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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 January 2019 (10.01.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/008586 A1

(51) International Patent Classification:
A61C 9/00 (2006.01) *A61B 5/00* (2006.01)

(21) International Application Number:
PCT/IL2018/050731

(22) International Filing Date:
04 July 2018 (04.07.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/528,496 04 July 2017 (04.07.2017) US

(71) Applicant: **DENTLYTEC G.P.L. LTD** [IL/IL]; 14 Mintz Street, 6951217 Tel-Aviv (IL).

(72) Inventors: **PESACH, Benny**; 18 Shir HaShirim Street, 4807209 Rosh HaAyin (IL). **REUVENNY, Amitai**; 17 HaKalanit Street, Apt. 23, 4428058 Kfar-Saba (IL). **LEHR, Blanc Zach**; 6 Zeev Rechter Street, Apt. 20, 6955106 Tel-Aviv (IL). **GRAD, Ygael**; 14 Mintz Street, 6951217 Tel-Aviv (IL).

(74) Agent: **EHRLICH, Gal** et al.; G. E. EHRLICH (1995) LTD., 11 Menachem Begin Road, 5268104 Ramat Gan (IL).

(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.

WO 2019/008586 A1

(54) Title: DENTAL DEVICE WITH PROBE

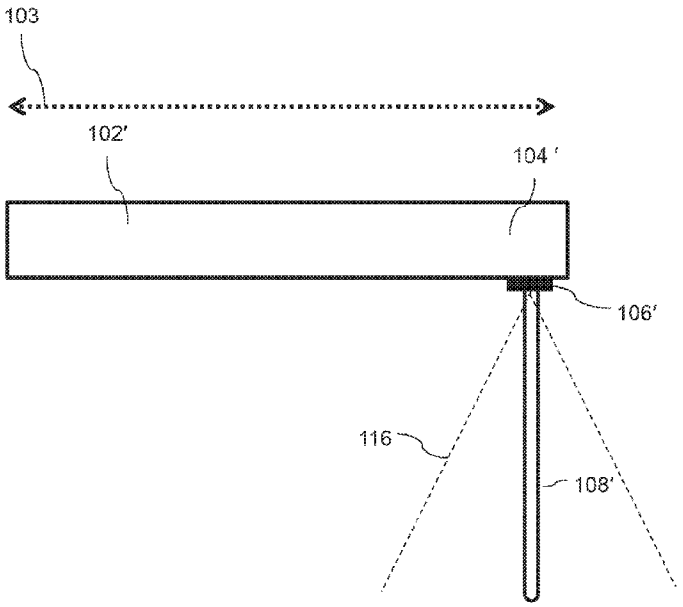


FIG. 1B

(57) Abstract: An intra oral scanner (IOS) including a probe is disclosed. Optionally, the probe is calibrated to measure locations at a higher accuracy than the IOS. For example, the probe may be used to locate points in a 3D map at high precision and/or the points used to increase the precision of location of other points and/or surfaces in the map. In some embodiments, the probe includes a sensor. Optionally, the probe may be used to measure locations that are hard to view with the IOS. For example, the IOS probe combination may be used to produce 3D maps of a recess in a tooth and/or gums and/or a periodontal pocket and/or to traduce a 3D map or periodontal disease. In some embodiments the probe may be used to measure physical properties, for example, the IOS probe combination may be used to produce a 3D image of hardness of mucosa.

[Continued on next page]

(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))*

DENTAL DEVICE WITH PROBE

RELATED APPLICATION/S

This application is a PCT application claiming priority from U.S. Provisional Application number 62/528,496 filed on 4 July 2017.

The contents of all of the above applications are incorporated by reference as if fully set forth herein.

FIELD AND BACKGROUND OF THE INVENTION

The present invention, in some embodiments thereof, relates to a dental probe, optionally provided as part of or an attachment for an intra oral scanner (IOS) and/or optionally providing imaging or sensing or other functionality.

SUMMARY OF THE INVENTION

According to an aspect of some embodiments of the invention, there is provided a method of making oral measurements, including: providing an IOS with an elongate probe extending therefrom; contacting a plurality of points inside the oral cavity with the probe, while scanning the cavity with the IOS; and determining a position of each of the plurality of points from the scanning, using the IOS scanning to determine a position in space of the elongate probe.

According to some embodiments of the invention, the accuracy of the determined position is more accurate than the position accuracy of point locations obtained by the IOS without the probe.

According to some embodiments of the invention, the method further includes: calculating a location of a surface using the determined positions.

According to some embodiments of the invention, the method further includes: calculating a measurement of a length using the determined positions.

According to some embodiments of the invention, the method further includes: calculating a position of a curved plane using the determined positions.

According to some embodiments of the invention, the determining includes determining positions of the points relative to each other.

According to some embodiments of the invention, the determining includes determining positions of the points relative to an oral feature.

According to some embodiments of the invention, the contacting includes contacting natural tissue.

According to some embodiments of the invention, the contacting includes contacting within a recess in the body.

According to some embodiments of the invention, the recess includes one of a socket of a tooth extraction, an excavated hole or groove or cavity in a bone, a drilled hole in a tooth, an excavated cavity in a tooth for an inlay, an excavated cavity in a tooth for an onlay, a grinding area in a tooth and a root of a tooth.

According to some embodiments of the invention, the method according further includes determining position of points which are located on areas which are difficult to be determined using IOS including at least one of a steep wall, an interproximal wall with a narrow interproximal gap, optionally a gap smaller or equal to than 2mm, a negative slope wall, a high reflectivity surface, a high absorbance surfaces, an obscured surface and a surface inside a recess.

According to some embodiments of the invention, the contacting includes contacting at least one point which is located on an area which is difficult to determined using IOS including at least one of a steep wall, an interproximal wall with a narrow interproximal gap, a negative slope wall, a high reflectivity surface, a high absorbance surfaces, an obscured surface and a surface inside a recess.

According to some embodiments of the invention, the recess is naturally formed or artificially formed in a bone, gum and/or a tooth.

According to some embodiments of the invention, the contacting includes contacting gum or other mucosal tissue.

According to some embodiments of the invention, the contacting includes inserting the probe through mucosal tissue to contact an underlying hard structure.

According to some embodiments of the invention, the contacting includes contacting gum is used for measuring gums thickness by comparing obtained 3D model to bone location in a CT 3D model.

According to some embodiments of the invention, the method includes measuring bone for an implant.

According to some embodiments of the invention, the contacting includes contacting tooth tissue.

According to some embodiments of the invention, the method includes measuring tooth abrasion or gaps between opposing teeth when a mouth is closed.

According to some embodiments of the invention, the method includes measuring gaps between opposing teeth when closed, for accurate closure mapping.

According to some embodiments of the invention, the method includes measuring a horizontal or vertical mismatch of a crown.

According to some embodiments of the invention, the method includes measuring the joint between a crown and a tooth to which it is attached.

According to some embodiments of the invention, the method includes measuring a tooth prepared for fitting of a crown.

According to some embodiments of the invention, the method includes estimating a mechanical or biomechanical property of the mechanical tissue by the contacting.

According to some embodiments of the invention, the mechanical property is one of tissue elasticity and tissue hardness.

According to some embodiments of the invention, the contacting includes contacting one or more artificially provided oral items.

According to some embodiments of the invention, the oral item includes a crown, a denture or an implant, brackets, laminates, esthetic elements, night guards, splints, surgical stents.

According to some embodiments of the invention, the method includes measuring a same intra-oral portion using the determining and the scanning, and improving an accuracy of a representation by the scanning using the determined positions.

According to some embodiments of the invention, the method includes using the scanning to generate a 3D reconstruction of an oral surface and identifying on the reconstruction one or more locations with a reduced accuracy and improving the accuracy using the determined positions.

According to an aspect of some embodiments of the invention, there is provided an iOS scanner, including: a body having a head; at least one imager suitable for intra-oral scanning from the head; and a hollow probe with an opening, the probe extending from the head and within a field of view of the at least one imager.

According to some embodiments of the invention, the scanner includes a channel extending from the probe to a source of pressurized material suitable for flowing through the channel and the probe to the opening.

According to some embodiments of the invention, the source includes water, abrasive material or adhesive.

According to some embodiments of the invention, the scanner includes a channel extending from the probe to a source of negative pressure.

According to some embodiments of the invention, the channel contains an optical fiber.

According to some embodiments of the invention, the fiber is coupled to a light source suitable for one or more of ablation, coagulation, tissue cutting, illumination and sending via the fiber.

According to some embodiments of the invention, the channel contains an electrical signal conductor.

According to some embodiments of the invention, the probe includes a tip and the IOS is used for determining a locations of the tip during a procedure.

According to some embodiments of the invention, the opening is on a side of the hollow probe.

According to some embodiments of the invention, the opening is at a distal end of the hollow probe and facing along an axis of the probe.

According to an aspect of some embodiments of the invention, there is provided a dental probe, including: a body having a head and a long dimension; at least one imager suitable for imaging in a lateral direction from the head; and a probe extending in a lateral direction from the head and within a field of view of the imager and including a side viewer.

According to some embodiments of the invention, the side-viewer includes a mirror which reflects light from a lateral direction towards the body with distortion low enough for imaging.

According to some embodiments of the invention, the viewer includes an ultrasonic distance sensor.

According to some embodiments of the invention, the viewer includes an ultrasonic imager.

According to some embodiments of the invention, the body (probe) includes a side viewing ultrasonic imager (IVUS).

According to some embodiments of the invention, the body (probe) includes a Piezoelectric Micromachined Ultrasound Transducer (PMUT) array.

According to some embodiments of the invention, the body includes a channel for dispensing acoustic coupling liquid.

According to some embodiments of the invention, the viewer includes an optical imager.

According to some embodiments of the invention, the viewer includes a 3D imager.

According to some embodiments of the invention, the viewer includes side viewing OCT or interference imager or sensor.

According to some embodiments of the invention, the body includes a plurality of mechanical contact sensors.

According to some embodiments of the invention, the side viewer includes a plurality of sensors, wherein a preferred sensor can be chosen according to local clinical conditions.

According to some embodiments of the invention, the local clinical condition includes at least one of bleeding, fluids, gums, biotype of the gums, flexibility, finish line coverage.

According to some embodiments of the invention, probe includes ultrasonic scaler, and where the imager is configured to determine if all the plaque was removed.

According to an aspect of some embodiments of the invention, there is provided an iOS scanner, including: a body having a head; at least one imager suitable for intra-oral scanning; and a probe designed for easy replacement.

In some embodiments the probe is detachably connected to the IOS body or to the IOS head, with a connection designed for quick release. In some embodiments the quick release is optionally performed using a tool. In some embodiments the quick release is optionally performed using a tool typically found in a dentist tool kit, by way of a non-limiting example using forceps.

According to an aspect of some embodiments of the invention, there is provided an iOS scanner, including: a body having a head; at least one imager suitable for intra-oral scanning; and a probe designed for easy movement along an intra-oral surface.

In some embodiments the probe includes a tip with a ball at the tip, potentially implementing a rolling ball tip. In some embodiments the ball is a stainless steel ball, or a plastic ball constructed of phenolics, acetals, Teflon (PTFE), ultra high molecular weight polyethylene (UHMWPE), and/or nylon.

In some embodiments the probe includes a tip shaped for easy movement along an intra-oral surface. In some embodiments the tip of the probe is rounded.

In some embodiments the probe includes a tip including a material selected for easy movement along an intra-oral surface. In some embodiments the tip of the probe includes stainless steel, or a plastic such as phenolics, acetals, Teflon (PTFE), ultra high molecular weight polyethylene (UHMWPE), and/or nylon.

According to an aspect of some embodiments of the invention, there are provided method for using an iOS scanner and a probe for producing a model of insides of a mouth.

In some embodiments gingiva is optionally scanned, and a three dimensional shape of gingiva is optionally calculated. In some embodiments a three-dimensional (3D) model is optionally produced.

In some embodiments an abutment is optionally scanned. In some embodiments the abutment is scanned inside the oral cavity. In some embodiments the abutment is scanned separately from a scan of the oral cavity.

In some embodiments the 3D model is made to combine a model of the oral cavity and a model of the abutment.

In some embodiments the 3D model is optionally used to design a custom abutment, which is optionally shaped according to the gingiva shape.

In some embodiments the 3D model is optionally used to measure parameters of a dental implant. The parameters optionally include a location of a dental implant within an oral cavity, an orientation of the dental implant, a shape of the dental implant, and similar geometric parameters, optionally relative to adjacent teeth and/or relative to a jaw bone and/or relative to gums.

In some embodiments the measurement is optionally done using a number of known point locations on an implant or in the oral cavity.

In some embodiments the measurement is optionally done using a known location of the probe or of a tip of the probe relative to the scanner. In some embodiments the location of the probe or of the tip of the probe relative to the scanner is optionally saved during scanning. By way of a non-limiting example, replacement probes may optionally have different shapes and/or sizes, and scanning the probes provides known locations based on knowing shapes and/or sizes of the probes.

In some embodiments the number of points is selected to enable determining a specific shape of an implant which are enough to determine the parameters due to the implant's shape.

In some embodiments measurement of the implant is optionally done even in presence of blood covering some or all of the implant, for example after implant insertion into bone or after opening covering gingiva to expose the implant.

In some embodiments detection and/or location and/or measurement of the implant is optionally performed using a metal detecting component in the IOS device and/or the probe.

In some embodiments measurement or measurements are made of a hole or holes in the oral cavity. In some embodiments the measurement(s) include one or more of depth, width, diameter, shape and inside threading of the hole(s).

In some embodiments the measurement(s) are optionally made by inserting the probe into the hole.

According to an aspect of some embodiments of the present invention there is provided an oral measuring method configured to make oral measurement within the oral cavity of a patient including providing an Intra Oral Scanner (IOS) with an elongate probe extending therefrom,

contacting a plurality of first points inside an oral cavity with the probe while scanning the cavity with the IOS, and determining a position of each of the plurality of first points based on the scanning to determine a position in space of the elongate probe.

According to some embodiments of the invention, further including calculating at least one of a location of a surface using the determined positions, a measurement of a length using the determined positions, and a position of a curved plane using the determined positions.

According to some embodiments of the invention, the determining includes determining positions of the points relative to an oral feature.

According to some embodiments of the invention, further including using the probe to collect data on periodontal health, producing a 3D model of the oral cavity, and automatically generating a periodontal chart.

According to some embodiments of the invention, further including using the elongate body to measure periodontal pocket depth, automatically generating a personalized periodontal chart that includes at least one of a map of clinical attachment level, a location of a cement to enamel junction, a mucogingival line, a periodontal conditions, an area of decay, a tooth cavity, a missing tooth, a depth of a gum pocket, a bleeding point discovered during probing, gum recession, an abnormality in a tooth, a 2D image of a tooth, and a 3D image of a tooth.

According to some embodiments of the invention, the contacting includes contacting within a recess of a tissue(s), a tooth(teeth), and a bone(s) within or proximate to the oral cavity.

According to some embodiments of the invention, the contacting includes contacting within a recess, and wherein the recess includes one of a socket of a tooth extraction, an excavated hole in a bone, a drilled hole in a tooth, an excavated cavity in a tooth for an inlay, an excavated cavity in a tooth for an onlay, and a root of a tooth.

According to some embodiments of the invention, further including determining a position of second points which are located on at least one of a steep wall, an interproximal wall with a narrow interproximal gap, a negative slope wall, a high reflectivity surface, a high absorbance surfaces, an obscured surface and a surface inside a recess.

According to some embodiments of the invention, the contacting includes contacting at least one point which is located on at least one of a steep wall, an interproximal wall with a narrow interproximal gap, a negative slope wall, a high reflectivity surface, a high absorbance surfaces, an obscured surface and a surface inside a recess.

According to some embodiments of the invention, the first plurality of points include gum or other mucosal tissue.

According to some embodiments of the invention, the contacting includes inserting the probe through mucosal tissue to contact an underlying tooth, implant or bone structure.

According to some embodiments of the invention, the plurality of first points include gum tissue, and wherein the method further includes determining gum thickness by creating a 3D model based on the determining step and comparing the 3D model to bone location in a CT 3D model.

According to some embodiments of the invention, the plurality of first points include points on tooth tissue.

According to some embodiments of the invention, further including measuring at least one of tooth abrasion and gaps between opposing teeth when a mouth is closed based upon the positions of the plurality of first points.

According to some embodiments of the invention, further including measuring a horizontal or vertical mismatch of a crown based upon the positions of the plurality of first points.

According to some embodiments of the invention, further including measuring the joint between a crown and a tooth to which it is attached based upon the positions of the plurality of first points.

According to some embodiments of the invention, further including measuring a tooth prepared for fitting of a crown based upon the positions of the plurality of first points.

According to some embodiments of the invention, further including estimating a mechanical property of a mechanical tissue by the contacting.

According to some embodiments of the invention, the mechanical property is at least one of tissue elasticity and tissue hardness.

According to some embodiments of the invention, the plurality of points includes points along artificially provided oral items.

According to some embodiments of the invention, the oral item includes a crown, a denture or an implant, brackets, laminates, esthetic elements, night guards, splints.

According to some embodiments of the invention, further including conducting a secondary scanning and determining positions of the first plurality of points so as to determine a refined determined position of the first plurality of points.

According to some embodiments of the invention, further including using the scanning to generate a 3D reconstruction of an oral surface, and identifying, on the reconstruction, one or more locations of one or more of the plurality of first positions having reduced accuracy.

According to an aspect of some embodiments of the present invention there is provided an IOS scanner, including a body having a head, at least one imager suitable for intra-oral scanning from the head, and a hollow probe with an opening, the probe extending from the head and within a field of view of the at least one imager.

According to some embodiments of the invention, further including a channel extending from the probe to a source of pressurized material suitable for flowing through the channel and the probe to the opening.

According to some embodiments of the invention, the source includes water, abrasive material or adhesive.

According to some embodiments of the invention, including a channel extending from the probe to a source of negative pressure.

According to some embodiments of the invention, including a channel extending from the probe to the opening, wherein the channel contains an optical fiber.

According to some embodiments of the invention, the fiber is coupled to a light source suitable for one or more of ablation, coagulation, tissue cutting, illumination and sending via the fiber.

According to some embodiments of the invention, including a channel extending from the probe to the opening, wherein the channel contains an electrical signal conductor.

According to some embodiments of the invention, the probe includes a tip and the IOS is configured for determining a location of the tip during a procedure.

According to some embodiments of the invention, the opening is on a side of the hollow probe.

According to some embodiments of the invention, the opening is at a distal end of the hollow probe and facing along an axis of the probe.

According to an aspect of some embodiments of the present invention there is provided a dental probe, including a body having a head, the body elongated in a first direction, at least one imager configured for imaging in a second direction different from the first direction, and a probe extending in the second direction and within a field of view of the imager and including a viewer.

According to some embodiments of the invention, the probe is configured for quick release from the body.

According to some embodiments of the invention, the quick release is configured for releasing using a standard dentist tool.

According to some embodiments of the invention, the viewer includes a mirror which reflects light towards the body with distortion low enough for imaging.

According to some embodiments of the invention, the viewer includes an ultrasonic distance sensor.

According to some embodiments of the invention, the viewer includes an ultrasonic imager.

According to some embodiments of the invention, the body (probe) includes a side viewing ultrasonic imager (IVUS).

According to some embodiments of the invention, the body (probe) includes a Piezoelectric Micromachined Ultrasound Transducer (PMUT) array.

According to some embodiments of the invention, the body includes a channel for dispensing acoustic coupling liquid.

According to some embodiments of the invention, the viewer includes an optical imager.

According to some embodiments of the invention, the viewer includes a 3D imager.

According to some embodiments of the invention, the viewer includes side viewing OCT or interference imager or sensor.

According to some embodiments of the invention, the body includes a mechanical contact sensor.

According to some embodiments of the invention, the viewer includes a plurality of sensors, wherein a preferred sensor can be chosen according to local clinical conditions.

According to some embodiments of the invention, a tip of the probe includes at least one of a structure and a material configured for gliding along a surface when the tip contacts the surface with limited to negligible friction.

According to some embodiments of the invention, a tip of the probe includes a ball for rolling along a surface when the tip contacts the surface.

According to some embodiments of the invention, wherein, probe includes an ultrasonic scaler, and where the imager is configured to determine if plaque was removed.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

As will be appreciated by one skilled in the art, some embodiments of the present invention may be embodied as a system, method or computer program product. Accordingly,

some embodiments of the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, some embodiments of the present invention may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon. Implementation of the method and/or system of some embodiments of the invention can involve performing and/or completing selected tasks manually, automatically, or a combination thereof. Moreover, according to actual instrumentation and equipment of some embodiments of the method and/or system of the invention, several selected tasks could be implemented by hardware, by software or by firmware and/or by a combination thereof, e.g., using an operating system.

For example, hardware for performing selected tasks according to some embodiments of the invention could be implemented as a chip or a circuit. As software, selected tasks according to some embodiments of the invention could be implemented as a plurality of software instructions being executed by a computer using any suitable operating system. In an exemplary embodiment of the invention, one or more tasks according to some exemplary embodiments of method and/or system as described herein are performed by a data processor, such as a computing platform for executing a plurality of instructions. Optionally, the data processor includes a volatile memory for storing instructions and/or data and/or a non-volatile storage, for example, a magnetic hard-disk and/or removable media, for storing instructions and/or data. Optionally, a network connection is provided as well. A display and/or a user input device such as a keyboard or mouse are optionally provided as well.

Any combination of one or more computer readable medium(s) may be utilized for some embodiments of the invention. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this

document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

Program code embodied on a computer readable medium and/or data used thereby may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

Computer program code for carrying out operations for some embodiments of the present invention may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

Some embodiments of the present invention may be described below with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

Some of the methods described herein are generally designed only for use by a computer, and may not be feasible or practical for performing purely manually, by a human expert. A human expert who wanted to manually perform similar tasks, such as 3D reconstruction, might be expected to use completely different methods, e.g., making use of expert knowledge and/or the pattern recognition capabilities of the human brain, which would be vastly more efficient than manually going through the steps of the methods described herein.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

FIG. 1A is a block diagram showing of an IOS including a laterally extending probe, in accordance with some embodiments of the invention;

FIG. 1B is a schematic showing of an IOS including a laterally extending probe, in accordance with some embodiments of the invention;

FIG. 2A is a block diagram of an IOS having a probe attachment mounted thereon, in accordance with some exemplary embodiments of the invention;

FIG. 2B is a schematic showing of an IOS configured to attach a probe thereon, in accordance with some exemplary embodiments of the invention;

FIG. 2C is a block diagram showing of an IOS having a laterally extending probe with a sensor, in accordance with some exemplary embodiments of the invention;

FIG. 2D is a block diagram showing of an IOS having a laterally extending probe with a channel, in accordance with some exemplary embodiments of the invention;

FIG. 2E is a schematic showing of an IOS having a laterally extending probe with an affector, in accordance with some exemplary embodiments of the invention;

FIGs. 3A-3C are schematic showings of IOS including a laterally extending imaging or sensing probe, in accordance with some embodiments of the invention;

FIGs. 3D-3F are schematic showings of IOS including a laterally extending pressure sensing probe, in accordance with some embodiments of the invention;

FIGs. 4A-4C are schematic showings of IOS including a laterally extending probe having a reflector in a field of view of the IOS, in accordance with some embodiments of the invention;

FIGs. 5A-5B are schematics showings of IOS including a laterally extending probe having a channel therein, in accordance with some embodiments of the invention;

FIG. 6 is a schematic showing of IOS including a laterally extending probe having an affector, in accordance with some embodiments of the invention;

FIG. 7A is a schematic showing of IOS including a telescopic probe, in accordance with some embodiments of the invention;

FIG. 7B is a schematic showing a probe with a tip designed for smooth or gliding movement along an oral surface in accordance with some embodiments of the invention;

FIGs. 7C and 7D are schematics showing an option for release of a probe from an IOS, in accordance with some embodiments of the invention;

FIG. 7E is an image of an optional tool for release of a probe from an IOS, in accordance with some embodiments of the invention;

FIG. 7F is a schematic showing a sleeve with a probe that is placed over an IOS, in accordance with some embodiments of the invention;

FIG. 7G is a schematic showing a probe with a tip including a ball designed for smooth movement along an oral surface in accordance with some embodiments of the invention.

FIGs. 8A-8K are schematic drawings showing various dental structures which may be measured using an IOS and a probe in accordance with some embodiments of the invention;

FIG. 8L is a simplified illustration of an IOS measuring gingiva surrounding a dental implant in accordance with some embodiments of the invention;

FIGs. 8M and 8N are simplified illustrations of an IOS measuring parameters of a dental implant in accordance with some embodiments of the invention;

FIG. 8O is a simplified illustration of an IOS measuring a hole made by a drill in accordance with some embodiments of the invention;

FIG. 8P is a simplified illustration of an IOS measuring parameters of a dental implant in accordance with some embodiments of the invention.

FIG. 9 is a flowchart of a method of improving IOS mapping accuracy, in accordance with some embodiments of the invention;

FIG. 10 is a flowchart of a method of intraoral mapping for an artificial object, in accordance with some embodiments of the invention;

FIG. 11 is a flowchart of a method of intraoral mapping a recess, in accordance with some embodiments of the invention;

FIG. 12A is a flowchart of a method of intraoral mapping of soft tissue, in accordance with some embodiments of the invention;

FIG. 12B is a simplified illustration of a probe used as a feature in an IOS scan in accordance with some embodiments of the invention;

FIG. 13A is a flowchart of a method of intraoral mapping of a periodontal pocket, in accordance with some embodiments of the invention;

FIG. 13B is a schematic showing of a side-looking IOS in a periodontal pocket, in accordance with some embodiments of the invention;

FIG. 14 is a portion of a chart display optionally provided by periodontal imaging, in accordance with some embodiments of the invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to a dental probe, optionally provided as part of or an attachment for an intra oral scanner (IOS) and/or optionally providing imaging or sensing or other functionality.

An aspect of some embodiments of the invention relates to an IOS with a laterally extending probe, integral or add-on. In some exemplary embodiments of the invention, the probe is within a field of view of the IOS imager. In some exemplary embodiments of the invention, the probe is used to contact an intraoral surface for providing geometrical or other measurement thereof. In some exemplary embodiments of the invention, a mapping by the IOS is improved by said contact. Optionally or alternatively, the probe contact is used to detect surface properties other than geometry relative to the IOS, for example, tissue stiffness.

In some embodiments, a probe may have an average width (e.g. diameter) ranging between 0.1 to 0.5 mm and/or between 0.5 to 1.0 mm and/or between 1 to 2 mm and/or between 2 to 4 mm.

In some exemplary embodiments of the invention, the probe is used to measure one or more of a tooth extraction socket, a drilled socket, a soft tissue surface, a bone surface under soft tissue, a dental implant, a tooth, space between teeth, periodontal pocket, a sub-gingival section of a tooth, a dental abrasion pattern and or a recess in a tooth. Optionally, the measured space is measurable using the IOS, and the probe provides enhanced resolution. Optionally or alternatively, the probe is used to measure surfaces that are not measurable using the IOS, for example, due to field of view limitations thereof.

