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(71) Applicant: **OSTEOPHILE LTD.** [IL/IL]; P.O. Box 272, 4994500 Newe Yaraq (IL).

(72) Inventor: **LAZAROVICI, Towy**; 72 Haegoz Street, P.O. Box 272, 4994500 Newe Yaraq (IL).

(74) Agent: **WEBB, Cynthia** et al.; Webb & CO., P.O. BOX 2189, 7612101 REHOVOT (IL).

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(54) **Title:** DEVICES, SYSTEMS AND METHODS FOR DISTRACTION OSTEOGENESIS

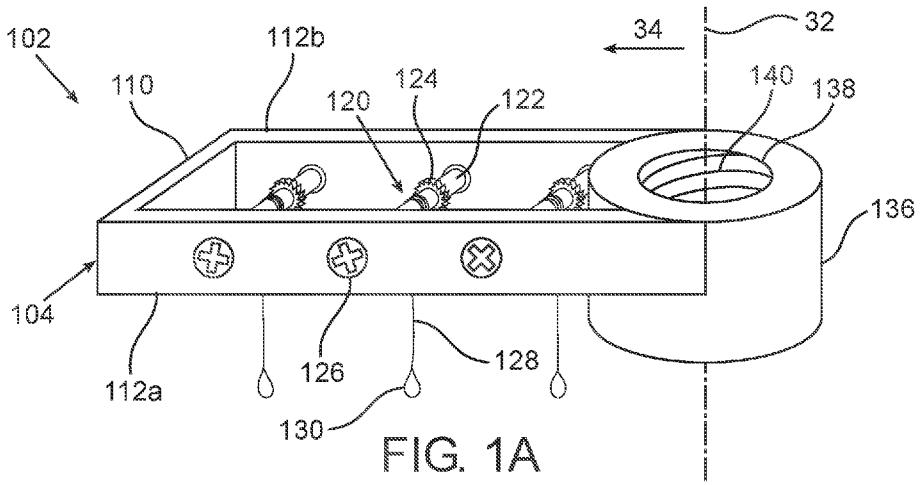

FIG. 1A

(57) **Abstract:** The present invention relates to the field of devices and methods for distraction osteogenesis, and, more particularly, to distraction devices and distraction systems used in the treatment of mandibular or maxillary alveolar ridge atrophy, and to methods for utilizing a distraction device or a distraction system for bone tensioning.

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DEVICES, SYSTEMS AND METHODS FOR DISTRACTION OSTEOGENESIS

FIELD OF THE INVENTION

The present invention relates to the field of devices and methods for distraction osteogenesis, and, more particularly, to distraction devices and distraction systems used in the treatment of mandibular or maxillary alveolar ridge atrophy, and to methods for utilizing a distraction device or a distraction system for bone lengthening.

BACKGROUND OF THE INVENTION

Mandibular or maxillary alveolar ridge atrophy is a known pathology, which can develop as a slow process of volume deterioration after tooth loss or acutely due to an inciting event as infection, cyst removal, traumatic tooth extraction, tumor resection or trauma. Adequate alveolar ridge volume is crucial for placement of dental implants. Placement of dental implants and the long-term prognosis of such primarily depend on the size of the dental implants, the ratio between them and the prosthesis attached to them and their spatial location relative to the intra jaw teeth and opposed jaw occlusion.

In some cases, the alveolar ridge atrophy can be overcome by placing short dental implants as a compromise, while in the majority of the cases a reconstructive phase needs to be applied prior to placement of dental implants. Several surgical procedures are known in the art, depending on the severity of alveolar ridge atrophy. Whereas mild atrophy can be resolved by guided tissue regeneration, intermediate and severe atrophy necessitates the use of bone grafts or bone lengthening. The severity of atrophy dictates the volume of the required bone graft, and consequently the grafting technique and materials. Since soft tissue coverage without tension of the entirety of the graft is crucial, causing limitations of the volume of the augmentation gain, vertical atrophy possesses the greatest challenge. As the latter increases, the challenge of soft tissue coverage becomes greater and less predictable. Thus, severe cases of alveolar ridge atrophy that cannot be predictively resolved by bone grafts, have been addressed in the last two decades by surgical technique of bone lengthening referred to as distraction osteogenesis.

Distraction osteogenesis is a technique of bone lengthening occurring by applying gradual controlled tension forces to an osteotomized bone segment. In contrast to traditional approaches, the soft tissue envelope is simultaneously expanded, thereby practically eliminating any limit to bone gain. This technique has become an important part of the reconstructive surgeon's armamentarium.

Most alveolar distractors comprise two attachment plates and a drive rod that connects them or pushes them apart. The purpose of the plates is to anchor the device to the basal bone and to an osteotomized bone segment. The purpose of the rod is to deliver tension forces to both bone segments, thereby distracting the mobile segment. Anchoring the device requires a minimal 5 mm vertical length of basal bone, and a similar length for the osteotomized segment, due to the dimensions of the attachment plates and the bone screws. When the procedure is performed in the posterior mandible, where the inferior alveolar nerve is located, care must be given to the position of the bone screws through the buccal cortex due to the proximity to the nerve. A peril of damaging the inferior alveolar nerve is unavoidable. Placing bone screws in the posterior maxilla can be similarly challenging due to thin bony wall of the maxillary sinus leading to defective device anchoring and stabilization. Due to these risks and limitations, distraction osteogenesis is rarely accepted by patients, although these patients frequently have no other reconstructive options. On the other hand, patients who fortunately have not experienced a previous extreme traumatic event such as resection of a benign tumor or trauma, lack the motivation to undergo a major surgical procedure and confront the relevant risks. Further reduction in motivation is also accountable to the fact that removal of the distraction appliance requires a second surgical procedure and accordingly more discomfort.

Alveolar distractors are composed of a single drive rod promoting movement according to a single vector. Bone gain is similar all along the distracted segment length. When atrophy is dissimilar in the anterior and posterior end of the distracted bone, often a compromise is required, or alternatively another surgical procedure is performed to remove excess bone in one side and add bone to a deficient side. Moreover, the vector set in the installation of the distractor cannot be changed or controlled after initiation of the distraction osteogenesis due to lack of accessibility and rigidity of the structure of the distractor. The mentioned above limitations, considerations and challenges raise the need for a different approach to bone gain via distraction osteogenesis. Major considerations as reduction of the

hazard to the inferior alveolar nerve when anchoring the lower bone plate parallel or near the latter and the risk of inadequate stability when attempting to place a bone plate parallel to the maxillary sinus prompts the perception that the anchoring of the distraction device must be achieved elsewhere than this means. This led to the advance in the notion that anchoring the device can be achieved outside the surgical field. Anchoring the device to an adjacent existing dental implant or a tooth can offer these benefits and eliminating the hazards mentioned above.

Devices equipped with a single point distraction apply uneven stress/strain concentration on the osteomized segment, wherein a high stress concentration is applied to the osteomized segment at the attachment point to the pulling element, while lower stresses act on adjacent remote sections of the same segment. A publication by Meyer et al. (Plast. Reconstr. Surg. 1999 Mar;103(3):800-7) presented experimental results showing that the strain magnitudes applied to the mandible during distraction osteogenesis can influence whether ossification occurs or unfavorable fibrous tissue is formed. Another publication by Meyer et al. (Int. J. Oral Maxillofac. Surg. 2001 Dec;30(6):522-30) further demonstrated that such mechanical strains influence the phenotype of cell differentiation.

Applying several points of tension to the osteotomized bone intended for distraction can overcome the drawback of single point distraction, by applying a more even stress/strain distribution along the osteomized segment. The ability to control each tension points separately is of great importance, as it can offer differential bone gain along the surgical field. Accessibility to the part applying the distraction forces during the distraction phase can help control the distractor vector and adapting it the desired direction if the need for a change arises. Tension can be delivered by pushing the distracted bone away from its original bed or by pulling it away therefrom.

SUMMARY OF THE INVENTION

The following embodiments and aspects thereof are described and illustrated in conjunction with systems, devices and methods which are meant to be exemplary and illustrative, not limiting in scope. In various embodiments, one or more of the above-described problems have been reduced or eliminated, while other embodiments are directed to other advantages or improvements.

According to some embodiments, there are provided devices, systems and methods for performing distraction osteogenesis. A distraction device, disclosed in the present specification, can be attached to any dental structure adjacent to an alveolar ridge, such as a bone screw or even a native tooth, directly or via a dental abutment. A strings positioning member of the distraction device, which can be formed in some embodiments as a frame, extends over the region of an osteotomized bone segment of the alveolar ridge, from which at least one string extends towards and is attachable to at least one anchoring implant means, such as miniscrews or orthodontic screws, suitable for anchoring to osteotomized bone segments with limited vertical length.

The distraction device is provided with a plurality of string pull assemblies, configured to enable wrapping of each string attached to anchoring implant means during rotation thereof. The wrapping of each string results in a pulling force applied to the osteotomized bone segment via the corresponding anchoring implant means, thereby promoting formation of new bone tissue in the gap formed between the osteotomized bone segment and the remaining basal bone.

Advantageously, a procedure utilizing the disclosed distraction device reduces the hazard to sensitive regions, such as the inferior alveolar nerve, due to the disclosed distraction device ability to pull small-dimensioned anchoring implant means, such as orthodontic implants, , instead of conventional larger bone plates. Moreover, the distraction method disclosed herein enables to perform distraction osteogenesis even in extremely complicated cases, where the amount bone in a region of an alveolar ridge is not suitable for distraction osteogenesis procedures by conventional distractors with bone plates. One such example is the posterior maxilla in which bone screws placed for anchoring a conventional distractor footplate cannot achieve reasonable stability due to thinness of the anterior maxillary sinus cavity.

A further advantage of the disclosed distraction device, having a plurality of string pull assemblies connected to a corresponding number of anchoring implant means, is that each string pull assembly can be operated independently, thereby applying a different pulling rate or a different distraction length to different regions of an osteotomized bone segment, to which a corresponding anchoring implant means is attached. Thus, applying several points of tension to the osteotomized bone intended for distraction can offer differential bone gain along the surgical region. Moreover, due to the fact the anchoring of the device is superficial

and not submerged enables the operator the change the lateral vector of distraction during the distraction phase if the need for a change in the pre-set vector arises. This can be achieved, for example, by disconnecting the distraction device from the dental abutment, adjusting the lateral position of the frame of the distraction device, and reconnecting it back to the abutment.

A further advantage of the disclosed distraction device, is that it can be easily supported by dental supports known in the art, such as bone screws with or without dental abutments, or even attached to a native tooth. Removal of the distraction device does not require a surgery and can be easily performed, thus providing a simpler, shorter and more comfortable solution, compared with conventional distractors' removal requiring another surgical procedure and the related comorbidities.

According to one aspect, there is provided a distraction device for bone lengthening, the distraction device comprising a main body and a plurality of string pull assemblies.

The main body comprises at least one adaptor member having at least one connection platform, and a strings positioning member comprising a plurality of positioning features, spaced from each other along a longitudinal direction of the strings positioning member attachable to the at least one adaptor body, extending along a longitudinal direction substantially perpendicular to a vertical axis of the at least one adaptor member.

Each of the plurality of string pull assemblies comprises a string having a first string end and a second string end attached to a string engagement portion, and a movable element attached to the first string end, configured to move so as to promote displacement of the string engagement portion in a distal direction.

The strings positioning member extends along the longitudinal direction thereof, substantially perpendicular to a vertical axis of the at least one adaptor member, each of the plurality of string pull assemblies is attached to the main body, and each string of the plurality of strings is configured to extend through or along a corresponding, different, positioning feature.

According to some embodiments, at least one string pull assembly of the plurality of string pulley assemblies is attached to the strings positioning member.

According to some embodiments, at least one string pull assembly of the plurality of string pulley assemblies is attached to the at least one adaptor member.

According to some embodiments, the at least one movable element is formed as a rotatable shaft, and wherein the string pull assembly is rotateably attached to the main body

According to some embodiments, the at least one string pull assembly further comprises a channel, and wherein the movable element is configured to axially move along at least one direction within the channel.

According to some embodiments, the channel comprises threading along at least a portion of its length, and wherein the movable element is formed as a screw threadedly engaged with the channel.

According to some embodiments, the channel comprises ratcheting teeth along at least a portion of its length, and wherein the movable element comprises at least one complementary tooth, configured to enable longitudinal one-directional movement of movable element along the channel.

According to some embodiments, the at least one string pull assembly further comprises a gear rigidly attached to the movable element, and the distraction device further comprises at least one pawl configured to engage with the gear, wherein the pawl is configured to allow free rotation of the string pull assembly in the one direction, while preventing its rotation in an opposite direction.

According to some embodiments, the at least one string pulley assembly further comprises a tooling interface rigidly attached to at least one end of the movable element, wherein rotation of the at least one tooling interface is one direction results in rotation of the movable element in the same direction.

According to some embodiments, the strings positioning member further comprises a first sidewall and a second sidewall, and wherein the at least one tooling interface is exposed through at least one opening in the first sidewall or the second sidewall.

According to some embodiments, the strings positioning member further comprises at least one positioning member chamber, bordered between the first sidewall and the second sidewall, and configured to house the at least one string pull assembly.

According to some embodiments, the strings positioning member further comprises a front panel, and wherein the at least one tooling interface is exposed through at least one opening in the front panel.

According to some embodiments, the strings positioning member further comprises a distal panel, and the at least one tooling interface is exposed through at least one opening in the in the distal panel.

According to some embodiments, the strings positioning member further comprises at least one support rod.

According to some embodiments, the at least one positioning feature is formed as an aperture, configured to allow passage and free movement of the string there through.

According to some embodiments, the at least one positioning feature is formed as a contact point between the string and the support rod.

According to some embodiments, the at least one connection platform comprises a mounting bore.

According to some embodiments, the mounting bore comprises a bore screw thread.

According to some embodiments, the mounting bore comprises an anti-rotational internal surface.

According to some embodiments, the adaptor member further comprises a stationary ring portion and a dynamic ring portion hinged thereto, wherein the dynamic ring portion comprises a tightening mechanism configured to form the mounting bore by detachably attaching an end of dynamic ring portion to either the stationary ring portion or the strings positioning member.

According to some embodiments, the adaptor member further comprises a tightening mechanism configured to adjust the diameter of central bore.

According to some embodiments, the strings positioning member is detachably attachable to the at least one adaptor member via a quick snap attachment.

According to some embodiments, the strings positioning member further comprises a positioning member's attachment means, and wherein the at least one adaptor body further comprises an adaptor attachment means, configured to engage with the strings positioning member attachment means.

According to some embodiments, the at least one adaptor member comprises two adaptor members connected to each other via an adaptor attachment means, the adaptor

attachment means comprising an adaptor attachment socket formed to receive the strings positioning member therein.

According to some embodiments, the at least one component of the distraction device is manufactured via the use of a CAD-CAM software, according to a design specific to a patient.

According to some embodiments, there is provided distraction system comprising the distraction device according to any of the aforementioned embodiments, and an abutment. The abutment comprises an abutment distal portion, configured to engage with the at least one connection platform of the at least one adaptor member, an abutment proximal portion, and an abutment mid-portion, fluidly connected to the abutment distal portion and to the abutment proximal portion. The largest cross-sectional diameter of the abutment mid-portion is larger than any of the largest cross-sectional diameter of the abutment distal portion and the largest cross-sectional diameter of the abutment proximal portion.

According to some embodiments, the abutment proximal portion comprises a polyhedral-shaped structure.

According to some embodiments, the abutment distal portion comprises an abutment distal portion screw thread.

According to some embodiments, the abutment distal portion comprises a polyhedral-shaped structure.

According to some embodiments, the abutment distal portion comprises a plurality of regularly spaced vertical notches that create a corresponding plurality of wings, wherein the plurality of wings are provided with intrinsic flexibility. Further, each wing comprises a wing inner surface and a wing outer surface, wherein the wing inner surfaces together with the notches define an abutment distal receiving opening.

According to some embodiments, the distraction system further comprises a plug having a plug distal portion, configured to be inserted through the abutment distal receiving opening into the abutment, thereby flexing the wings radially outwards.

According to some embodiments, the plug distal portion is provided with a frustoconical profile

According to some embodiments, the plug further comprises a plug base provided with a threading.

According to some embodiments, the distraction system further comprises at least one miniscrew, configured for engagement with the at least one string engagement portion.

According to some embodiments, the miniscrew further comprises a receiving area.

According to some embodiments, the receiving area of the miniscrew is formed as a through-hole.

According to some embodiments, the receiving area of the miniscrew is formed as a recess having at least one distal vertical extension.

According to some embodiments, the receiving area of the miniscrew comprises an opening with a latch.

According to some embodiments, the distraction system further comprises a bone screw, configured to receive and securely engage with the abutment.

According to yet another aspect of the invention, there is provided a method of using a distraction device, comprising the steps of:

(i) providing the distraction device according to any one of the aforementioned embodiments,

(ii) connecting the distraction device to a mount,

(iii) attaching the plurality of string engagement portions to the plurality of miniscrews, wherein each string engagement portion is attached to a single miniscrew,

(iv) stretching the plurality of strings between the plurality of movable elements and the plurality of miniscrews, by moving the plurality of movable element,

(v) displacing at least one of the plurality of miniscrew in the distal direction, by further moving the respective movable attached thereto, and

(vi) repeating the step of displacing at least one miniscrew in the distal direction periodically, for all miniscrews.

According to some embodiments, moving any of the plurality of movable element comprises rotating the movable element.

According to some embodiments, moving any of the plurality of movable element comprises axially displacing the movable element.

According to some embodiments, the mount is a bone screw.

According to some embodiments, the mount is an abutment attached to a bone screw.

According to some embodiments, each string pull assembly is operated independently, thereby applying a different pulling rate to different miniscrews.

According to yet another aspect of the invention, there is provided a distraction assembly comprising the distraction device according to any one of the aforementioned embodiments, and a clamp. The adaptor member of the distraction device further comprises a plurality of axial extensions, configured to bend radially inwards upon application of an external force along their circumference.

The clamp comprises a band and a worm gear mechanism, the worm gear mechanisms configured to cause contraction or expansion of the clamp and keep the clamp at the adjusted position. The clamp is configured to engage with the distraction device by placement thereof over the exterior of the adaptor member, and is further configured to exert force on the contractible adaptor member, sufficient bend the plurality of axial extensions radially inwards.

According to some embodiments, the distraction device further comprises an arcuate slot disposed between the strings positioning member and the adaptor member, dimensioned to accommodate at least a portion of the band, and a worm recess adjacent the arcuate slot, configured to accommodate the worm gear mechanism.

According to some embodiments, the band further comprises at least one retaining slot, and wherein the adaptor member comprises at least one retaining protrusion extending radially outwards therefrom, and configured to be positioned within the respective at least one retaining slot.

According to some embodiments, the distraction assembly further comprises an abutment, which comprises an abutment distal portion configured to engage with the at least one connection platform of the at least one adaptor member, an abutment proximal portion, and an abutment mid-portion, fluidly connected to the abutment distal portion and to the abutment proximal portion.

According to yet another aspect of the invention, there is provided a dental abutment comprising an abutment distal portion, an abutment proximal portion, and an abutment mid-portion, fluidly connected to the abutment distal portion and to the abutment proximal portion.

According to some embodiments, the abutment distal portion comprises a plurality of regularly spaced vertical notches that create a corresponding plurality of wings, wherein the plurality of wings are provided with intrinsic flexibility. Further, each wing comprises a wing inner surface and a wing outer surface, wherein the wing inner surfaces together with the notches define an abutment distal receiving opening.

According to some embodiments, the distraction system further comprises a plug having a plug distal portion, configured to be inserted through the abutment distal receiving opening into the abutment, thereby flexing the wings radially outwards.

According to some embodiments, the plug distal portion is provided with a frustoconical profile

According to some embodiments, the plug further comprises a plug base provided with a threading.

Certain embodiments of the present invention may include some, all, or none of the above advantages. Further advantages may be readily apparent to those skilled in the art from the figures, descriptions, and claims included herein. Aspects and embodiments of the invention are further described in the specification herein below and in the appended claims.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention pertains. In case of conflict, the patent specification, including definitions, governs. As used herein, the indefinite articles "a" and "an" mean "at least one" or "one or more" unless the context clearly dictates otherwise.

The following embodiments and aspects thereof are described and illustrated in conjunction with systems, tools and methods which are meant to be exemplary and illustrative, but not limiting in scope. In various embodiments, one or more of the above-described problems have been reduced or eliminated, while other embodiments are directed to other advantages or improvements.

BRIEF DESCRIPTION OF THE FIGURES

Some embodiments of the invention are described herein with reference to the accompanying figures. The description, together with the figures, makes apparent to a person having ordinary skill in the art how some embodiments may be practiced. The figures are for the purpose of illustrative description and no attempt is made to show structural details of an embodiment in more detail than is necessary for a fundamental understanding of the invention. For the sake of clarity, some objects depicted in the figures are not to scale.

In the Figures:

Fig. 1A constitutes a view in perspective of a distraction device without a distal panel, according to some embodiments.

Fig. 1B constitutes a top view in perspective of the distraction device of **Fig. 1B**.

Fig. 2A constitutes a view in perspective of a distraction device, according to some embodiments.

Fig. 2B constitutes a top view of a distraction device, according to some embodiments.

Fig. 2C constitutes a bottom view of a distraction device, according to some embodiments.

Fig. 3A constitutes a cross-sectional side view of a distraction device, according to some embodiments.

Fig. 3B constitutes a cross-sectional view of a distraction device devoid of a proximal panel, according to some embodiments.

Fig. 4A constitutes a view in perspective of a strings positioning member detached from an adaptor body, according to some embodiments.

Fig. 4B constitutes a view in perspective of the strings positioning member attached to the adaptor body of **Fig. 4A**.

Fig. 5A constitutes a view in perspective of a strings positioning member detached from two adaptor bodies, according to some embodiments.

Fig. 5B constitutes a view in perspective of the strings positioning member attached to both adaptor bodies of **Fig. 5A**.

Fig. 6A constitutes a view in perspective of a strings positioning member detached from two adaptor bodies, according to some embodiments.

Fig. 6B constitutes a view in perspective of the strings positioning member attached to both adaptor bodies of **Fig. 6A**.

Fig. 7A constitutes a view in perspective of a strings positioning member detached from two connected adaptor bodies, according to some embodiments.

Fig. 7B constitutes a view in perspective of the strings positioning member attached to the two connected adaptor bodies of **Fig. 7A**.

Fig. 7C constitutes a view in perspective of a strings positioning member detached from two connected adaptor bodies, according to some embodiments.

Fig. 7D constitutes a view in perspective of the strings positioning member attached to the two connected adaptor bodies of **Fig. 7C**.

Fig. 8A constitutes a view in perspective of a distraction device with tooling interfaces in the form of a Phillips sockets, according to some embodiments.

Fig. 8B constitutes a view in perspective of a distraction device with tooling interfaces in the form of hex or Allen screw-heads, according to some embodiments.

Fig. 8C constitutes a view in perspective of a distraction device with tooling interfaces in the form of hex or Allen sockets, according to some embodiments.

Fig. 9A constitutes a view in perspective of a distraction device with an Allen key-type rotation tool engaged with a tooling interface, according to some embodiments.

Fig. 9B constitutes a view in perspective of a distraction device with the Allen key of **Fig. 9A** rotated clockwise, according to some embodiments.

Fig. 9C constitutes a view in perspective of a distraction device with a rotation tool engaged with a tooling interface, according to some embodiments.

Fig. 10A constitutes a bottom view of a distraction device having a hexagonal-shaped mounting socket, according to some embodiments.

Fig. 10B constitutes a view in perspective of a distraction device having a hexagonal-shaped mounting socket, according to some embodiments.

Fig. 10C constitutes a view in perspective of a distraction device having an octagonal-shaped mounting socket, according to some embodiments.

Fig. 11A constitutes a view in perspective of a distraction device having diagonal string pull assemblies, according to some embodiments.

Fig. 11B constitutes a top view of a distraction device having diagonal string pull assemblies, according to some embodiments.

Fig. 12 constitutes a cross-sectional side view of a distraction device having vertical string pull assemblies, according to some embodiments.

Fig. 13A constitutes a view in perspective of a distraction device having longitudinal string pull assemblies, according to some embodiments.

Fig. 13B constitutes a cross-sectional top view of the distraction device of **Fig. 13A**, showing the string pull assemblies in a first position, according to some embodiments.

Fig. 13C constitutes a cross-sectional top view of the distraction device of **Fig. 13B**, showing the string pull assemblies in a second position, according to some embodiments.

Fig. 13D constitutes a cross-sectional side view marked in **Fig. 13B**.

Fig. 14A constitutes a view in perspective of a distraction device having threaded channels, according to some embodiments.

Fig. 14B constitutes a cross-sectional top view of the distraction device of **Fig. 14A**.

Fig. 14C constitutes a view in perspective of a distraction device having windows overlaid over threaded channels, according to some embodiments.

Fig. 14D constitutes a top view of the distraction device of **Fig. 14C**.

Fig. 14E constitutes a view in perspective of a distraction device having ratcheting channels, according to some embodiments.

Fig. 14F constitutes a top view of the distraction device of **Fig. 14E**.

Fig. 14G constitutes a view in perspective of a distraction device having ratcheting channels, according to some embodiments.

Fig. 14H constitutes a top view of the distraction device of **Fig. 14G**.

Fig. 15A constitutes a view in perspective of a distraction device having two string pull assemblies positioned within an adaptor boy, according to some embodiments.

Fig. 15B constitutes a cross-sectional side view of the distraction device of **Fig. 15A**.

Fig. 16A constitutes a view in perspective of a distraction device having two string pull assemblies positioned within an adaptor body, and a two support rods position within a strings positioning member, according to some embodiments.

Fig. 16B constitutes a cross-sectional side view of the distraction device of **Fig. 16A**.

Fig. 17A constitutes a view in perspective of a distraction device having an adaptor member in a loose state, according to some embodiments.

Fig. 17B constitutes a view in perspective of the distraction device of **Fig. 17A** in a tight state.

Fig. 17C constitutes a top view of the distraction device of **Fig. 17B** in a tight state.

Fig. 17D constitutes a view in perspective of a distraction device having an adaptor member formed as a ring clamp, according to some embodiments.

Fig. 17E constitutes a top view of the distraction device of **Fig. 17D**.

Fig. 17F constitutes a view in perspective of a distraction device having an adaptor member comprising a tongue configured for ratcheting engagement with a tightening mechanism, according to some embodiments.

Fig. 17G constitutes a top view of the distraction device of **Fig. 17F**.

Fig. 18A constitutes a view in perspective of an abutment having a threaded cylindrical abutment distal portion, according to some embodiments.

Fig. 18B constitutes a top view of the abutment of **Fig. 18A**.

Fig. 18C constitutes a view in perspective of an abutment having a polygonal abutment distal portion, according to some embodiments.

Fig. 18D constitutes a top view of the abutment of **Fig. 18C**.

Fig. 19A constitutes an exploded view in perspective of a distraction assembly, according to some embodiments.

Fig. 19B constitutes a view in perspective of an assembled distraction assembly, according to some embodiments.

Fig. 20A constitutes an exploded view in perspective of a distraction assembly, according to some embodiments.

Fig. 20B constitutes a view in perspective of an assembled distraction assembly, according to some embodiments.

Fig. 21A constitutes a view in perspective of a miniscrew next to a string engagement portion in the form of a hook, according to some embodiments.

Fig. 21B constitutes a view in perspective of the hook engaged with the miniscrew of **Fig. 21A**, according to some embodiments.

Fig. 21C constitutes a view in perspective of a miniscrew next to a string engagement portion in the form of a loop, according to some embodiments.

