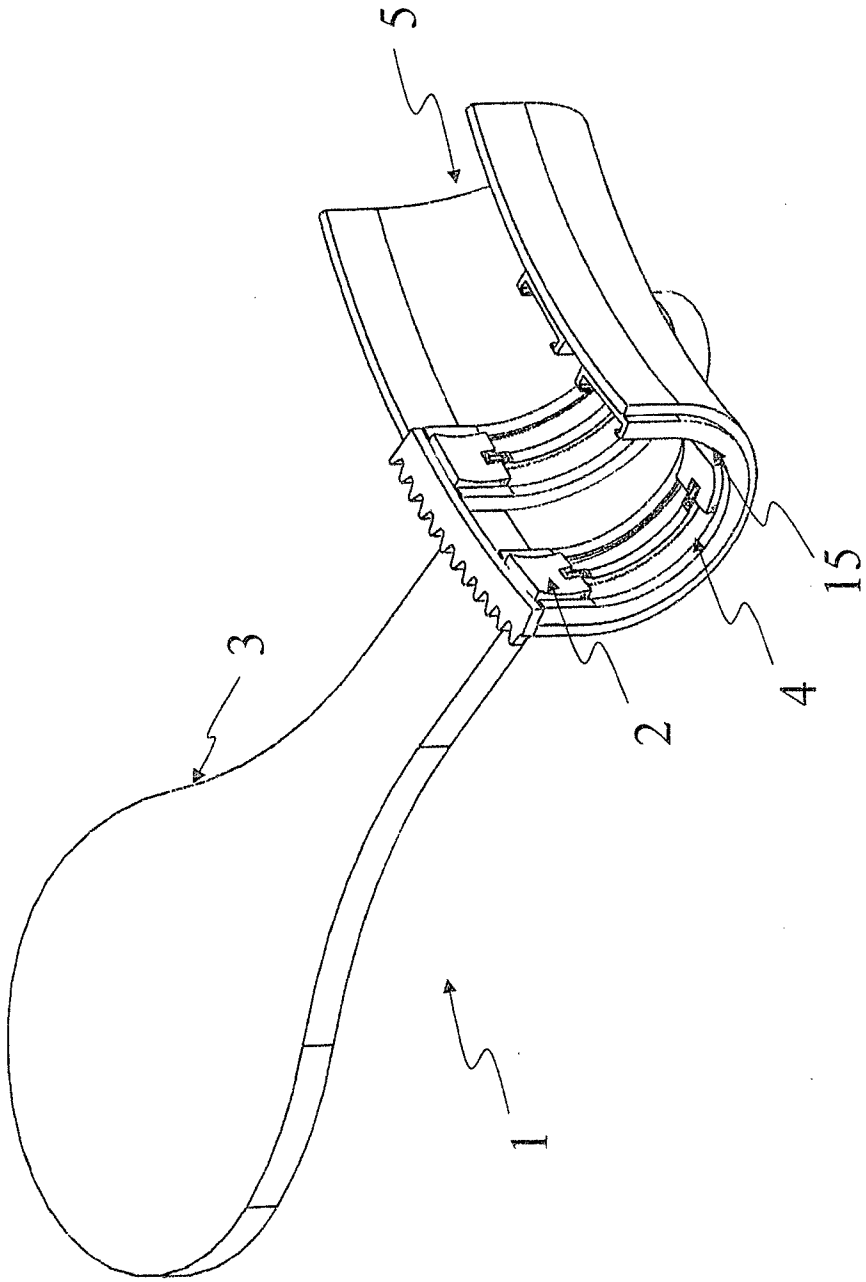


FIG. 2d

FIG. 3a



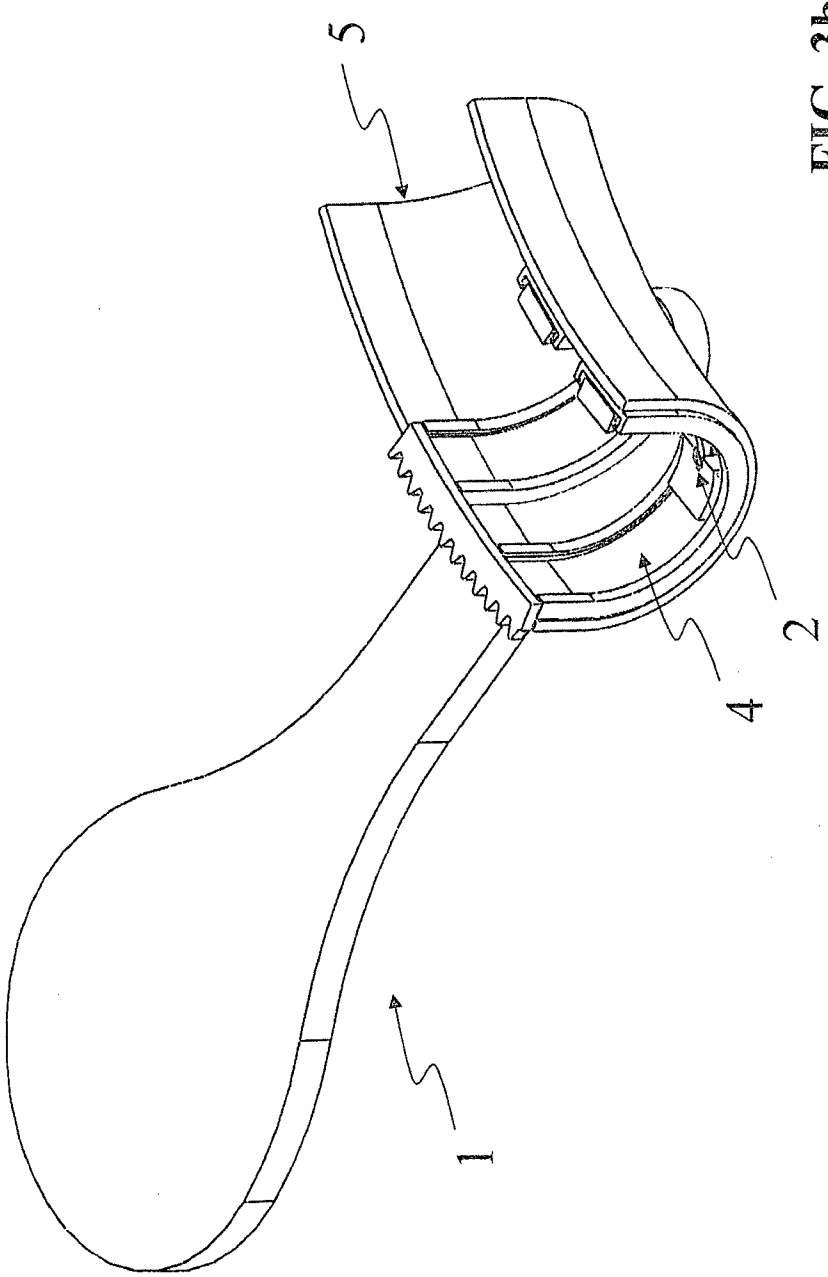


FIG. 3b

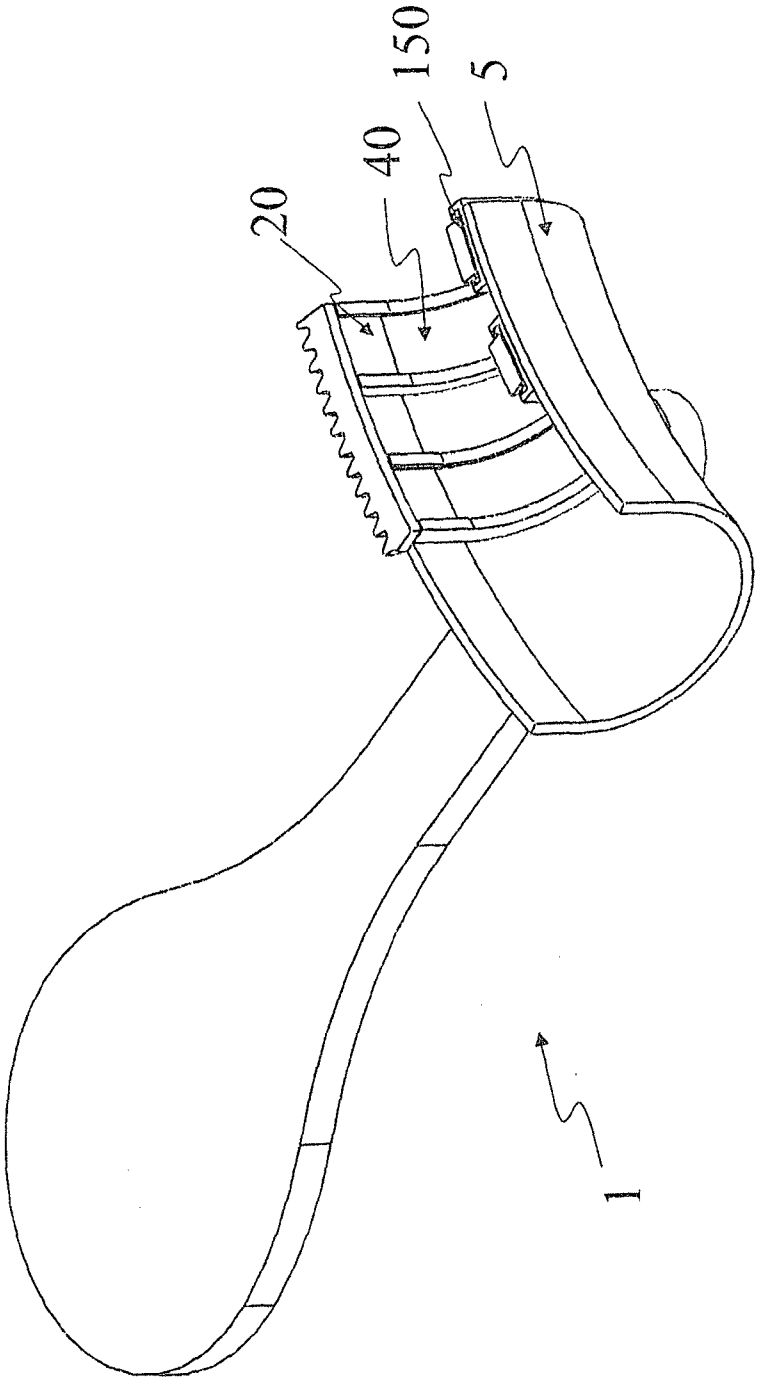


FIG. 3c

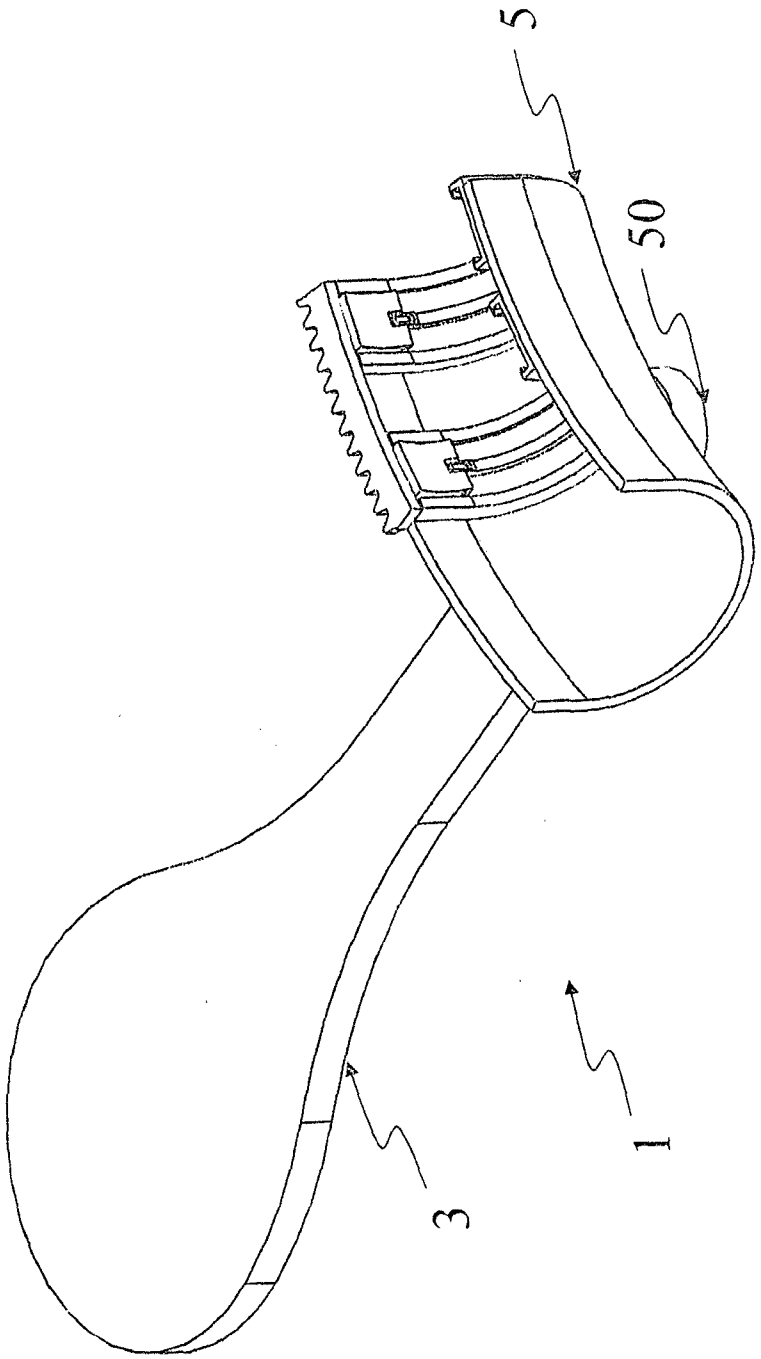


FIG. 3d

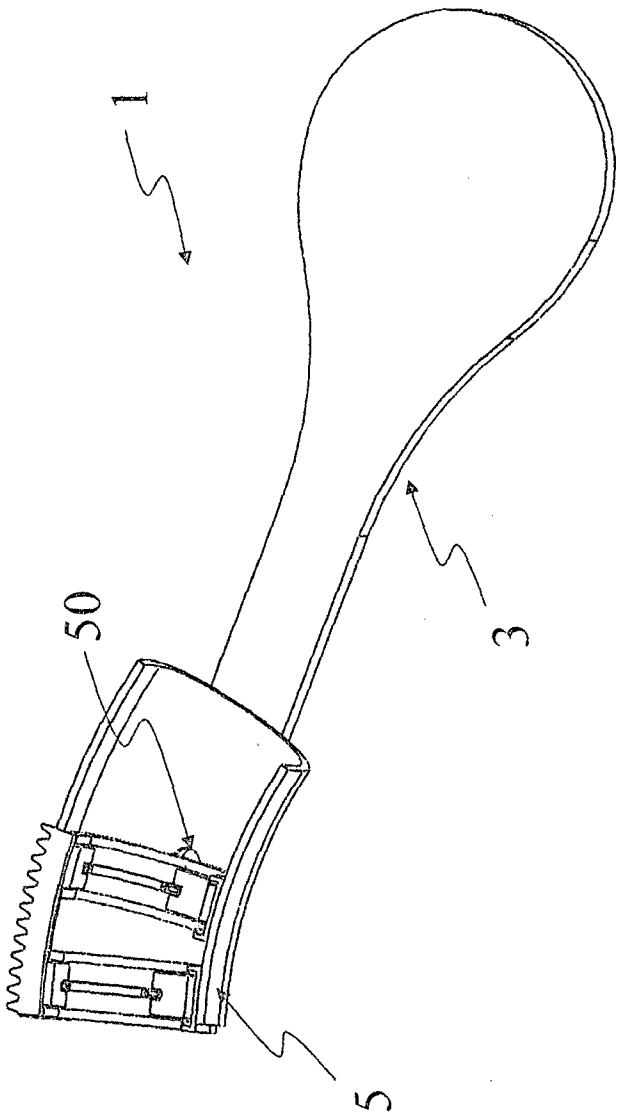
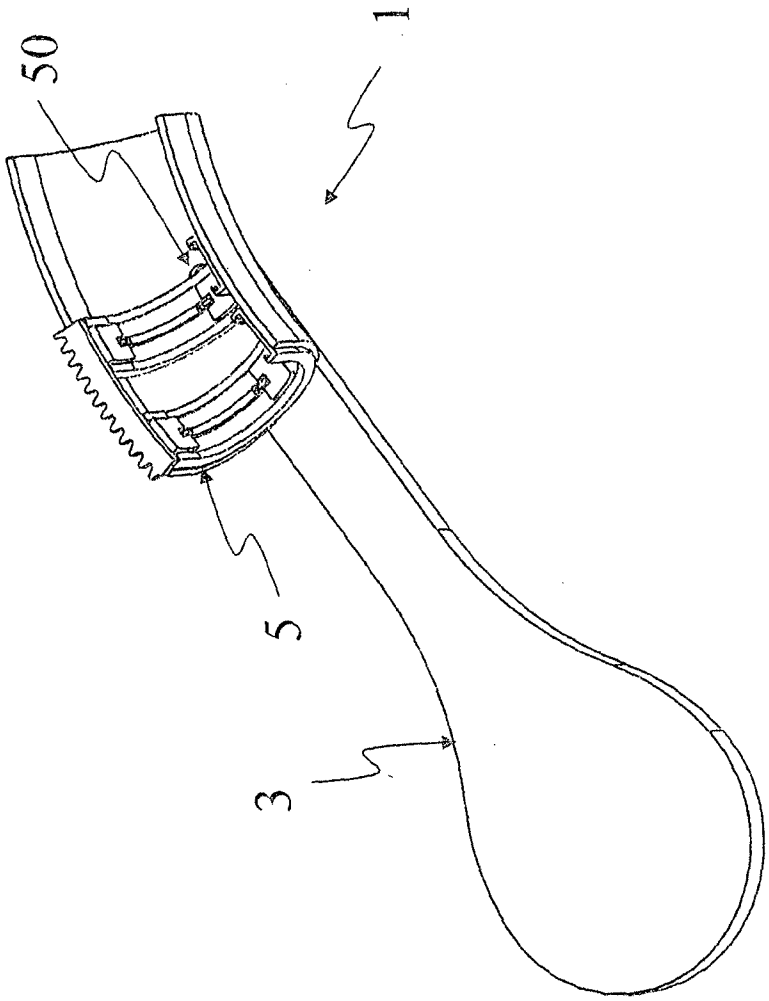


FIG. 3e

FIG. 3f



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/001376

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61C9/00 G01B11/24 A61B5/107
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 G01B A61B

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 2002/055082 A1 (DURBIN DUANE [US] ET AL) 9 May 2002 (2002-05-09) figures 1, 3, 8, 9 paragraphs [0039] - [0047], [0060]	1-4,12, 16-19, 21,22 13 6,7, 9-11,15
X	WO 2007/063980 A1 (TAKAHASHI ATSUSHI [JP]) 7 June 2007 (2007-06-07) the whole document	1,18
X	US 2006/154198 A1 (DURBIN DUANE [US] ET AL) 13 July 2006 (2006-07-13) figures 1-4 paragraphs [0018], [0020], [0028], [0052], [0089]	1,5,8, 14,18,20

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 March 2015	19/03/2015

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	Kerner, Bodo

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/001376

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2007 005726 A1 (SIRONA DENTAL SYSTEMS GMBH [DE]) 7 August 2008 (2008-08-07)	1,18
Y	figures 2, 3 paragraphs [0016], [0020], [0084], [0086]	13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2014/001376

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		DE 102007005726 A1	07-08-2008
		EP 2137489 A1	30-12-2009
		US 2009279103 A1	12-11-2009
		WO 2008092791 A1	07-08-2008