In some exemplary embodiments of the invention, the probe laterally extends, for example, at an angle of between 30 and 150 degrees relative to an axis of a handle of the IOS.

In some exemplary embodiments of the invention, the probe includes an imager, for example, an ultrasound imager (for example a side viewing ultrasonic imager (IVUS) or a Piezoelectric Micromachined Ultrasound Transducer (PMUT) array)), a sensor, for example, an ultrasound sensor or stain sensor and/or a mirror, for example, reflecting a view lateral to the probe to an imager of the IOS.

In some exemplary embodiments of the invention, the probe includes an effector, for example, a tool for tissue ablation or coagulation.

In some exemplary embodiments of the invention, the probe includes a channel, for example, for providing a fluid or removing fluid. Optionally, the channel is connected to a reservoir and/or a source, for example, of cement or sterilizing fluid. In some embodiments a channel may have an average cross sectional area along the probe ranging between 0.01 mm^2 to 0.1 mm^2 and/or between 0.1 mm^2 to 0.25 mm^2 and/or between 0.25 mm^2 to 1. mm^2 and/or between 1 mm^2 to 25 mm^2. Optionally the channel may take up between 1% to 10% and/or between 10% to 30% and/or between 30% to 60% and/or between 60% to 90% of the probe.

In some embodiments, IOS location measurement uncertainty will be reduced by between 50 to 90%. For example an IOS scanner may have a measurement error of less than 40 μm and/or a location of a feature at a probe tip may be measured with an error of less than 10 μm and/or 5 μm and/or less than 2 μm. One or more points of high accuracy measurements may be used to condition measurements in other locations to decrease measurement uncertainty in regions of the domain where the probe tip was not used for a direct measurement. For example, conditioning on accurately measured points, the error in a region may be reduced to below 5 μm and/or below 10

μm and/or below 20 μm and/or below 30 μm. For example, conditioning may be used to improve the accuracy of a depth mapped image.

An aspect of some embodiments of the invention relates to measurement of intraoral surfaces using an IOS having a laterally extending probe. In some exemplary embodiments of the invention, the probe tip is atraumatic. Optionally, the IOS is used to position the probe in a 3D representation of the oral cavity or apportion thereof.

In some exemplary embodiments of the invention, the IOS is used to measure one or more of mucosa, artificial objects (on their own, relative to each other, orientation, and/or relative to natural tissues and/or natural objects of various types), shapes of cavities (e.g., natural, artificial or resulting from tissue extraction), implant shapes, prosthesis shapes, shapes of surfaces that mate with prostheses (e.g., for bone onlay and/or supra-contact).

In some exemplary embodiments of the invention, measurement is used to determine one or more of teeth closure, abrasion patterns, plaque, post crown inaccuracy and/or root apex depth.

In some exemplary embodiments of the invention, the probe tip penetrates the gums and can be used to measure gum thickness by comparing pre- and post- penetration positions.

In some exemplary embodiments of the invention, the probe tip is used to sense non-geometrical properties, for example, elasticity (e.g., using a strain sensor) and/or color (e.g., using an optical detector). In some embodiments, the probe will be used to exert pressure on an object. Optionally, the IOS may collect data about the movement of the object and/or tissue and/or teeth due to forces exerted by the probe.

An aspect of some embodiments of the invention relates to measurement of intraoral surfaces using both IOS-based photometrics and using contact measurement. Optionally, the two measurements are combined to yield a higher accuracy, for example, a better resolution and/or better coverage of areas difficult to measure using only photometrics. Alternatively or additionally, a probe may include a fiducial marker. Optionally, a probe tip may include a sensor. For example the probe tip may include an imager and/or a linear measurement sensor (for example a laser range finder and/or an ultrasound range finder). Optionally the probe tip sensor may augment IOS measurements in areas that are difficult to measure with a conventional IOS sensor, for example, inside a recess and/or between teeth and/or in an area angled away from the sensor and/or in an obscured area.

In some exemplary embodiments of the invention, a same measurement tool is used both intraorally and on objects outside of the mouth, for example, a yet-to-be deployed prosthesis.

In some exemplary embodiments of the invention, intra-oral features are used to identify a location in a model or an image or a scan of a mouth.

In some exemplary embodiments of the invention, a location of a probe connected to the IOS is used to identify a location in a model or an image or a scan of a mouth relative to the IOS.

In some exemplary embodiments of the invention, a tip of a probe connected to the IOS is used to identify a location in a model or an image or a scan of a mouth relative to the IOS.

An aspect of some embodiments of the invention relates to augmenting an IOS with tools for treating tissue and/or assisting in dental treatment. In some exemplary embodiments of the invention, the IOS includes a laterally extending probe which includes one or more longitudinal channels for passage of materials to, from and/or within the intraoral cavity and optionally having an opening at the side and/or tip of the probe. For example, one or more of water, abrasive materials, adhesive materials, and/or filler materials may be provided via such a channel. Optionally or alternatively, the channel is connected to a suction source for material removal.

In some exemplary embodiments of the invention, such a channel includes an optical fiber for providing therapeutic and/or imaging light.

An aspect of some embodiments of the invention relates to an IOS having a laterally extending probe which supports side viewing. In some exemplary embodiments of the invention, the probe includes a mirror which reflects light towards an IOS imager component. Optionally or alternatively, the probe includes one or more optical or ultrasonic sensor or imager. Optionally, the imager is a 3D imager and/or software for reconstructing a 3D image form moving imagers is provided at a control station. Optionally a sensor may include an optical coherence tomography OCT system, for example to image areas below the surface of tissue.

An aspect of some embodiments of the invention relates to a probe may be used in evaluation and/or treatment of periodontal conditions. For example, a probe may be used to measure periodontal pocket depths. Alternatively or additionally, a probe with a sensor may be used to measure a periodontal condition. For example, the probe and/or the sensor may be inserted into a periodontal pocket. For example, the sensor may sense color. For example, a sensor may be used to identify a cemental enamel junction and/or bleeding and/or inflammation. Alternatively or additionally a probe may include a source of ultraviolet light and/or measure fluorescence, for example, to measure subgingival plaque.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details of construction and the arrangement of the components and/or methods set forth in the following description and/or illustrated in the drawings and/or the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

Exemplary IOS with laterally extending probe

Referring now to the drawings, Fig. 1A is a block diagram showing of an IOS including a laterally extending probe, in accordance with some embodiments of the invention. In some embodiment the probe includes an IOS imager **106** mounted on a head **104** of the device. For example head **104** may be mounted on a handle **102**. Optionally, a laterally extending probe **108** is attached to head **104**. In some embodiments, the tip of probe **108** is in the field of view (FOV) of imager **106** (for example in Fig. 1B a probe **108'** is shown in a FOV **116** of an imager **106'**). Optionally, the 3D position of the tip of probe **108** with respect to imager may be known to a high accuracy. Alternatively or additionally, the tip of probe **108** may include a fiducial marker. For example, markings on probe **108** and/or a size of the tip may be used in estimating location and/or distance to an object and/or size of the object. For example, the size and/or position of the tip of probe **108** may be known with an error of less than 5 μm.

In some embodiments, a probe may be made of stainless steel and/or another metal and/or plastic. Optionally the tip of the probe may be sharp. Alternatively or additionally, the tip may be rounded and/or blunt and/or include a widening. For example the widening may have width between 1 to 5 mm and/or between 5 to 10 mm and/or between 10 to 20 mm and/or between 20 to 30 mm.

In some embodiments, an IOS may include a handle. For example, the handle may be easily griped for example having a width of between 0.5 cm to 5 cm. Optionally, head **104** is sized for movement inside a mouth, for example a human mouth. Optionally the head has dimensions between 0.5 to 3 cm. For example, a user may manipulate handle **102** to scan the mouth with head **104** and/or probe **108**.

In some embodiments, imager **106** has a high enough resolution to produce depth mapped images and/or an STL file mapping 3D features of an oral cavity with an error of less than 30 μm and/or less than 100 μm and/or less than 10 μm. Optionally, imager **106** includes a light source. For example, the light source may include a structured light and/or a coherent light.

In some embodiments, probe **108** is used to increase the accuracy of an IOS image and/or a STL mapping made from the image. Alternatively or additionally, having probe **108** on a scanner may save time of a dentist by facilitating producing an IOS scan while the dentist probes, checks and/or treats dental conditions. Optionally, the IOS will produce a hard record of the procedure. For example, the record may be used for evaluating and/or training of dentists. Additionally or alternatively, the record may be useful to as evidence in cases of malpractice and/or for evaluating the efficacy of interventions and/or improvements therein. Additionally or

alternatively, the record may be used to evaluate progress of a procedure and/or condition and/or plan follow up. Alternatively or additionally, probe **108** may have functions that improve imaging, for example of difficult to sight surfaces (for example smooth and/or low reflectivity surfaces and/or surfaces that are obscured and/or located in a position which is difficult to reach at a good imaging pose).

Fig. 1B is a schematic diagram showing of an IOS including a laterally extending probe **108′**, in accordance with some embodiments of the invention. For example, a handle **102′** and a head **104′** may have a long axis **103**. Optionally probe **108′** is straight. Alternatively or additionally, a probe may be curved. For example, probe **108′** is mounted perpendicular to axis **103**. Alternatively or additionally, probe **108′** is mounted at an angle between 45 to 135 degrees to axis **103**.

Fig. 2A is a block diagram showing of an IOS having a probe attachment mounted thereon, in accordance with some exemplary embodiments of the invention. In some embodiments, an IOS scanner may include a mount **210** for attaching a probe attachment **208**. For example, mount **210** may include a snap in mount and/or a screw in mount and/or a protrusion and/or a locking switch and/or a locking pin and/or a tightening element (for example a screw).

In some embodiments an IOS with a detachable probe **208** may include a calibration procedure to determine the position and/or size of the tip of probe **208**. Optionally, probe **208** may be part of a exchangeable set of tools that may serve different functions and/or may have different shapes and/or sizes for example for patients having larger and/or smaller mouths and/or whose teeth are looser and/or tighter. Optionally, the IOS may be used with probe **208** unattached for conventional IOS scanning and/or with probe **208** attached for scanning and/or other functions using probe **208**.

Fig. 2B is a schematic diagram showing of an IOS having a probe attachment mountable thereon, in accordance with some exemplary embodiments of the invention. For example, the IOS includes a threaded mount **210′**. Mount **210′** secures one of a plurality of different probes for example a straight probe **208′** and/or a bent probe **208″**. For example, thread **225** of the probe **208′**, **208″** may connect to the mount **201′**

In some embodiments, a probe **208′,** of a first shape may be used for one part of the mouth while a probe **208″** of a second shape may be used for a different part of the mouth. For example, a straight probe **208** may be used for the facial side of front teeth while an angled probe **′, 208″** may be used for the lingual side. Optionally, changing the probe will allow use of the IOS with the probe to scan an entire mouth.

Fig. 2C is a block diagram showing of an IOS having a probe **108** with a sensor **212** thereon, in accordance with some exemplary embodiments of the invention. For example, a probe mounted sensor **212** may be used to image and/or measure a region that is not accessible to the IOS sensor **106**. Alternatively or additionally a probe mounted sensor **212** may be used to monitor progress of an intervention.

In some embodiments, a probe mounted sensor **212** includes an imager and/or a range finder. In some embodiments, an imager may include an ultrasound imager an optical imager (for example a monochrome imager and/or a multi-color imager and/or an ultraviolet UV imager and/or an infrared IR imager and/or an OCT imager). Optionally, a probe mounted imager may be used along with imager **106** of the IOS to make a stereoscopic and/or 3D image of an object (for example the two imagers may have overlapping fields of view). In some embodiments, a range finder may include a laser range finder and/or an ultrasonic range finder.

In some embodiments, a probe mounted sensor **212** may include a force sensor. For example, force on a probe **108** may be measured by a pressure sensor for example near the probe **108** tip. Alternatively or additionally, force on a probe may be measured by a strain sensor for example on a shank of probe **108**. Alternatively or additionally, a force sensor may be located at the joint between the probe and head **104**. Alternatively or additionally pressure on a probe may be estimated by measuring deformation (e.g. elastic bending) of the probe. For example, deformation may be evaluated from images produced by the IOS. For example, a force sensor may be used to evaluate the stiffness of a structure (for example a tooth and/or a bone) and/or the softness of a structure (for example gums and/or mucosa). For example, softness may be evaluated by correlating deformation of the tissue with the force applied.

Fig. 2D is a block diagram showing of an IOS having a lateral probe **108** including a channel **214**, in accordance with some exemplary embodiments of the invention. Optionally a channel **214** is hollow and/or connected to a reservoir **213**. For example, fluid in reservoir **213** may be to introduce into a zone being mapped by the IOS and/or explored with probe **108**. For example, a drug may be introduced to treat a condition and/or reduce pain. Alternatively, a cleaning fluid (for example water) may be introduced through channel **214**. Alternatively or additionally an abrasive compound may be introduced through channel **214**, for example for polishing and/or grinding oral features. Alternatively or additionally channel **214** may be used to suction fluid out from a zone being mapped by the IOS and/or explored with probe **108**. Alternatively or additionally, channel **214** include an optical fiber for introducing light into and/or viewing a zone and/or a zone being mapped by the IOS and/or explored with probe **108**. Alternatively or additionally, channel **214** may include an optical fiber. For example, the optical

fiber may be used for channeling light to a sensor and/or an imager. Alternatively or additionally, a tool may pass through channel **214**. For example, wires and/or a tissue ablator may be passed through channel **214** to affect tissue in an oral cavity. Optionally an optical fiber may be used to pass a laser signal for tissue ablation and/or cutting oral features.

FIG. 2E is a block diagram illustration of an IOS having a lateral probe **108** and an affector **215**. For example, an affector **215** may include an ablator. Optionally, a power source **217** supplies energy to affector **215**. For example, power source **217** and/or affector **215** may be controlled by a controller for example including a processor.

Figs. 3A-3E are schematic illustrations of IOS including a laterally extending imaging or sensing probes, in accordance with some embodiments of the invention.

FIG. 3A is a schematic illustration of a probe **308** including an imager **312a** in accordance with an embodiment of the current invention. Optionally, a field of view **316b** of sensor **312a** of probe **308** overlaps with a field of view **316a** of imager **306** of the IOS.

In some embodiments, imager **312a** will face laterally away from a side of probe **308**. Optionally, imager **312a** is used to image difficult to reach locations. For example imager **312a** may improve accuracy of an imaging of a surface angled away from the IOS imager **306**, for example a side view of a steep wall of tooth **309**. Optionally the probe may be moved for scanning a structure with imager **312a**, for example as illustrated arrow **318**. Alternatively or additionally, imager **312a** may be used to view subgingival features. For example, measured features may include inflammation, and/or calculus (for example the location and extent and/or thickness) and/or plaque. For example, the tip of the probe and/or sensor **312b** may be inserted into a periodontal pocket to make a measurement. In addition to and/or alternatively, a sensor may be directed along the axis of probe **308**.

FIG. 3B is a schematic illustration of a probe **308** including a narrow FOV sensor **312b** in accordance with an embodiment of the current invention. Optionally, a sensor **312b** is used to measure a feature in a field of view **316a** of imager **306** of the IOS.

In some embodiments, sensor **312b** will face laterally away from a side of probe **308**. Optionally, sensor **312b** is used to measure features in difficult to reach locations. Optionally the probe may be moved for scanning a structure with sensor **312b**, for example as illustrated arrow **318**. Alternatively or additionally, sensor **312b** may be used to detect and/or identify and/or measure subgingival inflammation, and/or calculus and/or plaque. For example, sensor **312b** may include a range finder and/or a color measuring sensor and/or a reflectivity measuring sensor. For example, while sensor **312b** is identifying features, IOS sensor **306** may be used to map the

location and/or extent of the feature. For example, the location of plaque and/or calculus may be entered into a 3D model of the mouth.

FIG. 3C is a schematic illustration of an IOS including probe having a plurality of sensors in accordance with an embodiment of the present invention. For example, probe **308** is shown with three sensors **312c**, **312c′** and **312c″** having fields of view **316b**, **316b′** and **316b″** respectively. Optionally, the fields of view **316b**, **316b′** and **316b″** overlap; for example, as overlapping fields of view **316b**, **316b′** and **316b″**. For example overlapping fields of view **316b**, **316b′** and **316b″** may facilitate stereoscopic and/or 3D imaging. Optionally, multiple fields of view **316b**, **316b′** and **316b″** may facilitate imaging a large surface of a tooth **309**. For example, a surface having a length ranging between 1 to 2 mm and/or between 2 to 8 mm and/or between 8 to 15 mm and/or between15 to 30 mm. Alternatively or additionally sensors **312c**, **312c′** and **312c″** may include sensors with a narrow FOV **316c**, **316c′** and **316c″**. For example, FOV's **316c**, **316c′** and **316c″** may not overlap.

In some embodiments, one or more of the sensors **312c**, **312c′** and/or **312c″** may be replaced by an illuminator. For example, an illuminator may illuminate a narrow field of illumination, for example a zone having a width of greater than 2 mm. Alternatively or additionally, an illuminator may illuminate a wide field of illumination, for example a zone having a width of less than 2 mm. For example, an illuminator may include a light emitting diode (LED) and/or a laser.

In some embodiments, sensors **312c**, **312c′** and/or 312c″may be used for 3D scanning. For example, overlapping scanners may be used for stereoscopic imaging. Alternatively or additionally, a combination of scanners and illuminators may be used to produce a 3D image. For example, probe **308** may include a laser line scanner.

FIGs. 3D, 3E and 3F are schematic illustrations of alternative embodiments of a scanner including a pressure sensor. For example, a probe may include a pressure sensor at a distal portion thereof (for example sensor **322a** as illustrated in *FIG. 3D*). Alternatively or additionally, a stress sensor may be provided at the base of a probe **308** (for example sensor **322c** as illustrated in *FIG. 3F*). Alternatively or additionally, a strain sensor may be including in probe **308** (for example sensor **322b** as illustrated in *FIG. 3E*). Alternatively or additionally, pressure may be estimated based on the image produced by sensor **306** of the IOS head **304**. For example the pressure on a flexible and/or elastic probe **308** may be estimated based on the location of contact of the probe **308** and an object and/or the distortion of the probe **308**. For example, an elastic probe may be calibrated to know how much lateral force is required at the tip of the probe to bend the probe to a particular angle. For example, from the direction and location of the point of

contact between the elastic probe and an object and from the bending of the probe, the force between the probe and the object can be computed.

Figs. 4A-4C are schematic showings of an IOS including a laterally extending probe having a reflector in a field of view **316a** of the IOS, in accordance with some embodiments of the invention. For example, a reflector may include a mirror. Optionally a reflector may by straight, and/or curved (for example concave and/or convex). For example, a reflector may give IOS sensor **106** a wider view and/or a view at an additional angle and/or a view at an additional view point than the unmodified view **316a** of sensor **306**. Optionally the mirror may be used to get a side view of a tooth **309** and/or another structure (for example to see inside a recess for example a cavity in a tooth or gums).

In some embodiments (for example as illustrated in *FIG. 4A*) a mirror **424a** may be located near a tip of probe **308**. For example, a portion **316d** of FOV **316a** of sensor **306** may be directed at mirror **424a**. Optionally, the mirror **424a** may allow IOS sensor **306** see an additional FOV **416a**. Optionally mirror **424b** may be mounted on a pivot **426**. For example, pivot **426** may facilitate adjusting of an angle and/or FOV **416a** of mirror **416a**. Alternatively or additionally, pivot **426** may facilitate pivoting mirror **424a** out of the way of an obstacle while positioning probe **308**. For example, pivot **426** may include an elastic element that allows mirror **424a** to pivot out of the way and/or return to its pose. For example, mirror **424a** may be located within 1 mm of the tip of probe **308** and/or within 5 mm and/or within 20 mm and/or within 100 mm.

In some embodiments, a mirror may be directed to produce a field of view **416a** approximately perpendicular to the probe and/or approximately perpendicular to the mean direction unmodified FOV of the IOS sensor **306**. Alternatively or additionally an angle **423** between the mean direction of the surface of the mirror and the a line from the base of the mirror and the IOS sensor **306** may range for example between 40 to 50 degrees and/or between 50 to 80 degrees and/or between 10 to 40 degrees. In some embodiments, angle **423** may be fixed. Alternately or additionally, angle **423** may be adjustable.

In some embodiments (for example as illustrated in *FIG. 4B*), a mirror **424b** may be mounted on an intermediate section of the probe **308**. For example, mirror **416b** may be more than 100 mm from the tip of the probe.

In some embodiments, (for example as illustrated in *FIG. 4C*) a probe **308** may have a widened portion at or near its tip. For example, a tip of a probe may form a ball. Optionally, a reflective surface **424c** of the widened portion may be located in the FOV **316a** of the IOS sensor **306**. For example, reflective surface **424c** may be convex and/or may give an expanded FOV **416b** at an angle to the unmodified FOV **316a** of sensor **306**.

FIGs. 5A-5B are schematic illustrations of an IOS including a laterally extending probe having a channel therein, in accordance with some embodiments of the invention. In some embodiments a channel may be partially or completely filled. In some embodiments a channel may be permanently filled. Alternatively or additionally, the channel may be filled with a temporary object and/or the contents of the channel may be changed. For example by a channel may include of fiber, and/or wire. Optionally an opening of channel may be on various locations and/or directed in various directions. For example opening **511b** of channel **514b** is on a distal end probe **308** as illustrated in *FIG. 5B*. Optionally, opening **511b** has a field of effect **530b**. Optionally probe **308** is straight and/or field of effect **530b** is directed along the long axis of probe **308**. Alternatively or additionally, opening **511a** of channel **514a** is located on a side of the probe **308** for example illustrated in *FIG. 5A*. Optionally probe **308** is straight and/or a field of effect **530a** is directed laterally with respect to the long axis of probe **308**. For example, a field of effect may include an area onto which a material is sprayed and/or a field of illumination of a light emitting fiber and/or a field of view of a sensor connected to an optical fiber. Optionally, a channel in a probe may be in fluid communication with a reservoir **513** in the head of the device and/or the handle and/or outside the device. Optionally, a channel in a probe may be in communication with a fluid source and/or an energy source outside the device

In some embodiments, reservoir **513** may contain a material to introduce into the mouth and/or may serve to store material removed from the mouth. Alternatively or additionally, reservoir **513** may include a channel to a source of a material to be introduced into the mouth (for example a source of high pressure fluid) and/or to a vacuum. Alternatively or additionally, the reservoir **513** may in include an energy source. For example, the reservoir may include a battery and/or a signal generator and/or a connection to an external power source. For example, power source may supply electrical power to an ablator. For example, the channel **514a**, **514b** may include a wire to pass electrical current. For example, a power source may include a light source (e.g. a non-coherent illumination source (e.g. of white light and/or Ultraviolent UV light and/or of Infra-Red IR light) and/or a coherent light source for example a laser). For example, channel **514a**, **514b** may include a light guide for example an optical fiber. Optionally, energy passing along channel **514a**, **514b** may be used to perform ablation, coagulation, cutting etc. Alternatively or additionally, reservoir **513** may include a sensor, for example an electrical tester and/or an optical sensor.

In some embodiments, while a probe is being used in a procedure, the IOS is optionally used to track progress of the procedure. For example, the probe may be used for scaling a tooth while the IOS is used to determine the initial extent of plaque and/or calculus. In some

embodiments, sensors on the probe will be used along with the IOS to improve identification of oral features and/or pathologies and/or their characteristics. For example, the probe may be used to explore a region while the IOS maps the explored region and/or detects optical properties of the region. In some embodiments, a probe will transfer materials into and/or out of the mouth to improve the performance of the IOS and/or of a probe mounted sensor (for example to increase light and/or visibility and/or to provide markings and/or acoustic coupling).

In some embodiments, a channel may be used to transfer materials into or out from a mouth of a patient. For example, a fluid (for example water) and/or a gas (for example air) may be injected through a channel and/or sprayed onto an object. Materials may be introduced at increased pressure, for example of between 0.1 to 1 atm and/or between 0.01 to 0.3 and/or between 1 atm to **5** atm and/or between 5 to 20 atm. For example, the introduced material may be used to rinse the object, for example to wash away blood. Alternatively or additionally a vacuum may be applied to a channel, for example for sucking the blood and/or other fluids/ from a mouth. For example, sucking away liquid and/or spraying gas may dry teeth and/or decrease specular reflections from the tooth. In some embodiments, reduced spectral reflection may improve the accuracy of 3D imaging. Alternatively or additionally a hemostatic material may be introduced, for example to reduce bleeding. Alternatively or additionally, an anesthetic material may be introduced, for example to reduce pain. Alternatively or additionally a hemostatic material may be introduced, for example to reduce bleeding. Alternatively or additionally an anti-bacterial material may be introduced, for example to reduce inflammation. In some embodiments a material may be applied to teeth (for example sprayed on the teeth) through a channel to create features on the teeth and help create 3D models. For example a fluid containing particles may be sprayed onto teeth. The particles may be used as visible features for locating features on a tooth. In some embodiments, a channel in a probe may be used for spraying or insert a material that causes gum retraction and/or a material that opens a sulcus. Alternatively a channel may be used to transfer a material for affecting a surface; for example a milling and/or polishing solution. For example, a milling solution containing particles may be sprayed onto a tooth through a channel in a probe.

In some embodiments, a channel may be used for a fiber and/or a wire. For example a hollow probe may include an internal fiber. Optionally, the fiber includes an optical fiber that transports light. For example, a light source may be included in reservoir **513** and/or at a proximal end of the fiber. For example, the light carried by the fiber may be coherent and/or the light source may include a laser. Alternatively or additionally the light may be non-coherent and/or the light source may include a light emitting diode.

In some embodiments, the fiber passing through probe **308** acts as a source of light. For example, probe **308** may include holes and/or windows that project light columns for calibration and/or measuring distance. Alternatively or additionally a fiber may carry light effective to cut tissue. For example, a hollow probe may include an internal fiber used for delivering light for soft tissue management, such as cutting gums and/or stopping bleeding for example by clotting blood.

In some embodiments a light transmitting fiber may be connected to a lights sensor. For example hollow probe may contain internal fiber connected to a light sensor that measures light reflected from an object towards the probe and/or the tip thereof and/or light reflected from the probe. For example, changes in reflected light may be used to identify when the probe is touching an intra-oral object, for example a tooth. For example, the sensor may measure changes in intensity and/or color. Alternatively or additionally, light may be measured with an optical detector on the probe, for example on or near a tip of the probe. In some embodiment, a fiber and light sensor may be used as a newton-meter for contact/force measurement detected via changes in light.