Fig. 21D constitutes a view in perspective of the loop engaged with the miniscrew of Fig. **21C**, according to some embodiments.

Fig. 21E constitutes a view in perspective of a miniscrew having a latch, next to a string engagement portion in the form of a hook, according to some embodiments.

Fig. 21F constitutes a view in perspective of the loop being inserted into a receiving portion past the latch of **Fig. 21E**.

Fig. 21G constitutes a view in perspective of the loop engaged with the miniscrew of Fig. **21E**, according to some embodiments.

Fig. 22A constitutes a view in perspective of a distraction device without a distal panel, engaged with an abutment, according to some embodiments.

Fig. 22B constitutes a top view of the distraction device and abutment of **Fig. 22A**.

Fig. 22C constitutes a side cross-sectional view of a distraction device engaged with an abutment, according to some embodiments.

Fig. 23A constitutes a view in perspective of a distraction device having positioning member chambers, without a distal panel, engaged with an abutment, according to some embodiments.

Fig. 23B constitutes a top view of the distraction device and abutment of **Fig. 23A**.

Fig. 23C constitutes a side cross-sectional view of a distraction device having positioning member chambers, engaged with an abutment, according to some embodiments.

Fig. 24A constitutes a view in perspective of an abutment, according to some embodiments.

Fig. 24B constitutes a side view in of the abutment of **Fig. 24A**.

Fig. 25 constitutes a view in perspective of a plug, according to some embodiments.

Fig. 26A constitutes a view in perspective of a plug positioned within an abutment, according to some embodiments.

Fig. 26B constitutes a cross-sectional side view in perspective of a plug positioned within an abutment, according to some embodiments.

Fig. 27 constitutes a cross-sectional side view of a distraction device, engaged with an abutment connected to a bone screw.

Fig. 28A constitutes a side view of the mandible with an alveolar ridge.

Fig. 28B constitutes a side view of the mandible of **Fig. 28A**.

Fig. 29A constitutes a side view of the mandible, with a bone screw positioned adjacent to an alveolar ridge, according to some embodiments.

Fig. 29B constitutes a side view of the mandible of **Fig. 29A**, with a crestal osteotomy line formed therein, according to some embodiments.

Fig. 29C constitutes a side view of miniscrews inserted into an osteotomized bone segment of the mandible of **Fig. 29B**, according to some embodiments.

Fig. 29D constitutes a side view of an abutment engaged with the miniscrews of **Fig. 29A**, according to some embodiments.

Fig. 29E constitutes a side view of the distraction device engaged with the abutment of **Fig. 29D**, according to some embodiments.

Fig. 29F constitutes a side view of the distraction device of **Fig. 29E** connected via strings to the miniscrews, at an initial position, according to some embodiments.

Fig. 29G constitutes a side view of new bone tissue formed in a gap between the osteotomized bone segment of **Fig. 29C** and basal jawbone, according to some embodiments.

Fig. 29H constitutes a side view of new bone tissue formed in a gap between the osteotomized bone segment of **Fig. 29C** and basal jawbone, at a final position, according to some embodiments.

Fig. 29I constitutes a side view of the new bone tissue of **Fig, 29H**, at a final stage of healing and hardening to form a new bone segment, according to some embodiments.

Fig. 29J constitutes a side view of the new bone segment of **Fig. 29I**, post removal of the distraction device, according to some embodiments.

Fig. 29K constitutes a side view of bone screws being placed within the new bone tissue of **Fig. 29J**, according to some embodiments.

Fig. 29L constitutes a side view of dental crowns engaged with the bone screws of **Fig. 29K**, according to some embodiments.

Fig. 30A constitutes a side view of spaced apart bone screws, being placed within the new bone tissue of **Fig. 29J**, according to some embodiments.

Fig. 30B constitutes a side view of dental bridge engaged with the bone screws of **Fig. 30A**, according to some embodiments.

Fig. 31A constitutes a side view of the mandible, with healthy bones positioned adjacent to an alveolar ridge, according to some embodiments.

Fig. 31B constitutes a side view of distraction device engaged with a healthy bone, according to some embodiments.

Fig. 32 constitutes a side view of the distraction device connected via strings at non-vertical angles to miniscrews, according to some embodiments.

Fig. 33 constitutes a side view of the distraction device connected via strings to fixation plates, according to some embodiments.

Fig. 34 constitutes a side view of the distraction device engaged with a bone screw in the maxilla, for distraction of an osteotomized bone segment in a sagittal portion of the maxilla, according to some embodiments.

Fig. 35 constitutes a side view of the distraction device engaged with a bone screw in the maxilla, for distraction of an osteotomized bone segment in the frontal portion of the maxilla, according to some embodiments.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

In the following description, various aspects of the disclosure will be described. For the purpose of explanation, specific configurations and details are set forth in order to provide a thorough understanding of the different aspects of the disclosure. However, it will also be apparent to one skilled in the art that the disclosure may be practiced without specific details being presented herein. Furthermore, well-known features may be omitted or simplified in order not to obscure the disclosure. In the figures, like reference numerals refer to like parts throughout.

Throughout the figures of the drawings, different superscripts for the same reference numerals are used to denote different embodiments of the same elements. Embodiments of the disclosed devices and systems may include any combination of different embodiments of the same elements. Specifically, any reference to an element without a superscript may refer to any alternative embodiment of the same element denoted with a superscript. Components having the same reference number followed by different lowercase letters may be collectively referred to by the reference number alone. If a particular set of components is being discussed, a reference number without a following lowercase letter may be used to refer to the corresponding component in the set being discussed.

Reference is now made to **Figs. 1A-6C. Figs. 1A** and **1B** constitute a view in perspective and a top view, respectively, of a distraction device **100** for bone lengthening, presented without a distal panel, according to some embodiments. **Figs. 2A**, **2B** and **2C** constitute a view in perspective, a top view and a bottom view, respectively, of the distraction device **100**, according to some embodiments. **Figs. 3A** and **3B** constitute a cross-sectional side view of two different embodiments of distraction device **100**. **Figs. 8A**, **8B** and **8C** constitute a view in perspective of the distraction device **100** with tooling interfaces in the form of Phillips sockets, hex or Allen screw-head, and hex or Allen sockets, respectively. **Figs. 9A**, **9B** and **9C** constitute a view in perspective of different embodiments of rotation tools engaged with a tooling interface. **Figs. 10A** and **10B** constitute a bottom view and a view in perspective, respectively, of a distraction device **100** having a hexagonal-shaped mounting socket. **Fig. 10C** constitutes a view in perspective of a distraction device **100** having an octagonal-shaped mounting socket.

Distraction device **100** comprises a main body **102** and a plurality of string pull assemblies **120**, each of the string pull assemblies **120** attached to at least one member of the main body **102**, wherein each of the plurality of string pull assemblies **120** is configured to be independently operated to pull a string **128** attached thereto. According to some embodiments, main body **120** comprises at least one adaptor member **136** and a strings positioning member **104**, such that each of the plurality of string pull assemblies **120** is attached to at least one of: adaptor member **136** or strings positioning member **104**.

The term "string pull assembly", as used herein, refers to any one of the plurality of string pull assemblies.

According to some embodiments, at least one string pull assembly **120** is attached both to at least one adaptor member **136** and to strings positioning member **104**, for example such that one end of the string pull assembly **120** is attached to at least one adaptor member **136**, and the opposite end of the string pull assembly **120** is attached to strings positioning member **104**.

According to some embodiments, all of the string pull assemblies **120** are attached to at least one adaptor member **136**. According to some embodiments, all of the string pull assemblies **120** are attached to strings positioning member **104**. According to some embodiments, some of the string pull assemblies **120** are attached to at least one adaptor member **136**, while the remainder to string pull assemblies **120** are attached to strings positioning member **104**.

Main body **102** is configured to connect with a mount via at least one adaptor member **136**. A mount can include any structure attached to or configured for attachment to a jaw, either directly or indirectly, such as an abutment, a dental crown, a dental screw, a dental bridge, a denture, a native tooth and the like. Axis **32** is a longitudinal axis of such a mount, extending between a proximal end and a distal end thereof.

Strings positioning member **104** extends from adaptor member **136** along a longitudinal direction **34** (see Fig. **1A**), substantially perpendicular to axis **32**. Strings positioning member **104** is configured to promote longitudinal distribution of each string **128** of the plurality of string pull assemblies **120**, such that each string **128** of the plurality of string pull assemblies **120** extends proximally (i.e. towards the jaw of a patient, when in use) through the strings positioning member **104** from a different position along its longitudinal direction **34**.

According to some embodiments, strings positioning member **104** comprises a plurality of positioning features **118**, spaced from each other along longitudinal direction **34**, wherein a string **128** of each string pull assemblies **120** is configured to extend through or along a corresponding, different, positioning feature **118**.

The term 'substantially perpendicular to axis', as used herein, refers to a direction that can be angled a range of 60°-120° relative to the axis.

According to some embodiments, strings positioning member **104** and adaptor member **136** are integrally formed. According to some embodiments, strings positioning member **104** and adaptor member **136** are attached to each other. According to some embodiments, strings positioning member **104** and adaptor member **136** are fixedly attached to each other. According to some embodiments, strings positioning member **104** and adaptor member **136** are removably attached to each other.

According to some embodiments, strings positioning member **104** is formed as a frame having a first sidewall **112a** and a second sidewall **112b** (see Figs **1A-3B**). According to some embodiments, strings positioning member **104** is formed as a plate (embodiment not shown). According to some embodiments, strings positioning member **104** further comprises a front panel **110**. According to some embodiments, front panel **110** and sidewalls **112** are integrally formed.

String pull assembly **120** comprises a movable element **122** attached to a string **128** having a string engagement portion **130** at a proximal end thereof, wherein the moving element **122** is configured to move so as to promote displacement of the second string end, along with the string engagement portion **130**, in a distal direction, i.e. towards the strings positioning member **104**.

According to some embodiments, string pull assembly **120** is a rotatable string pull assembly **120**, and the moving element **122** is a rotatable shaft, wherein at least one tooling interface **126** is located at an end of the moving element **122** formed as a shaft, and string **128** is connected at a first string end (not numbered) to the moving element **122** formed as a shaft. In such embodiments, string **128** is configured to wrap over the moving element **122** formed as a shaft during rotational movement of the moving element **122** formed as a shaft in one direction, and to unwrap during rotation movement of the moving element **122** formed as a in an opposite direction.

According to some embodiments, rotatable string pull assemblies **120** are rotateably attached to main body **102**. According to some embodiments, string pull assemblies **120** formed as rotatable string pull assemblies, are rotateably attached to strings positioning member **104**. According to some embodiments, as illustrated in **Figs. 1A-2C**, string pull assemblies **120** formed as rotatable string pull assemblies, are rotateably attached to at least one sidewall **112**.

According to some embodiments, string pull assembly **120** formed as a rotatable string pull assembly, is rotateably connected to at least one sidewall **112**, such that tooling interface **126** is exposed for engagement with a tooling device **76** (see **Figs. 9A-C**) through the at least one sidewall **112**. According to some embodiments, string pull assembly **120** formed as a rotatable string pull assembly, includes two tooling interfaces **126**, located at each end thereof such that each one of tooling interfaces **126** is exposed for engagement with a tooling device **76** through each one of first sidewall **112a** and second sidewall **112b**.

According to some embodiments, string pull assembly **120** formed as a rotatable string pull assembly, comprises a string **128** having a first string end and a second string end (not numbered). String **128** is affixed at first string end to movable element **122**, such the movement of movable element **122** promotes displacement of the opposite end of string **128** distally, i.e. towards the strung pull assembly **120**. According to some embodiments, string **128** is affixed at first string end to a movable element **122** formed as a shaft, such that **122** formed as a shaft in one direction causes wrapping of string **128** around movable element **122** formed as a shaft in a manner that shortens the length of the unwrapped portion of string **128**.

According to some embodiments, string **128** comprises a non-extensible material. According to some embodiments, string **128** comprises any string, cord, thread, wire or cable which is resilient along its length.

According to some embodiments, string **128** comprises a string engagement portion **130**. According to some embodiments, string engagement portion **130** comprises a loop (see **Fig. 1A**). According to some embodiments, string engagement portion **130** comprises a hook (see **Fig. 3A**). According to some embodiments, string engagement portion **130** is formed as a free end of string **128** (see **Figs. 8A-9C**), which can be tied onto itself so as to form, for example, a loop (such as the loop depicted in **Fig. 1A**).

According to some embodiments, string positioning member **104** comprises a proximal panel **106** (see **Figs. 2C**). According to some embodiments, proximal panel **106** is removably attached to sidewalls **112**. According to some embodiments, proximal panel **106** and sidewalls **112** are integrally formed. According to some embodiments, as illustrated in **Fig. 3B**, string positioning member **104** is devoid of proximal panel **106**.

Within the context of this application the term "proximal" generally refers to the side or end of any device or a component of a device, which is closer to a jaw-bone when in use. More particularly, a proximal end of distraction device **100** is the end which is closer to an alveolar ridge **52**.

Within the context of this application the term "distal" generally refers to the side or end of any device or a component of a device, which is opposite the "proximal end", and is farther from a jaw-bone when in use.

According to some embodiments, proximal panel **106** comprises at least one positioning feature **118** formed as an aperture. According to some embodiments, proximal panel **106** comprises at least one positioning feature **118** formed as an aperture, aligned with the region of attachment of string **128** to movable element **122**, configured to allow passage and free movement of string **128** there through. According to some embodiments, location of the at least one positioning feature **118** formed as an aperture, relative to the at least one movable element **122**, is such that string **128** passes there through without contacting any edge of positioning feature **118** formed as an aperture.

According to some embodiments, at least one positioning feature **118** comprises any one of: an aperture, an opening, a window, a slot, a channel and a duct.

According to some embodiments, at least one positioning feature **118** is formed by the contact point between the at least one movable element **122** and the at least one string **128** attached thereto or abutting it, such that the position of this contact point defines the position along direction **34** of the string positioning member **104**, from which the string **128** extends in the proximal direction (i.e. towards the alveolar ridge **52**) when in use.

According to some embodiments, the at least one movable element **122** comprises, at least one end thereof, a tooling interface **126**. According to some embodiments, the at least one movable element **122** formed as a shaft comprises two tooling interfaces **126**, one at each end of shaft **122**. Each tooling interface **126** is rigidly attached to the at least one end of

movable element **122** formed as a shaft, such that rotation of tooling interface **126** in one direction, results in rotation of the movable element **122** formed as a shaft in the same direction. According to some embodiments, the at least one movable element **122** and the at least one tooling interface **126** are integrally formed. According to some embodiments, tooling interface **126** is exposed through an opening (not numbered) of at least one sidewall **112**.

According to some embodiments, the at least one string pull assembly **120** formed as a rotatable string pull assembly, comprises gear **124** rigidly mounted on movable element **122** formed as a shaft, between sidewalls **112a** and **112b**, such that rotation of movable element **122** results in rotation of gear **124** in the same direction. According to some embodiments, distraction device **100** further comprises at least one pawl **114**, configured to engage with the gear **124** of the at least one string pull assembly **120**. According to some embodiments, gear **124** comprises a ratchet gear, whereby pawl **114** is configured to allow rotation of gear **124** in one direction, while preventing it from rotating in the opposite, or backwards, direction. According to some embodiments, the interface between gear **124** and pawl **114** is configured to allow free rotation of string pull assembly **120** formed as a rotatable string pull assembly, in a direction that wraps or loops string **128** around movable element **122** formed as a shaft, while preventing such rotation in the opposite direction, thereby preventing the option of unwrapping string **128** from movable element **122**. Direction of free rotation can be counter clockwise in some embodiments (see **Fig. 3A**), or clockwise in other embodiments (see **Fig. 3B**).

According to some embodiments, string positioning member **104** comprises a distal panel **108** (see **Figs. 2A-B**, not shown in **Figs. 1A-B** in order to expose components housed within string positioning member **104**). According to some embodiments, distal panel **108** is removably attached to sidewalls **112**. According to some embodiments, distal panel **108** and sidewalls **112** are integrally formed.

According to some embodiments, distal panel **108** comprises the at least one pawl **114**, attached to distal panel **108** on a first pawl end (not numbered), and is free to engage gear **124** on a second pawl end (not numbered). According to some embodiments, as illustrated in **Figs. 2A-B** and **3A**, distal panel **108** comprises at least one panel window **116**, overlaying the position of gear **124**, such that the first pawl end is attached to an edge of

panel window **116**. According to some embodiments, as illustrated in **Fig. 3B**, pawl **114[a]** is attached to a distal panel **108** devoid of panel windows **116**.

While **Figs. 3A** and **3B** depict embodiments in which pawl **114** or **114[a]**, respectively, is attached at one end to distal panel **108**. It will be understood by those skilled in the art that as long the second pawl end is engaged with the corresponding gear **124**, the first pawl end can be attached, directly or indirectly, to any other portion of distraction device **100**, such as, but not limited to, proximal panel **106** (see **Fig. 22C**), any one of side panels **112**, front panel **114**, other portions of the main string positioning member **104** and at least one adaptor member **136**.

According to some embodiments, pawl **114** is either formed as a spring or attached by a spring (not shown) to either distal panel **108** or other portions of distraction device **100**, such that pawl second edge is spring-biased against gear **124**.

While **Figs. 3A** and **3B** depict embodiments of specific ratcheting mechanisms, it will be understood by those skilled in the art that other mechanisms can be implemented to limit rotation of movable element **122** formed as a shaft to one direction, or at least control such rotational movement in each direction separately. Such mechanisms may include, but are not limited to, a double ratchet mechanism, a two-way ratchet mechanism, a friction ratchet mechanism, a one-way clutch, an anti-reverse clutch, and a revolution counter.

At least one adaptor member **136** comprises at least one connection platform configured as an internal, external and/or any combination thereof, configured to connect with a mount, which is directly or indirectly secured to a jaw bone. A mount may include an abutment, a dental crown, a dental screw, a dental bridge, a denture, a native tooth and the like. According to some embodiments, at least one adaptor member **136** is formed as an abutment, a dental crown or a dental bridge, configured to connect with a mount in the form of a denture, a native tooth, a bone screw and the like.

According to some embodiments, at least one adaptor member **136** comprises mounting bore **138** serving as a connection platform. According to some embodiment, mounting bore **138** comprises bore screw thread **140** along its length (see **Figs. 1A-3A**) or a portion thereof, provided for integrating with an external component having a matching screw thread.

According to some embodiment, adaptor member **136**[a] comprises mounting bore **138**[a] (see **Fig. 3B**), having an anti-rotational internal surface along its length. According to some embodiments, the anti-rotational internal surface is formed with a hexagonal cross-section along the length of mounting bore **138**[a] (see **Figs. 10A-10B**). According to some embodiments, the anti-rotational internal surface is formed with an octagonal cross-section along the length of mounting bore **138**[b] (see **Fig. 10C**). According to some embodiment, the anti-rotational internal surface comprises any non-circular cross-section, such as a convex or concave (e.g. star-shaped) polygon, ellipse or other oval, and/or crescent shape.

According to some embodiments, string positioning member **104** is attached to at least one adaptor member **136**. The term "string positioning member attached to at least one adaptor body", as used herein, refers to either string positioning member **104** rigidly attached to at least one adaptor member **136,** or to string positioning member **104** detachably attachable to at least one adaptor member **136**. According to some embodiments, string positioning member **104** is affixed to at least one adaptor member **136**. According to some embodiments, string positioning member **104** and at least one adaptor member **136** are integrally formed. According to some embodiments, string positioning member **104** is detachably attached to at least one adaptor body **136**.

According to some embodiments, string positioning member **104** comprises frame attachment means, configured to support attachment to at least one adaptor member **136**. According to some embodiments, at least one adaptor member **136** comprises adaptor attachment means **134**, configured to support attachment to string positioning member **104**. According to some embodiments, detachable attachment of frame **104** to at least one adaptor member **136** is supported via engagement between frame attachment means and adaptor attachment means **134.**

According to some embodiments, distraction device **100** comprises a plurality of adaptor members **136**. According to some embodiments, distraction device **100** comprises two adaptor members **136**, each one configured to be detachably attached to an opposite end of string positioning member **104**.

According to some embodiments, adaptor attachment means **134** is a quick-snap type of attachment, defined as an attachment enabling quick attachment of the string positioning member **104** to at least one adaptor member **136** by application of manual push/pull force, and quick removal of string positioning member **104** from at least one adaptor member **136**

by application of manual push/pull force. According to some embodiments, adaptor attachment means **134** is devoid of screws, thereby providing a quick and simple mode of attachment between the string positioning member **104** and at least one adaptor member **136**.

Reference is now made to **Figs. 4A-7D. Fig. 4A** constitutes a view in perspective of a main body **102^t** of a distraction device **100^t**, comprising string positioning member **104^t** detachably attachable to adaptor member **136^t**, via a quick-snap type of attachment. String positioning member **104^t** comprises first and second sidewalls **112^{t}a** and **112^{t}b**, and rear and front panels **110^{t}a** and **110^{t}b**, respectively. According to some embodiments, at least one adaptor member **136** is configured to attach to string positioning member **104** at one end thereof, such as to rear panel **110^{t}a** as depicted in **Fig. 4A**. Rear panel **110^{t}a** comprises a positioning member's attachment means having frame ribs **166^t** and positioning member's grooves **167^t**. Adaptor member **136^t** comprises adaptor attachment means **134^t** having adaptor ribs formed along at least a portion of the circumference of adaptor member **136^t**.

Fig. 4B constitutes a view in perspective of string positioning member **104^t** attached to adaptor member **136^t**, for example by moving string positioning member **104^t** in the direction of arrows **92** (see **Fig. 4A**) towards adaptor attachment means **134^t**. Adaptor ribs of adaptor attachment means **134^t** are formed to be received in grooves **167^t**, stably positioned therein by friction forces from ribs **166^t**, thereby securing and preventing spontaneous movement of string positioning member **104^t** relative to adaptor member **136^t**.

While **Fig. 4A** depicts an embodiment of the positioning member's attachment means having two frame ribs **166^t** and one frame groove **167^t**, and adaptor attachment means **134^t** having one adaptor rib, it will be understood by those skilled in the art that rear panel **110^{t}a** can include any other amount of positioning member's ribs **166^t** and positioning member's grooves **167^t**, and that adaptor attachment means **134^t** can include any other amount of adaptor ribs. Preferably, the number of adaptor ribs is matching the number of positioning member's grooves **167^t**.

According to some embodiments, positioning member's ribs **166^t** are formed with rounded edges, as depicted in **Fig. 4A**. According to some embodiments, positioning member's grooves **167^t** are formed as rounded grooves (embodiments not shown). According to some embodiments, the adaptor ribs are formed with rounded edges (embodiments not shown). According to some embodiments, the geometrical form of the adaptor ribs matches the geometrical form of positioning member's grooves **167^t**.

According to some embodiments, positioning member's ribs **166^{t}** further comprise dimples (not numbered) facing matching surfaces of the adaptor ribs of adaptor attachment means **134^{t}** (see **Fig. 4A**), configured to press against the adaptor ribs when received within frame grooves **167^{t}** to further secure and prevent movement of string positioning member **104^{t}** relative to adaptor member **136^{t}**. According to some embodiments, the adaptor ribs of adaptor attachment means **134^{t}** further comprise notches (not shown) configured for alignment with the dimples of positioning member's ribs **166^{t}**.

According to some embodiments, the adaptor ribs of adaptor attachment means **134^{t}** further comprises dimples facing matching surfaces of positioning member's ribs **166^{t}**, configured to press against positioning member's ribs **166^{t}** to further secure and prevent movement of string positioning member **104^{t}** relative to adaptor member **136^{t}** (embodiments not shown). According to some embodiments, positioning member's ribs **166^{t}** the adaptor ribs further comprise notches (not shown) configured for alignment with the adaptor ribs of adaptor attachment means **134^{t}**.

Fig. 5A constitutes a view in perspective of a main body **102^{u}** of a distraction device **100^{u}**, comprising string positioning member **104^{u}** detachably attachable to first adaptor member **136^{u}a** and to second adaptor member **136^{u}b**, via quick-snap type of attachments. String positioning member **104^{u}** comprises first and second sidewalls **112^{u}a** and **112^{u}b**, and rear and front panels **110^{u}a** and **110^{u}b**, respectively. Each of rear and front panels **110^{u}a** and **110^{u}b** comprises positioning member's attachment means having positioning member's ribs **166^{u}** and positioning member's grooves **167^{u}**. Each of first and second adaptor bodies **136^{u}a** and **136^{u}b** comprises first and second adaptor attachment means **134^{u}a** and **134^{u}b**, respectively, having adaptor ribs **170^{u}** and adaptor grooves **171^{u}**, formed along at least a portion of first and second adaptor bodies **136^{u}a** and **136^{u}b**, respectively.

In the example depicted in **Figs. 5A-5B**, rear panel **110^{u}a** comprises positioning member's ribs **166^{u}a** and **166^{u}b**, and positioning member's grooves **167^{u}a**, **167^{u}b** and **167^{u}c**. First adaptor attachment means **134^{u}a** comprises adaptor ribs **170^{u}a**, **170^{u}b** and **170^{u}c**, configured to be accommodated by positioning member's grooves **167^{u}a**, **167^{u}b** and **167^{u}c**, respectively. First adaptor attachment means **134^{u}a** further comprises adaptor grooves **171^{u}a** and **171^{u}b**, configured to accommodate positioning member's ribs **166^{u}a** and **166^{u}b**, respectively. Front panel **110^{u}b** comprises positioning member's ribs **166^{u}c** and **166^{u}d**, and positioning member's grooves **167^{u}d**, **167^{u}e** and **167^{u}f**. Second adaptor attachment means

134^{u}b comprises adaptor ribs **170^{u}d**, **170^{u}e** and **170^{u}f**, configured to be accommodated by positioning member's grooves **167^{u}d**, **167^{u}e** and **167^{u}f**, respectively. Second adaptor attachment means **134^{u}b** further comprises adaptor grooves **171^{u}c** and **171^{u}d**, configured to accommodate positioning member's ribs **166^{u}c** and **166^{u}d**, respectively.

Fig. 5B constitutes a view in perspective of string positioning member **104^{u}** attached to first and second adaptor members **136^{u}a** and **136^{u}b**, respectively, for example by moving string positioning member **104^{u}** in the direction of arrows **94** (see **Fig. 5A**) to facilitate engagement between the frame attachment means of rear and front panels **110^{u}a** and **110^{u}b** and adaptor attachment means **134^{u}a** and **134^{u}b**, respectively. Adaptor ribs **170^{u}** and adaptor grooves **171^{u}** are formed for engagement with positioning member's grooves **167^{u}** and positioning member's ribs **166^{u}**, respectively, stably positioned therein by friction forces, thereby securing and preventing spontaneous movement of string positioning member **104^{t}** relative to any of first or second adaptor members **136^{u}a** and **136^{u}b**, respectively.

While **Figs. 5A** and **5B** depict an embodiment of each positioning member's attachment means having two frame ribs **166^{u}** and three grooves **167^{u}**, and each of first and second adaptor attachment means **134^{u}a** and **134^{u}b** having three adaptor ribs **170^{u}** and two adaptor grooves **171^{u}**, it will be understood by those skilled in the art that each of rear panel **110^{u}a** and **110^{u}b** can include any other amount of positioning member's ribs **166^{u}** and positioning member's grooves **167^{u}**, and that each of first and second adaptor attachment means **134^{u}a** and **134^{u}b** can include any other amount of adaptor ribs **170^{u}** and adaptor grooves **171^{u}**. Preferably, the number of adaptor ribs adaptor ribs **170^{u}** is matching the number of positioning member's grooves **167^{u}** configured to engage each other, and the number of adaptor ribs adaptor grooves **171^{u}** is matching the number of positioning member's ribs **166^{u}** configured to engage each other.