In some embodiments, an optical fiber will be used to measure distance. For example, a fiber may be connected to an optical length meter. Optionally, one or more fibers will be open approximately perpendicular to the axis of probe **308**. For example, the fiber may be used to measure a distance from the side of probe **308** to an oral feature, for example a wall of a tooth. Alternatively or additionally, an optical length meter may be connected to a ribbon of fibers. For example, the device may measure distance from each fiber end to an oral feature. Alternatively or additionally, a probe channel may transfer light without an optical fiber. For example the channel may include a light reflecting interior or other options to transfer light for any of the purposes described above with respect to optical fibers.

Fig. 6 is a schematic showing of IOS including a laterally extending probe having an affector, in accordance with some embodiments of the invention. Optionally, an affector may include electrodes **638a** and/or **638b**. For example, electrodes **638a**, **638b** may be connected by a wire **636** to a power source **634** and/or a controller **635**. Optionally, controller **635** may include a processor. Optionally the power source **636** and/or controller may produce an electrical current (AC or DC and/or at a radio frequency). For example the affector may be used to ablate tissue and/or stop bleeding and/or measure resistance. Alternatively or additionally, a heated object may be mounted to a probe as an affector. Alternatively or additionally, an affector may transfer light to an intra-oral object. For example, light may be used for ablation and/or milling. For example, a tooth may be milled in preparation for a procedure such as attachment to prosthesis.

Fig. 7A is a schematic showing of IOS including a telescopic probe, in accordance with some embodiments of the invention. In any of the embodiments described herein, a probe may be fixed and/or telescoping and/or reversibly mounted to the handle **302**. For example, the IOS handle **302**, head **304** and/or sensor **306** may be used as a standard IOS (for example with the probe **708** and/or **208'** and/or **208''** collapsed and/or removed). Alternatively and/or additionally, the probe (for example with the probe **708** and/or **208'** and/or **208''**) may be extended and/or attached and then used for any of the procedures and/or embodiments as described herein. Optionally, a telescoping probe **708** may be extended automatically and/or manually. Optionally, the telescoping probe **708** may be configured for use in a fully retracted and/or a fully extended state. Alternatively or additionally, the telescoping probe may also work in a partially extended state.

In some embodiments, a telescoping probe **708** includes one or more nested parts. Optionally, the parts may retract one into the other and/or extend one from the other. The probe optionally extends and/or locks into an extended position. For example, the parts may be connected to a linear actuator and/or interconnected by screw threads and/or another locking mechanism.

Fig. 7B is a schematic showing a probe with a tip designed for smooth or gliding movement along an oral surface in accordance with some embodiments of the invention.

Fig. 7B is a schematic showing an IOS 100* with a probe 718; an imager 106*; a head 104* and a handle 102*.

In some embodiments, the probe 718 is designed with a ball 719 at a tip 720 of the probe 718. In some embodiments the probe 718 is optionally designed so that the ball 719 can roll, optionally like a ball-point pen refill.

In some embodiments, the probe 718 is optionally designed with a round tip 720.

In some embodiments, the probe 718 is optionally designed with a tip 720 made of a smooth material, such as, by way of some non-limiting examples, Teflon, nylon.

In some embodiments, the ball 719 is designed to roll as it touches a scanned object, for example teeth or gums.

In some embodiments, the scanner includes a component to measure a rolling distance of the ball 719. By way of a non-limiting example, markings such as lines or dots are drawn on the ball, and the scanner optionally images the markings, optionally with an imager, and the rolling distance is optionally calculated.

By way of another non-limiting example, the surface of the ball 719 optionally includes (optionally subtractive or additive) mechanical lines that are optionally sensed by a force sensor.

By way of another non-limiting example, the ball 719 is optionally optically clear and striped to act similarly to a computer mouse or scroll wheel encoder. In some embodiments the probe is optionally hollow, and optionally includes one or more internal optical fibers to enable viewing movement of the ball or through the ball, or collect information from the ball or through the ball.

In some embodiments, air pressure liquids, anti-aggregant or anti-clot material optionally keeps the ball 719 from sticking to the probe tip 720, potentially assisting the ball 719 rolling.

Figs. 7C and *7D* are schematics showing an IOS 100* with an option for release of a probe from an IOS, in accordance with some embodiments of the invention.

Figs. 7C and *7D* show a probe 108*; a probe release mechanism 723; a head 104* (in some embodiments with an optional scanner or imager, not shown) and a handle 102*, where *Fig. 7C* is a side view and *Fig. 7D* is a bottom view.

Fig. 7D shows the example embodiment where the probe release mechanism 723is configured to release the probe 108* by inserting a tool into one or more openings 704* in the probe release mechanism 723. By way of a non-limiting example there may be two openings 704* in the probe release mechanism 723, shaped to receive tips of a forceps (not shown). The forceps may optionally be squeezed or spread, acting via the openings 704* on a probe holder 702* to release the probe 108* from the IOS 100*.

Figs. 7C and *7D* show an option for a quick release of the probe from the IOS.

In some embodiments a quick release is used in order to replace a probe 108* between patients or to replace the probe 108* type according to an anatomy of the patient, for example to replace to a shorter probe in case of shorter molar teeth, and/or to a narrower probe in case of a narrow opening between two teeth and/or to a probe with a force sensor for example to measure the force applied to a tooth.

In some embodiments the quick release is optionally done with a specific tool that can create enough force to remove the probe 108* from its place. In some embodiments, a tool that is already usually used by dentists can be used, for example, a tooth ring placing forceps.

In some embodiments the probe holder 702* grips the probe 108* along a section long enough to provide stability against side forces shifting the probe 108* relative to an imager (not shown).

In some embodiments the IOS 100* is optionally calibrated to determine the location of a probe 108* after replacement.

Fig. 7E is an image of an optional tool for release of a probe from an IOS, in accordance with some embodiments of the invention.

FIG. 7E shows a forceps 706* which has tips 708* which can be used for releasing a probe from an IOS, for example, referring to Fig, 7C, by inserting the tips 708* into the openings 704* as described above.

Fig. 7F is a schematic showing a sleeve with a probe that is placed over an IOS, in accordance with some embodiments of the invention.

Fig. 7F shows a probe 108* attached to a sleeve 730 and the sleeve 730 is placed over an IOS 102*.

In some embodiments the sleeve 730 optionally includes a release component 732 for attaching to and detaching from the IOS 102*. In some embodiments the release component 732 is a quick release component 732. An enlarged portion 731 of *Fig. 7F* shows an optional quick release component 732.

In some embodiments the sleeve 730 optionally includes a clear window or windows 733 to enable a scanner to image through the window(s) 733 in the sleeve 730.

In some embodiments the sleeve 730 is made fully or partially of a light transferring material such as polycarbonate.

In some embodiments the sleeve 730 can be autoclaved, in order to sterilize between uses.

In some embodiments the sleeve 730 is configured so that when placed over the IOS 102* such that relative movement between the sleeve 730 and the IOS 102* is limited to less than 1 micron or 5 microns.

In some embodiments the release component 732 of the sleeve 730 is configured such that relative movement between the sleeve 730 and the IOS 102* is limited to less than 1 micron or 5 microns.

Fig. 7G is a schematic showing a probe with a tip including a ball designed for smooth movement along an oral surface in accordance with some embodiments of the invention.

Fig. 7G is a schematic showing an IOS 100* with an imager 106* and a probe 718.

The probe 718 of *Fig. 7G* is designed with a ball 719 at a tip 720 of the probe 718. In some embodiments the probe 718 is optionally designed so that the ball 719 can roll, optionally like a ball-point pen refill.

Fig. 7G shows the ball 719 at the tip 720 of the probe 718 rolling along a surface of a tooth 722.

Exemplary measurements using IOS with laterally extending probe

Figs. 8A-8K are schematic drawings showing various dental structures which may be measured using an IOS and a probe, in accordance with some embodiments of the invention.

FIG. 8A illustrates an IOS scanner with a probe exploring a periodontal pocket between a tooth **309** and a gum **807** in accordance with an embodiment of the current invention. For example, a probe **308** may be a simple probe without an additional sensor. Alternatively or additionally, a pocket may be explored using a probe with a probe mounted sensor, for example as illustrated in *FIG. 13B*.

Fig. 8B illustrates an IOS scanner including a probe measuring a recess **868** in a tooth in accordance with an embodiment of the current invention. For example, a recess **868** may be scanned at high resolution in order to fit an implant. Optionally, probe **308** is used to position a FOV **316b** of probe mounted sensor to get a good view of the recess **868**. Alternatively or additionally, a probe mounted sensor may inserted into the recess **868**. Alternatively or additionally, a probe may be used to physically contact an internal portion of the recess **868**. A probe physically contacting an internal portion of the recess **868** optionally includes a probe mounted sensor. Alternatively or additionally probe physically contacting an internal portion of the recess **868** may not include a probe mounted sensor.

FIG. 8C illustrates an IOS scanner including a probe measuring an exterior surface of a tooth in accordance with an embodiment of the present invention. For example, use of the probe to measure the outer surface may improve the accuracy of a 3D map and/or STL file. Alternatively or additionally, use of a probe along with the IOS scanner may produce a high accuracy map of the surface of the tooth and/or facilitate production of an improved fitting onlay. For example, mapping the surface may include touching points on the surface with the probe. Alternatively or additional, a probe mounted sensor may be used to scan a tooth surface.

FIG. 8D illustrates an IOS scanner including a probe measuring recess, for example a socket **870** remaining after extraction of a tooth in accordance with an embodiment of the present invention. For example, use of the probe to measure the socket **870** may improve the accuracy of a 3D map and/or STL file. Alternatively or additionally, use of a probe along with the IOS scanner may produce a high accuracy map of an inner surface of the socket and/or facilitate production of an improved fitting prosthesis, for example an inlay, an onlay and/or an implant fitting to a feature in the socket **870**. Alternatively or additional a probe mounted sensor may be used to scan an extraction socket **870**. For example, the probe mounted sensor may be inserted into the socket **870**. Alternatively or additionally a probe mounted sensor may be positioned outside the socket **870** to have a FOV with good coverage of the socket **870**, for example close to and/or adjacent to the opening of the socket **870**. Optionally, data from measurement of the socket **870** may be used to produce an implant for immediate and/or primary implantation. An

IOS including a probe is optionally used to measure grooves, holes and cavities in bone, for example to be designated for medical objectives, for example, for dental implants.

FIG. 8E illustrates a use of an IOS including a probe to measure a tooth abrasion **866** in accordance with an embodiment of the current invention. Optionally, probe **308** is used to position a FOV **316b** of a probe mounted sensor to get a good view of the abrasion **866**. Alternatively or additionally, a probe may be used to physically contact the abrasion **866**. A probe physically contacting a the abrasion **866** optionally includes a probe mounted sensor. Alternatively or additionally, a probe physically contacting abrasion **866** may not include a probe mounted sensor.

Fig. 8F illustrates an IOS scanner including a probe measuring a region prepared for a prosthesis (for example a surface of a tooth prepared for a crown) in accordance with an embodiment of the current invention. For example, prepared region may be scanned at high resolution in order to fit a prosthesis. Optionally, probe **308** is used to position a FOV **316b** of probe mounted sensor to get a good view of the region. Optionally the probe contacts the region. A probe physically contacting region optionally includes a probe mounted sensor. Alternatively or additionally probe physically contacting region may not include a probe mounted sensor.

FIG. 8G illustrates an IOS scanner including a probe measuring a prostheses after attachment in accordance with an embodiment of the present invention. For example, the probe is used to measure the joint **874** between a natural structure (for example between a prepared tooth **309** and a crown **872**) and the prosthesis. Alternatively or additionally, the probe may be used along with the IOS scanner to measure a height of a prosthesis and/or to measure closure of the prosthesis with an antagonistic tooth. In some embodiments a IOS scanner with a probe may measure a post insertion fit of a prosthesis without a probe mounted sensor. Alternatively or additionally, a probe measuring a post insertion fit of a prosthesis may include a probe mounted sensor.

FIG. 8H illustrates an IOS including a probe used to measure and/or treat a calculus and/or a plaque deposit **876** in accordance with an embodiment of the current invention. For example, a probe **308** may be used to contact deposit **876**, for example to measure the deposit **876** and/or to scrape the deposit **876**. Optionally, the IOS will be used to map the 3D extent of the deposit **876** and/or to track progress in its removal. In some embodiments, probe **308** will be a simple probe. For example, the probe may measure by contact and/or remove deposit **876** by physical scaling. Alternatively or additionally, a probe may include a sensor and/or an affector (for example an ultrasonic scaler) that may take part in the measurement and/or treatment.

FIG. 8I illustrates an IOS scanner including a probe measuring and/or treating a root of a tooth in accordance with an embodiment of the present invention. For example, the probe **308** may be used to remove organic tissues and debris **863** in a root and/or the IOS may be used to measure the extent of the procedure. Alternatively or additionally, use of a probe along with the IOS scanner may produce a high accuracy map of the removed tissue and/or facilitate production of an improved fitting prosthesis, for example an inlay, an onlay and/or an implant. In some embodiments, probe **308** may be a simple probe. Alternatively or additional the probe may include a probe mounted sensor. Alternatively or additional the probe may include a probe mounted affector. For example, the probe may include a laser and/or a light channel to ablate the nerve **863** and/or a vacuum to remove nerve tissue and/or debris. In some embodiments the probe may be curved and/or flexible.

FIG. 8J illustrates an IOS scanner including a probe measuring a sub-gingival structure in accordance with an embodiment of the present invention. For example, a probe may be inserted through soft tissue (for example gums **807**) to contact and/or measure hard tissue underneath. In some embodiments the probe 308 is optionally inserted through the gingiva of the gums 807 and optionally touches a bone in which the teeth are embedded. Such embodiments may be used to diagnose and for planning of periodontal surgery and/or in order to add measurement results to a periodontal chart and/or to a 3D model. In some embodiments a thickness of the gingiva tissue is optionally measured, optionally based on knowing the probe length, and knowing, optionally using the 3D scanner, where the gingiva is, and calculating the thickness of the gingiva.

In some embodiments, the probe 308 is made with a sharp tip, to ease insertion into a space between a tooth and gums and/or through soft tissue.

In some embodiments, a pressure sensor is optionally used to detect when the probe 308 contacts bone.

FIG. 8K illustrates an IOS scanner measuring soft tissue in accordance with an embodiment of the current invention. For example, a scanner may be used to measure mucosa for fitting a removable prosthesis. For example, a IOS and/or probe may be used to measure a 3D form of the tissue and/or a mechanical property, for example elasticity. The tip **372** of the probe may optionally include an enlarged portion for improving measurement of soft tissue and/or to protect the tissue from damage. Alternatively or additionally the probe may include a sensor, for example a force sensor.

Fig 8L is a simplified illustration of an IOS measuring gingiva surrounding a dental implant in accordance with some embodiments of the invention.

Fig. 8L shows gingiva 807* adjacent to an implant 808, and an IOS head 304 and probe 308.

In some embodiments the IOS head 304 and the probe 308 are optionally used to collect data for producing a 3D model of the gingiva 807*, and optionally of the implant 808, and optionally of an abutment.

In some embodiments the IOS head 304 and the probe 308 are optionally used to collect data for producing a 3D model of the gingiva 807* with no abutment.

In some embodiments the IOS head 304 and the probe 308 are optionally used to collect data for producing a 3D model of the gingiva 807* with an abutment present.

In some embodiments the 3D model is optionally used to design a custom abutment, which is optionally shaped according to the gingiva shape.

Figs 8M and *8N* are simplified illustrations of an IOS measuring parameters of a dental implant in accordance with some embodiments of the invention.

Fig 8M and *8N* show an IOS head 304 using a probe 308 measuring parameters of a dental implant 809.

Example parameters measured by the probe 308 include, by way of some non-limiting examples, a location of the dental implant 809, orientation of the dental implant 809, shape of the dental implant, and similar geometric parameters, optionally relative to adjacent teeth (not shown), and/or relative to a jaw bone and/or relative to gums.

In some embodiments the measurement is optionally done using a number of known point 810 locations on the implant 809.

In some embodiments the number of points is selected to enable determining a specific shape of an implant 809 that are enough in order to know the parameters due to the implant synthetic shape.

In some embodiments measurement of the implant 809 is optionally done in presence of blood covering some or all of the implant 809, for example after implant 809 insertion into bone or after opening covering gingiva 807* to expose the implant 809.

In some embodiments detection and/or location and/or measurement of the implant 809 is optionally using a metal detecting component (not shown) in the IOS head 304 and/or the probe 308 and/or a tip of the probe 308.

In some embodiment the metal detecting component optionally includes a one or more conductive loops, similar to those a metal detector head, connected to a metal detection circuitry in the IOS head 304.

In some embodiments the metal detector is optionally used to detect and/or locate an implant below gingiva, before punching the gingiva and exposing the implant. Such an embodiment potentially enables direction the punching or cutting open of the gingiva to the right place.

In some embodiments detecting a center of the implant is optionally done taking into account symmetry of the implant, that is, detecting a point where the metal detector detects the metal equally from all sides.

In some embodiments the metal detector optionally determines a location of the metal implant relative to a sensor inside the probe. The probe position is optionally determined relative to a scene captured by the scanner/imager. The implant location is optionally determined relative to, for example, teeth location.

In some embodiments an implant location is optionally printed on a printout which is optionally placed on a tooth or teeth, optionally with registering marks printed, and showing a location of the implant, in some embodiments even having a cut-out or opening at a location suitable for punching a gum to expose the implant.

In some embodiments measurement parameters are optionally determined based on knowing a tip position in scanned images, or in the scanner coordinate system.

In some embodiments reaching and/or locating a bone or tooth or implant is optionally determined by a force sensed by a force sensor.

In some embodiments, crown measurements are optionally determined based on measuring a prepared tooth.

In some embodiments, a custom abutment is optionally designed based on measuring the gingiva surrounding an implant.

In some embodiments, the probe is used to validate drill work.

In some embodiments, the probe is used to choose an implant size, shape or type when drill holes in the bone are measured.

In some embodiments the measurements are used to prepare a periodontal chart.

In some embodiments, data from the probe is optionally added to a 3D model. In some embodiments, data from the probe is optionally added to a 3D model at model location where there is no data from other scanner(s) and/or to potentially refine and/or improve accuracy of data from the other scanner(s).

In some embodiments the measurement is optionally done through blood 815 to a few points on the gingiva 807* or on bone (not shown) or a tooth, which can optionally be used to calculate position and/or orientation of the implant 809.

Fig 8O is a simplified illustration of an IOS measuring a hole made by a drill in accordance with some embodiments of the invention.

Fig. 8O shows gingiva 807*, bone 811 and a hole 812 in the bone 811, and an IOS head 304 and probe 308.

Fig 8O shows the IOS head 304 measuring the hole 812, for example a hole 812 made by one or more of various drill(s) in a drilling process before an implant is inserted. By way of a non-limiting example, the probe 308 optionally measures one or more of a depth of the hole 812, a width of the hole 812, a shape of the hole 812 and an inside threading made by the drill.

In some embodiments the measurements are optionally compared to a desired result corresponding to an implant planned for use and its geometric parameters.

In some embodiments, an optional ball 813 at a tip of the probe 308 optionally has a diameter which is desired for an implant, and potentially enables verifying that the hole 812 is wide enough for the desired implant.

In some embodiments the measurements are optionally used to measure drill holes prior to implanting an implant, to verify that a drill has reached bone and produced a hole of suitable width, depth, shape, and thread.

Fig 8P is a simplified illustration of an IOS measuring parameters of a dental implant in accordance with some embodiments of the invention.

Fig 8P shows an IOS head 304 using a probe 308 measuring parameters of a dental implant 809.

Example parameters measured by the probe 308 include, by way of some non-limiting examples, a location of the dental implant 809, orientation of the dental implant 809, shape of the dental implant, and similar geometric parameters, optionally relative to adjacent teeth (not shown), and/or relative to a jaw bone and/or relative to gums.

In some embodiments the measurement is optionally done using a number of known point 810 locations on the implant 809.

In some embodiments the number of known points 810 is optionally small, for example 6. In some embodiments, 6 known points 810 in a scan are optionally enough to produce a three-dimensional model and correctly register the model relative to a mouth with 6 degrees of freedom (DOF).

In some embodiments the spatial registration optionally gives up a DOF, for example rotation around a long axis of the implant 809 and 5 known points 810 are optionally used.

In some embodiments 3 known points 809 are used on an implant

In some embodiments a hollow cavity shape (not shown in *Fig. 8P*) represents the known points, providing a position and optionally an orientation vector for registration.

In some embodiments a hollow cavity shape (not shown in *Fig. 8P*) represents the known points, providing a position and optionally an orientation vector for registration and an addition known point is used in the registration.

In some embodiments the number of points is selected to enable determining a specific shape of an implant 809 that are enough in order to know the parameters due to the implant synthetic shape.

In some embodiments the known point 810 locations are optionally any touching point on an implant.

In some embodiments 3 known points are optionally marked on an implant. In some embodiments the 3 known points marked on the implant are not all on a straight line. In some embodiments data regarding the relative positions and/or distance between the 3 known points is known, optionally provided by an implant manufacturer. In some embodiments the probe is moved to make contact with the 3 known points, the known points are identified, and the implant is optionally registered in space and/or located with a model of the oral cavity based on knowing the size and shape of the implant relative to the locations of the 3 known points.

In some embodiments the implant is manufactured with probing holes at known locations on the implant. When the probe contacts the probing holes, the orientation and/or location of the implant is optionally calculated. by way of a non-limiting example, a 1mm distance between 2 points can mean that the 2 points are the points at 12 o'clock and 3 o'clock of the implant (for example this is how the implant was manufactured) and a 2mm distance between 2 points means that the 2 points are points at 3 o'clock and at 8 o'clock, for example.

In some embodiments the known point 810 locations are optionally configured so that a distance between the locations is greater than N pixels in in an image or scan of the locations. In some embodiments the number of pixels N is greater than 2 pixels, or greater than a number N in a range between 2 and 5,000.

Fig. 9 is a flowchart of a method of improving IOS mapping accuracy, in accordance with some embodiments of the invention. In some embodiments, the IOS is used to make an initial 3D model **940** of a feature and/or a portion of the mouth and/or of the whole mouth. Optionally, the probe is used measure **944** at a higher accuracy the feature and/or a sub-region of the mapped

area and/or another area. The high accuracy measurement is optionally added **946** to the 3D model. In some embodiments, the high accuracy measurement may be used to correct **948** the location of other points in the model at improved accuracy. Optionally, the probe may be moved **950** and/or further points may be measured **944** as needed. Optionally, the probe may be calibrated **942**, before during and/or after scanning.

In some embodiments, an IOS scanner with a probe may be used to determine a locations and/or shape of a surface. For example, the probe may be used to touch **944** a point on the surface and/or the precise position of the point touched by the probe may be used to correct **948** the position of the surface. Alternatively or additionally, the probe may be touched **944** to multiple points on the surface and/or dragged across the surface and/or the points may be added **946** to build a high precision 3D model of the surface. For example, the surface may be modelled as a plane and/or a curve. In some embodiments, multiple points may be defined on the surface (for example by touching **944** each point with the probe). The distance between the defined points may be used to define a measure and determine distance along the surface and/or in other parts of a 3D model. In some embodiments, a fiducial marker (for example the tip of the probe) may be placed on the surface. The precise distance measure of the marker is optionally used to determine distances on the surface and/or to produce a high precision model of the surface and/or to correct **948** the locations of other points to a high precision.

In some embodiments, a calibrated probe is combined with a 3D camera. For example, the accuracy of the measurements done with the probe may significantly exceed the initial accuracy of the 3D scanner. Optionally, a processer runs an algorithms that finds the probe location from the scanner location in at least one 3D frame. For example, the probe location can be obtained from many 3D points and/or features measured by the scanner in the same frame.

For example, many IOS produce depth maps, for instance using structured light, and/or by aligning multiple images together to get a single 3D model. A typical accuracy of a point on a tooth in a model produced by an IOS is for example approximately 30um. However the overall accuracy of alignment of a single depth map image that contains thousands of points to a 3D model may be significantly better. For example, the accuracy of the probe tip with respect to the rest of the model may be 10 μm instead of 30 μm. In some, embodiments this internal alignment of the probe measured point to the rest of the model may increase the accuracy of large areas on the model to within **10** μm.

In some embodiments, an IOS with a probe may be used measure a tooth prepared for fixed prosthesis (for example a crown for example as illustrated in *FIG. 8F* and/or an inlay for example as illustrated in *FIG. 8B* and/or an onlay for example as illustrated in *FIG. 8C*). For

example, the IOS may be used to make **940** an initial 3D model of prepared tooth and/or the area around the prepared tooth. The probe is optionally brought in contact with areas of the prepared tooth (for example as illustrated in *FIG. 8F*). For example, the probe may be used to measure the extent of the shoulder and/or the edges and/or cusps of the prepared tooth. Alternatively or additionally, the probe may be used to measure closure between a prepared tooth and an antagonistic tooth. The high accuracy measurements are optionally used to prepare a more precisely crown, for example a crown that will better fit the prepared tooth and/or better mesh with an antagonistic tooth.

In some embodiments, the data from the probe combined with the data from the camera may be used to improve the accuracy of an STL file. For example, accurate locations of multiple points in a single depth mapped image may be computed based on their relationship to sample points in the image that were touched by the probe and/or measured using the probe. The accurate locations may be added to the STL file and/or used to correct the STL file.

In some embodiments, the data from the probe is optionally combined with data from a prior art dental scanner. In that case, the measurements from the probe are optionally combined with the measurements of the prior art scanner. In that way, the prior art scan can provide additional data, for example from areas that were not scanned an embodiment of the present invention, or not scanned well enough. Problematic areas that can be scanned with the probe embodiment and that are hard to get using a prior art scanner can be, by way of some non-limiting examples, deep holes like a hole inside an abutment or a space between two adjacent teeth, especially below a finish line of a crown.

In some embodiments, the sample points may be on supragingival areas that are seen by the camera and were measured with the probe (for example as illustrated in *FIG. 3A-3F, 8F, 8G, 8C*). Optionally, a portion of the probe (for example the probe tip and/or graduations along the probe) may be used as a fiduciary marker. For example, by imaging a scaled object on the probe, the scale of an image from the IOS may be made more precise. In some embodiments, improved scaling on the IOS image will allow determining more precise geometric relationships between features and/or higher accuracy location of features. Optionally, a probe tip may be dragged along a surface, for example to measure a line along the surface and/or to get an accurate measure of the roughness of the surface.