Fig. 6A constitutes a view in perspective of a main body **102^{v}** of a distraction device **100^{v}**, comprising a string positioning member **104^{v}** detachably attachable to a first adaptor member **136^{v}a** and to a second adaptor member **136^{v}b**, via quick-snap type of attachments. String positioning member **104^{v}** comprises first and second sidewalls **112^{v}a** and **112^{v}b**, and rear and front panels **110^{v}a** and **110^{v}b**, respectively. Each of rear and front panels **110^{v}a** and **110^{v}b** comprises positioning member's attachment means in the form of positioning member's ribs **166^{v}** and positioning member's grooves **167^{v}**. Each of first and second adaptor members **136^{v}a** and **136^{v}b** comprises first and second adaptor attachment means **134^{v}a** and **134^{v}b**,

respectively, having circumferential adaptor ribs **170^{v}** and circumferential adaptor grooves **171^{v}** formed along the complete circumference first and second adaptor member **136^{v}a** and **136^{v}b**, respectively.

In the example depicted in **Figs. 6A-6B**, rear panel **110^{v}a** comprises positioning member's ribs **166^{v}a** and **166^{v}b**, and positioning member's grooves **167^{v}a**, **167^{v}b** and **167^{v}c**. First adaptor attachment means **134^{v}a** comprises adaptor ribs **170^{v}a**, **170^{v}b** and **170^{v}c**, configured to be accommodated by positioning member's grooves **167^{v}a**, **167^{v}b** and **167^{v}c**, respectively. First adaptor attachment means **134^{v}a** further comprises adaptor grooves **171^{v}a** and **171^{v}b**, configured to accommodate positioning member's ribs **166^{v}a** and **166^{v}b**, respectively. Front panel **110^{v}b** comprises positioning member's ribs **166^{v}c** and **166^{v}d**, and positioning member's grooves **167^{v}d**, **167^{v}e** and **167^{v}f**. Second adaptor attachment means **134^{v}b** comprises adaptor ribs **170^{v}d**, **170^{v}e** and **170^{v}f**, configured to be accommodated by positioning member's grooves **167^{v}d**, **167^{v}e** and **167^{v}f**, respectively. Second adaptor attachment means **134^{u}b** further comprises adaptor grooves **171^{v}c** and **171^{v}d**, configured to accommodate positioning member's ribs **166^{v}c** and **166^{v}d**, respectively.

Rear and front panels **110^{v}a** and **110^{v}b**, respectively, along with positioning member's ribs **166^{v}** and positioning member's grooves **167^{v}**, are curved arcuately, formed to match the circumferential shape of first and second adaptor attachment means **134^{v}a** and **134^{v}b**, along with circumferential adaptor ribs **170^{v}** and circumferential adaptor grooves **171^{v}**, respectively.

Fig. 6B constitutes a view in perspective of string positioning member **104^{v}** attached to first and second adaptor members **136^{v}a** and **136^{v}b**, for example by moving string positioning member **104^{v}** in the direction of arrows **96** (see **Fig. 6A**) to facilitate engagement between the positioning member's attachment means of rear and front panels **110^{v}a** and **110^{v}b** and adaptor attachment means **134^{v}a** and **134^{v}b**, respectively. Adaptor ribs **170^{v}** and adaptor grooves **171^{v}** are formed for engagement with positioning member's grooves **167^{v}** and positioning member's ribs **166^{v}**, respectively, stably positioned therein by friction forces, thereby securing and preventing spontaneous movement of positioning member's **104^{v}** relative to any of first or second adaptor bodies **136^{v}a** and **136^{v}b**, respectively.

Advantageously, the arcuate shape of the frame attachment means of rear and front panels **110^{v}a** and **110^{v}b**, matching the circumferential shape of adaptor attachment means **134^{v}a** and **134^{v}b**, respectively, enables an operator of distraction device **100^{v}** to rotate any one of first and second adaptor members **136^{v}a** and **136^{v}b**, respectively, while string

positioning member **104^{v}** remains engaged thereto. This may be achieved by designing the positioning member's attachment means of rear and front panels **110^{v}a** and **110^{v}b**, and adaptor attachment means **134^{v}a** and **134^{v}b**, to generate frictional force when engaged with each other so as to prevent spontaneous relative movement when no other external force, higher than the frictional force, is acting against any of string positioning member **104^{v}** or first or second adaptor members **136^{v}a** and **136^{v}b**, respectively. However, manual rotation of any one of first and second adaptor members **136^{v}a** and **136^{v}b**, respectively, at a force higher than the frictional force, enables such relative movement, and once such forced rotation is complete, the frictional force once again acts to prevent spontaneous movement between string positioning member **104^{v}** and any of first or second adaptor members **136^{v}a** and **136^{v}b**, respectively.

While **Figs. 6A-6B** depict an embodiment of string positioning member **104** formed to engage with two adaptor members **136**, in a manner which enables rotation of each one of adaptor members **136** while keeping string positioning member **104** engaged thereto, it will be understood by those skilled in the art that similar configuration may be adapted to string positioning member **104** being formed to engage with a single adaptor member **136**.

In the example depicted in **Figs. 6A-6B**, distraction device **100^{v}** comprises vertical string pull assemblies **120^{v}** (not shown) disposed between proximal panel **106^{v}** (not shown) and distal panel **108^{v}**, each comprising tooling interface **126^{v}** (similar to vertical string pull assemblies **120^{c}** depicted in **Fig. 12** and further described herein below). It will be understood by those skilled in the art that distraction device **100^{v}** may alternatively include any other embodiments of string pull assemblies **120**, disclosed throughout the specification.

While **Figs. 6A-6B** depict an embodiment of each frame attachment means having two positioning member's ribs **166^{v}** and three grooves **167^{v}**, and each of first and second adaptor attachment means **134^{v}a** and **134^{v}b**, respectively, having three adaptor ribs **170^{v}** and two adaptor grooves **171^{v}**, it will be understood by those skilled in the art that each of rear panel **110^{v}a** and **110^{v}b** can include any other amount of positioning member's ribs **166^{v}** and positioning member's grooves **167^{v}**, and that each of first and second adaptor attachment means **134^{v}a** and **134^{v}b**, respectively, can include any other amount of adaptor ribs **170^{v}** and adaptor grooves **171^{v}**. Preferably, the number of adaptor ribs **170^{v}** is matching the number of positioning member's grooves **167^{v}** configured to engage each other, and the number of

adaptor grooves **171**^{v} is matching the number of positioning member's ribs **166**^{v} configured to engage each other.

Fig. 7A constitutes a view in perspective of a main body **102**^{w} of a distraction device **100**^{w}, comprising a string positioning member **104**^{w} detachably attachable to a first adaptor member **136**^{w}**a** and a second adaptor member **136**^{w}**b**, via quick-snap type of attachments, wherein first and second adaptor members **136**^{w}**a** and **136**^{w}**b** are connected to each other via adaptor attachment means **134**^{w}. String positioning member **104**^{w} comprises first and second sidewalls **112**^{w}**a** and **112**^{w}**b**, and rear and front panels **110**^{w}**a** and **110**^{w}**b**, respectively. Adaptor attachment means **134**^{w} comprises an adaptor attachment socket **172**^{w}, formed to receive string positioning member **104**^{w} therein.

Fig. 7B constitutes a view in perspective of string positioning member **104**^{w} attached to first and second adaptor members **136**^{w}**a** and **136**^{w}**b**, for example by moving string positioning member **104**^{w} in the direction of arrows **98** (see **Fig. 7A**) to facilitate engagement between the sidewalls of adaptor attachment socket **172**^{w} (not numbered) and rear panel **110**^{v}**a**, front panel **110**^{v}**b**, first sidewall **112**^{w}**a** and second sidewall **112**^{w}**b**. String positioning member **104**^{w} is stably positioned within adaptor attachment socket **172**^{w} by friction forces acting there between, thereby securing and preventing spontaneous movement of string positioning member **104**^{w} relative to any of first or second adaptor members **136**^{w}**a** and **136**^{w}**b**.

According to some embodiments, adaptor attachment means **134**^{w} is rigidly attached to first and second adaptor members **136**^{w}**a** and **136**^{w}**b**. According to some embodiments, adaptor attachment means **134**^{w} is integrally formed with first and second adaptor members **136**^{w}**a** and **136**^{w}**b**. According to some embodiments, adaptor attachment means **134**^{w} is detachably attached to first and second adaptor members **136**^{w}**a** and **136**^{w}**b**.

According to some embodiments, string positioning member **104**^{w} is pushed in the direction of arrows **98** (see **Fig. 7A**), such that only a portion of rear panel **110**^{v}**a**, front panel **110**^{v}**b**, first sidewall **112**^{w}**a** and second sidewall **112**^{w}**b** are engaged with the sidewalls of adaptor attachment socket **172**^{w}, leaving tooling interface **126**, such as tooling interface **126**^{b} disposed along at least first sidewall **112**^{w}**a**, exposed for access (for example, access to rotation tools **76** described herein below) and unblocked by adaptor attachment socket **172**^{w} (see **Fig. 7B**).

According to some embodiments, adaptor attachment socket **172**^{w} further comprises a socket seat **173**^{w} (see **Fig. 7A**), such that string positioning member **104**^{w} can be pushed in the direction of arrows **98** until it abuts against socket seat **173**^{w}. Socket seat **173**^{w} is configured to prevent further movement of string positioning member **104**^{w} in the direction of arrows **98**, at a position such that tooling interfaces **126** are exposed for access and unblocked by adaptor attachment socket **172**^{w} (see **Fig. 7B**).

Fig. 7C constitutes a view in perspective of a main body **102**^{y} of a distraction device **100**^{y}, comprising a string positioning member **104**^{y} detachably attachable to a first adaptor member **136**^{y}**a** and a second adaptor member **136**^{y}**b**, via quick-snap type of attachments, wherein first and second adaptor members **136**^{y}**a** and **136**^{y}**b** are connected to each other via adaptor attachment means **134**^{y}. String positioning member **104**^{y} comprises first and second sidewalls **112**^{y}**a** and **112**^{y}**b**, and rear and front panels **110**^{y}**a** and **110**^{y}**b**, respectively. Adaptor attachment means **134**^{y} comprises an adaptor attachment socket **172**^{y}, formed to receive string positioning member **104**^{y} therein.

Fig. 7D constitutes a view in perspective of string positioning member **104**^{y} attached to first and second adaptor members **136**^{y}**a** and **136**^{y}**b**, for example by moving string positioning member **104**^{y} in the direction of arrows **98** (see **Fig. 7C**) to facilitate engagement between the sidewalls of adaptor attachment socket **172**^{y} (not numbered) and rear panel **110**^{y}**a**, front panel **110**^{y}**b**, first sidewall **112**^{y}**a** and second sidewall **112**^{y}**b**. String positioning member **104**^{y} is stably positioned within adaptor attachment socket **172**^{y} by friction forces acting there between, thereby securing and preventing spontaneous movement of string positioning member **104**^{y} relative to any of first or second adaptor members **136**^{y}**a** and **136**^{y}**b**.

According to some embodiments, adaptor attachment means **134**^{y} is rigidly attached to first and second adaptor members **136**^{y}**a** and **136**^{y}**b**. According to some embodiments, adaptor attachment means **134**^{y} is integrally formed with first and second adaptor members **136**^{y}**a** and **136**^{y}**b**. According to some embodiments, adaptor attachment means **134**^{y} is detachably attached to first and second adaptor members **136**^{y}**a** and **136**^{y}**b**.

In the example depicted in **Figs. 7C-7D**, string positioning member **104**^{y} comprises vertical string pull assemblies **120**^{y} (not shown, similar to vertical string pull assemblies **120**^{c} depicted in **Fig. 12** and further described herein below) with tooling interfaces **126**^{y} disposed along distal panel **108**^{y}, thereby enabling insertion of string positioning member **104**^{y} into

adaptor attachment socket **172**^{y} for engagement therewith, without the risk of tooling interfaces **126**^{y} being blocked by adaptor attachment socket **172**^{y}.

Advantageously, string positioning member **104**^{y} having tooling interfaces **126**^{y} disposed along distal panel **108**^{y} enables rear panel **110**^{y}**a**, front panel **110**^{y}**b**, first sidewall **112**^{y}**a** and second sidewall **112**^{y}**b**, according to some embodiments, to be designed to engage with the sidewalls of adaptor attachment socket **172**^{y} along the entire vertical height thereof (see **Figs. 7C-7D**), thereby providing a larger engagement surface between string positioning member **104**^{y} and adaptor attachment socket **172**^{y}, for example in comparison to distraction device **100**^{w}.

According to some embodiments, at least one adaptor member **136** is configured for attachment to string positioning member **104** using alternative mechanical affixation methods, including, but not limited to soldering, prongs, fasteners, biocompatible adhesives and/or via alternative structures that may extend either from at least one adaptor member **136**, from string positioning member **104**, or from both.

According to some embodiments, distraction device **100** is supplied as a kit including string positioning member **104** and at least one adaptor member **136**, separated from one another and configured for to be coupled together prior to placement over a jawbone as further disclosed herein.

According to some embodiments, string positioning member **104** is symmetrical such that rear and front panels **110a** and **110b**, respectively, are interchangeably, and string positioning member **104** may be rotated to either side such that rear panel **110a** acts as front panel **110b**, and front panel **110b** acts as rear panel **110a**.

As used herein, the term "front panel **110**", when mentioned in embodiments not specifically discriminating between rear and front panels **110a** and **110b**, refers to front panel **110b**.

It will be clear that string positioning member **104** and at least one adaptor member **136** are not limited to the geometries or attachment type exemplified hereinabove, and that the configurations depicted in **Figs. 4A-7D** serve as mere examples, while a person skilled in the art may utilize any other attachment methods and supporting structures between string positioning member **104** and at least one adaptor member **136**, as known in the art.

According to some embodiments, string positioning member **104** is symmetrical such that first and second sidewalls **112a** and **112b** are interchangeably, and string positioning member **104** may be rotated to either side such that first sidewall **112a** acts as second sidewall **112b**, and second sidewall **112b** acts as first sidewall **112a**.

According to some embodiments, at least one component of the distraction device **100**, such as a main body **102**, a strings positioning member **104**, at least one string pull assembly **120**, at least one adaptor member **136** or the like, is manufactured via the use of CAD-CAM software and CAD-CAM operated machines, based on at least one design file supplied to the CAD-CAM software.

The term CAD, as used herein, refers to Computer Aided Design.

The term CAM, as used herein, refers to Computer Aided Manufacturing.

According to some embodiments, the design file includes instructions for manufacturing the at least one component of the distraction device **100** according to a design specific to a patient, accounting for various parameters such as the geometry of the patient's jaw, the geometry of a patent-specific alveolar ridge atrophy, the geometry of mounts such as dentures or the patient's native teeth, the size and geometry of adjacent components of the distraction device **100**.

As used herein, the terms "adaptor member" and "at least one adaptor member" are interchangeable, and refer to either a single adaptor member **136** or a plurality of adaptor members **136**.

According to some embodiments, tooling interface **126** comprises a screw-drive (not numbered). In **Fig. 8A**, the screw-drive of tooling interface **126** is in the form of a Phillips or Fearson socket. In **Fig. 8B**, the screw-drive of tooling interface **126^{a}** is in the form of a hex or an Allen screw-head. In **Fig. 8C**, the screw-drive of tooling interface **126^{b}** is in the form of a hex or an Allen socket. It will be understood by those skilled in the art that other screw-drive shapes may be implemented, such as, but not limited to, Slot, Square, Robertson, Torx, TA, Tri-Wing, Clutch, Spanner-Head, Double-Square, Triple-Square, Double-Hex, Bristol and the like.

The term “screw-drive”, as used herein, refers to either screw-heads adapted to fit with a rotation tool in the form of screwdrivers, or to extension s formed with facets, adapted to fit rotation tools such as wrenches.

Fig. 9A depicts rotation tool **76**, engaged with tooling interface **126^{b}** in the direction of arrow **80**. **Fig. 9B** shows rotation of rotation tool **76** in the direction of arrow **82**. Such rotation, while rotation tool **76** is engaged with tooling interface **126^{b}**, will cause movable element **122** formed as a shaft to rotate in the same direction **82**, thereby shortening the length of the unwrapped portion of string **128**. According to some embodiments, rotation of rotation tool **76** in the direction opposite to arrow **82** is limited due to engagement of pawl **114** with gear **124**.

According to some embodiments, rotation of tooling interface **126** is performed with optional proprietary and/or customized tools. **Fig. 9A** depicts an embodiment of rotation tool **76^{a}**, engaged with tooling interface **126^{b}** and rotating in direction **84**.

The profile of rotation tool **76** corresponds with the screw-drive shape of tooling interface **126**. **Figs. 9A-9C** depict embodiments of a rotation tool **76** or **76^{a}**, shaped with an Allen head, inserted into the screw-drive socket of tooling interface **126^{b}**. However, rotation tool **76** may comprise other engagement forms, configured either for engagement with an inner socket or an outer circumferential profile of the tooling interface **126**, such as but not limited to, a screwdriver, a wrench, or a spanner.

Figs. 8A-8C depict embodiments of tooling interfaces **126** having a screw-drive, configured for engagement with a rotation tool **76**. However, it will be understood by those skilled in the art, that tooling interfaces **126** may comprise other features that enable its rotation, such as handles or extensions (not illustrated) that can be grasped either by tool or by hand, to be rotated in a similar manner.

According to some embodiments, mounting bore **138**comprises socket screw thread **140** (see **Figs. 1A-4B**). According to some embodiments, mounting bore **138** comprises a polyhedral-shaped structure (see **Figs. 10A-10B**).

Figs. 1A-10C depict exemplary embodiments of distraction device **100** comprising three string pull assemblies **120.** However, it will be understood by those skilled in the art that distraction device **100** may comprise any other amount of string pull assemblies, for example with corresponding pawls, such as one, two, four and so on.

According to some embodiments, the plurality of string pull assemblies **120** are aligned in parallel with each other. According to some embodiments, the plurality of string pull assemblies **120** are horizontally spaced from each other at even distances. According to

some embodiments, the plurality of string pull assemblies **120** are horizontally spaced from each other at uneven distances.

The term plurality, as used herein, refers to more than one.

The terms horizontal or horizontal plane, as used herein, are interchangeable and refer to a plane parallel to proximal panel **106** or to distal panel **108**, as illustrated and oriented in **Figs. 1A-10A**. The terms vertical of vertical direction, as used herein, are interchangeable and refer to a direction perpendicular to the horizontal plane, for example parallel to axis **32** (see **Fig. 1A**).

The terms "example" and "exemplary" are used herein to mean "serving as an example, instance or illustration". Any embodiment described as an "example" or "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments and/or to exclude the incorporation of features from other embodiments.

According to some embodiments, proximal panel **106** spans along a single horizontal plane. According to some embodiments, distal panel **108** spans along a single horizontal plane. According to some embodiments, string positioning member **104** is formed as a fully straight frame, meaning that the proximal and distal edges (not numbered) of each of first sidewall **112a** and second sidewall **112b**, are straight between adaptor member **136** and front panel **110**.

According to some embodiments, string positioning member **104** is formed as a fully straight frame, such that the proximal and distal edges of each of first sidewall **112a** and second sidewall **112b** are parallel to a horizontal plane, each edge being perpendicular to the vertical direction (see **Figs. 1A-10A**). According to some embodiments, string positioning member **104** is formed as a fully straight frame, such that the proximal and distal edges of each of first sidewall **112a** and second sidewall **112b** are angled relative to a horizontal plane, each edge being angled at a non-perpendicular angle relative to the vertical direction.

According to some embodiments, string positioning member **104** is formed as a plate, which spans along a single horizontal plane (embodiments not shown).

According to some embodiments, string positioning member **104** is formed as a partially straight frame, meaning that only either the proximal edges or the distal edges of each of first sidewall **112a** and second sidewall **112b**, are straight between adaptor member **136** and front panel **110**.

According to some embodiments, string positioning member **104** is formed as a partially straight frame, such that the proximal edges or the distal edges of each of first sidewall **112a** and second sidewall **112b** are arcuate.

According to some embodiments, string positioning member **104** is formed as a partially straight frame, such that the proximal edges or the distal edges of each of first sidewall **112a** and second sidewall **112b** are shaped to conform to a shape of a jawbone, such as the maxilla.

According to some embodiments, string positioning member **104** is formed as a non-straight frame, meaning that none of the proximal and the distal edges of each of first sidewall **112a** and second sidewall **112b**, are straight between adaptor member **136** and front panel **110**. According to some embodiments, string positioning member **104** is formed as a non-straight plate (embodiments not shown).

According to some embodiments, string positioning member **104** is formed as a non-straight frame, such that at least the proximal edges or the distal edges of each of first sidewall **112a** and second sidewall **112b** are arcuate.

According to some embodiments, string positioning member **104** is formed as a non-straight frame, such that at least the proximal edges or the distal edges of each of first sidewall **112a** and second sidewall **112b**, are shaped to conform to a shape of a jawbone, such as the maxilla.

Reference is now made to **Figs. 11A-13D**, depicting different embodiments of string pull assemblies **120** attached to a string positioning member **104**. According to some embodiments, at least one string pull assembly **120** is oriented diagonally relative sidewalls **112**, so as to be angled at an angle greater or smaller than 90° relative to either first sidewall **112a** or second sidewall **112b**. **Figs. 11A** and **11B** constitute a view in perspective and a top view, respectively, of a distraction device **100^{b}** having two exemplary parallel diagonal string pull assemblies **120^{b}** attached to main body **102^{b}**, horizontally angled relative to either first sidewall **112^{b}a** or second sidewall **112^{b}b**. Each string pull assembly **120^{b}** comprises a movable element **122^{b}**, a gear **124^{b}** rigidly attached to movable element **122^{b}**, a string **128** affixed to movable element **122^{b}**, and at least one tooling interface **126^{c}**, extending through at least one sidewall **112^{b}**.

According to some embodiments, at least one string pull assembly **120** is rotateably attached to distal panel **108**, such that at least one tooling interface **126** is exposed there through. According to some embodiments, the at least one string pull assembly **120** is oriented vertically between proximal panel **106** and distal panel **108**. According to some embodiments, the at least one vertical string pull assembly **120** is attached to both proximal panel **106** and distal panel **108**, such that a tooling interface **126** extends through the distal panel **108**. According to some embodiments, the at least one vertical string pull assembly **120** is attached to distal panel **108** but not to proximal panel **106**, such that a tooling interface **126** is exposed through the distal panel **108**.

Fig. 12 constitutes a cross-sectional side view of a distraction device **100^{c}** having three exemplary vertical string pull assemblies **120^{c}**, disposed between proximal panel **106^{c}** and distal panel **108^{c}** of main body **102^{c}**, and in parallel with front panel **110^{c}**. Each string pull assembly **120^{c}** comprises a movable element **122^{c}**, a gear **124^{c}** rigidly attached to movable element **122^{c}**, string **128** affixed to movable element **122^{b}** and extending through an positioning feature **118^{c}** of proximal panel **106^{c}**, and tooling interface **126^{d}**, extending through distal panel **108^{d}**.

According to some embodiments, at least one string pull assembly **120** is rotateably attached to front panel **110**, such that at least one tooling interface **126** is exposed there through. According to some embodiments, at least one longitudinal string pull assembly **120** is attached to both front panel **110** and an outer surface (not numbered) of adaptor member **136**. According to some embodiments, the at least one string pull assembly **120** is attached to front panel **110** but not to an outer surface of adaptor member **136**.

Fig. 13A and **13B** constitute a view in perspective and a cross-sectional top view, respectively, of distraction device **100^{d}** having two exemplary longitudinal string pull assemblies **120^{d}a** and **120^{d}b**, disposed between front panel **110^{d}** and an outer surface of adaptor member **136**, and in parallel with first sidewall **r** and second sidewall **112^{d}b**. Each string pull assembly **120^{d}** comprises a movable element **122^{d}**, a string **128** affixed to movable element **122^{d}** and extending through an aperture **118^{d}** of proximal panel **106^{d}**, and a tooling interface **126^{e}**, extending through front panel **110^{d}**. Each movable element **122^{d}** is formed as a screw having a screw threading (not numbered). Each string pull assembly **120^{d}** further comprises a channel **142**, having a threading along at least a portion of its length, corresponding to the screw threading of movable element **122^{d}** formed as a shaft, configured

to enable longitudinal movement of movable element **122**^{d} along its length. Channel **142** further comprises an opening (not numbered) through which string **128** may pass towards positioning feature **118**^{d}.

Fig. 13B and **13D** constitute a cross-sectional top view and a cross-sectional side view marked in **Fig 13B**, respectively, of longitudinal string pull assemblies **120**^{d}**a** and **120**^{d}**b** in a first position, defined as a position in which both tooling interface **126**^{e}**a** and tooling interface **126**^{e}**b** are in contact with front panel **110**^{d}. A rotation tool **76** can be engaged with either tooling interface **126**^{e} (bot shown), used to rotate it, thereby distancing tooling interface **126**^{e} away from front panel **110**^{d}, and distancing movable element **122**^{d} away from adaptor member **136**.

Fig. 13A and **13C** constitute a view in perspective and a cross-sectional top view, respectively, of longitudinal string pull assemblies **120**^{d}**a** and **120**^{d}**b** in a second position, defined as a position in which both tooling interfaces **126**^{e}**a** and **126**^{e}**b** are spaced from front panel **110**^{d}, and both corresponding movable elements **122**^{d}**a** and **122**^{d}**b** are spaced father away from adaptor member **136**, relative to the first position. Consequently, strings **128a** and **128b**, affixed at one end to movable element **122**^{d}**a** and **122**^{d}**b**, respectively, are pulled during the disposition of movable element **122**^{d}**a** and **122**^{d}**b** from the first to the second position, such that the string engagement portion **130** moves vertically towards proximal plate **106**^{c} from first position to second position.

According to some embodiments, the at least one string pull assembly **120** is rotateably attached to adaptor member **136**. Reference is now made to **Figs. 15A-16B**, depicting different embodiments of string pull assemblies **120** rotateably attached to adaptor member **136** having a mounting bore **138**. According to some embodiments, at least one end of at least one string pull assembly **120** is rotateably attached to adaptor member **136**, such that at least one tooling interface **126** extends through a sidewall (not numbered) of adaptor member **136**. According to some embodiments, both ends of at least one string pull assembly **120** are rotateably attached to adaptor member **136**, such that at least one tooling interface **126** extends through a sidewall (not numbered) of adaptor member **136**.

Reference now is made to **Figs. 14A-H**, depicting different embodiments of string pull assemblies **120**. **Fig. 14A** and **14B** constitute a view in perspective and a cross-sectional top view of a distraction device **100**^{p} comprising a plurality of string pull assemblies **120**^{p}. In the embodiments depicted in **Figs. 14A-B**, three string pull assemblies **120**^{p} are attached to a

strings positioning member **104**^{p} of main body **102**^{p}. According to some embodiments, string positioning member **104**^{p} comprises a distal panel **108**^{p}, shown in **Fig. 14A**.

According to some embodiments, string pull assemblies **120** comprises a channel, such that the movable element **122** is configured to axially move along at least one direction within the channel **120**.

According to some embodiments, string pull assemblies **120**^{p} comprises a channel **142**^{p}, having a threading along at least a portion of its length, corresponding to a screw threading of movable element **122**^{p} formed as an inner screw, configured to enable longitudinal movement of movable element **122**^{p} along channel **142**^{p}. According to some embodiments, movable element **122**^{p} formed as an inner screw is threadedly engaged with channel **142**^{p}.