In some embodiments, a IOS scanner with a probe is used to measure a surface for placement of an onlay. In some embodiments an onlay implant or graft is fixed to the bone with pins/screws, for example to obtain primary fixation. For example this may be used in cases where there is not enough volume of bone for the conventional implant and/or where the dentist decides

not to use augmentation procedure surgery. In some embodiments, an onlay will be produced via 3-D printing. For example, printing of titanium or CoCr using laser sintering. In some embodiments, data to produce the implant is obtained from a CT scan of the bone. Optionally an IOS scanner including a probe in accordance with an embodiment of the current invention may be used to produce a precise STL file of the outer surface selected to be underneath the onlay, for example a surface of the bone. Optionally, the data from the STL file is combined with the data from the CT scan to raise the accuracy of the final STL file. The combined CT, STL data is optionally used to determine the location and/or the size of the prosthesis and/or fixating screws of the prosthesis. In some embodiments, the IOS scanner probe in these cases will enable to produce a more accurate prosthesis. In some cases an onlay will be mounted to exposed bone or tooth, for example measurement may be similar to a crown described above. Alternatively or additionally, an onlay will be fitted to parts of a bone or tooth that are obscured. For example, measurement for such an onlay may be similar to measurements for an implant. In some embodiments, a CT and/or a STL file will be sent to a manufacturer who will produce the onlay and send it to the dental practitioner. In some cases data from a IOS scanner will be sent directly to an on-site 3D printer. For example, on-site printing or CNC may make it possible to reduce the time and/or number of dental visits for producing an implant and/or onlay.

In some embodiments, an IOS scanner with a probe may be used to measure a plaque layer or calculus, for example as illustrated in *FIG. 8H*. For example, the probe may be used in conjunction with the IOS sensor to locate and/or measure and/or evaluate exposed plaque deposits. Alternatively or additionally a probe may be used to explore a periodontal pocket for example to determine the depth of the pocket, for example as illustrated in *FIG. 8A* and/or *FIG. 13A* and/or *FIG. 13B*. Alternatively or additionally, the probe may be used to locate, measure and/or evaluate plaque deposits under the gum line. For example, the tip of the probe may be dragged along an obscured surface. For example, the presence of scales may be revealed by changes in roughness of the surface that are apparent in the 3D map made based on images of the position of the probe as it passes along the surface. Alternatively or additionally, a sensor may be provided near the tip of the probe. Optionally, the probe tip and/or sensor may be inserted into the periodontal pocked. For example, the sensor data may be used to locate, measure and/or evaluate a plaque deposit. For example, the IOS sensor may be used to evaluate the depth to which the probe is inserted in a periodontal pocket and/or the scale of movements as a probe is dragged along a surface. Optionally an IOS sensor may be used to determine a location of a probe (for example the IOS may sight and/or locate an exposed part of the probe, the location a concealed part of the probe and/or a sensor on the probe may be calculated for example based on the

location of an exposed portion of the probe and the geometry of the probe). The sensor on the probe is optionally used to evaluate a concealed feature, for example including a subgingival deposit.

In accordance with some embodiments of the current invention, an IOS scanner and probe may be used to detect measure and/or evaluate tooth abrasion, for example as illustrated in *FIG. 8E*. In some embodiments a probe may be fitted with a gauge to measure deposits of scale and/or plaque. For example, a gauge may include an ultrasonic range finder. Optionally, deposits may be measured above the gum line (supra gingival) and/or below the gum line (sub gingival). Measurement techniques listed above with respect to plaque may be applied to measure abrasion and/or scale deposits. Alternatively or additionally, a probe may include an ultrasonic scaler. For example, a tooth may be measured and/or deposits may be evaluated. For example, the scaling may be directed using images of the IOS while the probe is being used to remove the deposits. For example, IOS images and/or other sensor data may be used evaluate the progress of the scaling.

Fig. 10 is a flow chart illustrating post placement measuring of a prosthesis in accordance with an embodiment of the current invention. In some embodiments, a probe may be used to increase accuracy of measurement of the location and/or fit of a the prosthesis. For example, the probe tip may be placed in contact with the prosthesis and/or dragged along a surface of the prosthesis, for example to determine an exact location of the feature. For example, the probe (and/or a tip thereof) may be placed on **1052** and/or dragged along a joint where a prosthesis contacts a native structure. For example, the fit of the prosthesis at the joint (for example a finish line of a crown) may be evaluated and/or the placement of the prosthesis may be evaluated **1054**, for example as illustrated in *FIG. 8G*. While the fit of the prosthesis is being measured, the location of the probe may be determined using IOS images and/or by matching features in an STL file, This may improve measurement of the location of mismatched features of the prosthesis and the native structure. Optionally, the probe may be used to evaluate **1055** closure and/or positioning of prosthesis (for example a crown) with respect to antagonistic teeth. Measurements are optionally made of exposed features and/or caught in the IOS image (for example when testing the positioning of a crown and/or overlay). Alternatively or additionally measurements may be made of fit of concealed features, for example the matching of an implant and/or an extraction cavity. Optionally, measurements of concealed objects are made while touching the object with a probe and/or using a probe mounted sensor.

In some embodiments, the height of a prosthesis may be evaluated **1054** and compared to an expected height, for example to determine if the prosthesis was properly fit. Alternatively or

additionally, a probe may be used to measure a feature of a prosthesis and/or a prepared location for placement of the prosthesis. For example, a thread width of a screw thread and/or matching of threads may be measured in situ.

In some embodiments a IOS with a probe may be used to measure features of a man-made element itself (for example size, surface quality of a prosthesis). Alternatively or additionally, the IOS with a probe may be used to measure the placement of the man-made element with respect to a natural element (for example bone, teeth, gingiva, etc.) and/or with respect to other man-made elements. For example an IOS with a probe may be used to measure a dimension on an inlay and/or the insert height of an implant to the bone.

Fig.11 is a flow chart illustration of a method of measuring a recess in an oral cavity with an IOS including a probe in accordance with an embodiment of the current invention. In some instances, the inside of the recess may be obscured from an IOS scanner. In some embodiments a probe may be inserted **1144** into a recess and/or contact points in the recess, for example to measure a location on the walls of the recess and/or depth of the recess 8D. Alternatively or additionally, a sensor and/or light source on a probe may be positioned **1145** to get a better view of the recess, for example as illustrated in *FIG. 8B*. For example, the sensor **1145** of the probe may be positioned to view a recess from outside the recess. Alternatively or additionally the sensor may be inserted **1144** into a recess to view from the inside (for example inside a periodontal pocket as illustrated for example in *FIG. 8F*.

In some cases, a prosthesis, for example an implant and/or an inlay and/or an onlay, may be inserted **1144** into a recess. For example, the prosthesis may be inserted **1144** into a recess in a tooth and/or into a recess in a bone and/or into a recess in the gingiva. For example the probe may be used to measure a post extraction socket, for example as illustrated in *FIG. 8D*. Optionally, measurement data may be stored and/or sent to a manufacturer when ordering the prostheses. Alternatively or additionally, data from the measurements may be sent directly to a 3D printer to produce prosthesis. For example, the prosthesis may be printed on-site and/or in real time. For example, a dentist may measure and place prosthesis. For example the scanner may include a processor and/or a network adaptor allowing it to directly communicate with a printer.

In some embodiments, a probe may be inserted **1144** inside of a recess to measure the recess and/or determine a health condition and/or treat a health condition. For example a probe may be used to explore and/or clean a root **863** for example as illustrated in *FIG. 8I*. For example, the probe may be used to measure root apex depth. Optionally, a probe of an IOS may perform **1167** a treatment. For example a probe for probing a root may include a channel. For

example the channel may be used to sterilize the root (for example by introducing a chemical and/or by heat or a laser) alternatively or additionally a channel may be used to apply a vacuum to clean the root. Optionally the IOS may be used to map the location and/or evaluate the effect of the treatment.

For example, an embodiment of the current invention may be used to characterize the shape of a post extraction socket in the bone to prepare an exact fitting implant, For example, the root of a tooth may be engaged in the alveolar bone. After extracting the tooth and/or root, a cavity may remain in the bone. The cavity may be referred to herein as a "socket". The anatomy of the socket may correspond to the root that was previously held in it.

In some embodiments, measurements and/or a 3D map and/or 3D printed prosthesis may be produced quickly using an embodiment of the current invention. For example the pre preparation measurement of the bone and/or 3D map quickly enough to leave the dentist free to prepare that bone in the same sitting. Alternatively or additionally, after preparing the bone, a post preparation map of the bone may be made at the same sitting. and/or design for the prosthesis may be made in the same sitting. Alternatively or additionally, after preparing post preparation measurement of the bone production of the prosthesis (for example by 3D printing) and/or attaching of the prosthesis may be done in the same sitting. In some embodiments, using an embodiment of the present invention the number of sitting required to measure, prepare, produce and/or attach a prosthesis may be reduced. Optionally this shortens the time and/or cost of installing a prosthesis.

Some dental implants may be limited to a cylindrical shaped. In some cases, the cylindrical shape will not correspond to the socket anatomy which may for example be conical shaped. In case of multi rooted tooth such as a molar there may be a more significant discrepancy between the socket and a conventional prosthesis. Placing such an implant may include drilling and/or augmenting the bone.to produce a properly shaped socket for mounting the implant. In accordance with an embodiment of the current invention measuring of a socket and/or production of a custom insert is facilitated. In accordance with an embodiment of the current invention measuring of a socket and/or production of the insert is facilitated.

In some cases, a bone has appropriate height, but has insufficient width to receive a conventional implant. Optionally, a dentist and/or a surgeon can create a cavity in the bone, for example resembling a groove along the bone. Optionally, before creating the cavity in the bone, a 3D map giving precise information about of the shape of the bone may be obtained using an IOS with a probe, for example to produce a 3D map. For example, a surgeon may use the 3D map to plan where and/or how to connect the onlay to the bone. For example, the 3D map may be used to

determine where there is sufficient bone to connect to the onlay and/or what kind of connection is possible between the onlay and the bone. For example, a surgeon may use the 3D map to plan where to form the groove and/or what size to make the groove and/or what shape to make the groove.

In some embodiments a 3D map of the bone will be prepared using an embodiment of the present invention after the bone has been prepared. For example, the 3D file obtained by the probe and scanner may be used to produce an implant that precisely fits the outer surface of the bone and/or precisely fits into the groove. In some embodiments, the current invention facilitates production and/or fitting of a custom onlay that fits on the outer surface of the bone and/or a natural cavity and/or a cavity drilled by the dentist. For example this may enable the dentists to use an onlay in compromised bone conditions without bone augmentation and/or with less augmentation than conventional procedures. The custom prosthesis may be attachable to bones that were not able to support a conventional implant and/or a custom implant may be more stable than a conventional implant.

In some embodiments, using the probe and the scanner may facilitate immediate implantation. High accuracy mapping may improve primary fixation in some embodiments. For example, using a precisely fit and/or custom made prosthesis, surgery may be less complicated and/or less technical sensitive and/or suitable for less trained and experience dentists. Using an IOS probe combination may eliminate the need to augment the bone. In some cases this will lower the price of the surgery and/or reduce the side effects (swelling and infections). Measurement of the socket at higher resolution with an IOS probe may in some embodiments produce a better fitting prosthesis and/or eliminate the need to drill into bone for example to fit the prosthesis. Optionally, elimination of the need to drill into the bone will give the dentist the opportunity to have a more conservative surgery and/or lower the chances to harm other tissues for example nerves and sinuses. For example, a reduced time and primary fixation procedure may replace a multi-step implantation process that would require 6-8 weeks of recovery after the tooth extraction, in order for the socket to heal and be ready for the surgery of implant insertion.

In some cases, inserting the implant may include primary fixation of the implant in the bone. In some embodiments, an IOS with a probe is used to characterize the shape of a post extraction socket in the bone. For example, STL file, obtained from the scanner, can be exported to create an well-fitting implant to the anatomy of the socket. For example, the IOS with probe may be used to map multiple cavities in a socket of a multi-rooted tooth. Creating a well-fitting implant is optionally done via 3D printing. The resulting implant is optionally attached to the bone with reduced preparation of the bone, for example without drilling.

Using the probe optionally facilitates immediate implantation in some cases. For example this may shorten the time needed between the extraction of the tooth and delivering the final prosthesis and/or reduce the number of surgical procedures. In some embodiments the above may result in faster, less costly procedures, more comfort to the patient and/or more simplicity to the dentist.

Fig. 12A is a flowchart of a method of intraoral mapping soft tissue in accordance with some embodiments of the invention. For example, an IOS including a probe may be used to map out the surface of the lining mucosa. This data may be used for producing and/or fitting a removable prosthesis, for example to treat edentulism.

In some embodiment, an IOS with a probe may be used to scan the oral mucosa. Scanning the mucosa may be challenging due to lack of features (for example when there are no teeth). In some embodiments, the probe, touching the mucosa can improve the ability to produce an STL file and/or improve its accuracy.

In some embodiments, the probe is optionally used as a feature which can be identified and located in an oral scan or map produced by the IOS.

In some embodiments the probe is optionally used as a feature in a map or scene with only few features, by way of a non-limiting example in a scan of a partially edentulous arch. The probe, touching the gingiva, is optionally used as a feature that the processing unit can use in order to create a model, potentially a more accurate model than previously.

In some embodiments the probe is placed at a stationary place while the scanner orientation is changed, to capture different areas around the probe. Such example embodiments potentially produce a more accurate model, optionally based on more features in a scene.

Fig. 12B is a simplified illustration of a probe used as a feature in an IOS scan in accordance with some embodiments of the invention.

Fig. 12B shows an IOS head 304 304' 304'' and a probe 308 308' 308'', and example teeth 1202 in an example intra-oral section 1204 to be scanned.

Fig. 12B shows the IOS head 304 304' 304'' scanning the intra-oral section 1204 to be scanned from several angles, by way of a non-limiting example three angles as shown in *Fig. 12B*.

In some embodiments a tip 1206 of the probe 308 is optionally kept at one specific location in the intra-oral section 1204 to be scanned, and optionally provides a static position, enabling one method of identifying a same location in scans from the three angles.

In some embodiments other known features in the three scans, for example the teeth 1202, are optionally used to identify same location(s) in scans from the three angles.

In some embodiments the IOS head 304 is manipulated to move between the three positions 304 304' 304''. The 3 positions are optionally used, by way of a non-limiting example, to capture image(s) of a first tooth 1202 and a location of the probe tip 1206, then optionally to capture image(s) of the probe tip 1206, then optionally capture image(s) of the probe tip location 1206 and a second tooth 1202.

In some embodiments known locations of the first tooth 1202 and the second tooth 1202 are optionally used to correctly register a location of the probe tip 1206 relative to the teeth 1202.

In some embodiments, once locations of the first and the second tooth positions are registered relative to the same probe position, the location of the first and the second teeth are optionally also registered in a 3D model of the mouth.

In some embodiments, an IOS for mapping the surface of the lining mucosa the probe has an enlarged tip **372**. For example, tip **372** may be formed into a sphere with large diameter for example in the range of 1-5 mm and/or 5-10 mm and/or 10-20 mm. Alternatively or additionally a sphere may be mounted on tip **372**. The sphere may facilitate better mapping of the surface of the lining mucosa features which are relevant for removable prosthesis good fit. Optionally, widened tip may be made out of steel and/or hard rubber and/or plastic.

In some embodiments a physical property of the tissue may be tested **1256**. For example, the elasticity of the surface of the lining mucosa is measured **1256** or mapped. Optionally, the surface of the lining mucosa is scanned with said probe. For example, scanning may include applying low force with the probe during scan of the surface of the lining mucosa and or measuring **1256** the deformation of the surface. For example the applied force may range between 0.001 to 0.1 Newton and/or between 0.01 to 0.1 Newton and/or between 0.01 to 0.1 Newton and/or between 0.1 to 1 Newton.

In some embodiments, the applied force may be measured from the probe deflection. Alternatively or additionally, the applied force may be measured using force sensor on the probe (for example as illustrated in *FIGs. 3D-3F*). The deformation of the tissue as the sphere is pushed into the surface of the lining mucosa may be measured, for example, using the 3D scanner. From the combination of the deformation of the tissue and the applied force the elasticity can be computed. In addition, The vitality of an area may be measured, for example using the flow of the blood out and into the area when applying and removing the force. The changes in the blood supply is optionally measured using the camera to capture changes in color due to the changes in the quantity and/or pressure of blood present. Alternatively or additionally, a depth of soft tissue may be measured **1258**. For example, a sharp probe may be pushed through soft tissue until it

reaches a hard feature (for example bone or tooth). The depth of penetration can then be recorded as the depth of the tissue. Optionally, the resistance to penetration of the tip may be measured.

FIG. 13A is a flow chart illustrating use of a IOS including a probe to explore a periodontal pocket in accordance with an embodiment of the current invention. In some embodiments a probe will be inserted into a periodontal pocket. Optionally the pocket will be explored **1344** using the probe. Optionally, data will be collected **1359** from the IOS and/or probe mounted sensors. The 3D location of the probe and/or areas being explored is optionally calculated using the IOS. Optionally, data and position information will be used to evaluate **1347** periodontal health. In some embodiments, data will be collected **1359** from a probe based sensor (for example an optical sensor **1312** as illustrated for example in *FIGs. 13B, 3A-3C* and/or a force sensor for example sensors **322a-322c** as illustrated in *FIGs. 3D-3F* and/or a remote sensor for example an external x-ray imager and/or an external sensor connect to the probe for example through an optical fiber as described for example in relation to *FIGs. 5A and 5B*)

In some embodiments, during exploration **1344** the probe may be inserted to the end of the pocket. Optionally, the IOS will image an exposed portion of the probe, for example extending out of the pocket and/or the IOS will calculate **946** the position of the probe and/or depth of the pocket may be measured.

In some embodiments, the probe will be used to exert pressure on an object. Optionally, the IOS may collect **1359** data about the movement of the object and/or tissue and/or teeth due to forces exerted by the probe. For example, pressure may be exerted on an object inside the periodontal pocket. Alternatively or additionally, data about the force exerted by the probe on an object may be collected **1359** using force sensors on the probe (for example as described with respect to *FIGs. 3D-3F*) and/or the IOS may collect **1359** data on bending of the probe (for example from images of the probe) the force exerted is optionally calculated based on bending of the probe apparent from IOS images. Optionally, periodontal health will be evaluated based the position of probed objects, the size of the pocket and/or the stiffness and/or softness of teeth and/or other tissue.

In some embodiments, a sensor on the probe will be used to collect **1359** data on periodontal health. For example, the probe may include an optical sensor (for example sensor **1312** illustrated in *FIG. 13B*) near the tip thereof. For example the sensor may include, for example a large FOV imaging sensor and/or a small FOV sensor or the like. Alternatively or additionally, optical sensing at the tip may be via an optical fiber (for example through a channel as illustrated in *FIG. 5A-5B*) transmitting light to a remote sensor. The images may be evaluated **1347** to diagnose inflammation and/or bleeding (for example from the color of teeth and/or other

tissue). Data from a sensor on the probe and/or from the IOS sensor may be used to locate a CEJ (cement to enamel junction) and/or a mukoginigival line for example based on the color difference. Optionally the position of measured features is calculated **946** and/or combined with a 3D model. The 3D data optionally is used to evaluate **1347** the location and/or extent of periodontal conditions. Alternatively or additionally, the 3D data may be used to output a personalized periodontal chart for example as illustrated in *FIG. 14*. The periodontal chart is optionally generated automatically.

In some embodiments, the probe may also be used to collect **1359** data and/or the IOS may be used calculated position **946** and/or map CAL (clinical attachment level/loss). The probe may also be used to collect data 1359 on furcation involvement. The probe may also be used to collect **1359** data on subgingival plaque. For example plaque may be to identified and/or measured using fluorescence. For example, the probe may include optical fibers and/or probe mounted sensors and/or illumination sources to measure fluorescence.

In some embodiments full dental charting which lists and describes the health of teeth and gums is automatically produced.

In some embodiments, Periodontal charting includes one or more, and up to six measurements (e.g. in millimeters) that are taken around each tooth.

In some embodiments the charting is done during dental checkups, by the hygienist and/or the dentist.

In some embodiments the charting provides a graphic method of organizing and presenting information about a patient's dental health, i.e. it is a graphical tool for organizing information about teeth and gums.

In some embodiments the chart includes a graphical, or pictorial, representation of the patient mouth. In some embodiments the chart shows one or even all of the teeth as a real image, optionally using 2D or 3D graphics, optionally using color and/or shading.

In some embodiments the chart includes additional information on the condition of the teeth and gums, such as, for example: areas of decay (cavities), missing teeth, depths of the gum pockets, bleeding points during probing, gum recession, abnormalities in the teeth, such as rotations, erosion, or abrasions in the teeth or enamel, damage to the teeth, presence of crowns, bridges, implants, and fillings, attachment of the teeth to the gums, movement and/or mobility in the teeth, bleeding in the gums, exposed teeth furcation, presence of suppuration.

In some embodiments, the chart information is stored in a memory as a record, optionally in the cloud.

In some embodiments stored chart information is optionally compared to current chart information, for example during a dental checkup, potentially enabling progress of dental health to be tracked.

In some embodiments, the charting process optionally begins by finding a scanned tooth number so the measured parameters can be attributed to a correct scanned tooth. A hygienist and/or a dentist optionally examines the teeth, optionally by probing gums to check the depths of the gum pockets. In some embodiments up to six readings per tooth are recorded in the periodontal charting process.

In some embodiments the IOS automatically identifies the probing location around the tooth, and optionally display a pocket depth in the chart accordingly.

In some embodiments, if a tooth has mobility and moves during the probing, the IOS optionally identifies the mobility level and adds the mobility level to the chart.

In some embodiments, movement of a tooth is optionally obtained by applying force, optionally lateral force, to a crown area of the tooth, optionally with a tip portion of the probe, and measuring and/or calculating movement of the tooth relative to a model or to known points in an image and/or by measuring and/or calculating a bending of the probe.

In some embodiments, a color image obtained from the IOS is used for detection of parameters such as the CEJ, mucogingival junction, bleeding, suppuration, presence of crowns, bridges, implants, and fillings.

In some embodiments, a 3D model obtained from IOS with or without the addition of the probe information is optionally used for detection of tooth furcation and the free gingival line.

In some embodiments a clinical attachment level (CAL) is optionally automatically presented by calculating relevant data, such as, for example, pocket depth, free gingival line, CEJ, mucogingival line. Data from an X-ray image is optionally combined in a calculation, such as, by way of a non-limiting example, a length of a tooth and/or a root of a tooth.

In some embodiments, if some features are hidden by blood, for example furcation or CEJ, the probe is used to detect the feature, for example furcation, even in the presence of blood. The detection is optionally performed by touching the furcation with the probe, or by detecting the CEJ using a color difference between enamel and cement/cementum in an image optionally captured, optionally by a fiber, optionally through the probe, optionally while air pressure clears a view between the fiber and the enamel and/or cementum.

FIG. 13B is a schematic illustration of a IOS including a probe **308** exploring a periodontal pocket **1362** between a tooth **309** and gums **1307**. In some embodiments, a tip of a

probe **308** will be used to explore a periodontal pocket **1362**. Optionally, information gathered by the probe will be integrated with 3D mapping.

In some embodiments, the device may automatically compute pocket depth as a function of position. For example, the IOS may track the position of probe **308** over time and/or find the maximum insertion depth as a function of a 3D location and/or compute a spatial distribution of pocket depth. Alternatively or additionally, the user may signal to the IOS when probe **308** has reached the end of the pocket and/or reaching the end of a pocket may be registered by a pressure sensor.

In some embodiments a probe **308** may include a tool. For example, an optical sensor **1312** and/or a light source may be provided near the tip of probe **308**. Optionally sensor **1312** is used to detect and/or identify periodontal features. In some, embodiments optical data gathered by sensor **1312** may be combined with data gathered by IOS sensor **306** to map features in 3D and/or to find relationship between exposed features and periodontal or unexposed features.

FIG. 14 illustrates a periodontal chart. In some embodiments, an IOS with a probe will be connected to a processor and/or an output device that will automatically generate the table from sensor data and/or 3D IOS information. Optionally the processor will store a 3D map of dental features (for example teeth) and/or data on periodontal conditions and/or their locations. For example, as a dental practitioner probes periodontal pockets with the probe, a processor may store data on periodontal conditions. For example, periodontal conditions may be determined by the processor based on probe measurements and/or sensor measurements for example as described in the description of FIG. 13A, 13B. Optionally, the processor will determine the location of the measured condition based on output of the IOS sensor and/or in relation to a 3D map (for example an STL file). For example, the probe location when a particular condition was measured will be correlated with the locations of various teeth to determine the particular tooth and/or on particular face of the tooth on which the condition was measured. The probe location at the time of measurement is optionally detected by an IOS sensor and/or stored by the processor. The resulting correlation between dental structures and measured conditions may be output as a periodontal chart listing detected conditions and/or the location of the conditions on various intra-oral features for example as illustrated in FIG. 14.

It is expected that during the life of a patent maturing from this application many relevant IOS will be developed; the scope of the term IOS is intended to include all such new technologies for scanning and/or 3D reconstruction *a priori*.

As used herein with reference to quantity or value, the term "about" means "within ± 10% of".

The terms "comprises", "comprising", "includes", "including", "has", "having" and their conjugates mean "including but not limited to".

The term "consisting of" means "including and limited to".

The term "consisting essentially of" means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure.

As used herein, the singular forms "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound" may include a plurality of compounds, including mixtures thereof.

Throughout this application, embodiments of this invention may be presented with reference to a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as "from 1 to 6" should be considered to have specifically disclosed subranges such as "from 1 to 3", "from 1 to 4", "from 1 to 5", "from 2 to 4", "from 2 to 6", "from 3 to 6", etc.; as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Whenever a numerical range is indicated herein (for example "10-15", "10 to 15", or any pair of numbers linked by these another such range indication), it is meant to include any number (fractional or integral) within the indicated range limits, including the range limits, unless the context clearly dictates otherwise. The phrases "range/ranging/ranges between" a first indicate number and a second indicate number and "range/ranging/ranges from" a first indicate number "to", "up to", "until" or "through" (or another such range-indicating term) a second indicate number are used herein interchangeably and are meant to include the first and second indicated numbers and all the fractional and integral numbers therebetween

Unless otherwise indicated, numbers used herein and any number ranges based thereon are approximations within the accuracy of reasonable measurement and rounding errors as understood by persons skilled in the art.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable

subcombination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting.

WHAT IS CLAIMED IS:

1. An oral measuring method configured to make oral measurement within the oral cavity of a patient comprising:
providing an Intra Oral Scanner (IOS) with an elongate probe extending therefrom;
contacting a plurality of first points inside an oral cavity with said probe while scanning said cavity with said IOS; and
determining a position of each of said plurality of first points based on said scanning to determine a position in space of said elongate probe.

2. A method according to claim 1, further comprising calculating at least one of:
a location of a surface using said determined positions;
a measurement of a length using said determined positions; and
a position of a curved plane using said determined positions.

3. A method according to any of the preceding claims, wherein said determining comprises determining positions of said points relative to an oral feature.

4. A method according to any of the preceding claims, and further comprising;
using said probe to collect data on periodontal health;
producing a 3D model of the oral cavity; and
automatically generating a periodontal chart.

5. A method according to any one of claims 1-3, and further comprising:
using said elongate body to measure periodontal pocket depth;
automatically generating a personalized periodontal chart that includes at least one of:
a map of clinical attachment level;
a location of a cement to enamel junction;
a mucoginigival line;
a periodontal conditions;
an area of decay;
a tooth cavity;
a missing tooth;
a depth of a gum pocket;
a bleeding point discovered during probing;
gum recession;
an abnormality in a tooth;
a 2D image of a tooth; and'
a 3D image of a tooth.