According to some embodiments, channel **142**^{p} has a fully closed circular profile along a plane perpendicular to its length, provided with a thread there along.

According to some embodiments, a sidewall, such as first sidewall **112**^{d}**a**, comprises at least one opening to allow access to tooling interface **126**^{p} of movable element **122**^{p}. String **128** is affixed at first string end to movable element **122**^{p}, such that axial displacement of movable element **122**^{p} is configured to drag the string **128** in the same direction, without wrapping the string **128** around the movable element **122**^{p} it is attached to.

According to some embodiments, movable element **122**^{p} further comprises an inner core connected to an outer shell of the movable element **122**^{p} via a bearing, in order to allow axial displacement of a string **128** attached to the movable element **122**^{p} without being wrapped there around during rotational movement of the movable element **122**^{p} (embodiments not shown).

According to some embodiments, string positioning member **104** comprises a plurality of positioning features **118**, for example formed as apertures, through which string **128** are configured to extend, such that the positioning features **118** are closer to one sidewall of string positioning member **104** than the opposite sidewall

String positioning member **104**^{p} comprises a plurality of positioning features **118**^{p}, for example formed as apertures, through which string **128** are configured to extend. According to some embodiments, the positioning features **118**^{p} are closer to a first sidewall **112**^{p}**a** than the second sidewall **112**^{p}**b** (see **Fig. 14B**).

In use, rotation of movable element **122^{p}** formed as an inner screw, in one direction, for example by rotation tool **76**, leads the movable element **122^{p}** along channel **142^{p}** in direction **36** (the direction from the first sidewall **112^{p}a** to the second sidewall **112^{p}b**). The first string end of string **128** is axially displace along with movable element **122^{p}** in direction **36**, in a manner that retracts the string engagement portion **130**, such as the open ended string engagement portion **130^{b}**, in the distal direction.

Figs. 14A-B show an exemplary embodiment of thee string pull assemblies **120^{p}**, wherein each movable element **122^{p}a**, **122^{p}b** and **122^{p}c** is positioned at a different position along channel **142^{p}a**, **142^{p}b** and **142^{p}c**, corresponding to a different position of string engagement portion **130^{b}a**, **130^{b} b** and **130^{b} c** of Fig. **14A**, respectively.

According to some embodiments, distal panel **108** comprises at least one viewing window **117**, overlaying the position of channel **142**, configured to enable a user of the distraction device **100^{p}** to see the position of movable element **122** within channel **142**. According to some embodiments, the at least one viewing window **117** is formed as an opening in distal panel **108**. According to some embodiments, the at least one viewing window **117** comprises a transparent material.

Fig. 14C and **14D** constitute a view in perspective and a top view of a distraction device **100^{q}** comprising a plurality of string pull assemblies **120^{q}**. In the embodiments depicted in **Figs. 14C-D**, three string pull assemblies **120^{q}** are attached to a strings positioning member **104^{q}** of main body **102^{q}**.

According to some embodiments, string positioning member **104^{p}** comprises a distal panel **108^{q}**, shown in **Fig. 14C** but removed from view in **Fig. 14D** in order to expose the inner components housed within string positioning member **104^{q}**. According to some embodiments, distal panel **108^{q}** comprises at least one viewing window **117^{q}**, overlaying the position of a respective channel **142^{q}**, configured to enable a user of the distraction device **100^{q}** to see the position of movable element **122^{q}** within channel **142^{q}**.

According to some embodiments, the at least one viewing window **117^{q}** comprises markings, such as graduation marks, indicating the position of the movable element **122^{q}**. According to some embodiments, distal panel **108^{q}** comprises markings, such as graduation marks, adjacent to the at least one viewing window **117^{q}**.

According to some embodiments, other regions of strings positioning member **104** comprise at least one viewing window, to allow viewing current position of movable element **122**, such as sidewalls **112a** and **112b** or front panel **110** (embodiments now shown).

According to some embodiments, string pull assemblies **120^{q}** comprises a channel **142^{q}**, having a threading along at least a portion of its length, corresponding to a screw threading of movable element **122^{q}** formed as an inner screw, configured to enable longitudinal movement of movable element **122^{q}** along channel **142^{q}**. According to some embodiments, movable element **122^{q}** formed as an inner screw is threadedly engaged with channel **142^{q}**.

According to some embodiments, channel **142^{q}** has a partially open circular profile along a plane perpendicular to its length, extending along less than 360 degrees, such that a slot is formed along a distal portion thereof. The position of movable element **122^{q}** within channel **142^{q}**, as seen through viewing window **117^{q}**, can be visible through the slot disposed axially in direction **36** at the distal portion of channel **142^{q}**.

Fig. 14E and **14F** constitute a view in perspective and a top view of a distraction device **100^{r}** comprising a plurality of string pull assemblies **120^{r}**. In the embodiments depicted in **Figs. 14C-D**, three string pull assemblies **120^{r}** are attached to a strings positioning member **104^{r}** of main body **102^{r}**.

According to some embodiments, string positioning member **104^{r}** comprises a distal panel **108^{r}**, shown in **Fig. 14E** but removed from view in **Fig. 14F** in order to expose the inner components housed within string positioning member **104^{r}**.

According to some embodiments, string pull assemblies **120^{r}** comprises a channel **142^{r}**, having ratcheting teeth along at least a portion of its length, corresponding to at least one complementary ratcheting tooth or pawl of movable element **122^{r}** formed as ratcheting element, configured to enable longitudinal one-directional movement of movable element **122^{r}** along channel **142^{r}**.

According to some embodiments, movable element **122** further comprises an extension **123**, configured to allow grasping thereof, either by hand or by a tool. Extension **123** is configured to allow axial displacement of movable element **122** by pushing or moving the extension **123** in a desired direction, to a desired new position.

According to some embodiments, movable element **122^{r}** further comprises an extension **123^{r}** in the form of a vertical extension (see **Figs. 14E-F**). According to some embodiments, distal panel **108^{q}** comprises at least one window **117^{r}**, overlaying the position of a respective channel **142^{r}**.

According to some embodiments, window **117^{r}** is configured to enable extension **123^{q}** to extend there through (for example, in the vertical direction), and move there along, for example in direction **36**. According to some embodiments, distal panel **108^{q}** comprises markings, such as graduation marks, adjacent to the at least one window **117^{r}**.

String **128** is affixed at first string end to movable element **122^{r}**, such that axial displacement of movable element **122^{r}** is configured to drag the string **128** in the same direction, without wrapping the string **128** around the movable element **122^{r}** it is attached to.

According to some embodiments, movable element **122^{r}** further comprises an inner core connected to an outer shell of the movable element **122^{r}** via a bearing, in order to allow axial displacement of a string **128** attached to the movable element **122^{r}** without being wrapped there around during rotational movement of the movable element **122^{r}** (embodiments not shown).

String positioning member **104^{q}** comprises a plurality of positioning features **118^{r}**, for example formed as apertures, through which string **128** are configured to extend. According to some embodiments, the positioning features **118^{r}** are closer to a first sidewall **112^{r}a** than the second sidewall **112^{r}b** (see **Fig. 14F**).

In use, axial displacement of movable element **122^{r}** formed as ratcheting element, for example by grasping extension **123^{r}** and pushing it in direction **36**, results in axial displacement of the first string end of string **128** there along, in a manner that pulls the string engagement portion **130** at the second string end in the distal direction.

Figs. 14E-F show an exemplary embodiment of string pull assemblies **120^{r}**, wherein each movable element **122^{r}** is positioned at a different position along its respective channel **142^{r}**, similar to the positions exemplified in **Figs. 14A-B**.

Fig. 14G and **14H** constitute a view in perspective and a top view of a distraction device **100^{r}** comprising a plurality of string pull assemblies **120^{s}**. Distraction device **100^{s}**, along with all of its internal components, are similar in structure and function to the embodiments of distraction device main body **102^{r}** and its respective components, as

described herein and shown in **Figs. 14E-F**, except that the channels **142^{s}**, and potentially windows **117^{s}**, extend longitudinally along a shorter path than channels **142^{r}**, and that the positioning features **118^{s}** are positioned at different positions along the proximal panel **106^{s}**, for example evenly spaced from both sidewalls **112^{s}a** and **112^{s}b**.

According to some embodiments, string pull assembly **120** comprises a pump, and movable element **122** is formed as a piston configured to move within the pump (embodiments not shown).

According to some embodiments, string pull assembly **120** comprises a spring, and movable element **122** is configured to axially displace against the force of the spring (embodiments not shown).

According to some embodiments, movement of movable element **122**, including rotational and axial movement, is facilitated by manual force application, such as gripping an extension **123** and moving it in an axial direction, or rotating movable element **122** via rotation tool **76**.

According to some embodiments, movement of movable element **122**, including rotational and axial movement, is facilitated by electronic control means.

Fig. 15A and **15B** constitute a view in perspective and a cross-sectional side view, respectively, of a distraction device **100^{f}** having two exemplary string pull assemblies **120^{f}** disposed within adaptor member **136^{d}**. Adaptor member **136^{d}** comprises mounting bore **138^{d}**, within which two string pull assemblies **120^{f}a** and **120^{f}b** are disposed, each of which are attached at both ends thereof to the sidewall of adaptor member **136^{d}**. Each string pull assembly **120^{f}** comprises a movable element **122^{f}** formed as a shaft, a string **128** affixed to movable element **122^{f}** and extending through an adaptor aperture **144^{d}** of adaptor member **136^{d}** towards positioning feature **118^{f}** formed as an aperture within proximal panel **106^{f}**, and a tooling interface **126^{f}**, extending through a sidewall of adaptor member **136^{d}**. According to some embodiments, string pull assemblies **120^{f}a** and **120^{f}b** are vertically aligned in parallel to each other. According to some embodiments, bore screw thread **140^{d}** extends along a proximal portion of the vertical length of mounting bore **138^{d}**, such that it does not cross the region of contact between the most proximal movable element **122^{f}b** and mounting bore **138^{d}**.

Fig. 16A and **16B** constitute a view in perspective and a cross-sectional side view, respectively, of a distraction device **100^{g}** having two exemplary single string pull assemblies **120^{f}** of **Figs. 15A** and **15B**, and at least one support rod **146** positioned within and attached to string positioning member **104^{g}**. In the exemplary embodiments of **Figs. 16A-16B**, positioning features **118** are formed as the contact point between the strings **128** and the support rods **146**. Specifically, each support rod **146** is configured to direct a corresponding string's **128** path, passing through adaptor aperture **144^{c}**, over the support rod **146** and towards the jaw when in use. According to some embodiments, each support rod **146** is attached at both ends to sidewalls **112^{g}**.

According to some embodiments, adaptor member **136** is fittable to any implant abutment **150** as is known in the art. According to some embodiments, a distraction system **200** is a system comprising at least a distraction device **100**, and an abutment **150** configured to be associated with the at least one connection platform of the adaptor member **136** of the distraction device **100**.

According to some embodiments, the at least one connection platform of adaptor member **136** is formed as a mounting socket (not numbered, see **Fig. 29E** for example). The main difference between a mounting socket and a mounting bore **138**, is that mounting bore **138** is open-ended at both a proximal and a distal end thereof, while a mounting socket is open-ended only at the proximal end thereof. Otherwise, the mounting socket can include any of the other features or components described throughout the specification for all embodiments of mounting bore **138**, such as being formed with internal threading, being formed with internal polygonal facets and the like, and not described here for the sake of brevity.

Reference now is made to **Figs. 17A-G**, depicting different embodiments of adaptor member **136**. **Figs. 17A** and **17B** constitute views in perspective of a distraction device **100^{o}** comprising an adaptor member **136^{o}** in a loose and tight states, respectively. **Fig. 17C** constitutes a top view of distraction device **100^{o}** in a tight state.

Adaptor member **136^{t}** is formed as a hinged ring, having a stationary ring portion **135^{o}** and a dynamic ring portion **137^{o}** hinged thereto via hinge **139^{o}** at its hinged end, and detachably attachable to the main body **102^{o}** at its opposite dynamic end equipped with tightening mechanism **143^{o}**.

Fig. 17A shows the adaptor member **136^{o}** in a loose state, defined as a state in which the dynamic end having the tightening mechanism **143^{o}** is detached from the main body **102^{o}**.

Figs. 17B-C show the adaptor member **136^{o}** in a tight state, defined as a state in which the dynamic end having the tightening mechanism **143^{o}** is attached to the main body **102^{o}**, such that the static ring portion **135^{o}** and the dynamic ring portion **137^{o}** together form central bore **138^{o}**.

According to some embodiments, the tightening mechanism **143^{o}** is configured to attach to adaptor member **136^{o}**, for example to an end of static ring portion **135** opposite to the hinge **139**.

According to some embodiments, the tightening mechanism **143^{o}** is configured to attach to string positioning member **104^{o}**, for example a sidewall **112^{o}** at a position adjacent to its connection to adaptor body **136^{o}**.

According to some embodiments, the dynamic end of the dynamic portion **137^{o}** is detachably attachable to the main body **102^{o}** via tightening member **141^{o}**, such as a screw (exemplified in **Figs. 17A-C**) configured to screw through the tightening mechanism **143^{o}** into a screw-bore **113^{o}** of sidewall **112^{o}a**.

According to some embodiments, the dynamic end of the dynamic portion **137** is detachably attachable to the main body **102** via According to some embodiments, the dynamic end of the dynamic portion **137^{o}** is detachably attachable to the main body **102^{o}** via attachment means **143^{o}** comprising a snap-fit (not shown) or other attachment means known in the art.

According to some embodiments, the tightening mechanism **143^{o}** is configured to adjust the diameter of central bore **138^{o}**. Advantageously, tightening member **141^{o}** comprising a screw enable adjusting the degree of tightening of adaptor body **136^{o}**, essentially by adjusting the diameter of central bore **138^{o}**.

Fig. 17D and **17E** constitute a view in perspective and a top view, respectively, of a distraction device **100^{i}** comprising an adaptor member **136^{i}**, according to some embodiments. Adaptor member **136^{i}** is formed as ring clamp having a tightening mechanism **143^{i}** comprising a tightening member **141^{i}**, for example in the form of a screw (see **Figs. 17D-E**). According to some embodiments, the tightening mechanism **143^{i}** is configured to adjust the diameter of central bore **138^{i}**.

According to some embodiments, at least one end of adaptor member **136^{i}** is configured for advancement through a respective receiving portion of tightening mechanism **143^{i}**, wherein tightening member **141^{i}** can affix the position of both ends of the adaptor member **136^{i}** relative to each other, thereby retaining central bore **138^{i}** at a desired diameter.

Fig. 17F and **17G** constitute views in perspective of a distraction device **100^{j}** comprising an adaptor member **136^{j}** in a loose and tight states, respectively. Adaptor member **136^{j}** is formed as an adjustable ring or clamp having a tightening mechanism **143^{j}**.

According to some embodiments, dynamic end **143^{j}** comprises a tongue having ridges there along, configured for a ratcheting engagement with a receiving portion of tightening mechanism **143^{j}**. According to some embodiments, the tightening mechanism **143^{j}** is configured to adjust the diameter of central bore **138^{j}**.

According to some embodiments, adaptor member **136** is formed as ring clamp, wherein the tightening mechanism **143** comprises a pair of diametrically opposed jaws that are biased radially inwardly toward each other (embodiments not shown).

Reference is now made to **Figs. 18A-18D**, depicting different embodiments of abutment **150**. **Figs. 18A** and **18B** constitute a view in perspective and a top view, respectively, of abutment **150**, according to some embodiments. Abutment **150** comprises an abutment distal portion **152**, an abutment proximal portion **176,** and an abutment mid-portion **174** fluidly connected to abutment distal portion **152** and to abutment proximal portion **176**. Abutment proximal portion **176** is configured to be inserted into a matching socket (not shown) of a bone screw **20**. According to some embodiments, abutment proximal portion **176** comprises a screw thread (not illustrated), matching a screw thread of a bone screw **20**. According to some embodiments, abutment proximal portion **176** comprises a polyhedral-shaped structure (see **Fig. 18A**), matching a similarly shaped structure within a bone screw **20**. According to some embodiments, abutment distal portion **152** comprises an abutment distal portion screw thread **178**, matching bore screw thread **140**. According to some embodiments, the largest cross-sectional diameter of abutment mid-portion **174** is larger than any of the largest cross-sectional diameter of abutment distal portion **152**, and the largest cross-sectional diameter of abutment proximal portion **176**. According to some embodiments, abutment distal portion **152**, abutment mid-portion **174** and abutment proximal portion **176** are integrally formed.

Figs. 18C and **18D** constitute a view in perspective and a top view, respectively, of abutment **150**[a], according to some embodiments. Abutment **150**[a] comprises an abutment distal portion **152**[a], abutment mid-portion **174**[a] and abutment proximal portion **176**[a]. Abutment proximal portion **176**[a] is configured to be inserted into a matching socket (not shown) of a bone screw **20**. According to some embodiments, abutment proximal portion **176**[a] comprises a polyhedral-shaped structure, such as a hexagon (see **Fig. 18C**), matching a similarly shaped structure within a bone screw **20**. According to some embodiments, abutment distal portion **152** comprises a polyhedral-shaped structure, such as a decagon (see **Figs. 18C-18D**), matching a similarly shaped, matching polyhedral-shaped mounting bore **138**. According to some embodiments, the largest cross-sectional diameter of abutment mid-portion **174**[a] is larger than either the largest cross-sectional diameter of abutment distal portion **152**[a], or the largest cross-sectional diameter of abutment proximal portion **176**[a]. According to some embodiments, abutment distal portion **152**[a], abutment mid-portion **174**[a] and abutment proximal portion **176**[a] are integrally formed.

According to some embodiments, abutment **150** further comprises a channel through which an internal screw can be inserted, to couple abutment **150** with a bone screw **20** having a threaded receiving channel for the internal screw.

According to some embodiments, adaptor member **136** comprises a mounting extension (not illustrated) instead of a mounting socket, which can be either threaded or shaped as a polyhedral extension, configured to be received within a matching socket of an abutment **150** or a bone screw **20**.

Bone screw **20** is an implant provided with means (such as screw threads) to securely engage bone surfaces of a bone socket, such as a socket created in a jaw bone. According to some embodiments, bone screw **20** comprises any bone implant know in the art, configured to receive and securely engage with either abutment **150** or distraction device **100**.

Reference now is made to **Figs. 19A-20B**, depicting different embodiments of a distraction assembly. **Figs. 19A** and **19B** constitute exploded and assembled views in perspective of a distraction assembly comprising a distraction device **100**[x] and a contraction ring **145**[x], according to some embodiments. **Figs. 20A** and **20B** constitute exploded and assembled views in perspective of a distraction assembly comprising a distraction device **100**[z] and a clamp **145**[z], according to some embodiments.

According to some embodiments, there is provided a distraction assembly comprising a distraction device **100** equipped with a contractible adaptor member **136**, and a clamp **145** configured to engage with the distraction device **100** by placement thereof over the exterior of the contractible adaptor member **136**, and is further configured to exert force on the contractible adaptor member **136**, sufficient bend at least a portion of the contractible adaptor member **136** radially inwards, for example against an implant abutment **150**.

Aside from the contractible adaptor member **136**, the distraction device **100** of such a distraction assembly can be similar in structure and function to any other embodiment of a distraction device **100** disclosed throughout the specification.

A contractible adaptor member **136** is configured such that at least a portion thereof can bend or contract radially inwards, upon application of an external force thereon. According to some embodiments, the contractible adaptor member **136** is configured to contract along at least a portion thereof, by an amount sufficient to press against or engage an abutment **150** in a manner that will prevent spontaneous disengagement thereof.

According to some embodiments, the contractible adaptor member **136** comprises a plurality of axial extensions **131**, separated by notches **138** there between. The plurality of axial extensions **131** are configured to bend or contract radially inwards, upon application of an external force along their circumference. According to some embodiments, the material properties and/or dimension of the plurality of axial extensions **131**, including their thickness, are chosen to enable a desired amount of radial inward bending, responsive to a predetermined range of forces applied thereon.

According to some embodiments, the clamp **145** is configured for placement over the circumference contractible adaptor member **136**, such that at least a portion of the clamp **145** may encircle and contact at least a portion of the plurality of axial extensions **131**.

According to some embodiments, the clamp **145** comprises a band **147** and a worm gear mechanism **159** configured to contract or expand a formed by the band **147**. According to some embodiments, the worm gear mechanism **159** comprises a worm gear **161**. According to some embodiments, the clamp **145** comprises a backing support **157**.

The band **147** comprises a first end portion **155** and a second end portion (hidden from view in **Fig. 19A-20B**). According to some embodiments, the second end portion **155** is connected to the worm gear mechanism **159**, but could be connected to the backing support

157, or could be connected to both. According to some embodiments, the first end portion **155** is threaded in the worm gear mechanism **159** and mechanically interconnected with the worm gear mechanism **159**. According to some embodiments, the second end portion moves in response to operation of the worm gear mechanism **159**.

According to some embodiments, the band **147** comprises a plurality of laterally extending slots (not numbered). The amount of slots can be determined according to the expected or desired contraction adjustment amount. According to some embodiments, the slots extend only along a relatively small portion of the band **147**, for example only along less than a quarter of the total length of the band **147**, since the desired contraction adjustment amount is relatively small (e.g. reduction of less than 2 mm. of the diameter of the loop formed by the band **147** when placed over the contractible adaptor member **136**).

The worm gear mechanism **159** is configured to cause contraction or expansion of the clamp **145** and keep the clamp **145** at the adjusted position. According to some embodiments, the worm gear mechanism **159** comprises a worm **161**, configured to rotate within a cavity of the worm gear mechanism **159** and engage the slots of the band **147** to adjust the diameter of the clamp **145**. The worm **161** comprises a tooling interface exposed for engagement with a tooling device. The tooling interface of the worm **161** can be similar to any embodiments disclosed herein for the tooling interface **126**.

The backing support **157** supports the worm gear mechanism **159** and guides the band **147** along a portion of its circumferential extent.

According to some embodiments, the main body **102** of the distraction device further comprises an arcuate slot **111** disposed between the strings positioning member **104** and the contractible adaptor member **136**, configured to accommodate at least a portion of the clamp **145** when place therein. According to some embodiments, the arcuate slot **111** is dimensioned to accommodate at least a portion of the band **147**. According to some embodiments, the arcuate slot **111** is dimension to accommodate at least a portion of the band **147** and the backing support **157**.

According to some embodiments, the strings positioning member **104** further comprises a worm recess **115** adjacent the contractible adaptor member **136**, preferably adjacent the arcuate slot **111**. The worm recess **115** is configured to accommodate the worm gear mechanism **159**. According to some embodiments, the worm recess **115** is open ended at least along one of the sidewalls **112**, to provide access to the tooling interface of the worm

161. According to some embodiments, there is a continuity formed between the arcuate slot **111** and the worm recess **115** along at least a portion of their interfacing border.

According to some embodiments, the band **147** further comprises at least one retaining slot **151** extending in a circumferential direction, and the contractible adaptor member **136** comprises at least one retaining protrusion **133** extending radially outwards therefrom, and configured to be positioned within the respective retaining slot **151** when the clamp **145** is engaged with the distraction device **100**, thereby preventing axial movement of the clamp **145** in the distal or proximal directions, to minimize the risk of the clamp **145** slipping out of position when engaged with the distraction device **100**.

Figs. 19A constitutes an exploded view in perspective of a distraction assembly comprising a distraction device **100^{x}** and a contraction ring **145^{x}**, configured to be used in conjunction with an implant abutment **150^{b}**, according to some embodiments.

The clamp **145^{x}** comprises a band **147^{x}**, a worm gear mechanism **159^{x}** having a worm **161^{x}**, and a backing support **157^{x}**. The distraction device **100^{x}** comprises a contractible adaptor member **136^{x}** having a plurality of axial extensions **131^{x}**, separated by notches **138^{x}** there between. The distraction device **100^{x}** further comprises an arcuate slot **111^{x}** and a worm recess **115^{x}**.

The contractible adaptor member **136^{x}** further comprises a retaining protrusion **133^{x}** in the form of a radially extending pin, and the clamp **145^{x}** further comprises a retaining slot **151^{x}**, preferably located closer to a proximal edge of the band **147^{x}**, so as to be able to accommodate a respective retaining protrusion **133^{x}** located at a region proximal to the axial extensions **131^{x}**.

The contractible adaptor member **136** comprises a connection platform in the form of a mounting bore (similar to mounting bore **138** disclosed herein), configured to connect with a mount. In the embodiment exemplified in **Figs. 19A-20B**, the mount is an abutment **150^{b}**, which can be either a standard abutment as used by and known to persons skilled in the art, or an abutment specifically designed for use with a distraction system having a distraction device **100** equipped with a contractible adaptor member **136**.

The abutment **150^{b}** exemplified in the embodiments shown in **Figs. 19A-20B** differs from the embodiments shown in **Figs. 18A-D** in that the abutment distal portion **152^{x}** is formed as a cylinder extending distally from the abutment mid-portion **174^{b}**, devoid of screw

threads or polyhedral circumferential surfaces. However, it will be clear that in according to other embodiments, a distraction device **100** equipped with a contractible adaptor member **136** can be used with any other type of a mount, including abutments **150** having a threaded or polyhedral formed abutment distal portions **152**, a dental crown, a dental screw, a dental bridge, a denture, a native tooth and the like.

Fig. 19B shows the distraction assembly of **Fig. 19A** assembled over the abutment $\mathbf{150^b}$, wherein the abutment distal portion $\mathbf{152^b}$ is received within the mounting bore of the contractible adaptor member $\mathbf{136^x}$, and the clamp $\mathbf{145^x}$ is engaged with the distraction device $\mathbf{100^x}$ such that the band $\mathbf{147^x}$ and backing support $\mathbf{157^x}$ are accommodated within the arcuate slot $\mathbf{111^x}$, the worm gear mechanism $\mathbf{159^x}$ is accommodate within the worm recess $\mathbf{115^x}$, and the retaining protrusion $\mathbf{133^x}$ is accommodated within the retaining slot $\mathbf{151^x}$.

In use, rotating the worm $\mathbf{161^x}$ in a predefined directing facilitates contraction of the clamp $\mathbf{145^x}$ over the contractible adaptor member $\mathbf{136^x}$, thereby exerting sufficient force to bend the axial extensions $\mathbf{131^x}$ radially inwards, until they are pressed against the abutment distal portion $\mathbf{152^b}$ at a force sufficient to prevent relative spontaneous movement between the distraction device $\mathbf{100^x}$ and the abutment $\mathbf{150^b}$.

The retaining slot $\mathbf{151^x}$ is configured to allow it to move over the retaining protrusion $\mathbf{133^x}$ extending there through in a circumferential direction, thereby enabling contraction or expansion of the clamp $\mathbf{145^x}$ while preventing it from slipping in a proximal or distal directions.

Figs. 20A constitutes an exploded view in perspective of a distraction assembly comprising a distraction device $\mathbf{100^z}$ and a contraction ring $\mathbf{145^z}$, configured to be used in conjunction with an implant abutment $\mathbf{150^b}$, according to some embodiments. **Fig. 20B** shows the distraction assembly of **Fig. 20A** assembled over the abutment $\mathbf{150^b}$.

The main difference between the distraction assembly comprising a distraction device $\mathbf{100^z}$ and a contraction ring $\mathbf{145^z}$ from the distraction assembly comprising a distraction device $\mathbf{100^x}$ and a contraction ring $\mathbf{145^x}$, is that while the contraction ring $\mathbf{145^x}$ is configured to engage with distraction device $\mathbf{100^x}$ from a proximal direction, such that the proximal edge of the clamp $\mathbf{145^x}$ is distally spaced from the proximal edge of the contractible adaptor member $\mathbf{136^x}$ when engaged therewith, the contraction ring $\mathbf{145^z}$ is configured to engage with distraction device $\mathbf{100^z}$ from a distal direction, such that the distal edge of the clamp $\mathbf{145^z}$ is

proximally spaced from the distal edge of the contractible adaptor member **136**^{z} when engaged therewith.