6. A method according to claim 5, wherein said contacting comprises contacting within a recess of a tissue(s), a tooth(teeth), and a bone(s) within or proximate to the oral cavity.

7. A method according to claim 5, wherein said contacting comprises contacting within a recess, and wherein said recess comprises one of a socket of a tooth extraction, an excavated hole in a bone, a drilled hole in a tooth, an excavated cavity in a tooth for an inlay, an excavated cavity in a tooth for an onlay, and a root of a tooth.

8. A method according any of the preceding claims, further comprising determining a position of second points which are located on at least one of a steep wall, an interproximal wall with a narrow interproximal gap, a negative slope wall, a high reflectivity surface, a high absorbance surfaces, an obscured surface and a surface inside a recess.

9. A method according any of claims 1-7, wherein said contacting includes contacting at least one point which is located on at least one of a steep wall, an interproximal wall with a narrow interproximal gap, a negative slope wall, a high reflectivity surface, a high absorbance surfaces, an obscured surface and a surface inside a recess.

10. A method according to claim 5, wherein said first plurality of points comprise gum or other mucosal tissue.

11. A method according to claim 5, wherein said contacting comprises inserting said probe through mucosal tissue to contact an underlying tooth, implant or bone structure.

12. A method according to any of claims 10 and 11, wherein said plurality of first points comprise gum tissue, and wherein the method further comprises determining gum thickness by creating a 3D model based on the determining step and comparing the 3D model to bone location in a CT 3D model.

13. A method according to claim 5, wherein said plurality of first points comprise points on tooth tissue.

14. A method according to claim 13, further comprising measuring at least one of tooth abrasion and gaps between opposing teeth when a mouth is closed based upon the positions of the plurality of first points.

15. A method according to claim 13, further comprising measuring a horizontal or vertical mismatch of a crown based upon the positions of the plurality of first points.

16. A method according to claim 13, further comprising measuring the joint between a crown and a tooth to which it is attached based upon the positions of the plurality of first points.

17. A method according to claim 13, further comprising measuring a tooth prepared for fitting of a crown based upon the positions of the plurality of first points.

18. A method according to any of claims 5-17, further comprising estimating a mechanical property of a mechanical tissue by said contacting.

19. A method according to claim 18, wherein said mechanical property is at least one of tissue elasticity and tissue hardness.

20. A method according to any of the preceding claims, wherein the plurality of points comprises points along artificially provided oral items.

21. A method according to claim 20, wherein said oral item comprises a crown, a denture or an implant, brackets, laminates, esthetic elements, night guards, splints.

22. A method according to any of the preceding claims, further comprising conducting a secondary scanning and determining positions of the first plurality of points so as to determine a refined determined position of the first plurality of points.

23. A method according to claim 22, further comprising:
using said scanning to generate a 3D reconstruction of an oral surface; and
identifying, on said reconstruction, one or more locations of one or more of the plurality of first positions having reduced accuracy.

24. An IOS scanner, comprising:
a body having a head;
at least one imager suitable for intra-oral scanning from said head; and
a hollow probe with an opening, said probe extending from said head and within a field of view of said at least one imager.

25. A scanner according to claim 24, comprising a channel extending from said probe to a source of pressurized material suitable for flowing through said channel and said probe to said opening.

26. A scanner according to claim 25, wherein said source comprises water, abrasive material or adhesive.

27. A scanner according to claim 24, comprising a channel extending from said probe to a source of negative pressure.

28. A scanner according to claim 24, comprising a channel extending from said probe to said opening, wherein said channel contains an optical fiber.

29. A scanner according to claim 28, wherein said fiber is coupled to a light source suitable for one or more of ablation, coagulation, tissue cutting, illumination and sending via said fiber.

30. A scanner according to claim 24, comprising a channel extending from said probe to said opening, wherein said channel contains an electrical signal conductor.

31. A scanner according to any of claims 24-30, wherein said probe includes a tip and said IOS is configured for determining a location of said tip during a procedure.

32. A scanner according to any of claims 24-30, wherein said opening is on a side of said hollow probe.

33. A scanner according to any of claims 24-30, wherein said opening is at a distal end of said hollow probe and facing along an axis of said probe.

34. A dental probe, comprising:
a body having a head, the body elongated in a first direction;
at least one imager configured for imaging in a second direction different from the first direction; and
a probe extending in the second direction and within a field of view of said imager and including a viewer.

35. A probe according to claim 34, wherein said probe is configured for quick release from the body.

36. A probe according to claim 35, wherein said quick release is configured for releasing using a standard dentist tool.

37. A probe according to claim 34, wherein said viewer comprises a mirror which reflects light towards said body with distortion low enough for imaging.

38. A probe according to claim 34, wherein said viewer comprises an ultrasonic distance sensor.

39. A probe according to claim 34, wherein said viewer comprises an ultrasonic imager.

40. A probe according to claim 34, wherein said body (probe) comprises a side viewing ultrasonic imager (IVUS).

41. A probe according to claim 34, wherein said body (probe) comprises a Piezoelectric Micromachined Ultrasound Transducer (PMUT) array.

42. A probe according to claim 40, wherein said body includes a channel for dispensing acoustic coupling liquid.

43. A probe according to claim 34, wherein said viewer comprises an optical imager.

44. A probe according to claim 34, wherein said viewer comprises a 3D imager.

45. A probe according to claim 34, wherein said viewer comprises side viewing OCT or interference imager or sensor.

46. A probe according to claim 34, wherein said body includes a mechanical contact sensor.

47. A probe according to any one of claims 34-46, wherein said viewer includes a plurality of sensors, wherein a preferred sensor can be chosen according to local clinical conditions.

48. A probe according to any of claims 34-47, wherein a tip of said probe comprises at least one of a structure and a material configured for gliding along a surface when the tip contacts the surface with limited to negligible friction.

49. A probe according to any of claims 34-48, wherein a tip of said probe comprises a ball for rolling along a surface when the tip contacts the surface.

50. A probe according to any one of claims 34-46, wherein, probe includes an ultrasonic scaler, and where said imager is configured to determine if plaque was removed.

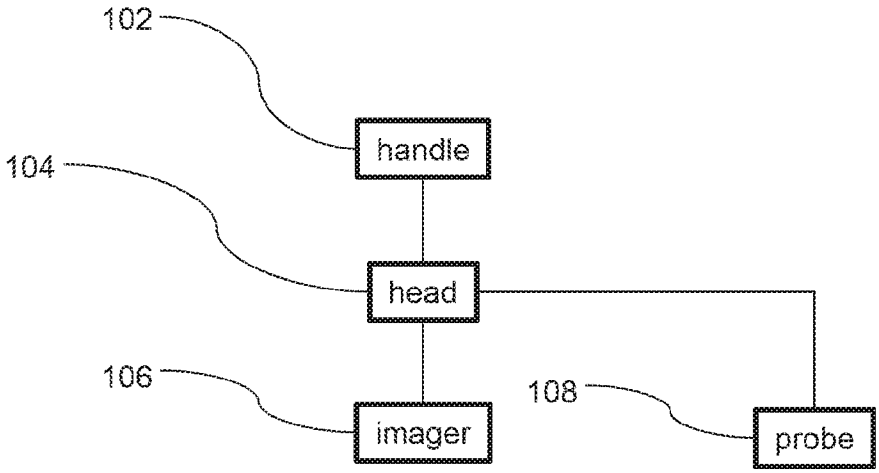

102
handle
104
head
106
imager
108
probe

FIG. 1A

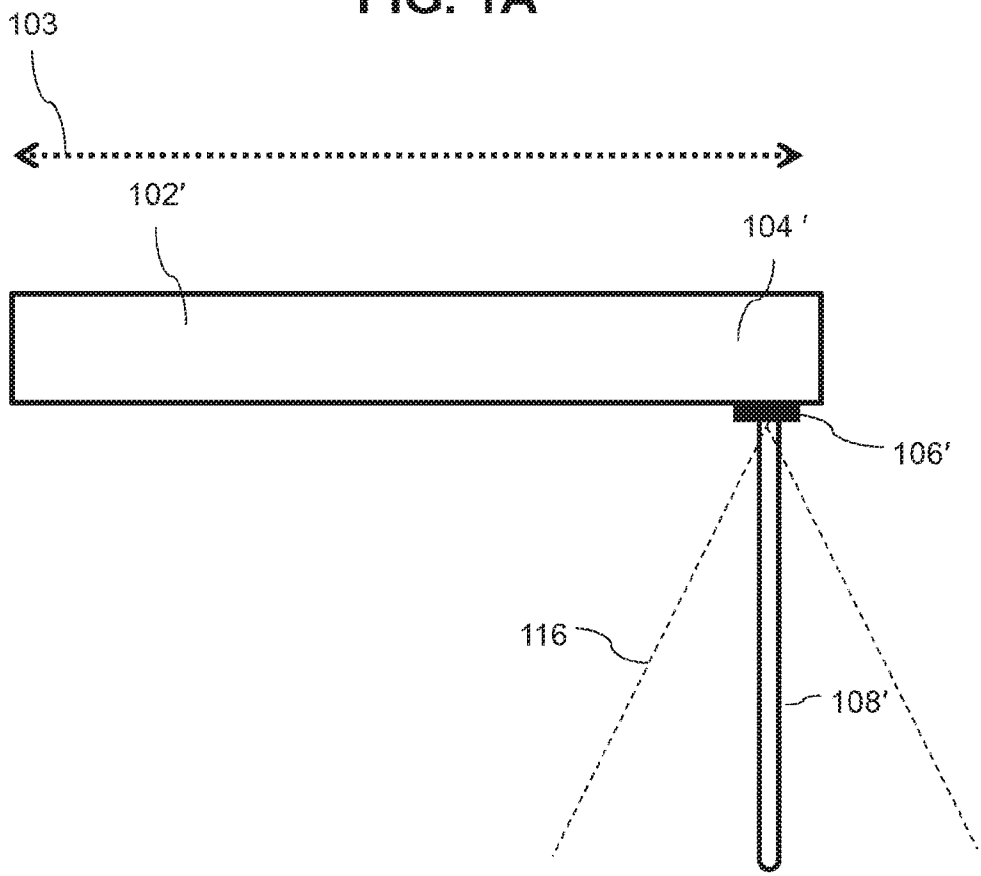

103
102'
104'
106'
116
108'

FIG. 1B

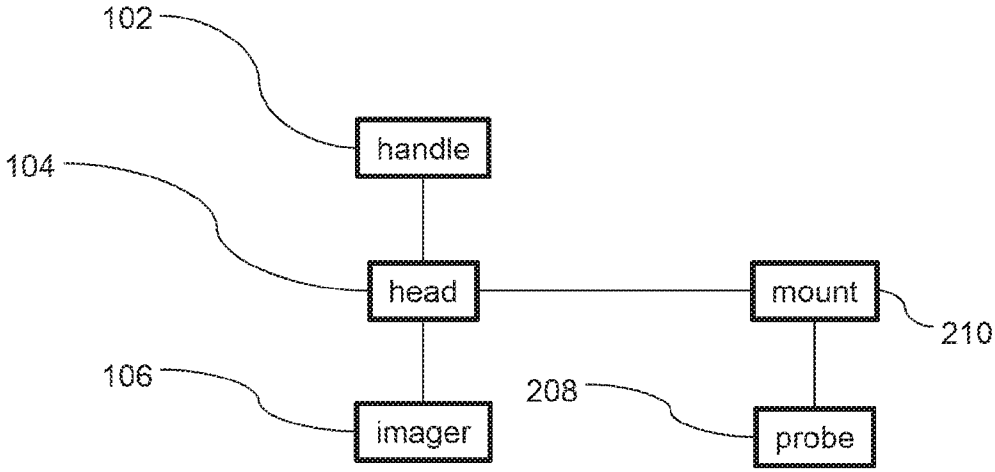

102
handle
104
head
mount
210
106
imager
208
probe

FIG. 2A

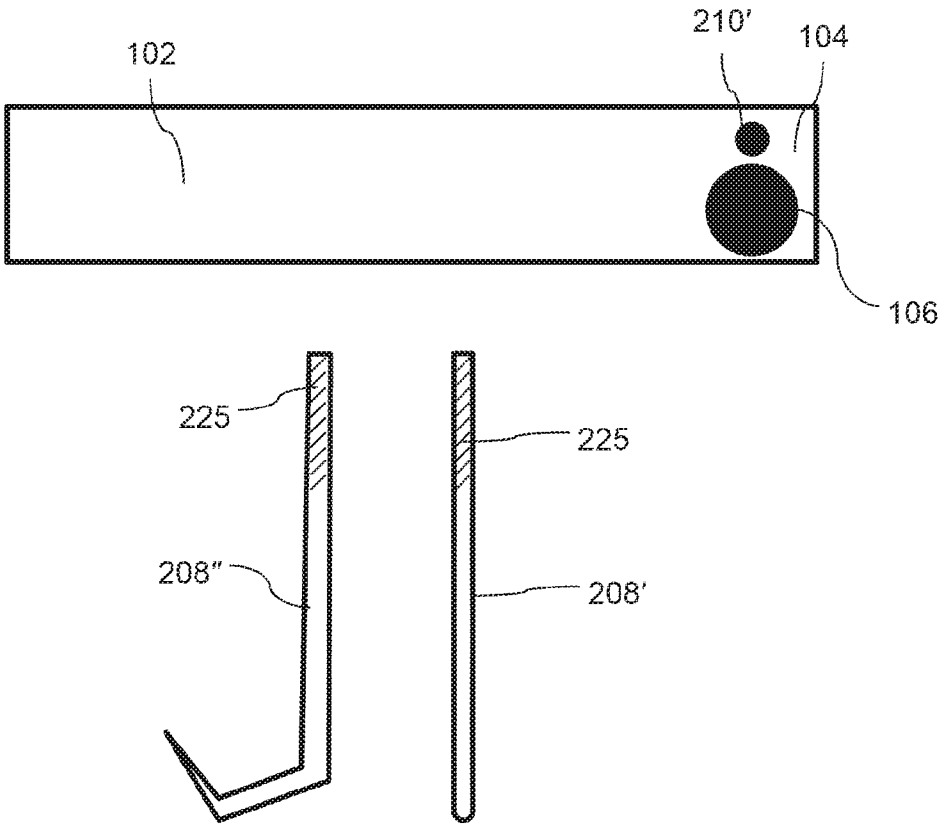

210'
104
102
106
225
225
208"
208'

FIG. 2B

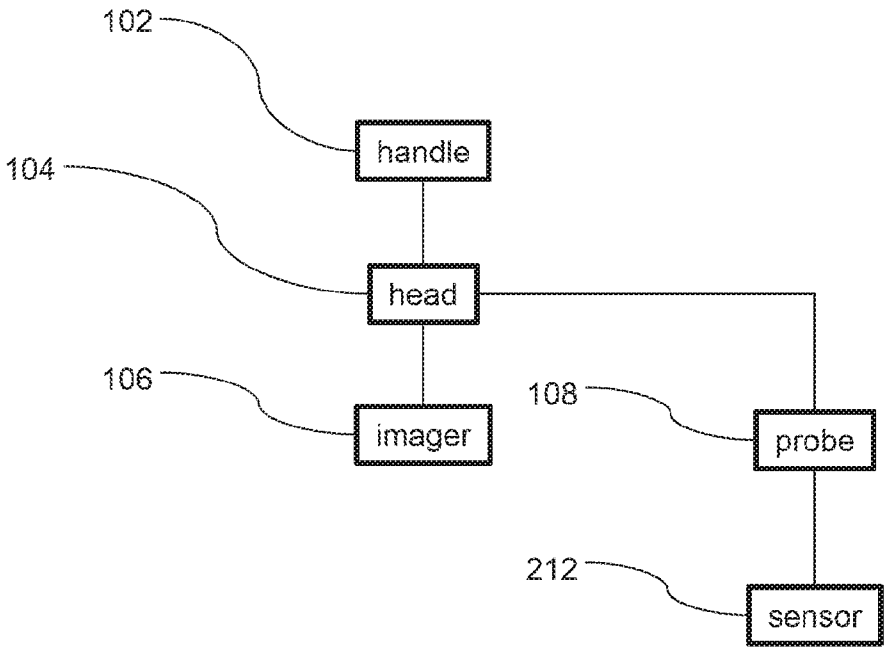


FIG. 2C

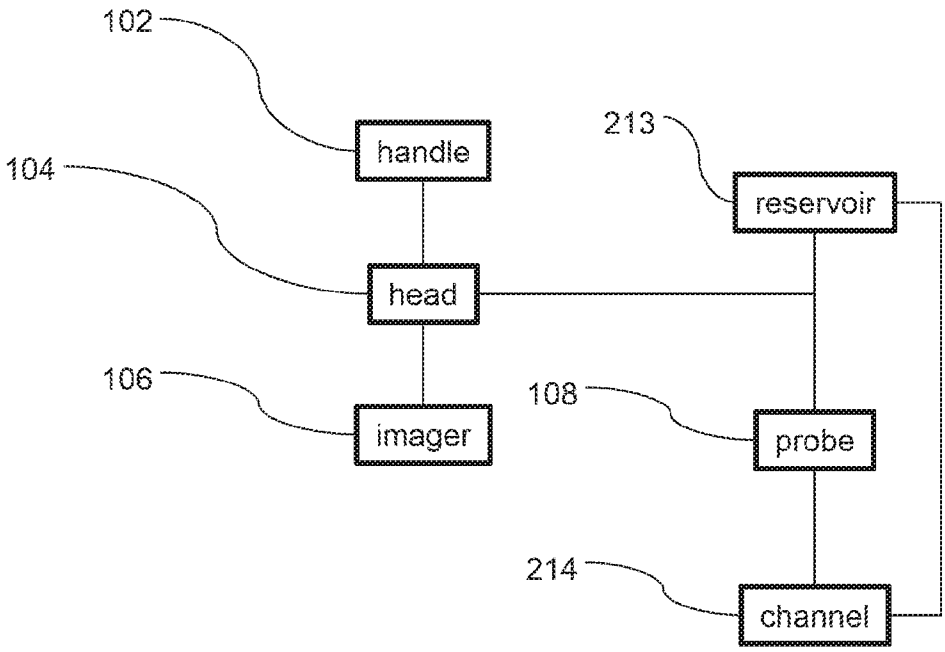

102
handle
213
reservoir
104
head
106
imager
108
probe
214
channel

FIG. 2D

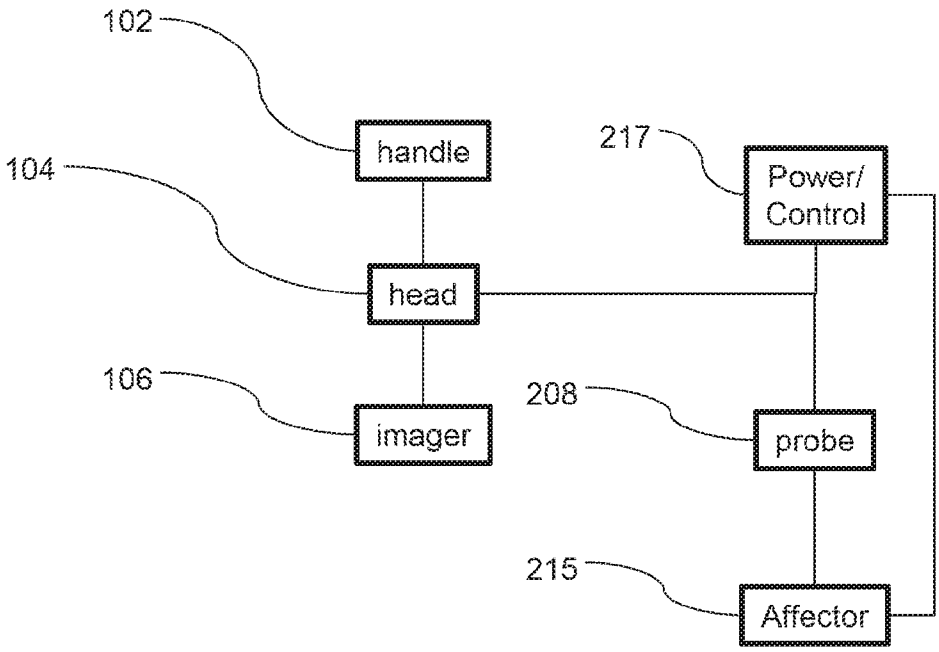

102
handle
104
head
106
imager
217
Power/
Control
208
probe
215
Affector

FIG. 2E

FIG. 3A

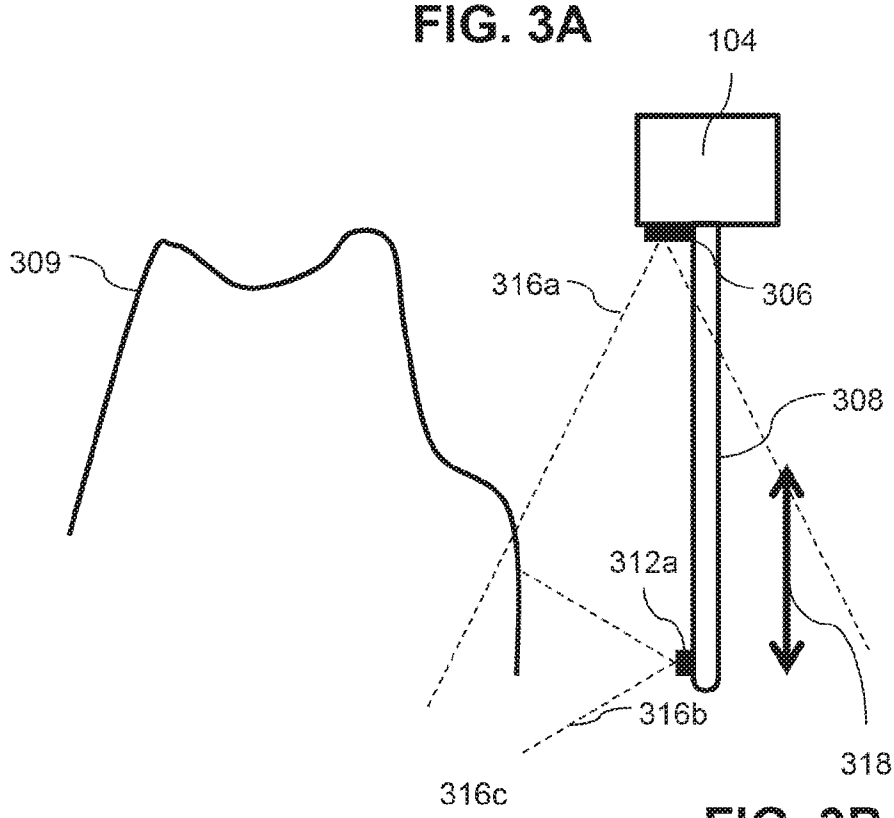

104
309
316a
306
308
312a
316b
318
316c

FIG. 3B

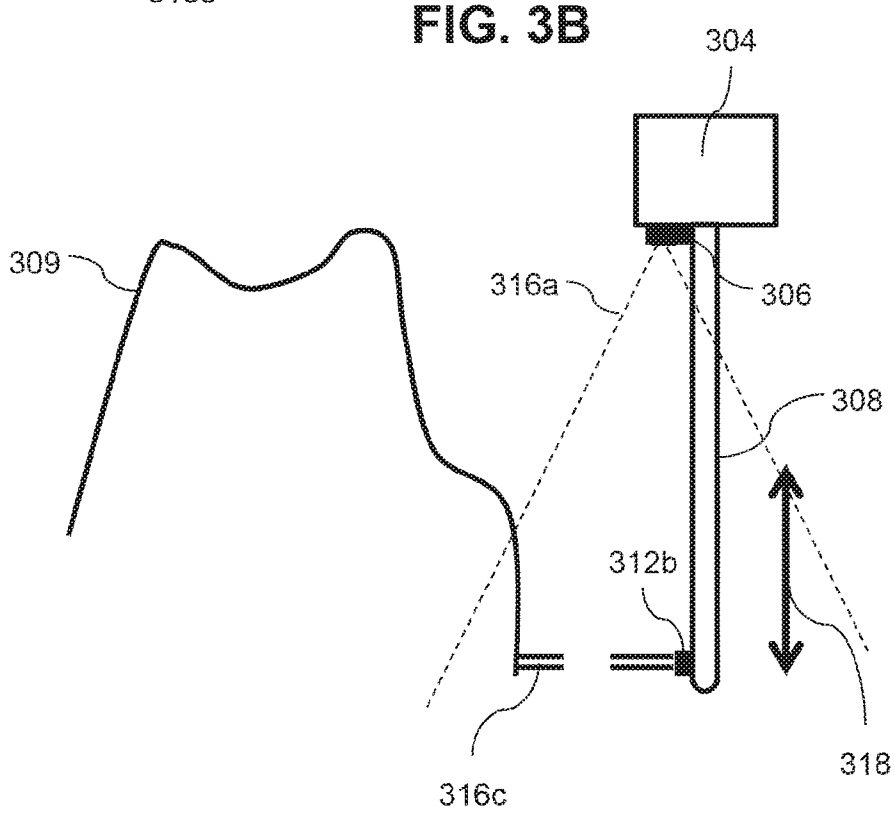

304
309
316a
306
308
312b
318
316c

FIG. 3C

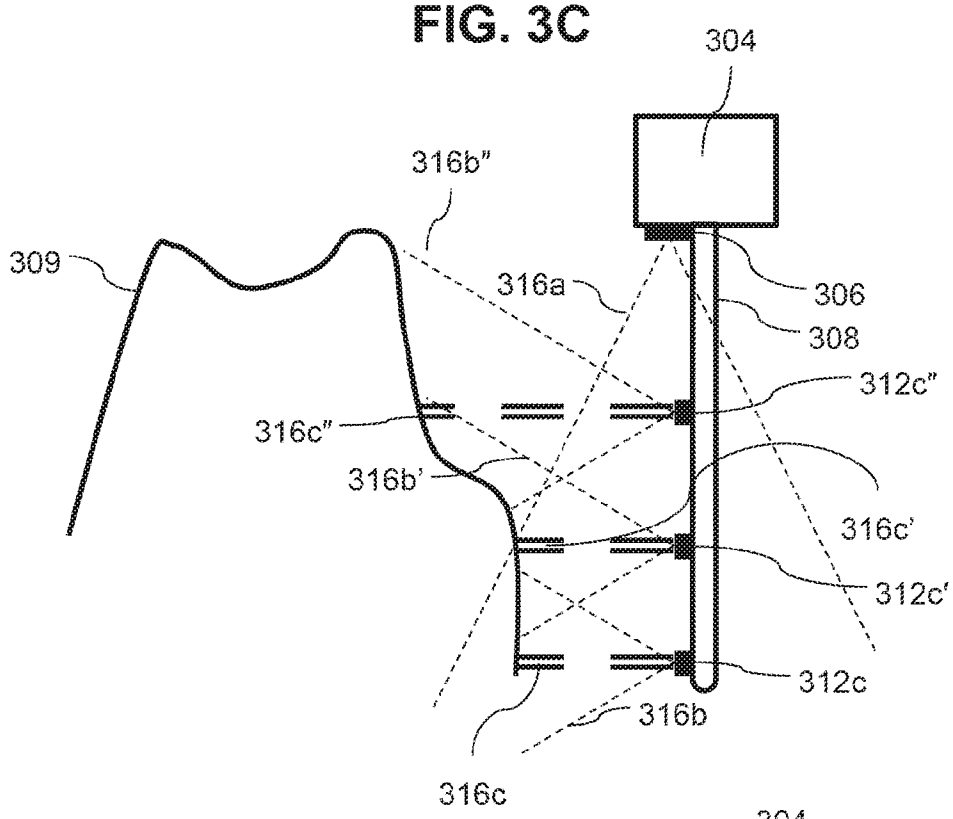
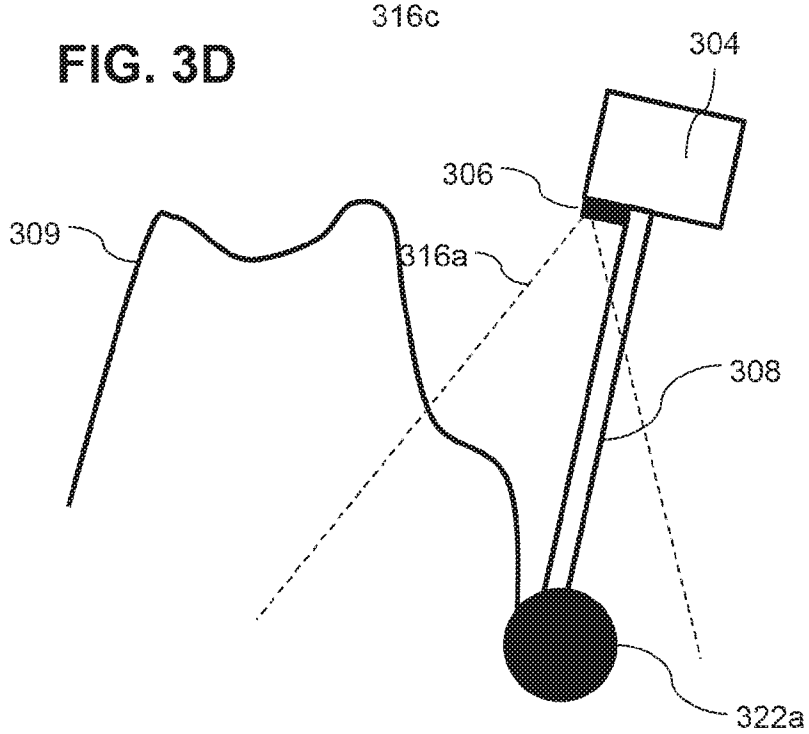

304
316b"
309
316a
306
308
312c"
316c"
316b'
316c'
312c'
312c
316b
316c

FIG. 3D


304
306
309
316a
308
322a

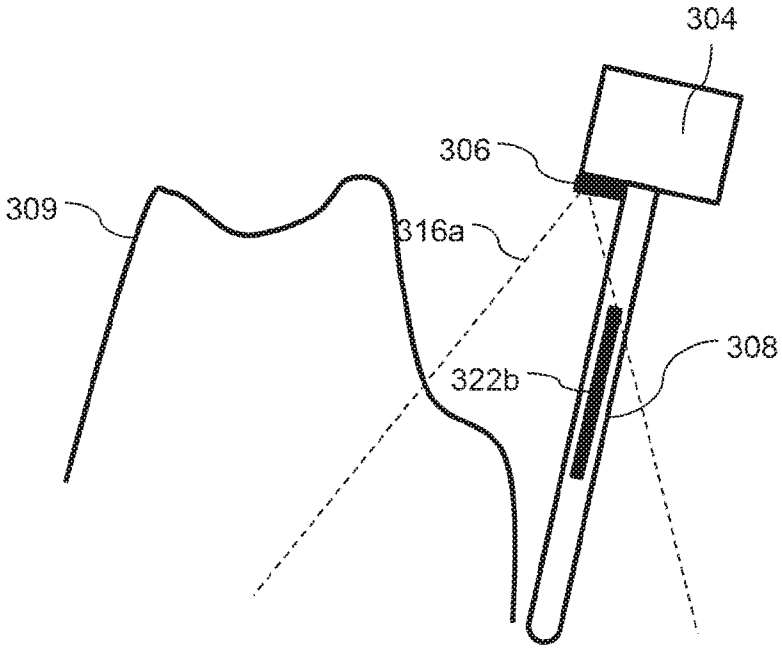


FIG. 3E

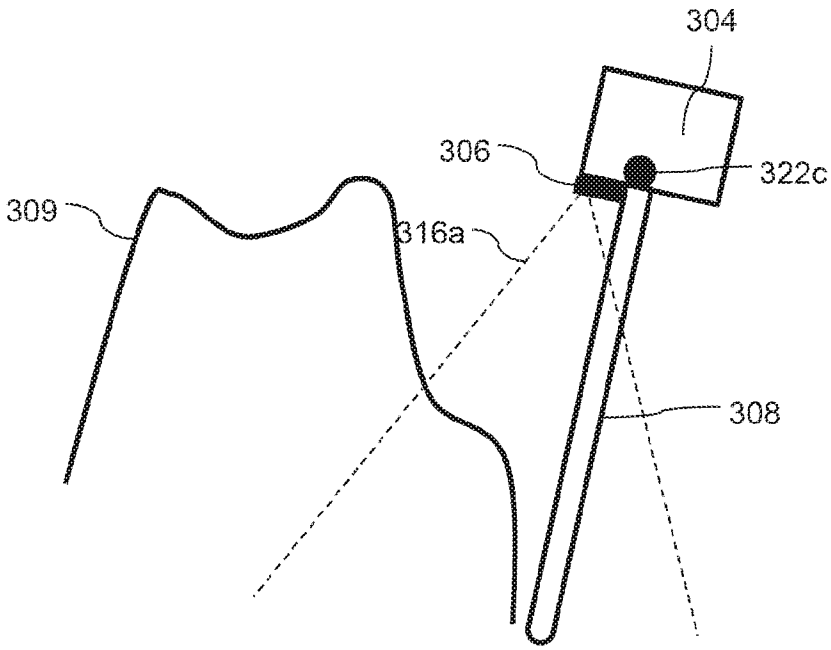


FIG. 3F

FIG. 4A

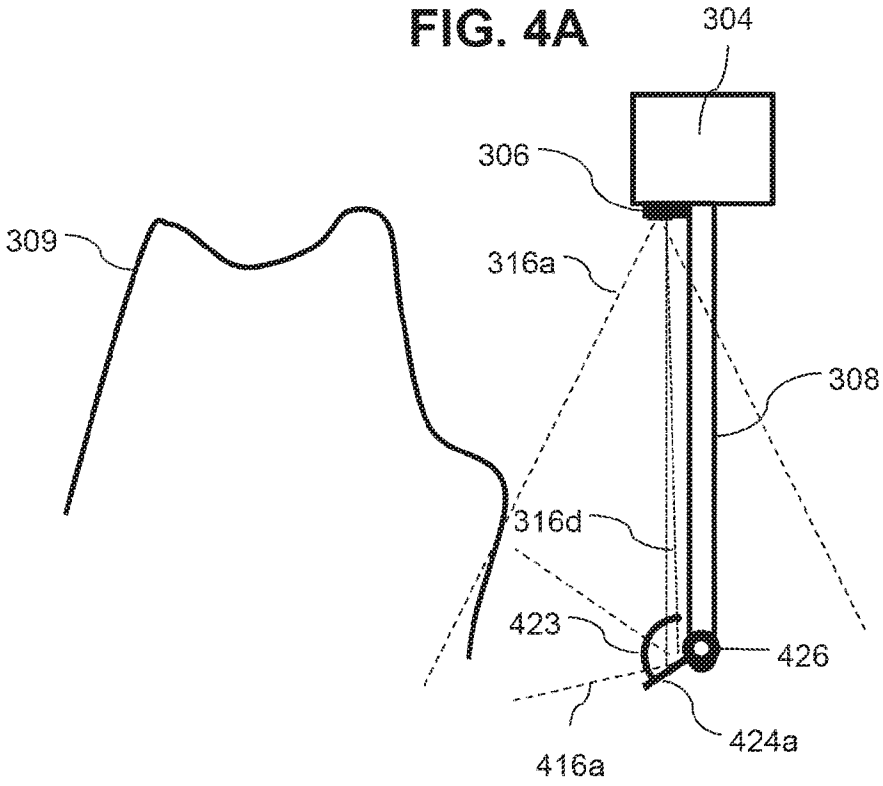

304
306
309
316a
308
316d
423
426
424a
416a

FIG. 4B

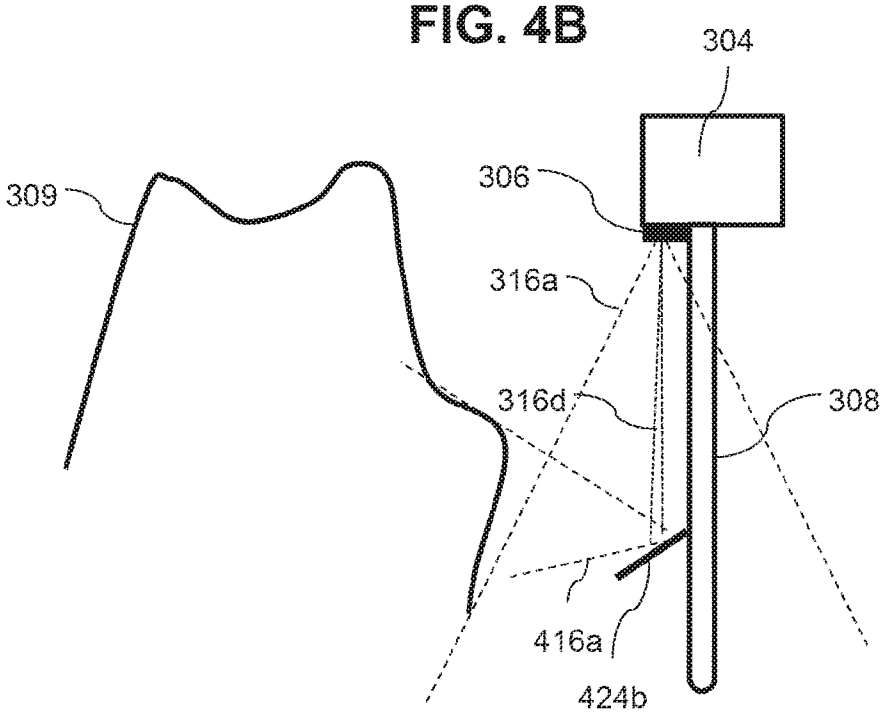

304
306
309
316a
316d
308
416a
424b

FIG. 4C

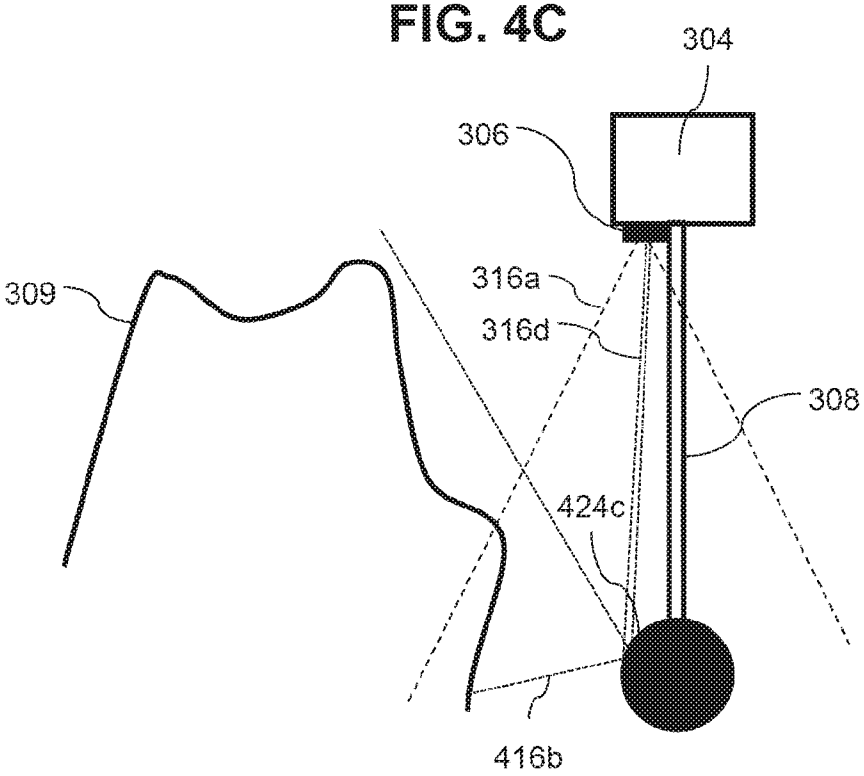


FIG. 5A

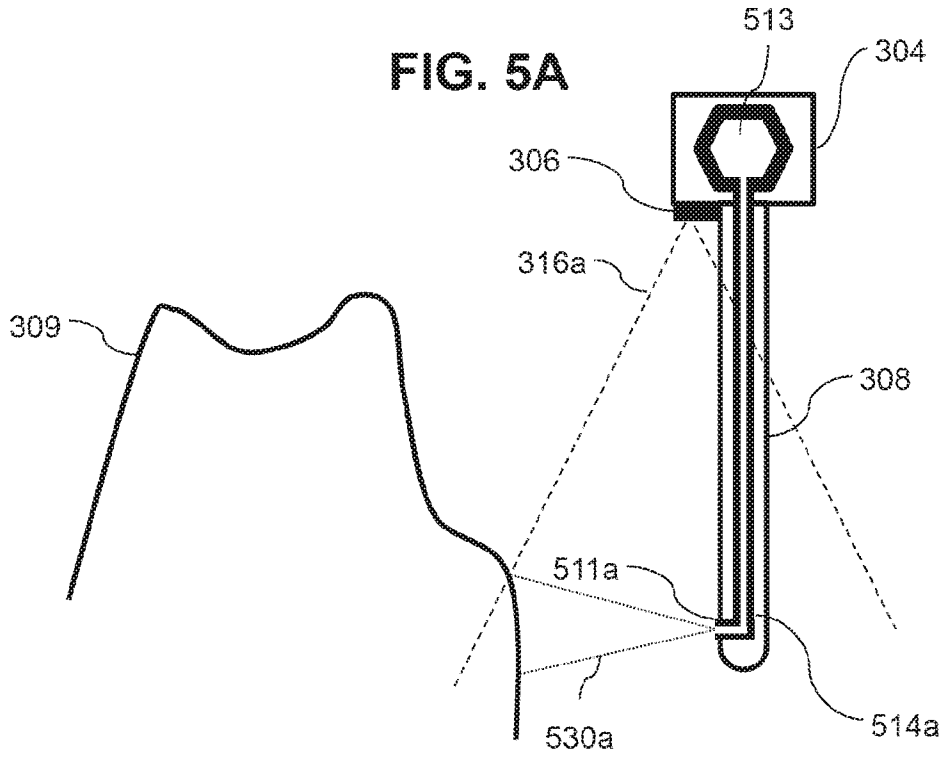
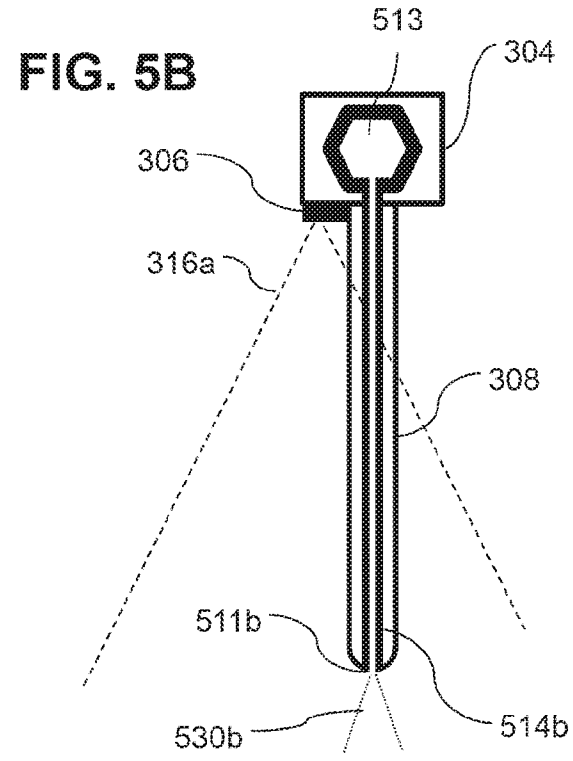

513
304
306
316a
309
308
511a
514a
530a

FIG. 5B


513
304
306
316a
308
511b
514b
530b

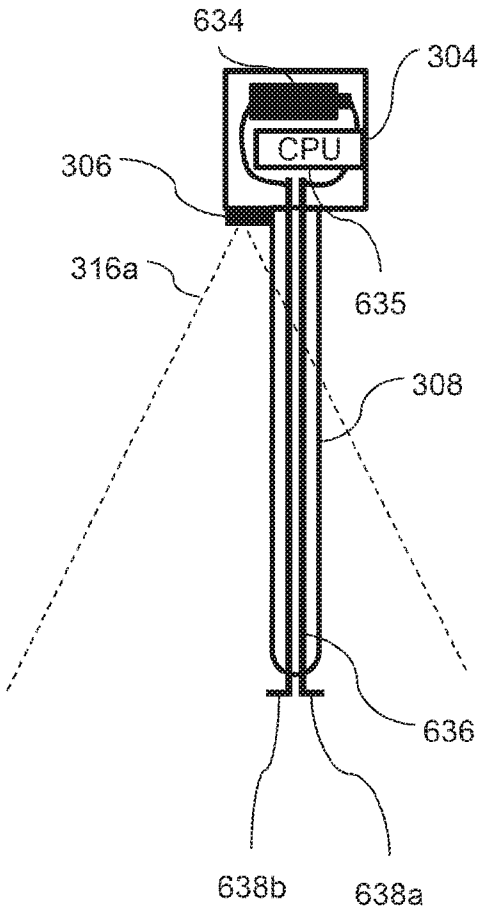
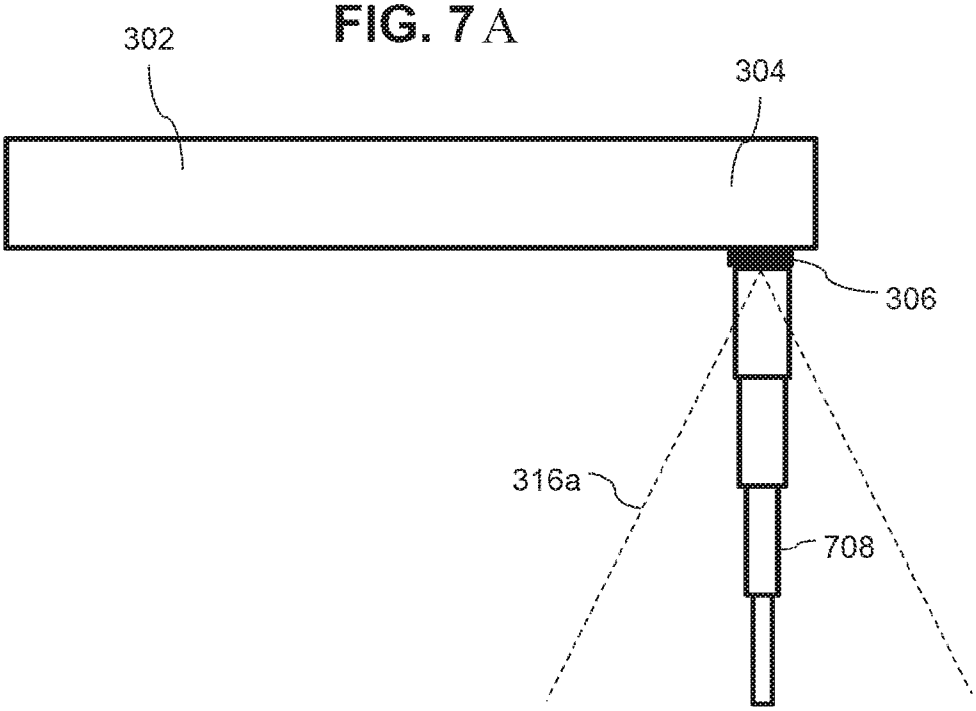