Fig. 20B shows the distraction assembly of **Fig. 20A** assembled over the abutment **150**^{b}, wherein the clamp **145**^{z} is positioned between the abutment mid-portion **174**^{b} and a distal end of the arcuate slot **111**^{z}. Accordingly, the retaining slot **151**^{z} is located closer to a distal edge of the band **147**^{z}, so as to be able to accommodate a respective retaining protrusion **133**^{z} located at a region proximal to the axial extensions **131**^{z}.

According to some embodiments, the distraction assembly further comprises an abutment, such as abutment **150**^{b}. String engagement portion **130** is configured to engage a receiving area **42** of a miniscrew **40**. According to some embodiments, miniscrew **40** comprises any orthodontic screw or other anchoring appliance such as bone plates or dental implants known in the art.

According to some embodiments, miniscrew **40** comprises proprietary and/or customized screws, configured for engagement with string engagement portion **130**. According to some embodiments, distraction system **200** is a system comprising at least a distraction device **100**, and any of: an abutment **150**, bone screw **20**, rotation tool **76**, at least one miniscrew **40**, and any combination thereof.

The terms "miniscrew" and "anchoring implant means", as used herein, are interchangeable.

Reference now is made to **Figs. 21A-21G**, depicting different embodiments of miniscrew **40**. According to some embodiments, receiving area **42** of a miniscrew **40** is formed as a through-hole (see **Figs. 21A-21B**). **Fig. 21A** illustrates a string engagement portion formed as a hook **130**^{a}, configured to be received, in the direction of arrow **86**, within receiving area **42**. Once hook **130**^{a} is inserted within receiving area **42**, pulling string **128** in the direction of arrow **88** (see **Fig. 21B**) exerts a pull-force in the same direction on miniscrew **40**.

According to some embodiments, receiving area **42** of miniscrew **40** is formed as a recess having at least one distal vertical extension (not numbered). **Fig. 20C** illustrates a string engagement portion formed as loop **130**, configured to be received, in the direction of arrow **90**, within receiving area **42**^{a}. Once string engagement portion **130** is accepted within receiving area **42**^{a}, pulling string **128** in the direction of arrow **88** (see **Fig. 20D**) exerts a pull-

force in the same direction on miniscrew **40**[a]. The distal vertical extension (not numbered) prevents string engagement portion **130** from slipping out of receiving area **42**[a] as long as string **128** is kept in vertically tensed.

According to some embodiments, receiving area **42** of a miniscrew **40** comprises an opening with a latch **46**. **Fig. 21E** illustrates a string engagement portion formed as a loop **130**, configured to be received, in the direction of arrow **90**, within receiving area **42**[b]. A latch **46** is movably connected to an edge of receiving area **42**[b] via a pivot **44**. Latch **46** is movable between an open position (see **Fig. 21F**) and a closed position (see **Fig. 21G**). String engagement portion **130** can force latch **46** to pivotally rotate about pivot **44** in the direction of arrow **92**. According to some embodiments, pivot **44** comprises a spring, such as a coil spring, configured to force latch **44** to a closed position when string engagement portion **130** no longer interacts there with. Once string engagement portion **130** is accepted within receiving area **42**[b], pulling string **128** in the direction of arrow **88** (see **Fig. 21G**) exerts a pull-force in the same direction on miniscrew **40**[b]. Latch **46**, while in a closed position, prevents string engagement portion **130** from slipping out of receiving area **42**[b].

Reference now is made to **Figs. 22A-27**, illustrating a more particular embodiments of distraction device **100**[h] or **100**[k], abutment **150**[h], and distraction system **200**[h]. **Figs. 22A**, **22B** and **22C** constitute a view in perspective, a top view and a cross-sectional side view, respectively, of a distraction device **100**[h] mounted on an abutment **150**[h], according to some embodiments.

Distraction device **100**[h] comprises a string positioning member **104**[h] integrally formed with an adaptor member **136**[h]. String positioning member **104**[h] comprises first and second sidewalls **112**[h]**a** and **112**[h]**b**, respectively. String positioning member **104**[h] further comprises a curved front panel **110**[h], integrally formed with sidewalls **112**[h]. According to some embodiments, string positioning member **104**[h] further comprises a distal panel **108**[h] (shown in **Fig. 22C**, but not shown in **Figs. 22A-22B** in order to expose components housed within string positioning member **104**[h]). According to some embodiments, string positioning member **104**[h] further comprises a proximal panel **106**[h], provided with at least one positioning feature **118**[h] formed as an aperture.

Distraction device **100**[h] further comprises at least one string pull assembly **120**[h]. **Figs. 22A-22C** illustrate an embodiment with three exemplary string pull assemblies **120**[h] formed as rotatable string pull assemblies. Each string pull assembly **120**[h] comprises a movable

element **122^{h}** formed as a shaft, at least one tooling interface **126^{b}** extending through at least one sidewall **112^{h}**, a gear **124^{h}** rigidly connected to movable element **122^{h}**, and a string **128** affixed at the first string end (not numbered) to movable element **122^{h}**, passing through the at least one positioning feature **118^{h}**, and having a string engagement portion **130**, such as a hook **130^{a}** (see **Fig. 22C**), at the second string end.

Distraction device **100^{h}** further comprises at least one pawl **114**, configured to engage with the at least one gear **124^{h}**. **Fig. 18C** illustrates an exemplary pawl **114^{h}**, attached to proximal panel **106^{h}**.

In the example provided by **Fig. 22B**, each string pull assemblies **120^{h}** comprises two tooling interfaces **126^{b}**, one at each end of movable element **122^{h}**, while movable element **122^{h}** is supported by both first sidewall **112^{h}a** and second sidewall **112^{h}b**. According to some embodiments, distraction device **100^{h}** further comprises at least one movable element support **148**. According to some embodiments, movable element **122^{h}** is further supported by a movable element support **148** (see **Figs. 22B-22C**), extending vertically from proximal panel **106^{h}**.

Adaptor member **136^{h}** comprises mounting bore **138^{h}**, configured to receive abutment distal portion **152^{h}** of abutment **150^{h}**. According to some embodiments, mounting bore **138^{h}** comprises a circular cross section, devoid of any threading.

Figs. 23A, **23B** and **23C** constitute a view in perspective, a top view and a cross-sectional side view, respectively, of a distraction device **100^{k}** mounted on an abutment **150^{h}**, according to some embodiments.

Distraction device **100^{k}** comprises a string positioning member **104^{k}** integrally formed with an adaptor member **136^{k}**. String positioning member **104^{k}** comprises first and second sidewalls **112^{k}a** and **112^{k}b**, respectively. String positioning member **104^{k}** further comprises a curved front panel **110^{k}**, integrally formed with sidewalls **112^{k}**. Distraction device **100^{k}** further comprises at least one string pull assembly **120^{h}**. **Figs. 23A-23C** illustrate an embodiment with three exemplary string pull assemblies **120^{h}**, formed as rotatable string pull assemblies.

According to some embodiments, string positioning member **104^{k}** further comprises a distal panel **108^{k}** (shown in **Fig. 23C**, but not shown in **Figs. 23A-23B** in order to expose components housed within string positioning member **104^{k}**). According to some

embodiments, distal panel **108**^{k} comprises at least one distal panel opening (not numbered), configured to accommodate a distal portion of a fastening element **198**. According to some embodiments, string positioning member **104**^{h} further comprises a proximal panel **106**^{k}, provided with at least one positioning feature **118**^{k} formed as an aperture and at least one proximal panel opening (not numbered) configured to accommodate a proximal portion of fastening element **198**. According to some embodiments, proximal panel **106**^{k} is detachably connected to any of: sidewalls **112**^{k}, front panel **110**^{k}, distal panel **108**^{k}, and any combination thereof.

Distraction device **100**^{k} further comprises at least one pawl **114**, configured to engage with the at least one gear **124**^{h}. **Fig. 23C** illustrates an exemplary pawl **114**^{k}, attached to proximal panel **106**^{k}.

According to some embodiments, string positioning member **104**^{k} further comprises at least one positioning member chamber **190**, bordered between first sidewall **112**^{k}**a** and second sidewall **112**^{k}**b**, and when present, between distal panel **108**^{k} and proximal panel **106**^{k}. Each chamber **190** is configured to house a string pull assembly **120**^{h}. **Figs. 23A-23C** illustrate an exemplary embodiment of three positioning member chambers **190**, each housing a string pull assembly **120**^{h}, the movable element **122**^{h} extending through between first sidewall **112**^{k}**a** and second sidewall **112**^{k}**b**, and further supported by movable element support **148**^{k}, vertically extending from proximal panel **106**^{k}. Neighboring positioning member chambers **190** are spaced apart by a positioning member rib (not numbered). According to some embodiments, each positioning member rib comprises a channel (not numbered) configured to accommodate the body (not numbered) of fastening element **198**.

According to some embodiments, string positioning member **104**^{k} comprises at least one fastening element **198**, such as a bolt or a rivet, configured to fasten detachable elements of string positioning member **104**^{k}. According to some embodiments, fastening elements **198** are configured to attach detachable proximal panel **106**^{k} to the remainder of frame **104**^{k} (see **Figs. 23A-23C**). According to some embodiments, fastening elements **198** are configured to attach detachable distal panel **108**^{k} to the remainder of string positioning member **104**^{k} (embodiment not illustrated).

Advantageously, fastening elements **198** provide additional structural reinforcement to string positioning member **104**^{k} in the vertical direction.

Adaptor member **136**^{k} comprises mounting bore **138**^{k}, configured to receive abutment distal portion **152**^{h} of abutment **150**^{h}. According to some embodiments, mounting bore **138**^{k} comprises a circular cross section, devoid of any threading.

Figs. 24A and **24B** constitute a view in perspective and a side view, respectively, of abutment **150**^{h}, also presented in a cross-sectional side view in **Figs. 22C** and **23C**, according to some embodiments. Abutment **150**^{h} comprises an abutment distal portion **152**^{h}, abutment mid-portion **174**^{h} and abutment proximal portion **176**^{h}. Abutment proximal portion **176**^{h} comprises a polyhedral-shaped structure, configured to be inserted into a matching socket of a bone screw **20** (illustrated in **Fig. 27**). According to some embodiments, abutment distal portion **152**^{h}, abutment mid-portion **174**^{h} and abutment proximal portion **176**^{h} are integrally formed.

Abutment distal portion **152**^{h} is provided with a plurality of regularly spaced vertical notches **156** that create a corresponding plurality of wings **154**, provided with intrinsic flexibility. According to some embodiments, such as illustrated in **Figs. 24A** and **24B**, all wings **154** are oriented in the vertical direction. According to some embodiments, each notch **156** is provided at its proximal end with a notch groove **158**, having a diameter larger than the width of notch **156**, thereby providing additional flexibility to wings **154**.

Each wing **154** comprises a wing inner surface **162** and a wing outer surface **168**. All of the wing inner surfaces **162**, together with the notches **156**, define an abutment distal receiving opening **160**, configured to receive a plug **180** (see **Fig. 25**).

The largest cross-sectional diameter of abutment mid-portion **174**^{h} is larger than either the largest cross-sectional diameter of abutment distal portion **152**^{h}, or the largest cross-sectional diameter of abutment proximal portion **176**^{h}. According to some embodiments, mid-portion **174**^{h} is formed with a cylindrical convexly curved shape. **Figs. 24A** and **24B** illustrate abutment mid-portion **174**^{h} having a variable cross-section along its length, expanding in diameter from its distal connection edge (not numbered) with abutment distal portion **152**^{h} to a maximal diameter (not numbered), and then reduced in diameter towards the proximal connection edge (not numbered) with abutment proximal portion **176**^{h}.

According to some embodiments, the proximal edge of wings **154** (not numbered), positioned at about a vertical center point of notch grooves **158**, is spaced from abutment mid-portion **174**^{h}, thereby defining an abutment distal portion base (not numbered).

According to some embodiments, abutment **150^{h}** is in a resting position, as depicted in **Figs. 24A-24B**, when no plug **180** is inserted therein. According to some embodiments, angle α (see **Fig. 26B**), defined as the angle between each wing **154** and the abutment distal portion base, equals 180° in a resting position. According to some embodiments, angle α is within a range of 160°-200° in a resting position. According to some embodiments, angle α is within a range of 175°-180° in a resting position.

Fig. 25 constitutes a view in perspective of a plug **180**, according to some embodiments. Plug **180** comprises a plug distal portion **182** having a plug distal outer surface **184**, and a plug base **186**. Plug **180** is configured to be received within abutment **150^{h}**, inserted thereto through abutment distal receiving opening **160**. Plug distal portion **182** is formed with at least one region along its length, having a diameter slightly larger than the diameter of abutment distal receiving opening **160** when abutment **150^{h}** is in a resting position.

According to some embodiments, as depicted in **Fig. 25**, plug distal portion **182** is provided with a frustoconical profile, such that its diameter at its distal edge (not numbered) is wider than its diameter at its proximal connection edge (not numbered) with plug base **186**. According to some embodiments, plug base **186** is provided with a threading (nut numbered), configured to match a complementary threading of abutment base receiving portion **164** (see **Figs. 22C** and **23C**).

According to some embodiments, as depicted in **Fig. 25**, plug distal portion **182** is provided at its distal face (not numbered) with a plug screw-head **188**, configured to receive an external tool (such as a key or a wrench) for rotation thereof.

According to some embodiments, plug distal portion **182** is provided with a thread, matching a thread on wing inner surfaces **162** (embodiment not shown).

According to some embodiments, plug **180** is devoid of screw threads, configured for insertion into abutment **150^{h}** by means of impact instead of by means of rotary motion (embodiment not shown).

Figs. 26A and **26B** constitute a view in perspective and a cross-sectional side view, respectively, of a plug **180** positioned within abutment **150^{h}**, according to some embodiments. When plug **180** is inserted through abutment distal receiving opening **160** into abutment **150^{h}**, plug distal outer surface **184** is engaged with wing inner surfaces **162**. Plug

distal portion **182** acts as a wedge, exercising a divaricating force in a radial direction towards wings **154**. According to some embodiment, wings **184** are flexed radially outwards, such that angle α is smaller than its value in a resting position.

According to some embodiments, plug **180** is inserted into abutment **150^{h}** with rotary motion, wherein plug base **186** is threaded into abutment base receiving portion **164**, along at least a portion of plug base **186**. According to some embodiments, α_{min} is defined as the resulting angle α, when plug base **186** is threaded into abutment base receiving portion **164** along the entire length of plug base **186**. According to some embodiments, the extent to which wings **154** are radially flexed is controlled by partial insertion of plug base **186**, such that only a portion of its length is threaded into abutment base receiving portion **164**, resulting in an angle α in a range between α_{min} and its value in a resting position.

According to some embodiments, wings **154** are spring-biased against plug **180** when plug **180** positioned within abutment **150^{h}**.

Fig. 27 constitutes a cross-sectional side view of a distraction system **200^{h}**, according to some embodiments. Distraction system **200^{h}** comprises distraction device **100^{h}**, abutment **150^{h}**, plug **180**, bone screw **20** and at least one miniscrew **40**. Bone screw **20** is provided with external threading at its proximal portion, configured for insertion and anchoring into a socket of a jaw bone. Bone screw **20** is further provided with internal threading (not numbered), configured to receive an internal screw (not numbered). Abutment **150^{h}** is connected to bone screw **20**, such that abutment proximal portion **176^{h}** is placed within a matching socket (not numbered) of bone screw **20**, and an internal screw (not numbered) is threaded through a channel of abutment **150^{h}** into an internal threading (not numbered) provided in bone screw **20**, while the wider head of the internal screw contacts a shoulder (not numbered) provided at the distal portion of said internal channel of abutment **150^{h}**.

Mounting member **138^{h}** of distraction device **100^{h}** is placed over abutment **150^{h}** at a preferred position. According to some embodiments, a preferred position of distraction device **100^{h}**, selected by a user, includes either a preferred horizontal angle, a preferred vertical height along abutment distal portion **152^{h}**, or a combination of both.

Once distraction device **100^{h}** is positioned at a preferred position, plug **180** is inserted into abutment distal receiving opening **160**. According to some embodiments, an external tool such as a key or a wrench (not shown) is engaged with plug screw-head **188**, utilized to exert rotary motion by which screw plug base **186** is screwed into abutment base receiving portion

164. Plug distal portion **182** forces wings **154** to expand radially, such that wing outer surfaces **168** press against or are spring-biased against inner wall of mounting bore **138^{h}**.

Advantageously, due to the presence of plug **180**, the interference between wing outer surfaces **168** and the inner wall of mounting bore **138^{h}** is stronger and capable of preventing occasional uncoupling of distraction device **100^{h}** and abutment **150^{h}** in the vertical direction, as well as preventing any undesired movement of distraction device **100^{h}** in the horizontal plane.

Miniscrews, bone plates or dental implants **40** are configured for anchoring into a portion of a jawbone intended for distraction. **Fig. 27** depicts an exemplary distraction system **200^{h}**, comprising a distraction device **100^{h}** having three string pull assemblies **120^{h}** and three matching miniscrews **40**. Once the miniscrews **40** are inserted into a jawbone, string engagement portions **130**, formed as hooks **130^{a}** in **Fig. 27**, are engaged with receiving portions **42** of screws **40**.

According to some embodiments, abutment **150^{h}** is provided with plug **180**, as described heretofore, and can be used with any embodiment of distraction device **100** described herein, such that abutment **150^{h}** is configured to serve as an anchoring means to any other external device equipped with a receiving bore to receive abutment **150^{h}** therein, whereby during insertion of plug **180** into abutment distal receiving opening **160**, wings **184** are flexed radially outwards, as described heretofore, thereby affixing the other external device to abutment **150^{h}** at a desired position and orientation.

It will be clear that a distraction device **100** according to the current disclosure, can include any combination between any embodiment of string positioning member **104**, adaptor member **136** and string pull assemblies **120** described throughout the specification.

Reference is now made to **Figs. 28A-28B**, depicting a problem potentially solved by a distraction device **100** or a distraction system **200**, as disclosed throughout the specification, according to some embodiments. **Fig. 24A** constitutes a side view of a mandible **50**, with posterior alveolar ridge atrophy **52** above inferior alveolar nerve **54**. In the illustrated example of **Fig. 28A**, the distance between the edge of alveolar ridge **52** and alveolar nerve **54** is too short to permit placement of a bone screw **20** therein, as during such placement, insertion of bone screw **20** too far through alveolar ridge **52**, may contact and damage the alveolar nerve **54**.

The terms "inferior alveolar nerve" and "alveolar nerve", as used herein, are interchangeable.

Fig. 28B constitutes a potential solution known in the art to the challenge presented in **Fig. 28A**, by anchoring an implant **20** to a region (not numbered) adjacent to alveolar ridge **52**, supporting a dental bridge **24**. The region of dental implantation is chosen to be such that there is sufficient bone to support implant **20**, without contacting nerves, such as alveolar nerve **54**. Dental bridge **24** is secured at one end to implant **20**, or alternatively, by abutting a tooth if one is available in the same location (not illustrated). Dental bridge **24** may provide aesthetic resemblance of teeth covering the region of ridge atrophy **52**. However, dental bridge **24** lacks support at its other end, opposing the end secured to implant **20**. Therefore, such a solution may prove to be unstable over time and the dental bridge **24** may collapse due to external forces, for example during regular chewing or biting.

The terms "implant" and "dental screw", as used herein, are interchangeable, and refer to any conventional dental implant known in the art, or proprietary dental implants designed and configured to support a distraction device **100** or an abutment **150**, as disclosed throughout the specification.

The terms "mandible" and "lower jaw", as used herein, are interchangeable.

The terms "maxilla" and "upper jaw", as used herein, are interchangeable.

The term "jaw bone", as used herein, refers to either the mandible or the maxilla.

Reference is now made to **Figs. 29A-35**, depicting methods of using a distraction device **100** or a distraction system **200**, according to some embodiments. **Fig. 29A** constitutes a side view of a mandible **50**, wherein a bone screw **20** is anchored thereto, by any method known in the art for dental implantation. The region of dental implantation is a region adjacent to alveolar ridge **52**, devoid of native teeth, chosen to be such that there is sufficient bone to support anchoring of bone screw **20**, without bulging into nerves, such as alveolar nerve **54**.

According to some embodiments, jaw bone such as mandible **50** includes native teeth adjacent to the site of bone screw **20** implantation (see **Fig. 29A**). According to some embodiments, jaw bone such as mandible **50** includes more than one bone screw **20**, some of which may support dental crowns or dental bridges (see **Fig. 29B**). According to some embodiments, when jaw bone such as mandible **50** includes more than one bone screw **20**,

the bone screw **20** closest to ridge atrophy **52** is chosen to support a distraction device **100** for the procedure disclosed throughout the specification.

A crestal osteotomy line **56**, created in a manner that does not harm alveolar nerve **54**, separates between osteotomized bone segment **58** and the remaining basal bone of the mandible **50**, as depicted in **Fig. 29B**.

According to some embodiments, the step of anchoring a bone screw **20** to a jaw bone, at a region adjacent to ridge atrophy **52** is performed prior to the step of creation of an osteotomy line **56**. According to some embodiments, the step of creating an osteotomy line **56** is performed prior to the step of anchoring a bone screw **20** to a jaw bone, at a region adjacent to ridge atrophy **52**.

At least one miniscrew **40** is anchored to osteotomized bone segment **58**, as depicted in **Fig. 29B**. The optimal number of miniscrews **40** for obviously varies according to each particular clinical situation. **Fig. 29C** depicts an exemplary embodiments of two miniscrews **40a** and **40b**, anchored to osteotomized bone segment **58**.

According to some embodiments, miniscrews **40** are shorter in length than bone screw **20**. According to some embodiments, the length of the portion of miniscrew **40** engaged with osteotomized bone segment **58**, is shorter than the distance between the edge of alveolar ridge **52** and osteotomy line **56**, such that miniscrew **40** will not penetrate osteotomy line **56** when anchored to osteotomized bone segment **58**. According to some embodiments, miniscrew **40** is an orthodontic screw.

According to some embodiment, a step of anchoring at least one miniscrew **40** to the jaw bone is performed after the step of creating osteotomy line **56**, such that the location of osteotomy line **56** is chosen to be distanced adequately from the inferior alveolar nerve or the maxillary sinus cavity. Anchoring means such as bone plates or miniscrews **40** are placed safely after osteotomy due to the option of placing a protecting tool (not shown) in the osteotomy gap the prevents invasion of the anchoring means to the underosteotomy area in the mandible which houses the inferior alveolar nerve or the supraosteotomy area in the maxilla which is adjacent to the maxillary sinus cavity.

Fig. 29D depicts a further step of attaching an abutment **150** to bone screw **20**. According to some embodiments, abutment **150** is any dental abutment known in the art, configured to engage with the bone screw **20** anchored to the jaw bone. According to some

embodiments, abutment **150** refers to any embodiment thereof, as specified throughout the specification, configured to engage both with the bone screw **20** anchored to the jaw bone and with a distraction device **100**.

Fig. 29E depicts a further step of attaching a distraction device **100** to abutment **150**. Distraction device **100** refers to any embodiment thereof, as specified throughout the specification, configured to engage with abutment **150**.

According to some embodiments, distraction device **100** is configured in its geometry to connect directly with a bone screw **20**, without the aid of mediating abutment **150** (embodiment not shown). According to some embodiments, distraction device **100** is directly connected to a mount, such as an abutment, a dental crown, a dental screw, a dental bridge, a denture, a native tooth and the like.

According to some embodiments, placement of distraction device **100** either on abutment **150** or directly on bone screw **20** can be achieved at different horizontal orientation. According to some embodiments, a preferred horizontal orientation is selected such that frame **104** is aligned with osteotomized bone segment **58**, or with miniscrews **40**.

According to some embodiments, a preferred horizontal orientation is achieved by screwing adaptor member **136** having a bore screw thread **140** to a preferred lateral angle. According to some embodiments, a preferred horizontal orientation is achieved by placement of a polygonal mounting bore **138** at a preferred angle over a matching polygonal abutment distal portion **152**. According to some embodiments, a preferred horizontal orientation is achieved by inserting a plug **180** into an abutment, such as abutment **150^{h}**, while distraction device **100** is positioned at a preferred horizontal orientation.

According to some embodiments, placement of distraction device **100** on abutment **150** can be achieved at different vertical positions. According to some embodiments, distraction device **100** is configured not to extend vertically beyond the bite line, defined as the line or region separating between upper and lower teeth when a patient's mouth is closed.

According to some embodiments, a preferred vertical position is achieved by inserting a plug **180** into an abutment, such as abutment **150^{h}**, while distraction device **100** is positioned at a preferred height over abutment distal portion **152**, and more specifically over abutment distal portion **152^{h}**.

A lateral angle, as used herein, refers to an angle in a horizontal plane.

Fig. 29F depicts a further step of attaching at least one string engagement portion **130** to at least one miniscrew **40**. According to some embodiments, the number of string pull assemblies **120** provided in distraction device **100** matches the number of miniscrews **40** anchored to the osteotomized bone segment **58**, such that each string **128** is attached, via its string engagement portion **130**, to a different miniscrew **40**. **Fig. 29F** depicts an exemplary embodiment of a distraction device **100** provided with two string pull assemblies **120a** and **120b**, having respective strings **128a** and **128b**, attached via string engagement portions **130a** and **130b** to receiving portion **42a** and **42b** (not indicated in **Fig. 29F**) of miniscrews **40a** and **40b**, respectively.

According to some embodiments, string engagement portions **130** are provided in the form of loops (see **Fig. 29F**), which are engaged with receiving portions **42** of miniscrews **40**. According to some embodiments, strings **128** are provided with open ended string engagement portions **130** (see **Fig. 29E**), which can be either knotted to create a loop prior to engagement with receiving portions **42** of miniscrews **40**, or first threaded through receiving portions **42** of miniscrews **40**, and then knotted to create loops that prevent disengagement of string engagement portions **130** from the receiving portions **42**. According to some embodiments, string engagement portions **130** are provided in the form of hooks (see **Fig. 27**), which are engaged with receiving portions **42** of miniscrews **40**.

After attachment of string engagement portions **130** to miniscrews **40**, stretching of each string **128** between movable element **122** formed as a shaft and miniscrew **40** is achieved by rotating each corresponding movable element **122**, via its tooling interface **126**, such that string **128** is wrapped around movable element **122** until string **128** is fully stretched between movable element **122** and miniscrew **40**. An initial position is defined as the position of osteotomized bone segment **58** when strings **128** are fully stretched on one hand, yet no displacement of osteotomized bone segment **58** has initiated on the other hand.

According to some embodiments, the shape of osteotomized bone segment **58** is variable, such that a plurality of miniscrews **40** may be anchored at different vertical heights, such that the distance between string positioning member **104** and at least one of miniscrews **40** is different from at least one other miniscrew **40**. According to some embodiments, distraction device **100** may be positioned such that string positioning member **104** is not parallel to any plane passing through the receiving portions **42** of at least two of miniscrews

40, resulting in a distance between string positioning member **104** and at least one of miniscrews **40** being different from at least one other miniscrew **40**.