FIG. 6

FIG. 7A



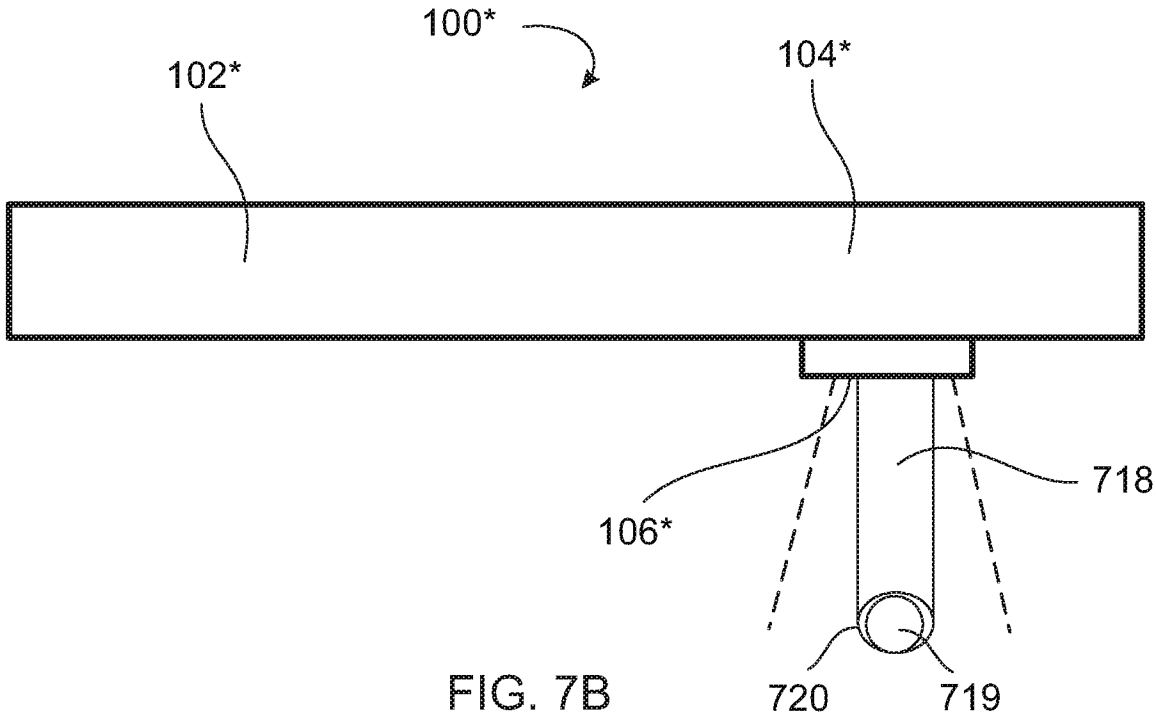


FIG. 7B

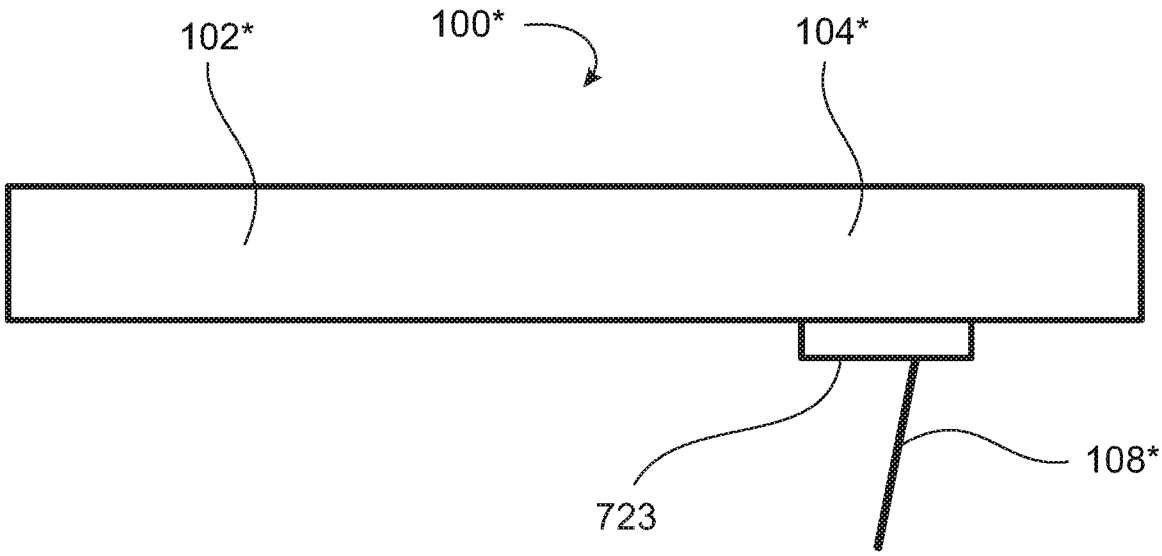


FIG. 7C

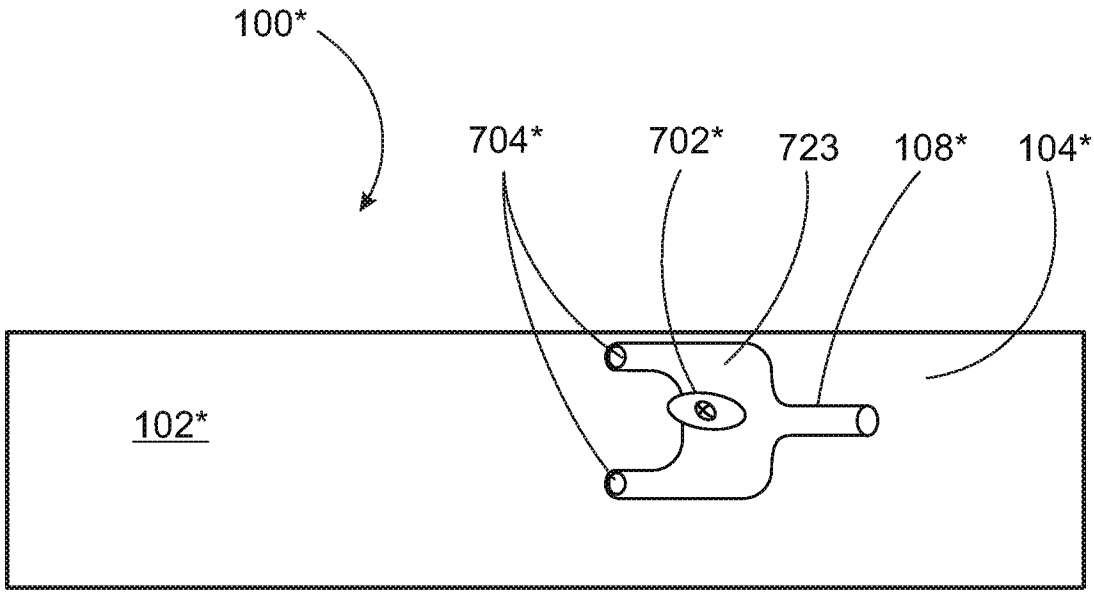


FIG. 7D

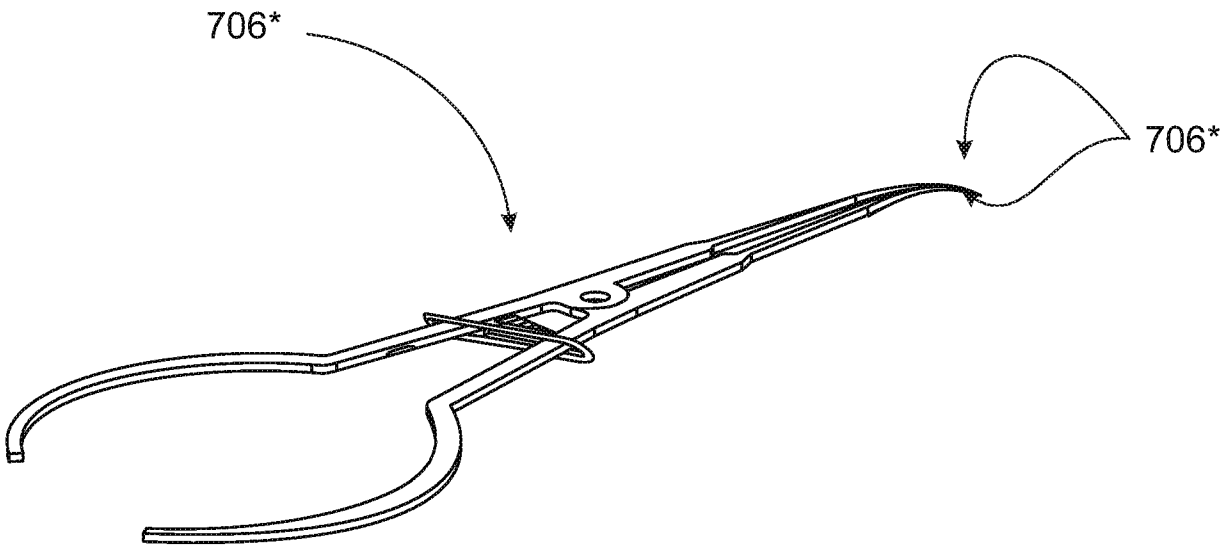


FIG. 7E

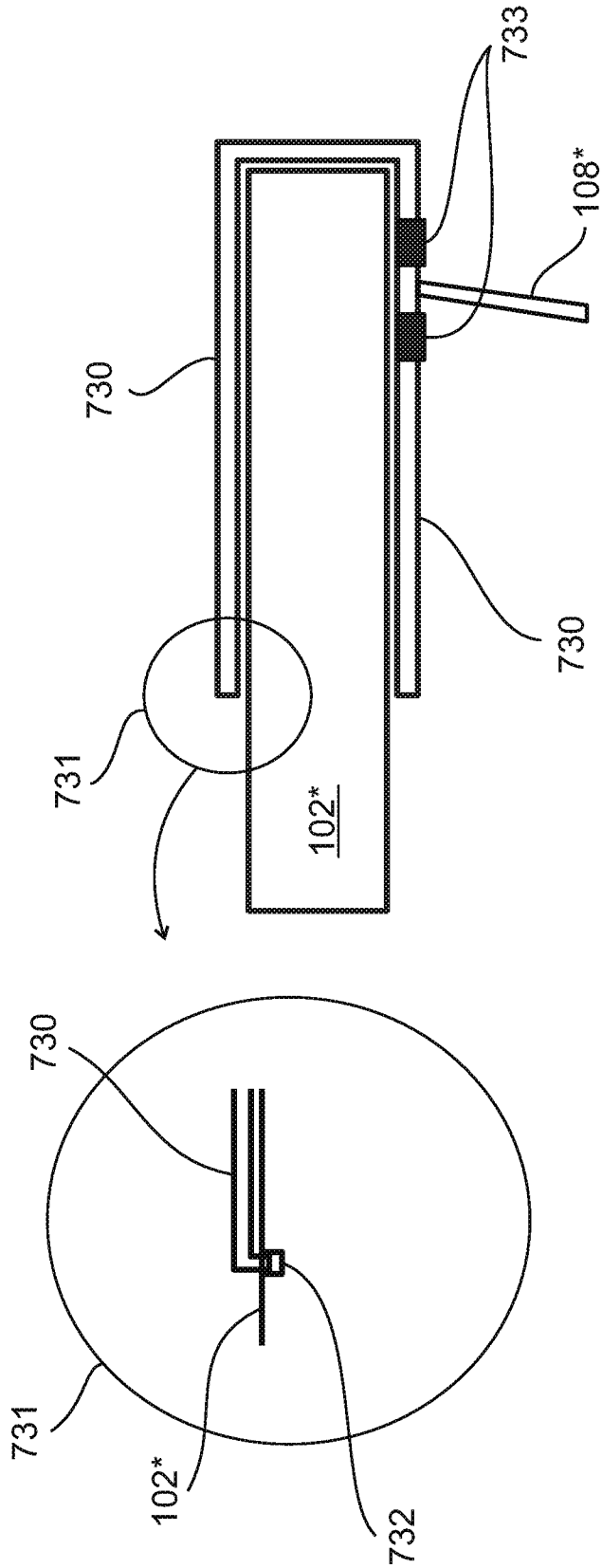


FIG. 7F

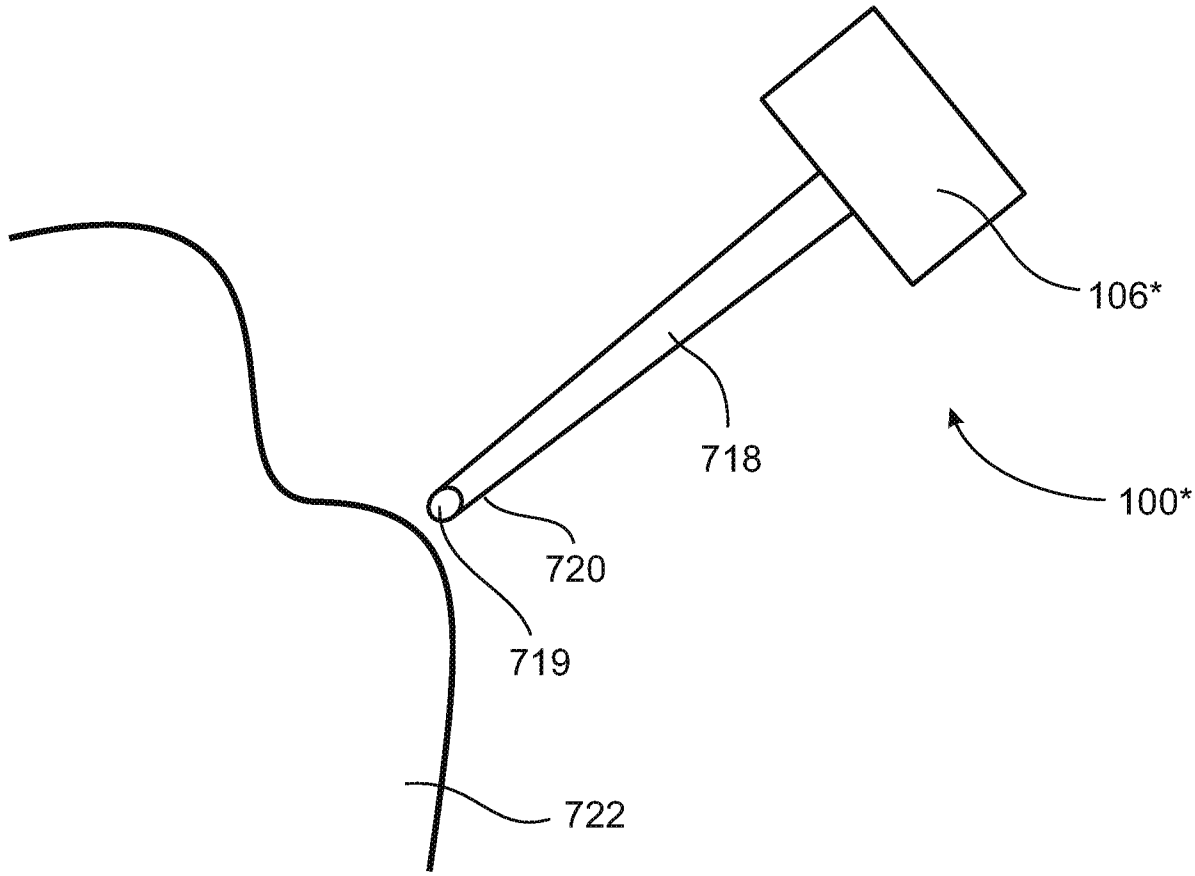


FIG. 7G

FIG. 8A

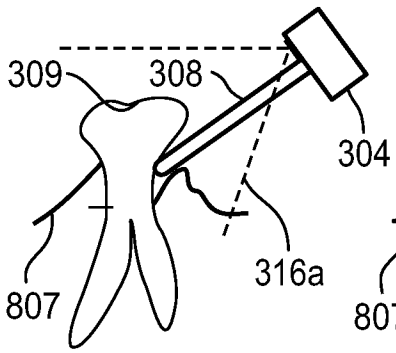


FIG. 8B

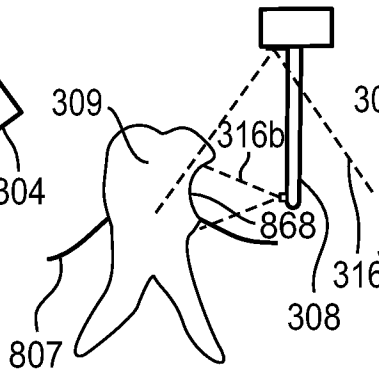


FIG. 8C

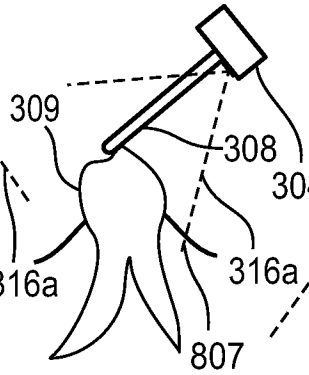


FIG. 8D

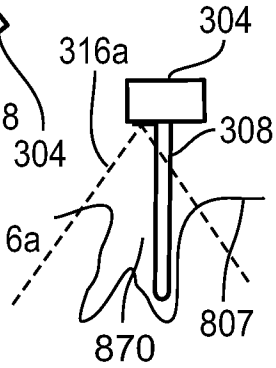


FIG. 8E

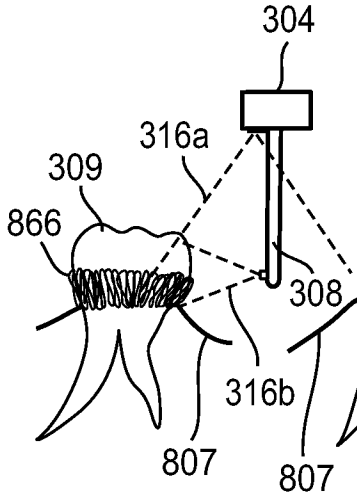


FIG. 8F

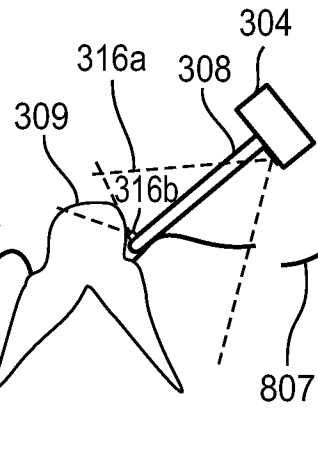


FIG. 8G

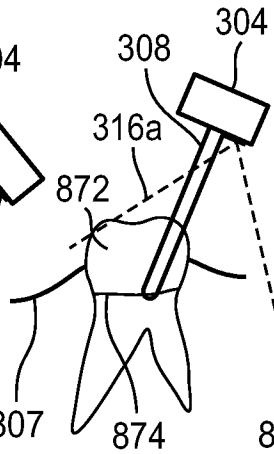


FIG. 8H

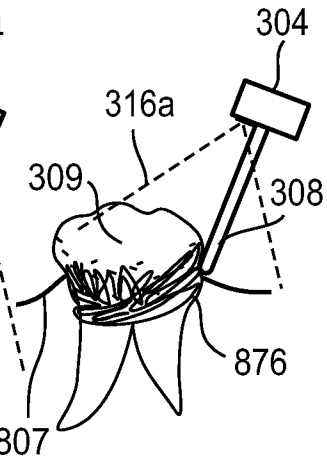


FIG. 8I

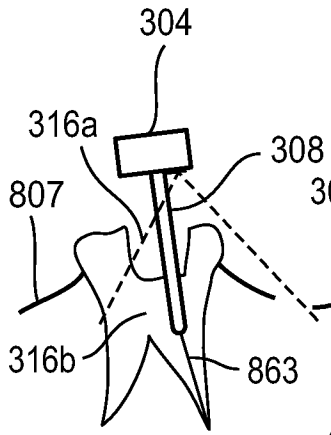


FIG. 8J

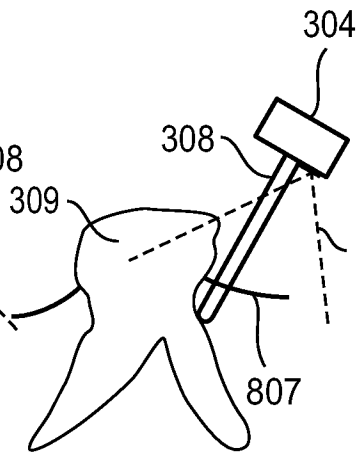
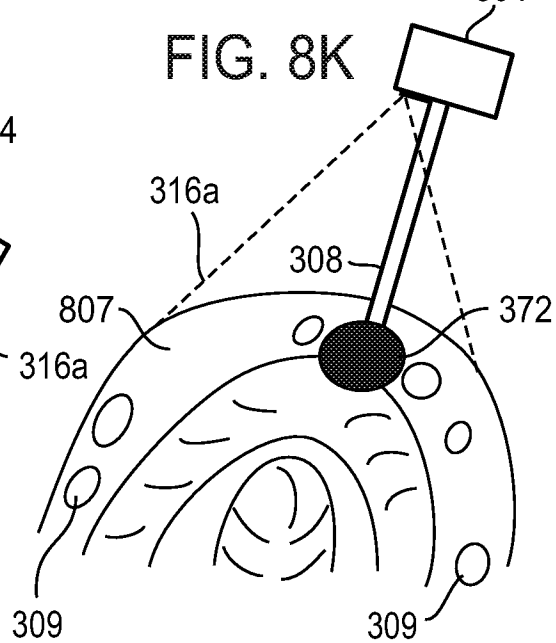


FIG. 8K



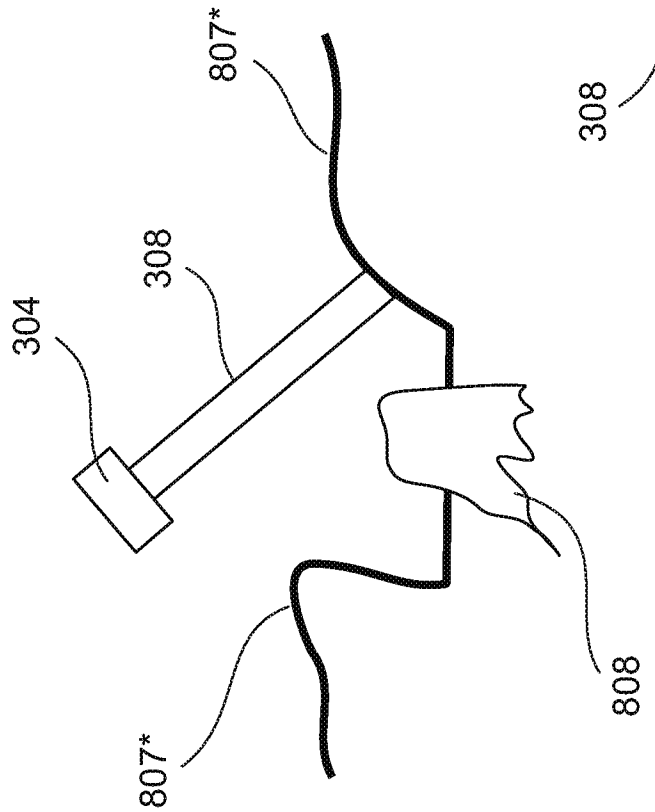


FIG. 8L

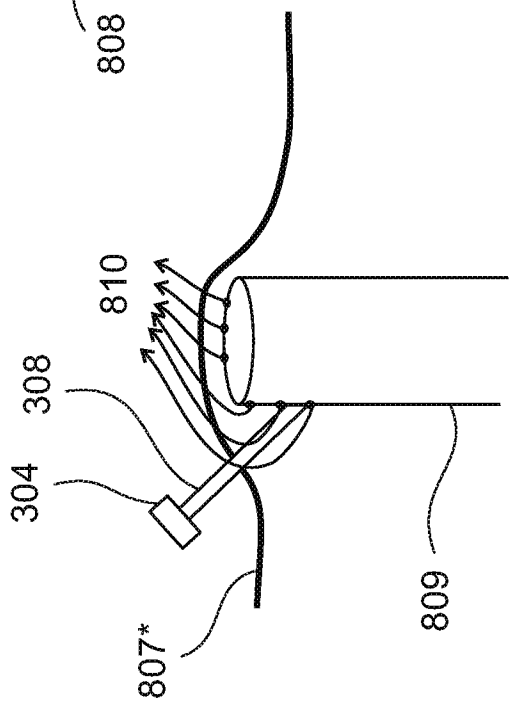


FIG. 8M

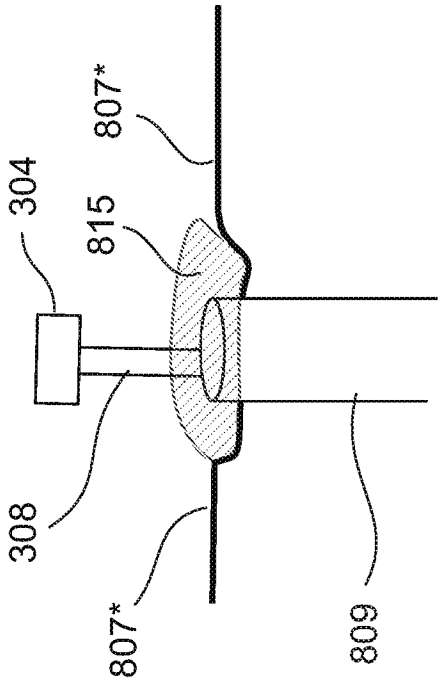


FIG. 8N

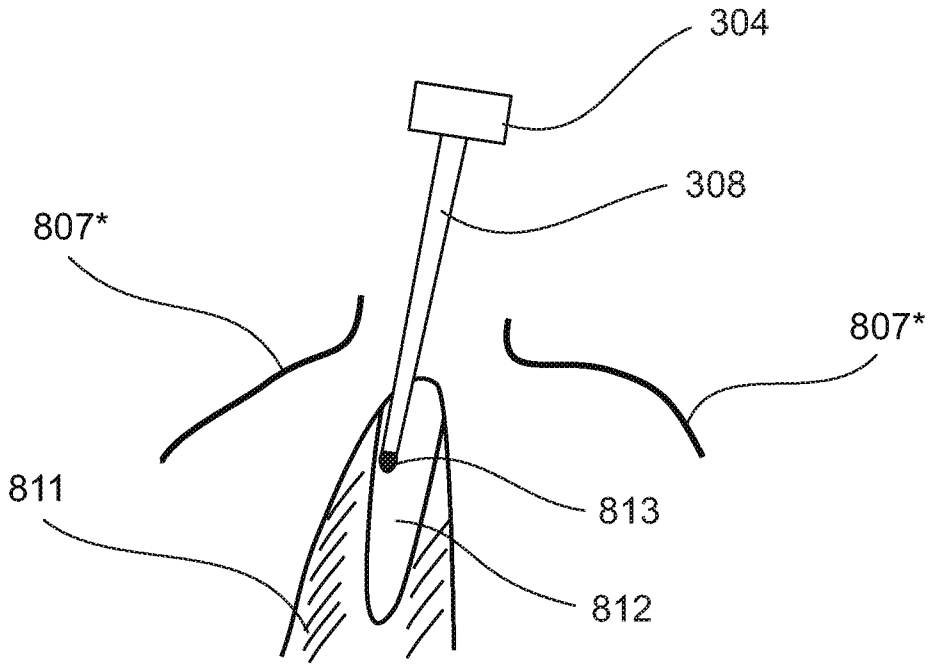


FIG. 8O

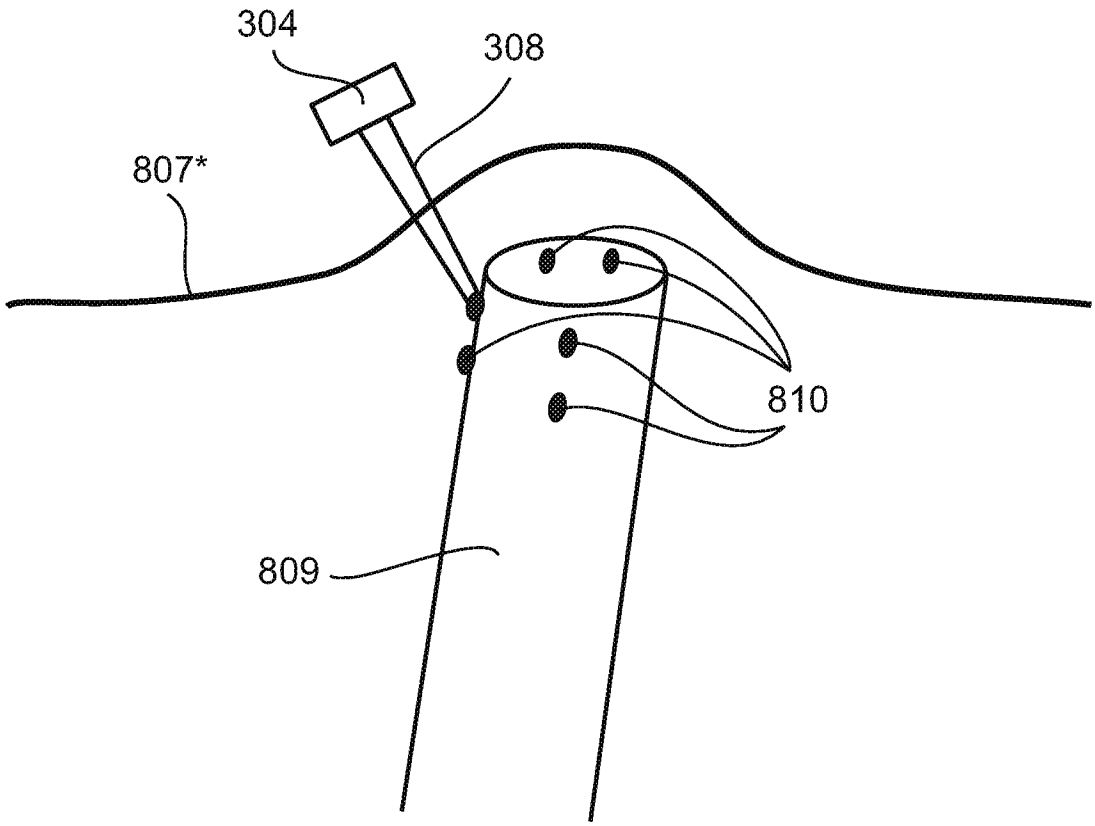


FIG. 8P

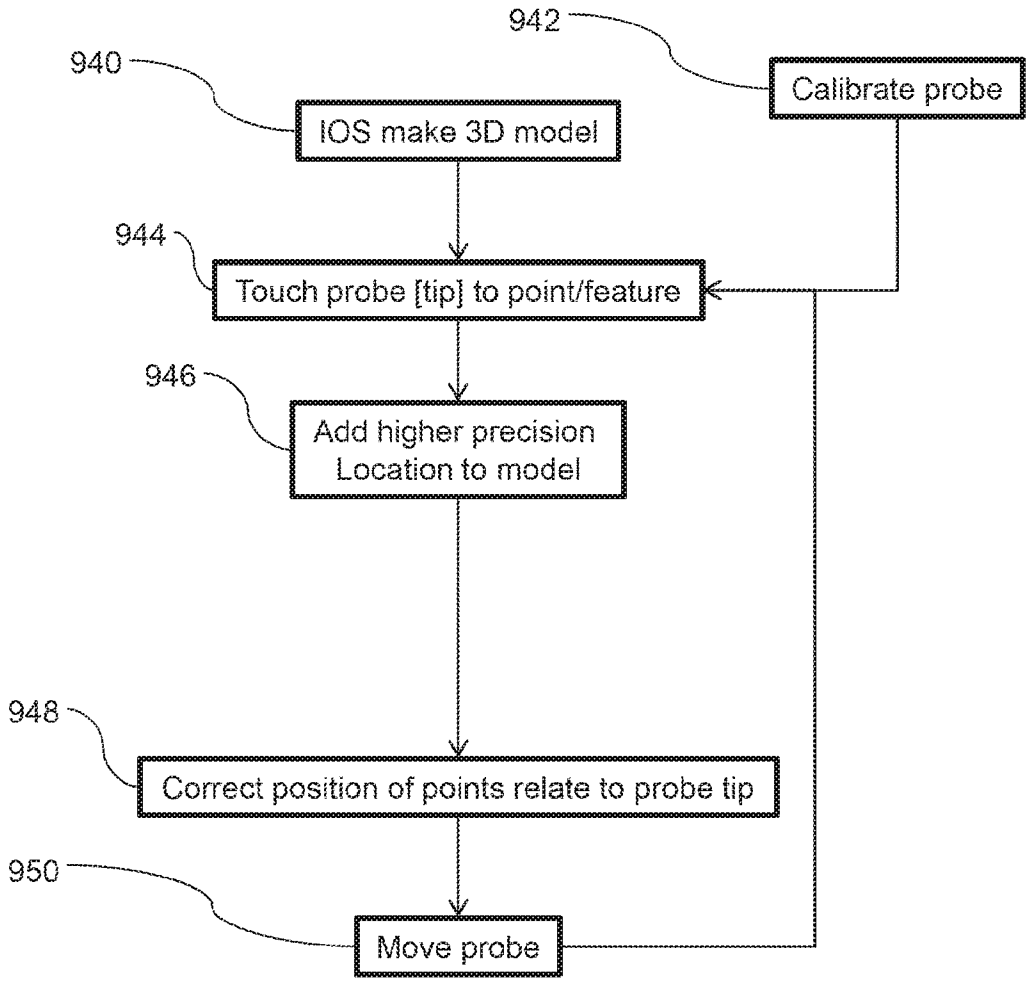

942
940
Calibrate probe
IOS make 3D model
944
Touch probe [tip] to point/feature
946
Add higher precision
Location to model
948
Correct position of points relate to probe tip
950
Move probe