Advantageously, each string pull assembly **120** is independent and may be operated separately, such that each string positioning member **122** can be rotated differently to achieve a desired goal of either stretching string **128** according to the specific distance between frame **104** and miniscrew **40**, or moving each segment of osteotomized bone segment **58** corresponding to a specific miniscrew **40** at an appropriate paste or to an appropriate distance. A desired goal, including an appropriate pace and an appropriate distance, can vary by a user, such as a clinician, according to a clinical situation.

In the exemplary embodiment illustrated in **Fig. 29F**, two miniscrews **40** are anchored to osteotomized bone segment **58** at different vertical heights. Each of tooling interfaces **126a** and **126b** are rotated separately, potentially via the assistance of a rotation tool **76**, until each of strings **128a** and **128b**, respectively, is fully stretched. The distance between string positioning member **104** and miniscrew **40a**, along which string **128a** is stretched, is longer in **Fig. 29F** than the distance between string positioning member **104** and miniscrew **40b**, along which string **128b** is stretched.

According to some embodiments, the amount of string pull assemblies **120** provided in distraction device **100** is larger than the number of miniscrews **40** anchored to the osteotomized bone segment **58** (embodiments not shown), such that only a fraction of string pull assemblies **120** are utilized, matching the number of miniscrews **40**, while the remaining string pull assemblies **120** are unutilized throughout the procedure. According to some embodiments, strings **128** of unutilized string pull assemblies **120** are either cut or wrapped over their corresponding movable elements **122**, so as to avoid interference with the procedure and minimize contact with the jaw, tongue and other regions of a patient's mouth unnecessarily.

Fig. 29G depicts a further step of distracting osteotomized bone segment **58** away from the basal bone of the mandible **50**, by rotating the at least one of movable elements **122** via tooling interfaces **126**. Each string **128** is wrapped around its movable elements **122** during its rotation wraps, resulting in a pull force acting on the miniscrew **40** attached thereto. Movement of osteotomized bone segment **58** corresponds to the movement of each of miniscrews **40** anchored thereto. According to some embodiments, rotation tool **76** is engaged with tooling interfaces **126** to facilitate turning thereof.

According to some embodiments, distracting osteotomized bone segment **58** includes repeating the step of rotating at least one shaft over a period of time defined as the distraction period of time. According to some embodiments, the distraction period of time spans over the course of a plurality of days. According to some embodiments, the distraction period of time spans over the course of a plurality of weeks. According to some embodiments, the distraction period of time spans over the course of a plurality of months. According to some embodiments, distracting osteotomized bone segment **58** occurs at least once a day during the period of time. According to some embodiments, distracting osteotomized bone segment **58** occurs at least twice a day during the period of time.

According to some embodiments, osteotomized bone segment **58** is distracted at a rate in a range of about 0.1 mm to 2 mm per day. According to some embodiments, osteotomized bone segment **58** is distracted at a rate in a range of about 0.3 mm to 1.5 mm per day. According to some embodiments, osteotomized bone segment **58** is distracted at a rate in a range of about 0.3 mm to 0.7 mm per day.

The term "about", as used herein, means "within ±10% of".

According to some embodiments, a full rotation of movable elements **122** via tooling interfaces **126** corresponds to a predefined distraction distance per revolution. According to some embodiments, the predefined distraction distance per revolution is about 1 mm. According to some embodiments, the predefined distraction distance per revolution is about 0.3 mm.

According to some embodiments, a protocol for use of revolution device **100** includes instructions for number of revolutions per day. According to some embodiments, a protocol for use of distraction device **100** includes instructions for a complete revolution once a day. According to some embodiments, a protocol for use of distraction device **100** includes instructions for a complete revolution twice a day. According to some embodiments, a protocol for use of distraction device **100** includes instructions for a half a revolution once a day. According to some embodiments, a protocol for use of distraction device **100** includes instructions for a half a revolution twice a day. According to some embodiments, a protocol for use of distraction device **100** includes instructions for a two revolutions once a day.

According to some embodiments, osteotomized bone segment **58** is distracted at a different rates over the distraction period of time. According to some embodiments, different movable elements **122**, via corresponding tooling interfaces **126**, are rotated at different rates.

Osteogenesis is promoted during the distraction period of time, as bone tissue **70** is formed between the distracted osteotomized bone segment **58** and the remaining jaw bone. Distraction rate is chosen by a user, such as a clinician, in order to promote formation and healing of bone tissue **70**.

The distraction period of time ends when osteotomized bone segment **58** reaches a preferred position, defined as a final position. **Fig. 29H** illustrates an exemplary final position, wherein the distal edge of osteotomized bone segment **58** is aligned with adjacent regions of the jaw bone. According to some embodiments, final position is a position at which enough bone is formed to allow anchoring implant **20** therein, without the risk of penetrating a nerve, such as alveolar nerve **54**.

When a desired final position is reached, a consolidation phase follows in which distraction device **100**, remaining attached via string **128** to miniscrews **40**, keeps bone tissue **70** stable to allow the bone to fully heal, as depicted in **Fig. 25I**. According to some embodiments, consolidation phase spans over the course of a plurality of days. According to some embodiments, consolidation phase spans over the course of a plurality of weeks. According to some embodiments, consolidation phase spans over the course of a plurality of months. According to some embodiments, consolidation phase spans over the course three to seven days.

Fig. 29J depicts a step of detachment of distraction device **100** from miniscrews **40**, and its removal from either abutment **150** or bone screw **20**. Removal of miniscrews **40** follows thereafter (step not illustrated separately).

Once a new bone **70** is formed, it is possible to anchor implants **20** therein, without a risk of penetrating a nerve, such as alveolar nerve **54**. The number of bone screws **20** to be anchored obviously varies according to each particular clinical situation. **Fig. 29K** depicts an exemplary embodiment of a mandible having several implants **20**, three of which are implants **20** anchored to a region formed with new rigid bone tissue **70**. Such implants **20**, as depicted in **Fig. 29L**, can support dental crowns **22**.

According to some embodiments, implants **20** anchored within new rigid bone tissue **70** support a dental bridge. **Fig. 30A** depicts an exemplary embodiment of a mandible having several implants **20**, two of which are implants **20** anchored to a region formed with new rigid bone tissue **70**. Such implants **20**, as depicted in **Fig. 30B**, support dental crown **24**[a].

According to some embodiments, once the distraction procedure, utilizing distraction device **100** is completed, the anchored bone screw **20** used during the procedure to support abutment **150** or utilizing distraction device **100**, serves as a support for a dental crown (see **Figs. 29K-30B**) or alternatively, a dental bridge.

Fig. 31A depicts a mandible **50** with native teeth **12** positioned adjacent to alveolar ridge **52**. In the illustrated example, no region is available, absent of native teeth and adjacent to alveolar ridge **52**, for anchoring a bone screw **20** to serve as a support for an abutment **150** or direct placement of a distraction device **100** thereon. **Fig. 31B** depicts an embodiment of a distraction device **100^{m}**, comprising an adaptor member **136^{m}** provided with a socket or a bore (not visible in **Fig. 31B**), configured for secure attachment over native tooth **12** adjacent to alveolar ridge **52**. According to some embodiments, adaptor member **136^{m}** is formed for engagement with native tooth **12** by any configuration known in the art for attaching a dental bridges to native teeth. Otherwise, distraction device **100^{m}** comprises any components described in previous embodiments, such as string positioning member **104** having at least one string pull assembly **120**, configured for attachment via string **128** having a string engagement portion **130**, to at least one miniscrew **40**.

According to some embodiments, the at least one string pull assembly **120** is not aligned with a corresponding miniscrew **40**, such that the string **128**, either when fully stretched or during the distraction period of time, is not necessarily vertical or horizontal but rather diagonal along the region between miniscrew **40** and movable element **122**. **Fig. 32** depicts an exemplary embodiment of two strings **128a** and **128b**, diagonally stretched between miniscrews **40a** and **40b** to movable elements **122a** and **122b** (hidden from view), respectively. Each of strings **128a** and **128b** is stretched at a different angle, relative for example to a vertical projection line, to a longitudinal axis along the length of each corresponding miniscrew **40**, or to a horizontal plane parallel for string positioning member **104**.

According to some embodiments, distraction device **100** is attached via at least one string **128** to other fixation means anchored to an osteotomized bone segment **58**, which are not necessarily miniscrews **40**. **Fig. 33** depicts an exemplary embodiment of a distraction device **100**, attached via strings **128** to fixation plates **72**. Fixation plates **72** comprise any fixation plates known in the art for procedures of distraction osteogenesis, having structural components to which strings **128** of a distraction device **100** can be attached.

According to some embodiments, distraction device **100** is used not only distraction procedures in the mandible, but other facial bones as well. **Fig. 34** depicts a maxilla **60** with an alveolar ridge **62** in a sagittal portion thereof. The distance between the edge of alveolar ridge **62** and maxillary sinus **64** is too short to permit placement of a bone screw **20** therein, as during such placement, insertion of bone screw **20** too far through alveolar ridge **62**, may damage the region of maxillary sinus **64**, dislodged into the latter or have a low bone interface and anchorage due to the fact that only the bony interface offers anchorage. A distraction device **100** is attached, via abutment **150**, to a bone screw **20** anchored to the maxilla **60** adjacent to an alveolar ridge **62**. Strings **128** having string engagement portions **130** are attached to miniscrews **40**, anchored to an osteotomized bone segment of alveolar ridge **62**. Crestal osteotomy line **66** is formed distal to maxillary sinus **64**. Otherwise, the method of using distraction device **100** for distraction of an osteotomized bone segment in the maxilla is carried out as described throughout the specification for use in the mandible.

Fig. 35 depicts a midface portion of the upper jaw **60** with an alveolar ridge (not numbered). The distance between the edge of the alveolar ridge and the nasal crest (not numbered) is too short to permit placement of a bone screw **20** therein. A distraction device **100** is attached, via abutment **150**, to a bone screw **20** anchored to the upper jaw **60** adjacent to the alveolar ridge. Strings **128** having string engagement portions **130** are attached to miniscrews **40**, anchored to an osteotomized bone segment of the alveolar ridge. Crestal osteotomy line **66** is formed inferior to the nasal crest. Otherwise, the method of using distraction device **100** for distraction of an osteotomized bone segment in the midface portion of a jaw bone is carried out as described throughout the specification for use in the mandible.

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 sub-combination or as suitable in any other described embodiment of the invention. No feature described in the context of an embodiment is to be considered an essential feature of that embodiment, unless explicitly specified as such.

Although the invention is described in conjunction with specific embodiments thereof, it is evident that numerous alternatives, modifications and variations that are apparent to those skilled in the art may exist. 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 herein. Other embodiments may be practiced, and an embodiment may be carried out in various ways. Accordingly, the invention embraces all such alternatives, modifications and variations that fall within the scope of the appended claims.

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CLAIMS

1. A distraction device for bone tensioning, the distraction device comprising:
   (i) a main body comprising:
      at least one adaptor member having at least one connection platform;
      a strings positioning member comprising a plurality of positioning features, spaced from each other along a longitudinal direction of the strings positioning member attachable to the at least one adaptor body, extending along a longitudinal direction substantially perpendicular to a vertical axis of the at least one adaptor member; and
   (ii) a plurality of string pull assemblies, each comprising:
      a string having a first string end and a second string end attached to a string engagement portion; and
      a movable element attached to the first string end, configured to move so as to promote displacement of the string engagement portion in a distal direction,

   wherein the strings positioning member extends along the longitudinal direction thereof, substantially perpendicular to a vertical axis of the at least one adaptor member,

   wherein each of the plurality of string pull assemblies is attached to the main body;

   wherein each string of the plurality of strings is configured to extend through or along a corresponding, different, positioning feature.

2. The distraction device of claim 1, wherein at least one string pull assembly of the plurality of string pulley assemblies is attached to the strings positioning member.

3. The distraction device of claim 1, wherein at least one string pull assembly of the plurality of string pulley assemblies is attached to the at least one adaptor member.

4. The distraction device of any one of claims 1-3, wherein the at least one movable element is formed as a rotatable shaft, and wherein the string pull assembly is rotateably attached to the main body.

5. The distraction device of any one of claims 1-3, wherein the at least one string pull assembly further comprises a channel, and wherein the movable element is configured to axially move along at least one direction within the channel.

6. The distraction device of claim 5, wherein the channel comprises threading along at least a portion of its length, and wherein the movable element is formed as a screw threadedly engaged with the channel.

7. The distraction device of claim 5, wherein the channel comprises ratcheting teeth along at least a portion of its length, and wherein the movable element comprises at least one complementary tooth, configured to enable longitudinal one-directional movement of movable element along the channel.

8. The distraction device of claim 4, wherein the at least one string pull assembly further comprises a gear rigidly attached to the movable element, and the distraction device further comprises at least one pawl configured to engage with the gear, wherein the pawl is configured to allow free rotation of the string pull assembly in the one direction, while preventing its rotation in an opposite direction.

9. The distraction device according to claim 4, wherein the at least one string pulley assembly further comprises a tooling interface rigidly attached to at least one end of the movable element, wherein rotation of the at least one tooling interface is one direction results in rotation of the movable element in the same direction.

10. The distraction device according to claim 9, wherein the strings positioning member further comprises a first sidewall and a second sidewall, and wherein the at least one tooling interface is exposed through at least one opening in the first sidewall or the second sidewall.

11. The distraction device according to claim 10, wherein the strings positioning member further comprises at least one positioning member chamber, bordered

between the first sidewall and the second sidewall, and configured to house the at least one string pull assembly.

12. The distraction device according to claim 9, wherein the strings positioning member further comprises a front panel, and wherein the at least one tooling interface is exposed through at least one opening in the front panel.

13. The distraction device according to claim 9, wherein the strings positioning member further comprises a distal panel, and wherein the at least one tooling interface is exposed through at least one opening in the in the distal panel.

14. The distraction device according to claim 3, wherein the strings positioning member further comprises at least one support rod.

15. The distraction device according to any one of claims 1 to 14, wherein the at least one positioning feature is formed as an aperture, configured to allow passage and free movement of the string there through.

16. The distraction device according to claim 14, wherein the at least one positioning feature is formed as a contact point between the string and the support rod.

17. The distraction device according to any one of claims 1 to 16, wherein the at least one connection platform comprises a mounting bore.

18. The distraction device of claim 17, wherein the mounting bore comprises a bore screw thread.

19. The distraction device of claim 17, wherein the mounting bore comprises an anti-rotational internal surface.

20. The distraction device of claim 17, wherein the adaptor member further comprises a stationary ring portion and a dynamic ring portion hinged thereto, wherein the dynamic ring portion comprises a tightening mechanism configured to form the mounting bore by detachably attaching an end of dynamic ring portion to either the stationary ring portion or the strings positioning member.

21. The distraction device of claim 17, wherein the adaptor member further comprises a tightening mechanism configured to adjust the diameter of central bore.

22. The distraction device of claim 1, wherein the strings positioning member is detachably attachable to the at least one adaptor member via a quick snap attachment.

23. The distraction device of claim 22, wherein the strings positioning member further comprises a positioning member's attachment means, and wherein the at least one adaptor body further comprises an adaptor attachment means, configured to engage with the strings positioning member attachment means.

24. The distraction device of claim 22, wherein the at least one adaptor member comprises two adaptor members connected to each other via an adaptor attachment means, the adaptor attachment means comprising an adaptor attachment socket formed to receive the strings positioning member therein.

25. The distraction device according to any one of claims 1 to 24, wherein the at least one component of the distraction device is manufactured via the use of a CAD-CAM software, according to a design specific to a patient.

26. A distraction system, comprising:

(i) the distraction device according to any one of claims 1 to 25; and

(ii) an abutment comprising:

an abutment distal portion, configured to engage with the at least one connection platform of the at least one adaptor member;

an abutment proximal portion; and

an abutment mid-portion, fluidly connected to the abutment distal portion and to the abutment proximal portion,

wherein the largest cross-sectional diameter of the abutment mid-portion is larger than any of the largest cross-sectional diameter of the abutment distal portion, and the largest cross-sectional diameter of the abutment proximal portion.

27. The distraction system of claim 26, wherein the abutment proximal portion comprises a polyhedral-shaped structure.

28. The distraction system according claim 26, wherein the abutment distal portion comprises an abutment distal portion screw thread.

29. The distraction system according to claim 26, wherein the abutment distal portion comprises a polyhedral-shaped structure.

30. The distraction system according to any one of claims 26 to 29, further comprising at least one miniscrew, configured for engagement with the at least one string engagement portion.

31. The distraction system according to claim 30, wherein the miniscrew further comprises a receiving area.

32. The distraction system according to claim 31, wherein the receiving area of the miniscrew is formed as a through-hole.

33. The distraction system according to claim 31, wherein the receiving area of the miniscrew is formed as a recess having at least one distal vertical extension.

34. The distraction system according to claim 31, wherein the receiving area of the miniscrew comprises an opening with a latch.

35. The distraction system according to any one of claims 26 to 34, further comprising a bone screw, configured to receive and securely engage with the abutment.

36. A method of using a distraction device, comprising the steps of:

(i) providing the distraction device according to any one of claims 1 to 25 and a plurality of miniscrews;

(ii) connecting the distraction device to a mount;

(iii) attaching the plurality of string engagement portions to the plurality of miniscrews, wherein each string engagement portion is attached to a single miniscrew;

(iv) stretching the plurality of strings between the plurality of movable elements and the plurality of miniscrews, by moving the plurality of movable element;

(v) displacing at least one of the plurality of miniscrew in the distal direction, by further moving the respective movable attached thereto; and

(vi) repeating the step of displacing at least one miniscrew in the distal direction periodically, for all miniscrews.

37. The method according to claim 36, wherein moving any of the plurality of movable element comprises rotating the movable element.

38. The method according to claim 36, wherein moving any of the plurality of movable element comprises axially displacing the movable element

39. The method according to any one of claims 36 to 38, wherein the mount is a bone screw.

40. The method according to any one of claims 36 to 38, wherein the mount is an abutment attached to a bone screw.

41. The method according to any one of claims 36 to 40, wherein each string pull assembly is operated independently, thereby applying a different pulling rate to different miniscrews.

42. A distraction assembly comprising:

(i) the distraction device according to any one of claims 1 to 25, wherein the adaptor member further comprises a plurality of axial extensions, configured to bend radially inwards upon application of an external force along their circumference;

(ii) a clamp comprising a band and a worm gear mechanism, the worm gear mechanisms configured to cause contraction or expansion of the clamp and keep the clamp at the adjusted position,

wherein the clamp is configured to engage with the distraction device by placement thereof over the exterior of the adaptor member; and

wherein the clamp is further configured to exert force on the contractible adaptor member, sufficient bend the plurality of axial extensions radially inwards.

43. The distraction assembly of claim 42, wherein the distraction device further comprises:

(i) an arcuate slot disposed between the strings positioning member and the adaptor member, dimensioned to accommodate at least a portion of the band; and

(ii) a worm recess adjacent the arcuate slot, configured to accommodate the worm gear mechanism.

44. The distraction assembly according to any one of claims 42 to 43, wherein the band further comprises at least one retaining slot, and wherein the adaptor member comprises at least one retaining protrusion extending radially outwards therefrom, and configured to be positioned within the respective at least one retaining slot.

45. The distraction assembly according to any one of claims 42 to 44, further comprising an abutment, comprising:

an abutment distal portion, configured to engage with the at least one connection platform of the at least one adaptor member;

an abutment proximal portion; and

an abutment mid-portion, fluidly connected to the abutment distal portion and to the abutment proximal portion.