FIG. 9

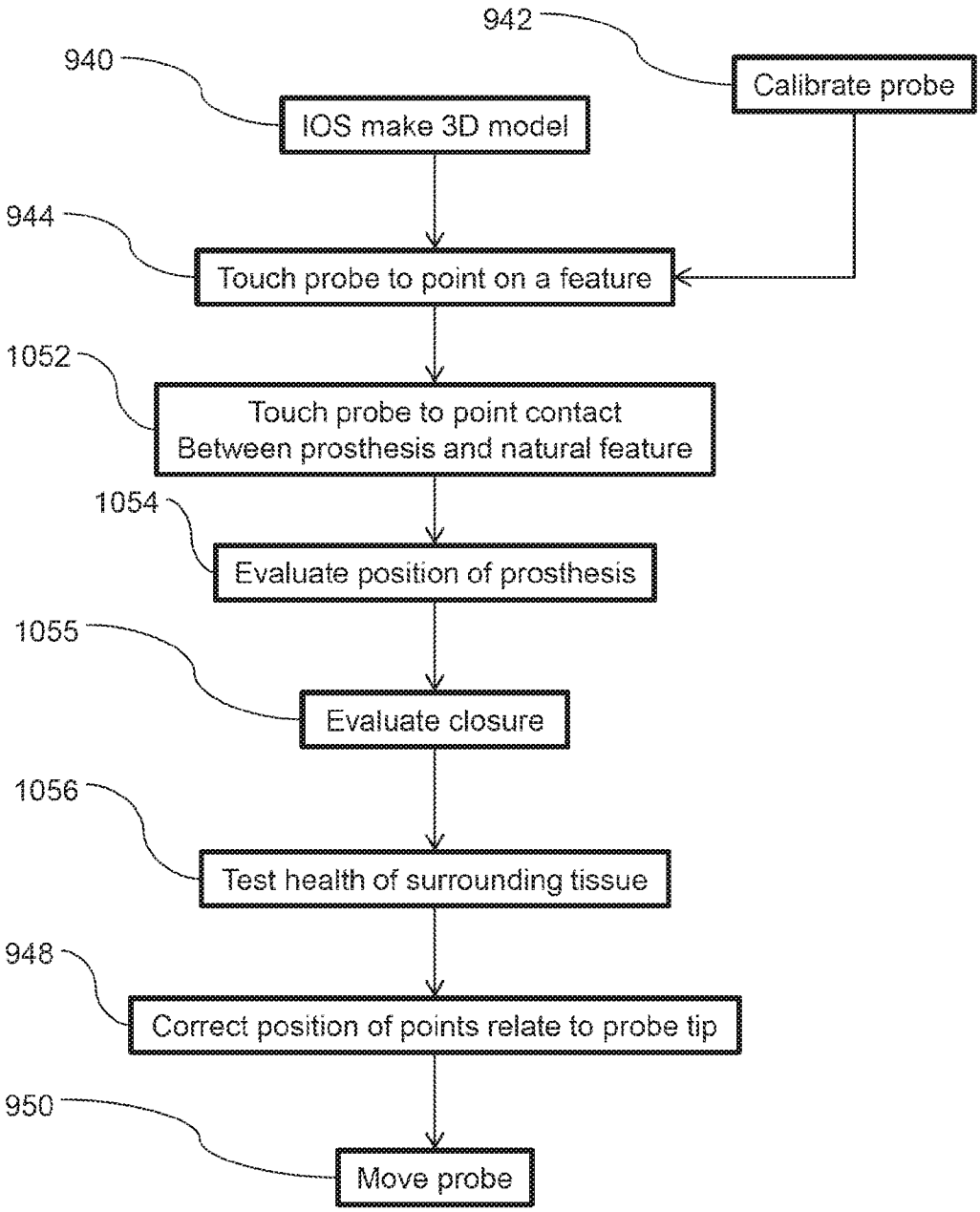

942
Calibrate probe
940
IOS make 3D model
944
Touch probe to point on a feature
1052
Touch probe to point contact
Between prosthesis and natural feature
1054
Evaluate position of prosthesis
1055
Evaluate closure
1056
Test health of surrounding tissue
948
Correct position of points relate to probe tip
950
Move probe

FIG. 10

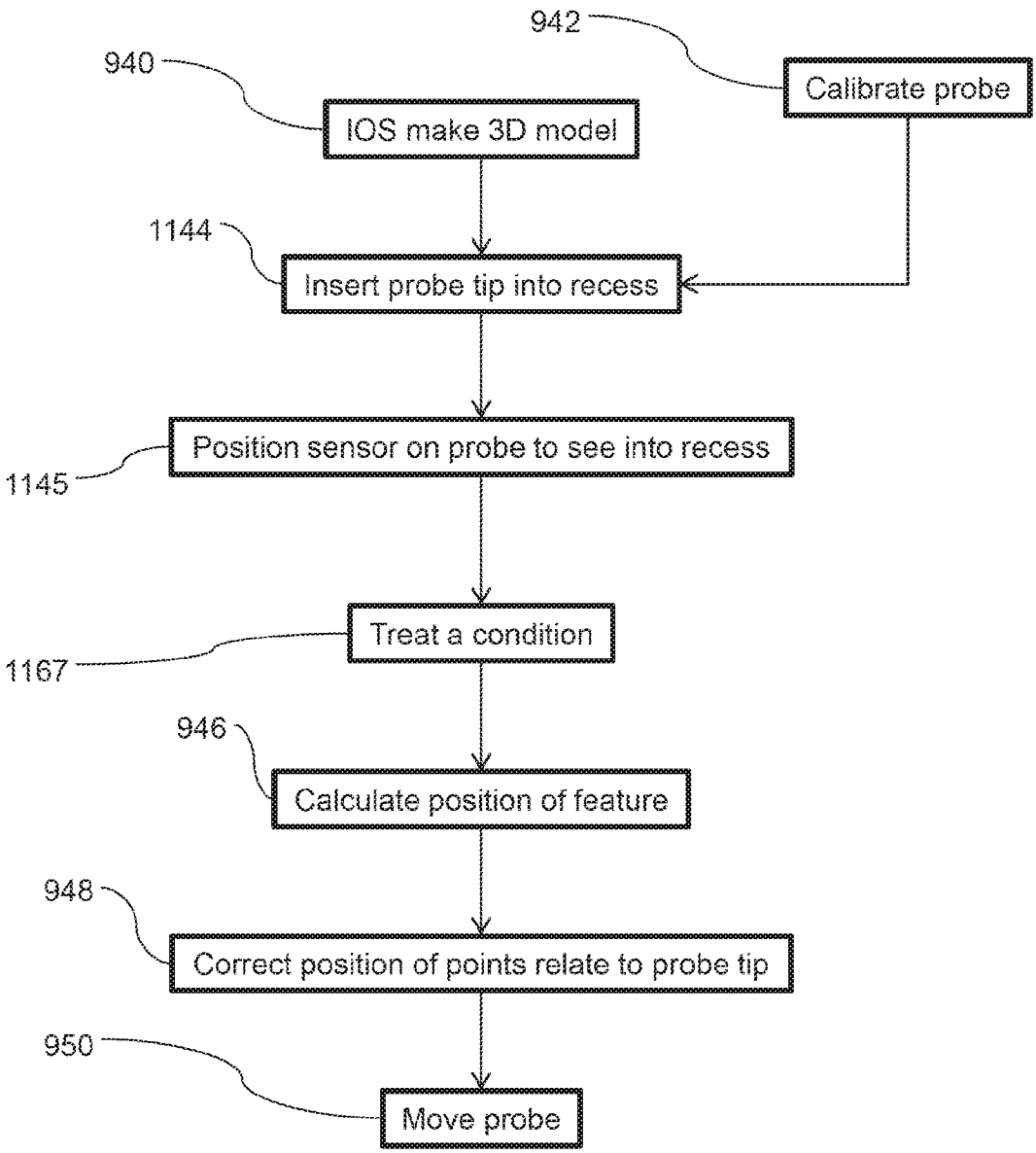

942
Calibrate probe
940
IOS make 3D model
1144
Insert probe tip into recess
Position sensor on probe to see into recess
1145
Treat a condition
1167
946
Calculate position of feature
948
Correct position of points relate to probe tip
950
Move probe

FIG. 11

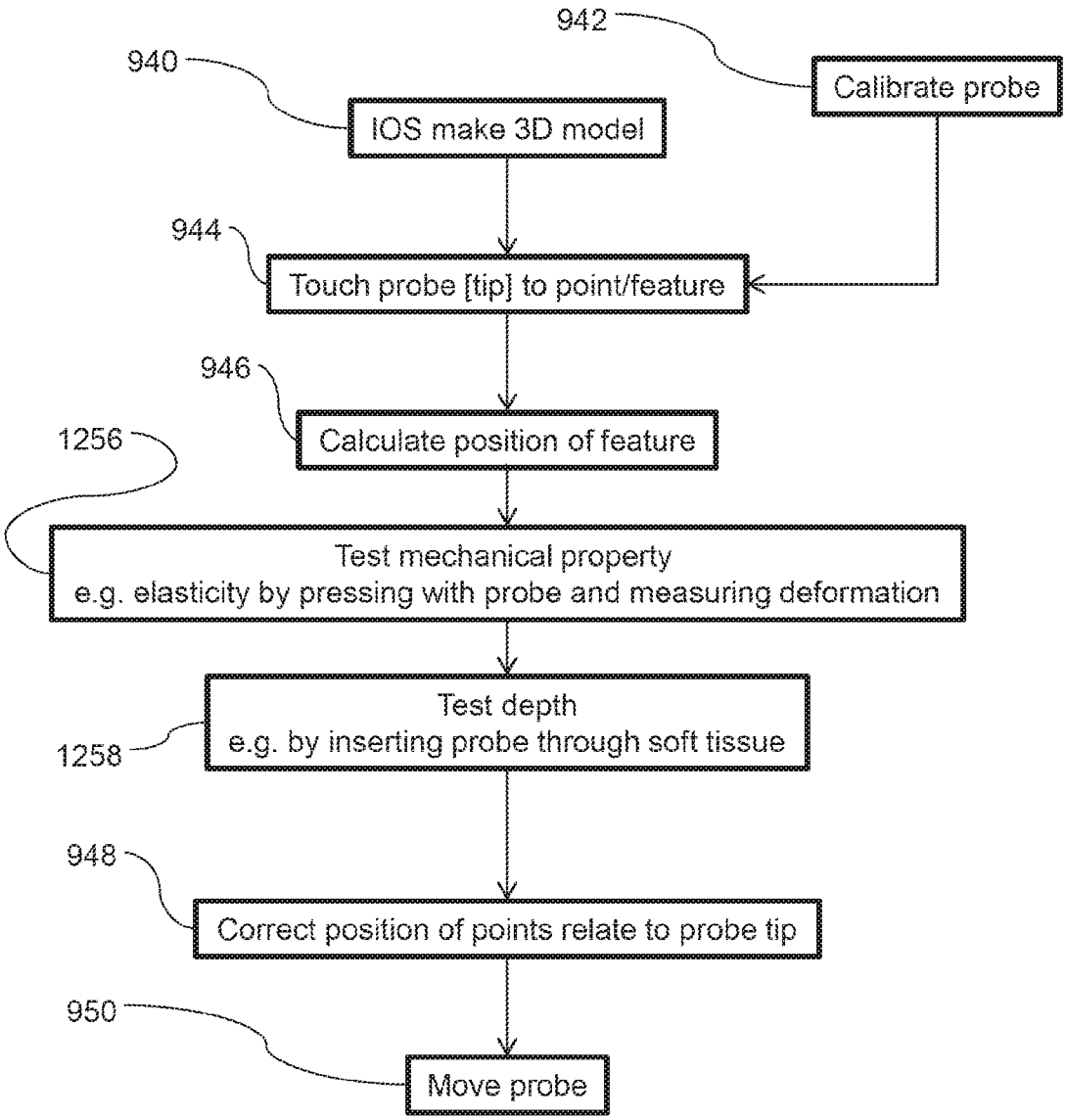

942
Calibrate probe
940
IOS make 3D model
944
Touch probe [tip] to point/feature
946
Calculate position of feature
1256
Test mechanical property
e.g. elasticity by pressing with probe and measuring deformation
Test depth
e.g. by inserting probe through soft tissue
1258
948
Correct position of points relate to probe tip
950
Move probe

FIG. 12 A

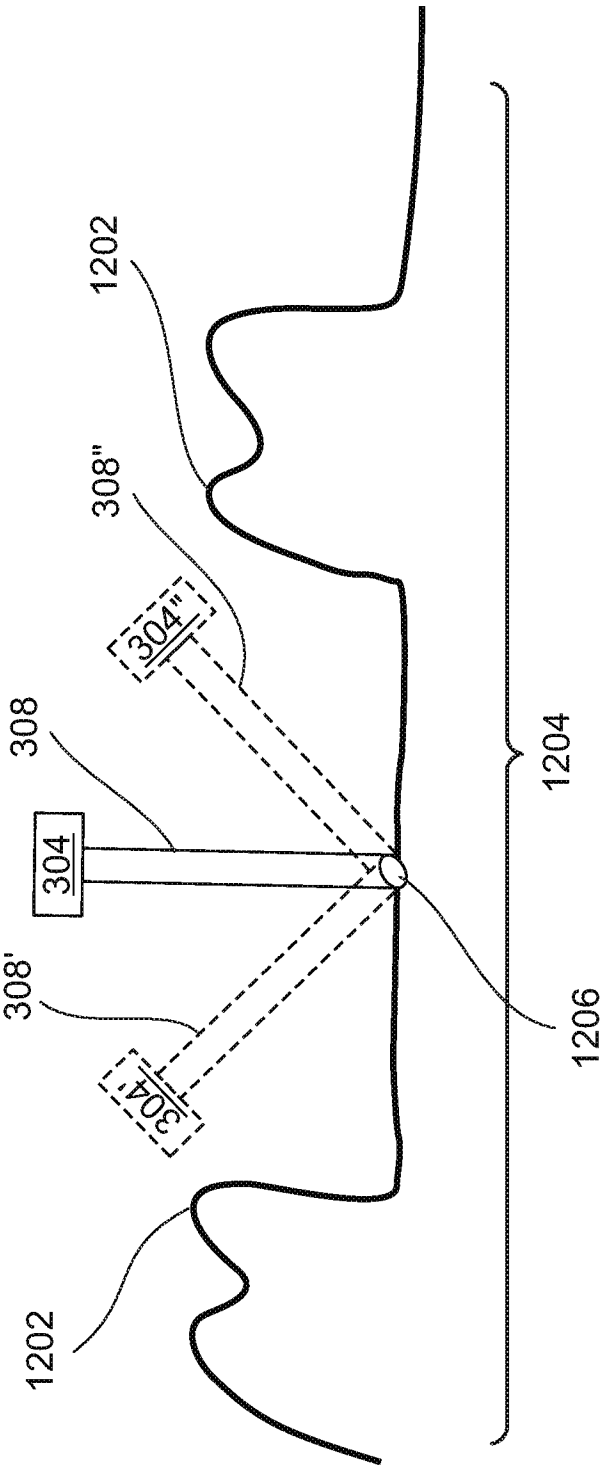


FIG. 12B

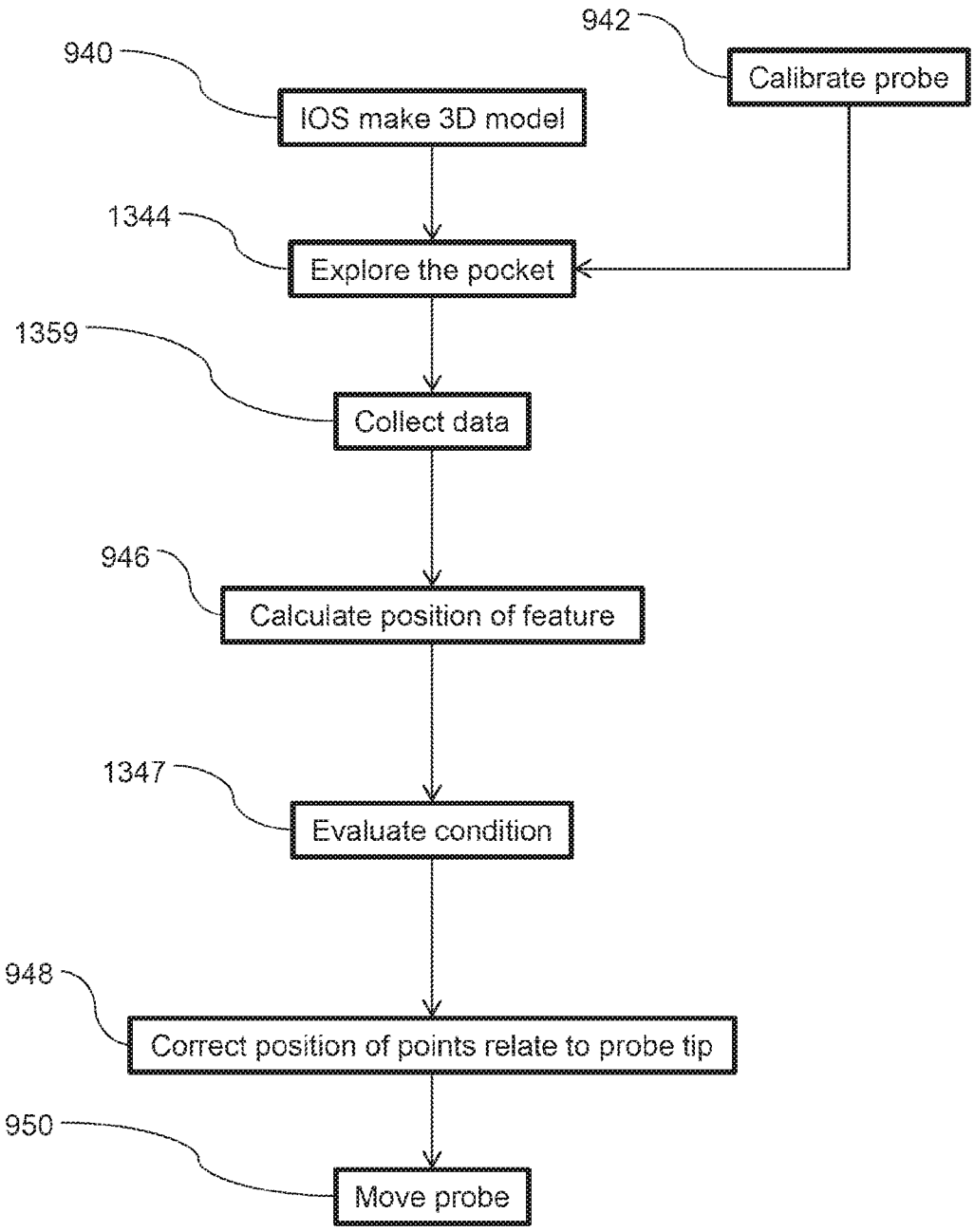

940
IOS make 3D model
942
Calibrate probe
1344
Explore the pocket
1359
Collect data
946
Calculate position of feature
1347
Evaluate condition
948
Correct position of points relate to probe tip
950
Move probe

FIG. 13A

FIG. 13B

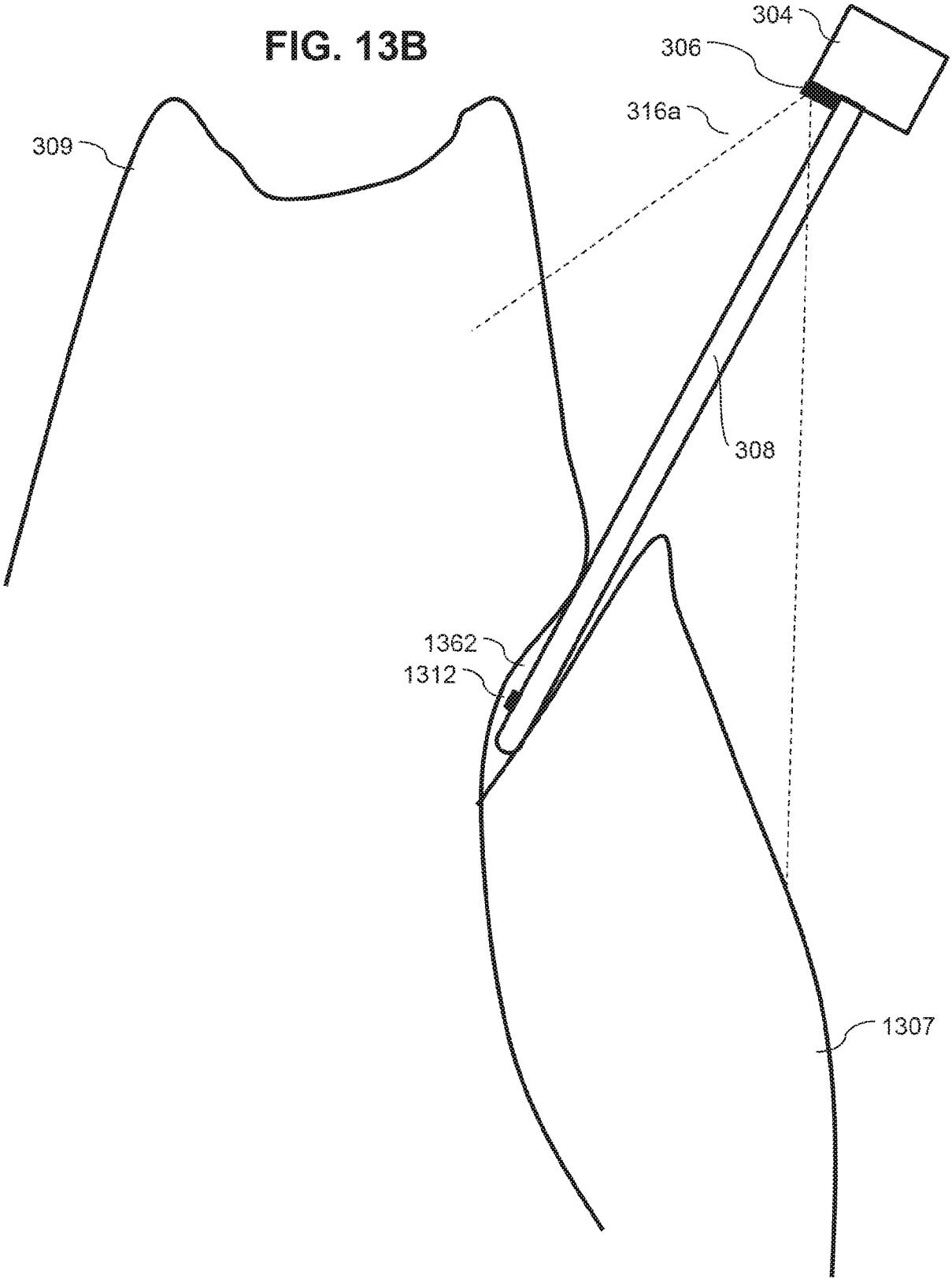


FIG. 14

Periodontal Evaluation Chart

Patient Name _____ 1st Clinician Name _____

1st Visit Date _____ 2nd Clinician Name _____ 2nd Visit Date _____

Upper Right →	1	2	3	4/A	5/B	6/C	7/D	8/E	9/F	10/G	11/H	12/I	13/J	14	15	16
CAL (Rec+Probe)= Total																
3rd Probe Date:																
CAL (Rec+Probe)= Total																
2nd Probe Date:																
CAL (Rec+Probe)= Total																
1st Probe Date:																
2nd ○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○
1st ○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○
Sub Calc																
Maxillary Facial																
2nd ○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○
1st ○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○
Occlusal Supra Calc																
1st ○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○
2nd ○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○
Maxillary Palatal/Lingual																
Sub Calc																
1st ○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○
2nd ○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○	○ ○ ○
1st Probe Date:																
CAL (Rec+Probe)= Total																
2nd Probe Date:																
CAL (Rec+Probe)= Total																
3rd Probe Date:																
CAL (Rec+Probe)= Total																

Occlusion

- ☐ Class I
- ☐ Class II
- ☐ Class III
- ☐ Other Occlusal Factors

_____

_____

_____

_____

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2018/050731

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61C9/00 A61B5/00
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)
A61B 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.
X	US 2017/007377 A1 (PESACH BENNY [IL] ET AL) 12 January 2017 (2017-01-12) abstract; figures 2a,3b,7,9a,9b paragraphs [0003], [0043], [0044], [0095] - [0098], [0124], [0201], [0202], [0229], [0242], [0253] - [0258], [0325]	24-50
A	US 2016/338803 A1 (PESACH BENNY [IL]) 24 November 2016 (2016-11-24) the whole document	24-50
A	WO 2016/178212 A1 (DENTLYTEC G P L LTD [IL]) 10 November 2016 (2016-11-10) the whole document	24-50

-/--

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

[X] 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
24 September 2018	01/10/2018

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	Pereda Cubián, David

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2018/050731

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2016/259515 A1 (SABINA MICHAEL [US] ET AL) 8 September 2016 (2016-09-08) the whole document	24-50
A	US 2010/047733 A1 (NAHLIELI ODED [IL]) 25 February 2010 (2010-02-25) the whole document	24-50

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2018/050731

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

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

1. [X] Claims Nos.: 1-23
because they relate to subject matter not required to be searched by this Authority, namely:

Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery

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

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

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

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

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

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

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

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

Remark on Protest

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

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

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IL2018/050731

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017007377 A1	12-01-2017	CA 2896210 A1	03-07-2014
		CN 104955418 A	30-09-2015
		EP 2941220 A2	11-11-2015
		JP 6253665 B2	27-12-2017
		JP 2016508754 A	24-03-2016
		JP 2018047299 A	29-03-2018
		KR 20150103133 A	09-09-2015
		US 2015348320 A1	03-12-2015
		US 2017007377 A1	12-01-2017
		WO 2014102779 A2	03-07-2014
US 2016338803 A1	24-11-2016	US 2016338803 A1	24-11-2016
		WO 2016113745 A1	21-07-2016
WO 2016178212 A1	10-11-2016	EP 3288486 A1	07-03-2018
		US 2018263725 A1	20-09-2018
		WO 2016178212 A1	10-11-2016
US 2016259515 A1	08-09-2016	CN 107427345 A	01-12-2017
		EP 3265021 A1	10-01-2018
		US 2016259515 A1	08-09-2016
		WO 2016142817 A1	15-09-2016
US 2010047733 A1	25-02-2010	NONE	