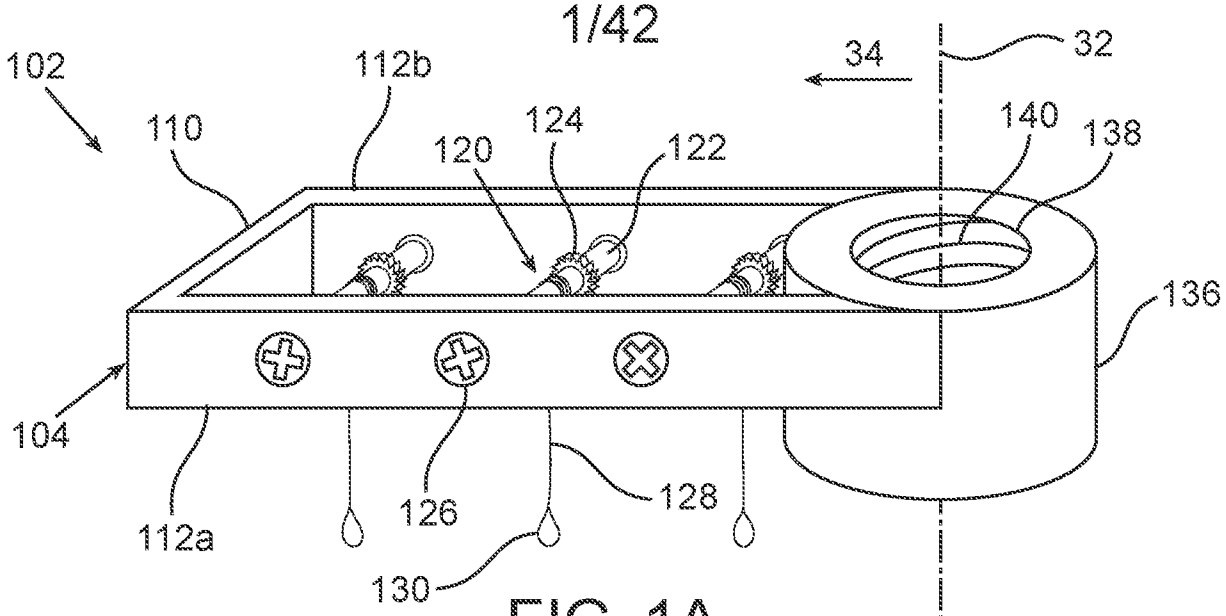


FIG. 1A

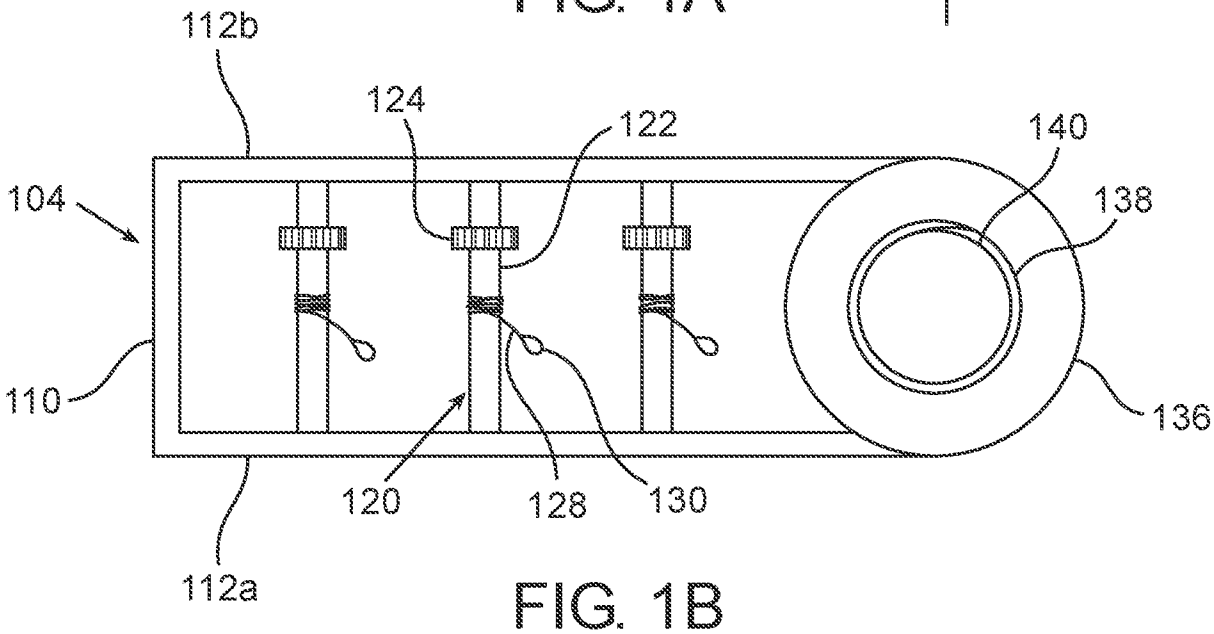


FIG. 1B

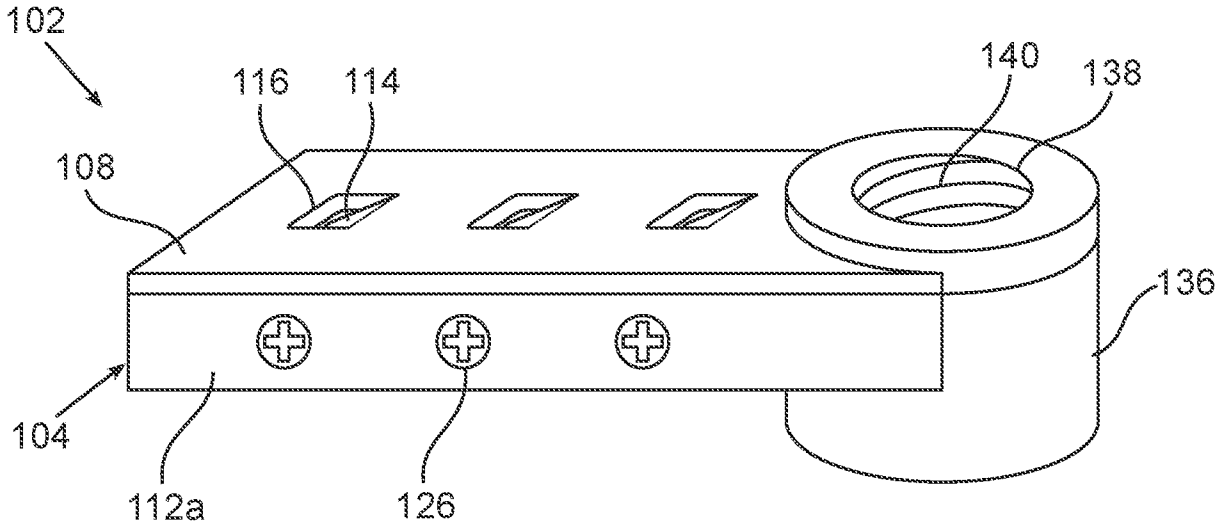


FIG. 2A

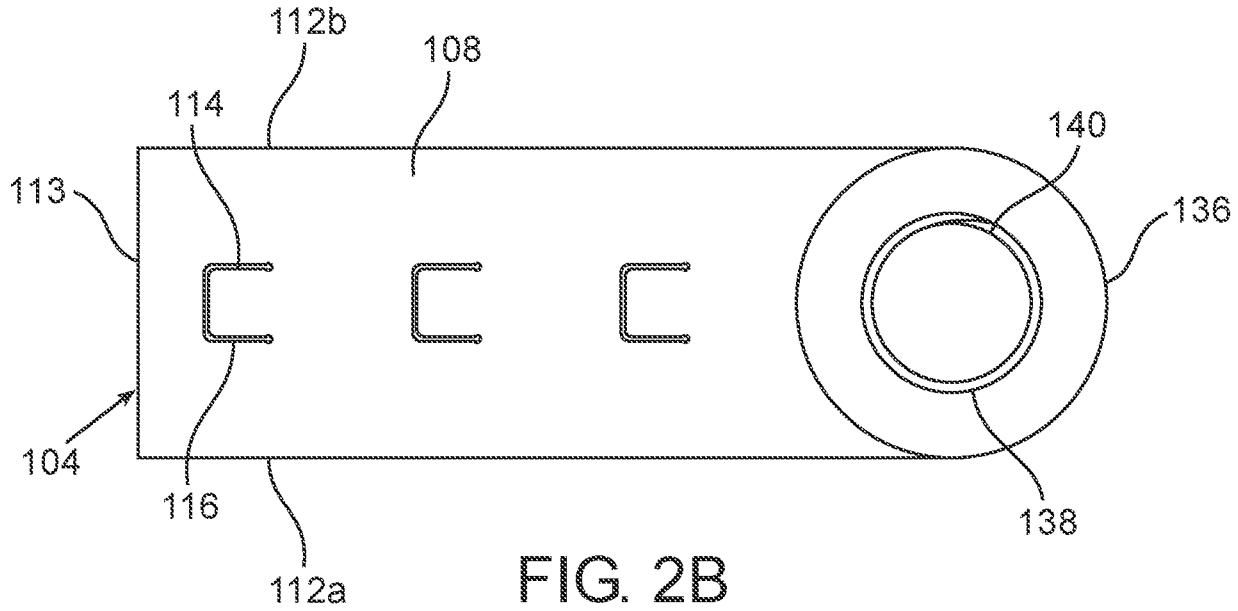


FIG. 2B

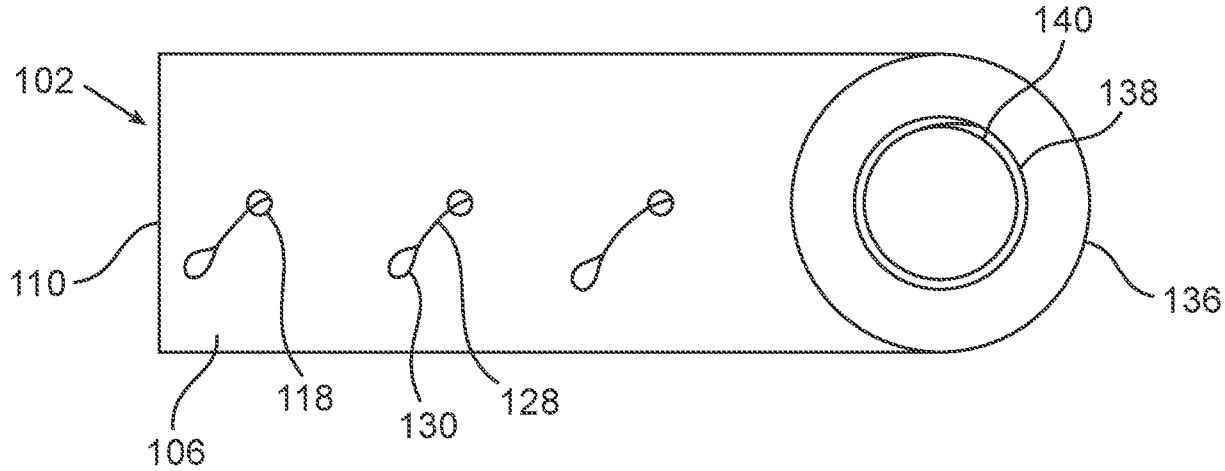


FIG. 2C

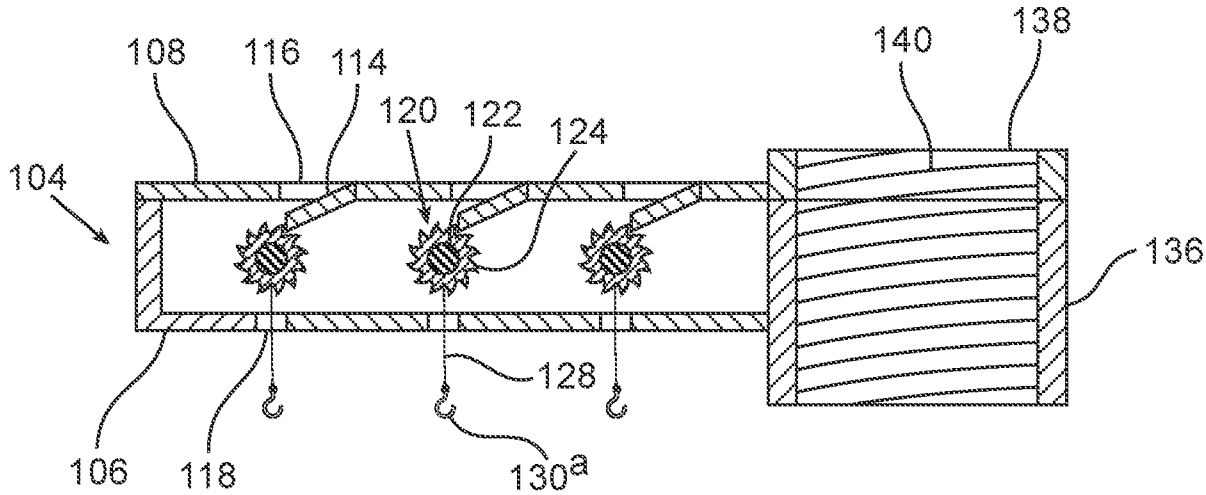


FIG. 3A

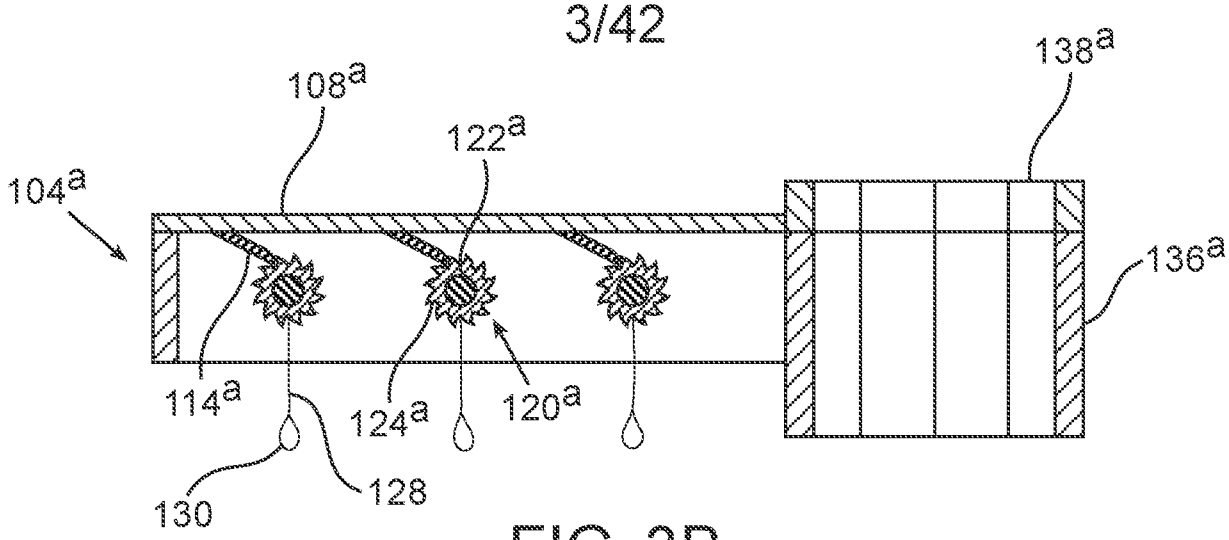


FIG. 3B

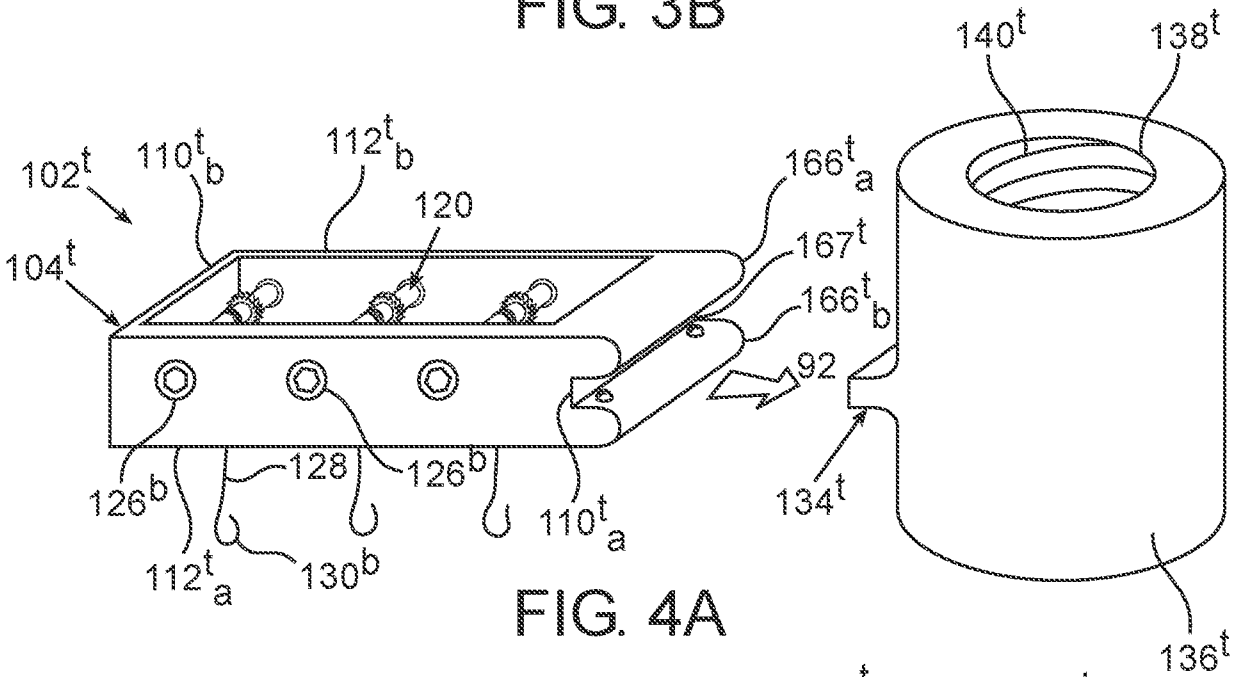


FIG. 4A

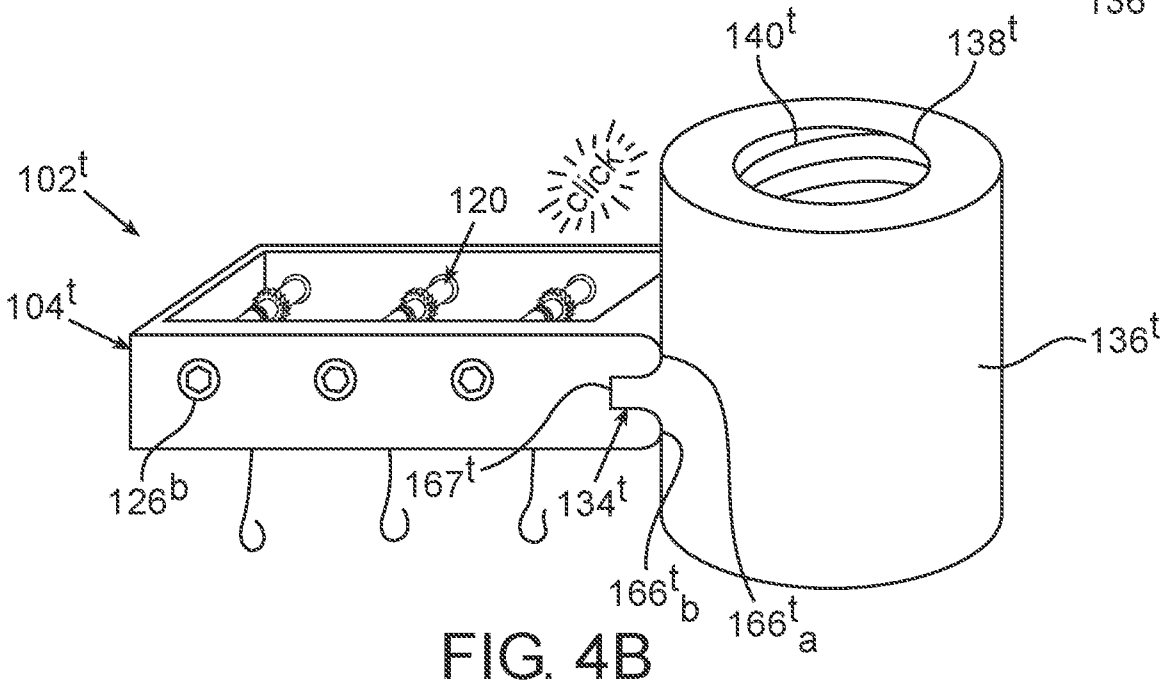
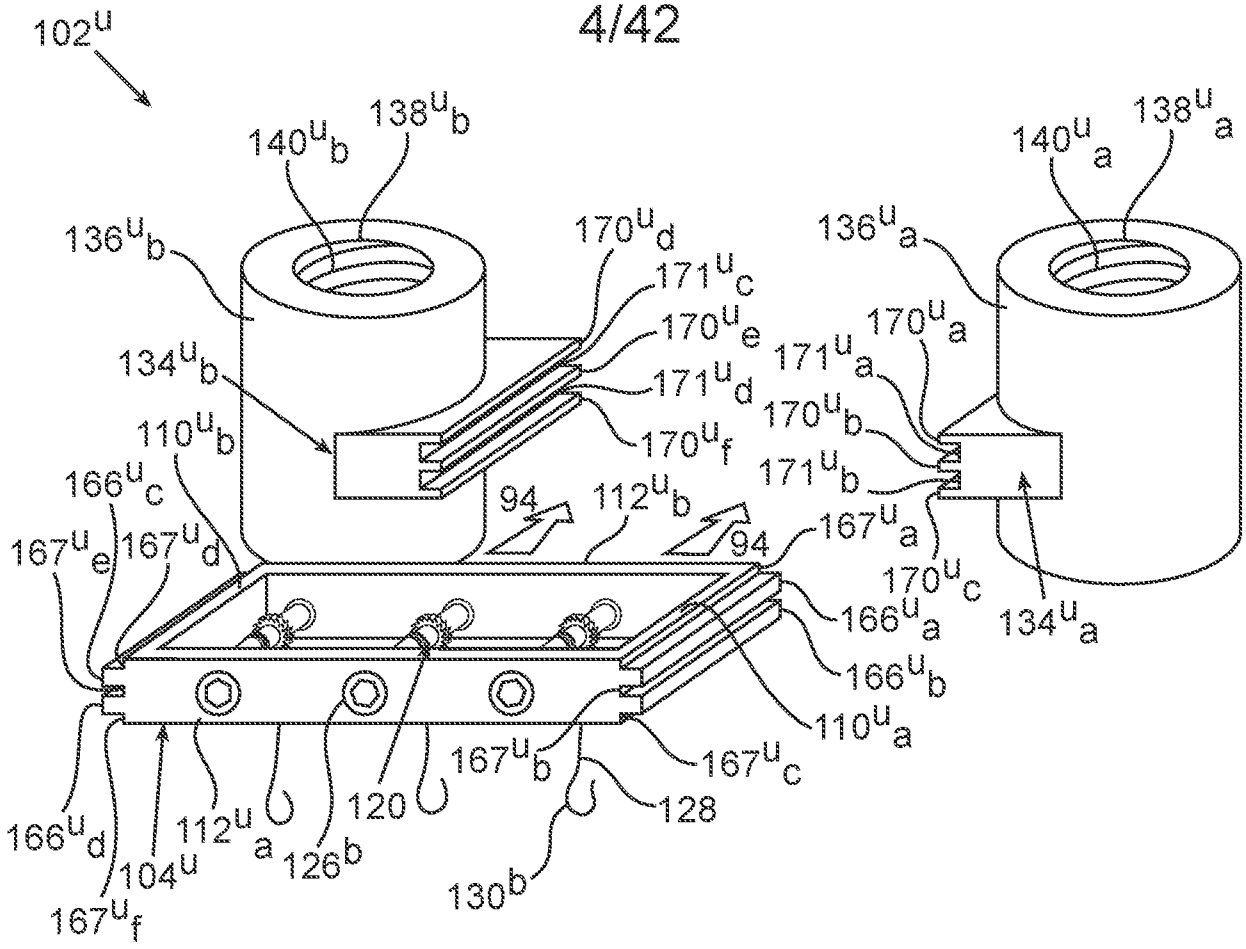


FIG. 4B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171ub
170uc
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FIG. 5A

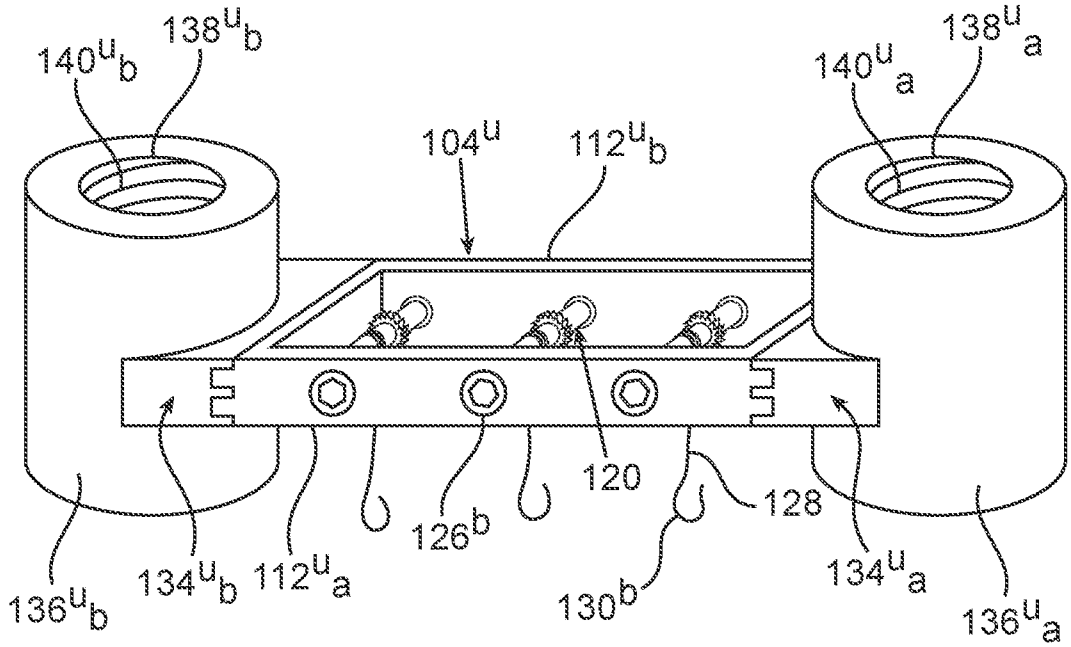
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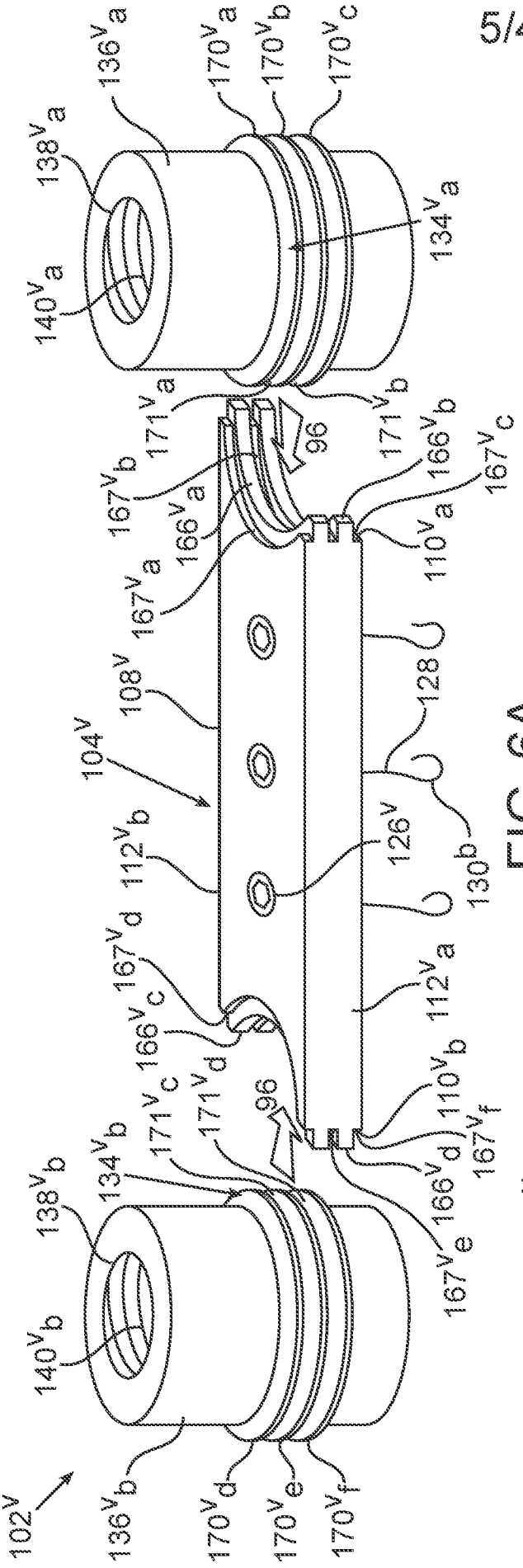
FIG. 5B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167vf
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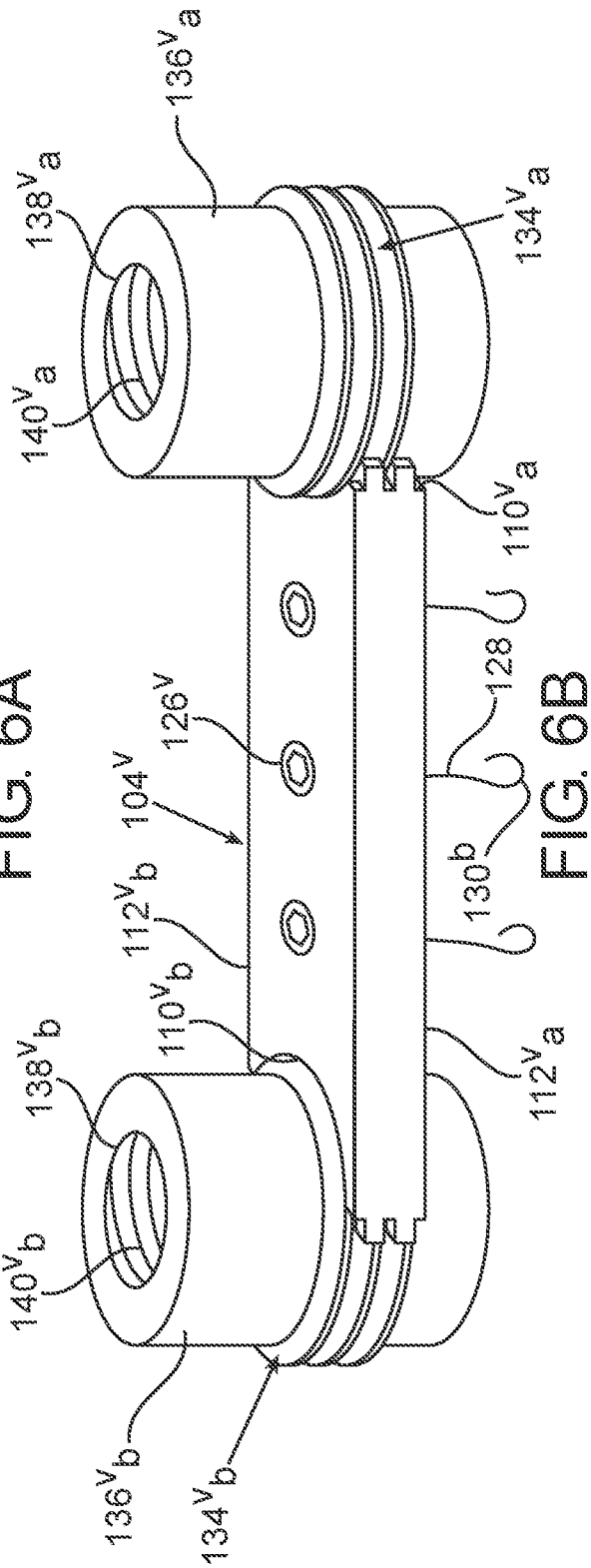
104v
108v
126v
128
130b

FIG. 6A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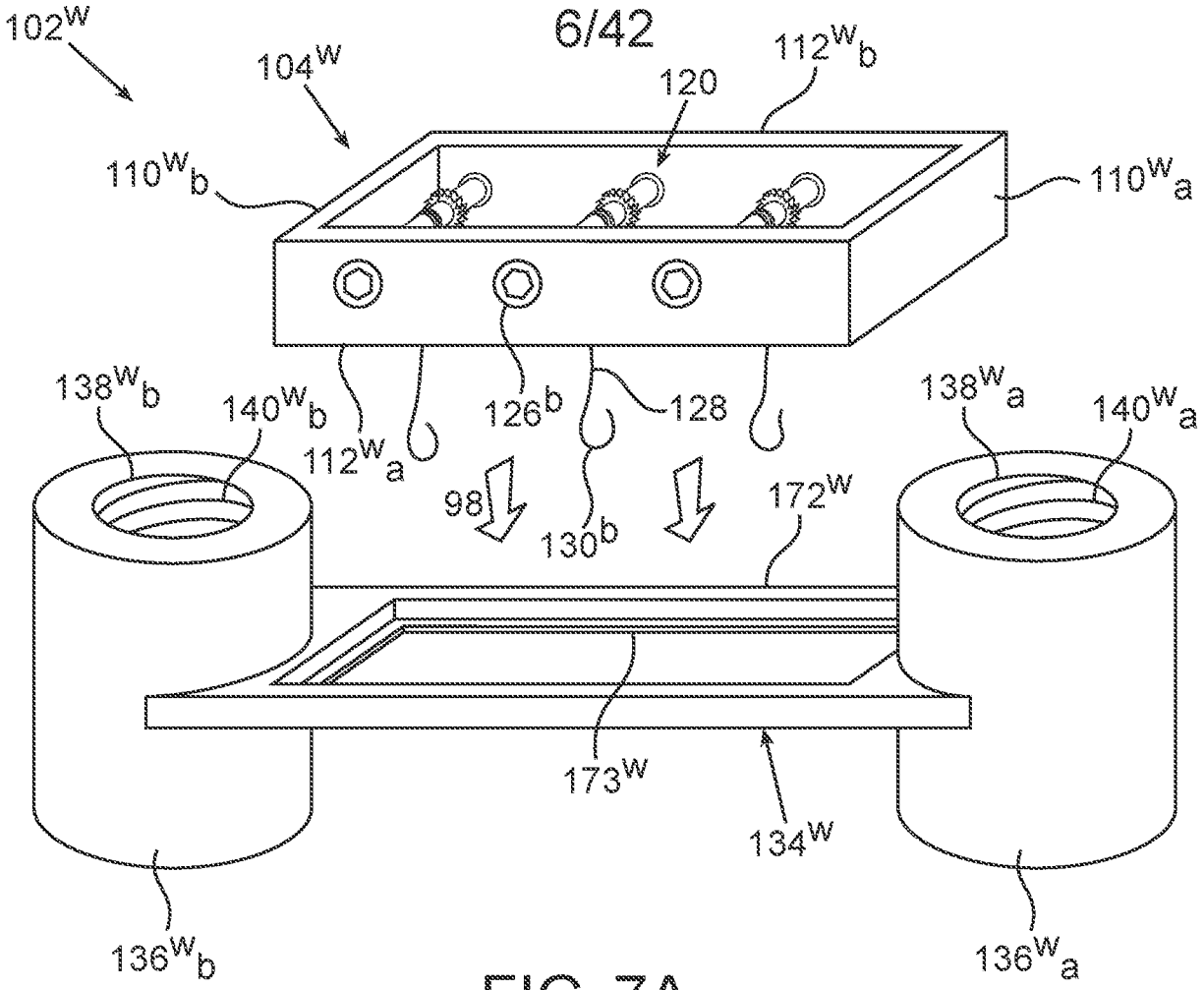
134vb

FIG. 6B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134w
136wb
136wa

FIG. 7A

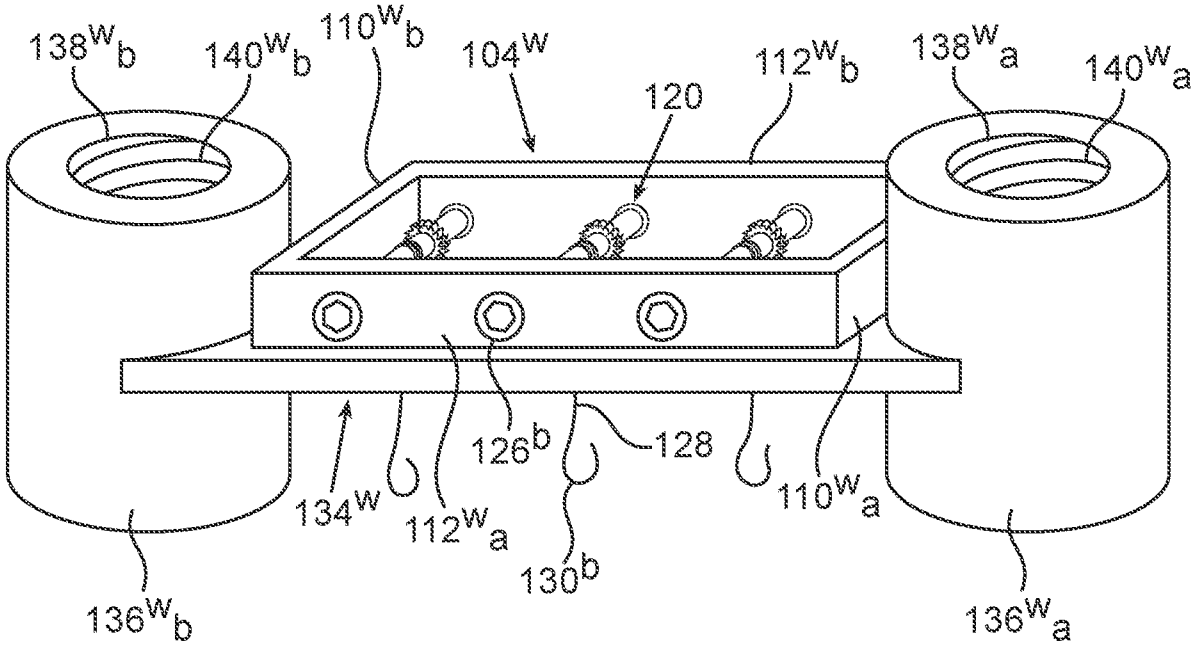
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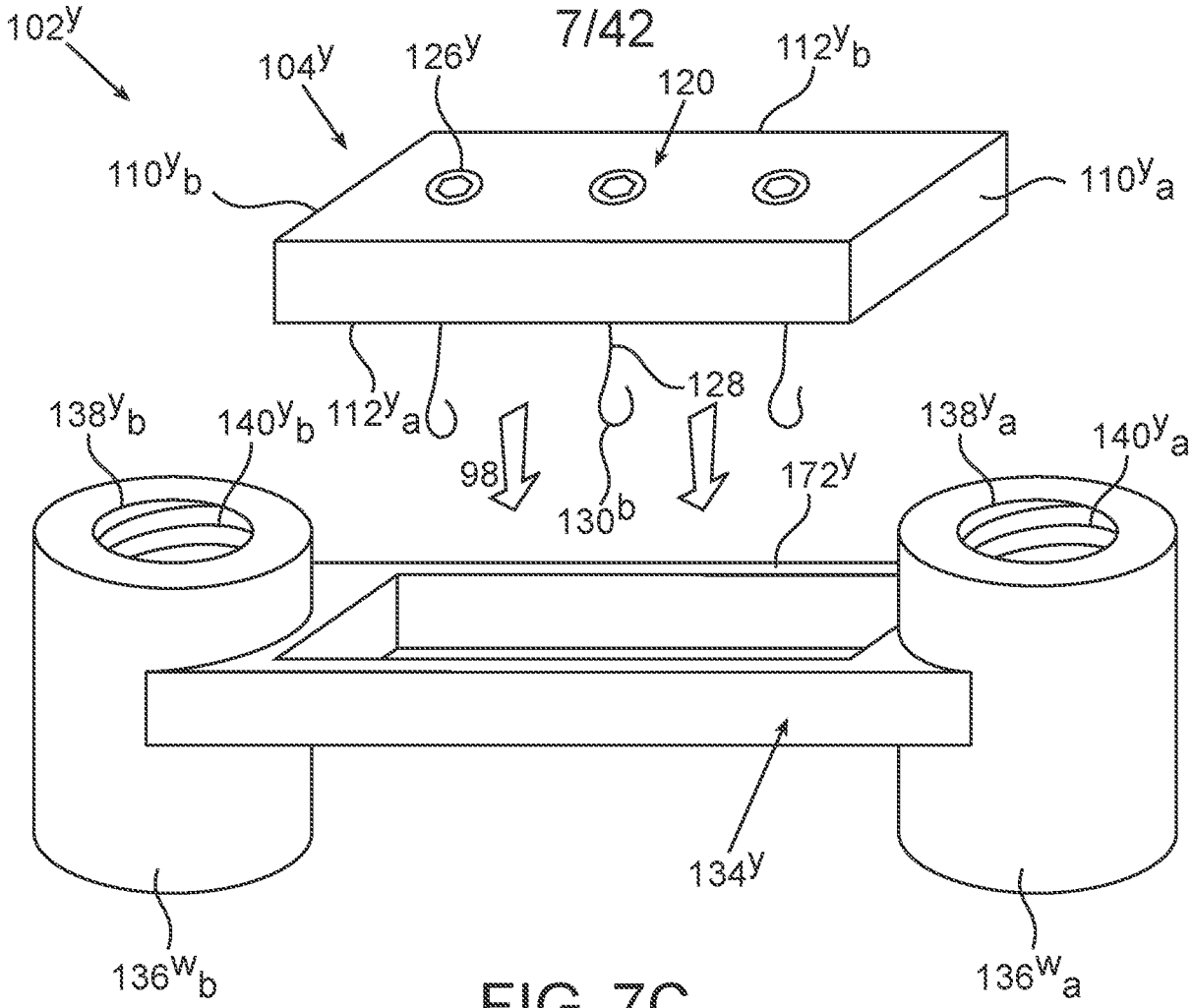
FIG. 7B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134y
136wb
136wa

FIG. 7C

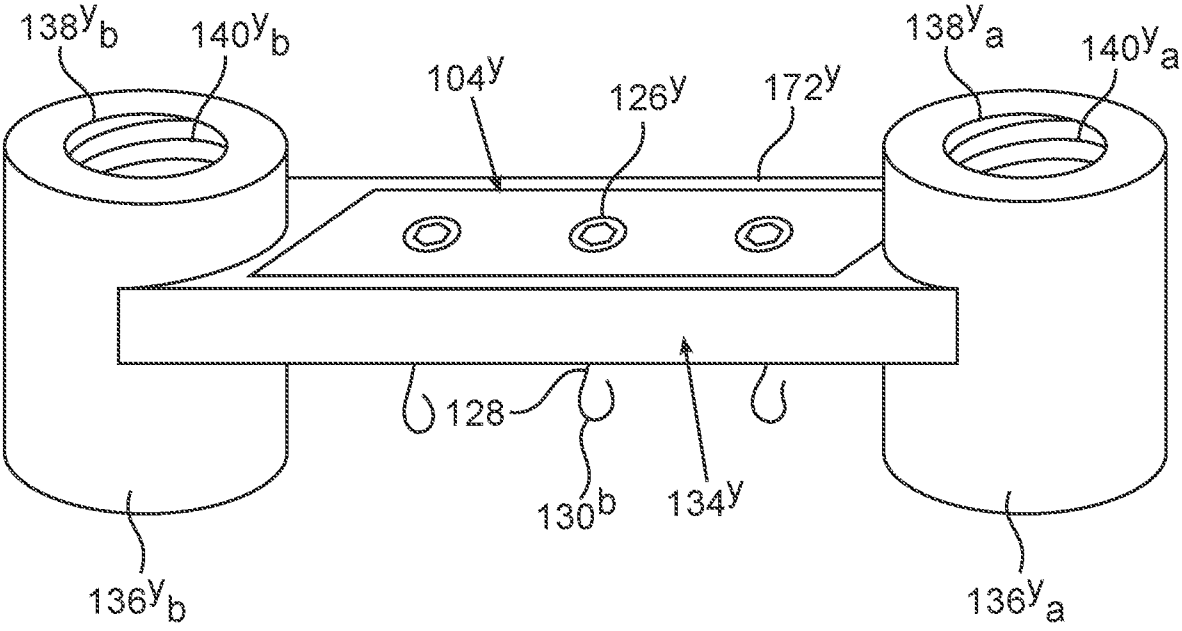

138yb
140yb
104y
126y
172y
138ya
140ya
128
130b
134y
136yb
136ya

FIG. 7D

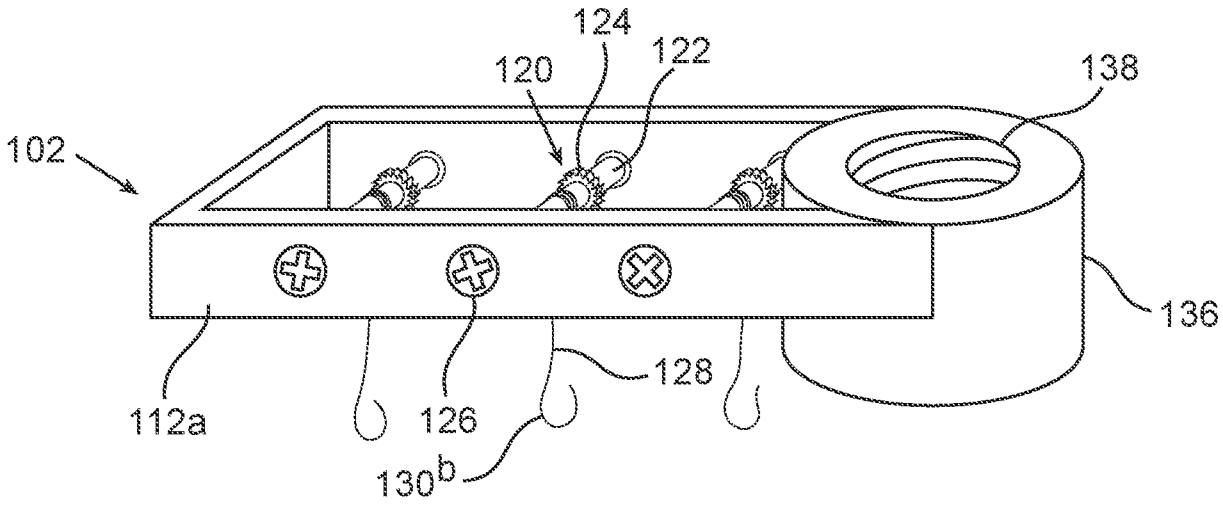

124
120
122
138
102
136
128
112a
126
130b

FIG. 8A

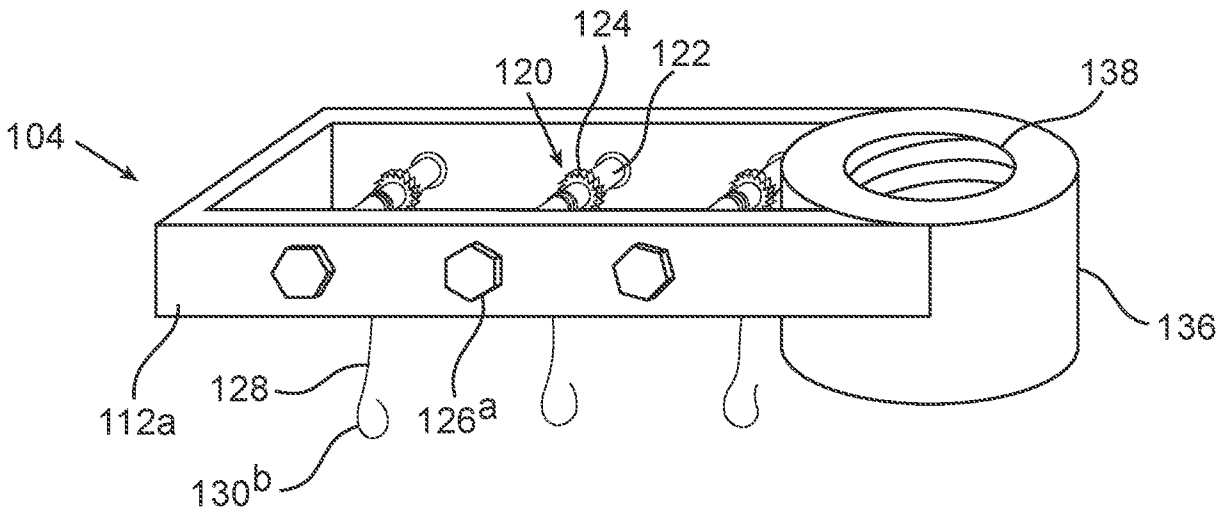

124
120
122
138
104
136
128
112a
126a
130b

FIG. 8B

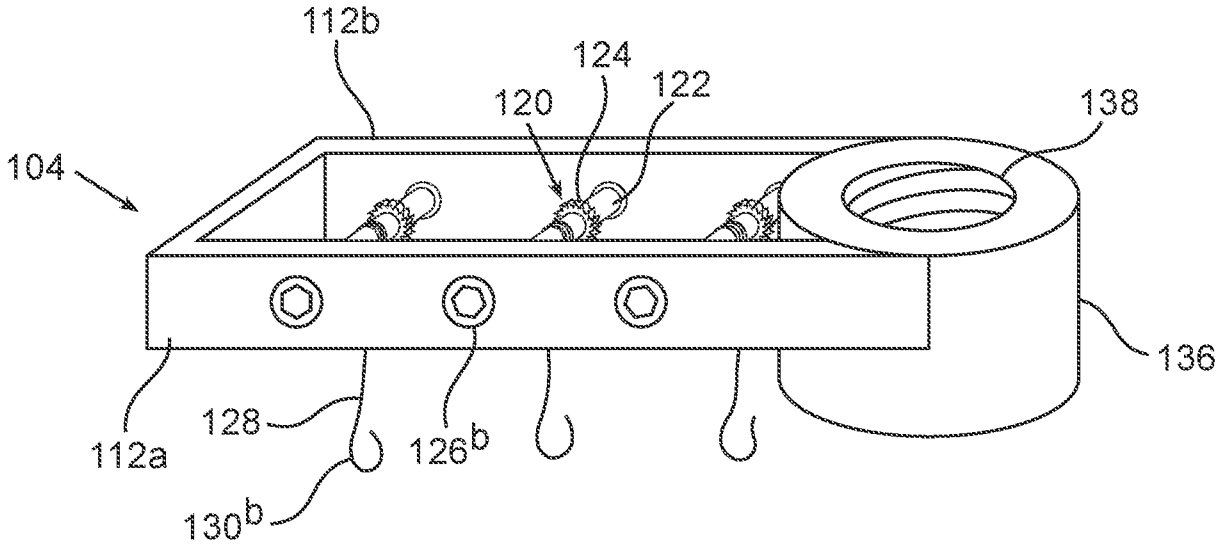


FIG. 8C

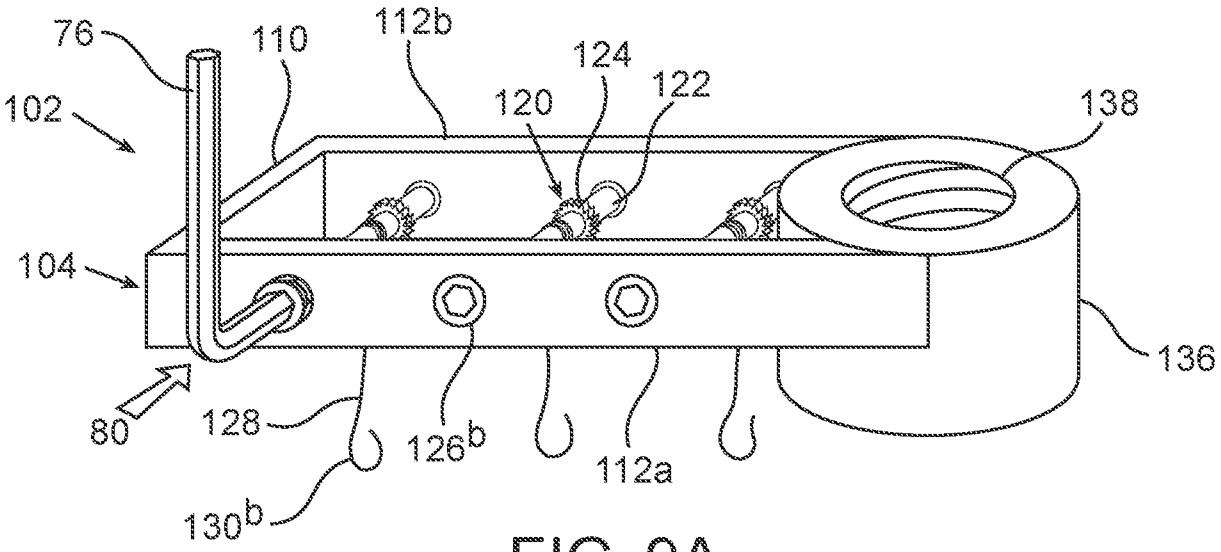


FIG. 9A

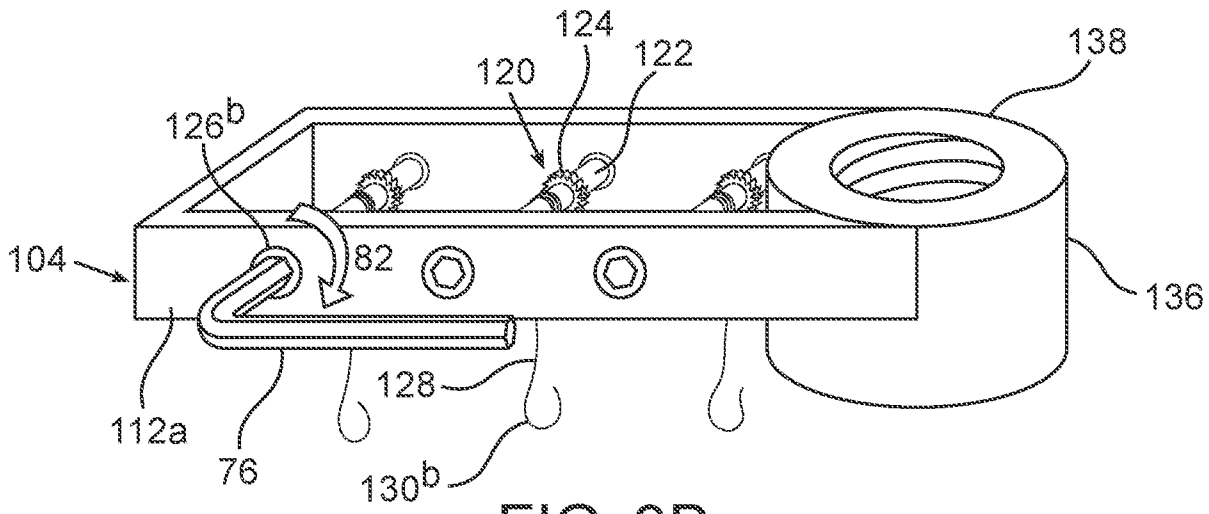


FIG. 9B

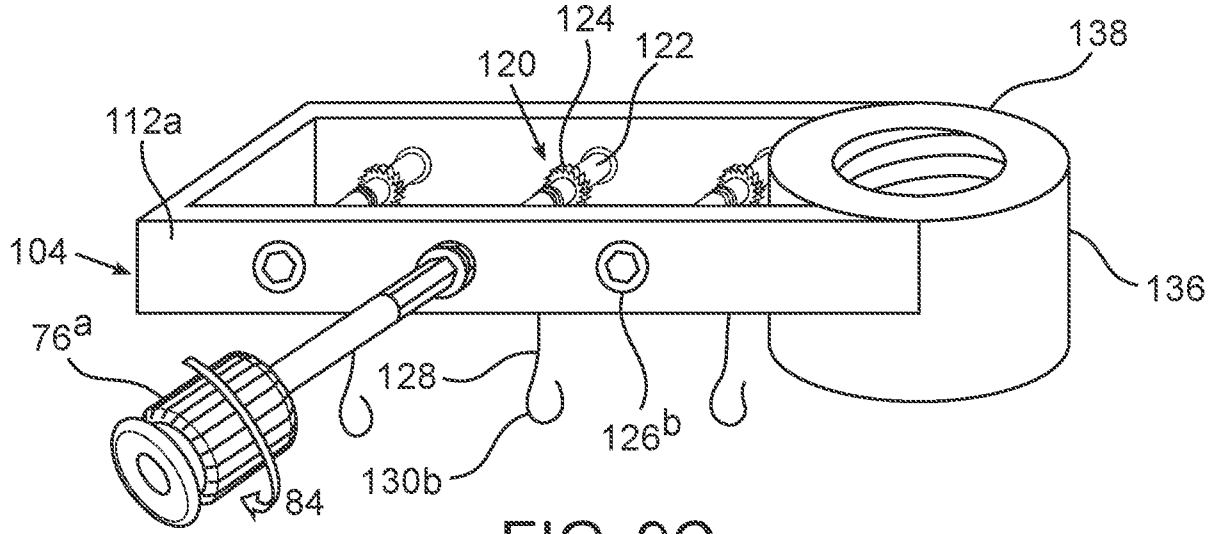


FIG. 9C

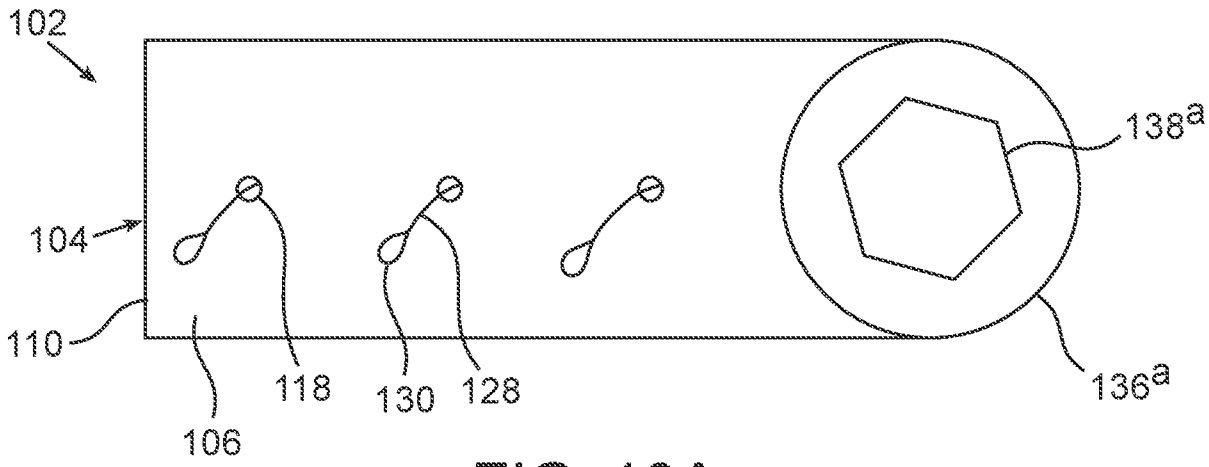


FIG. 10A

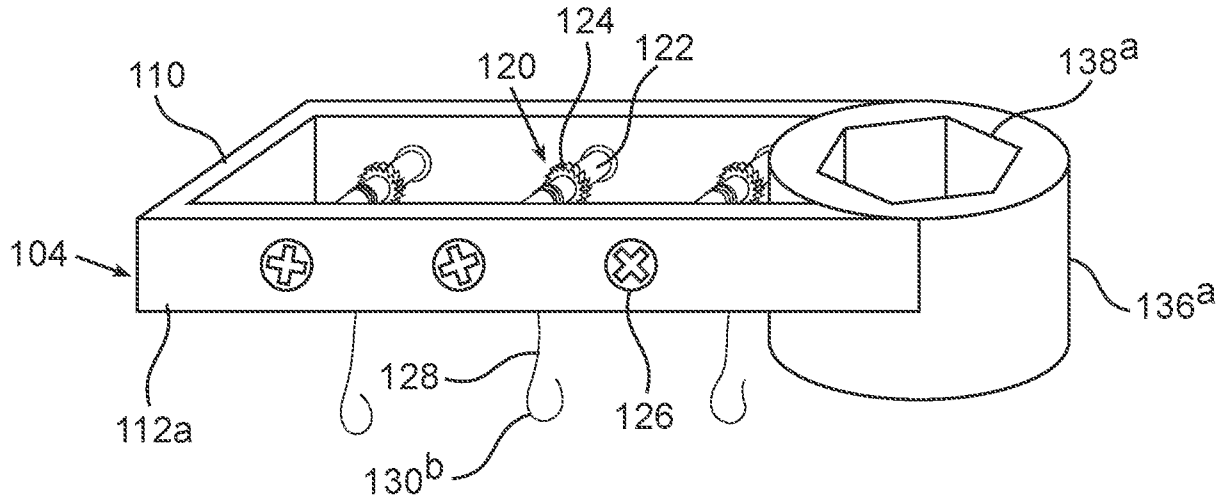


FIG. 10B

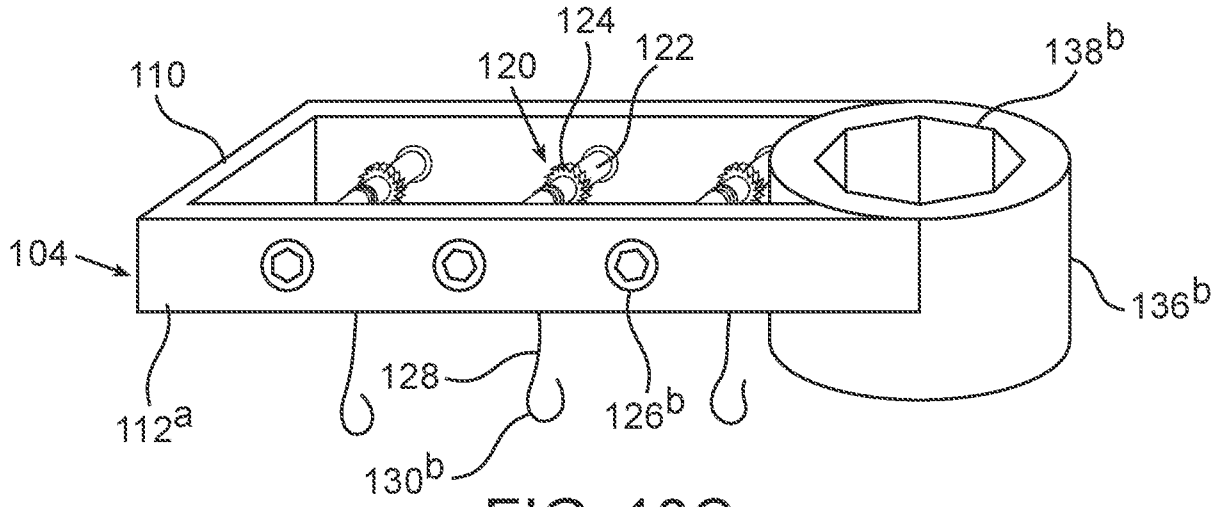


FIG. 10C

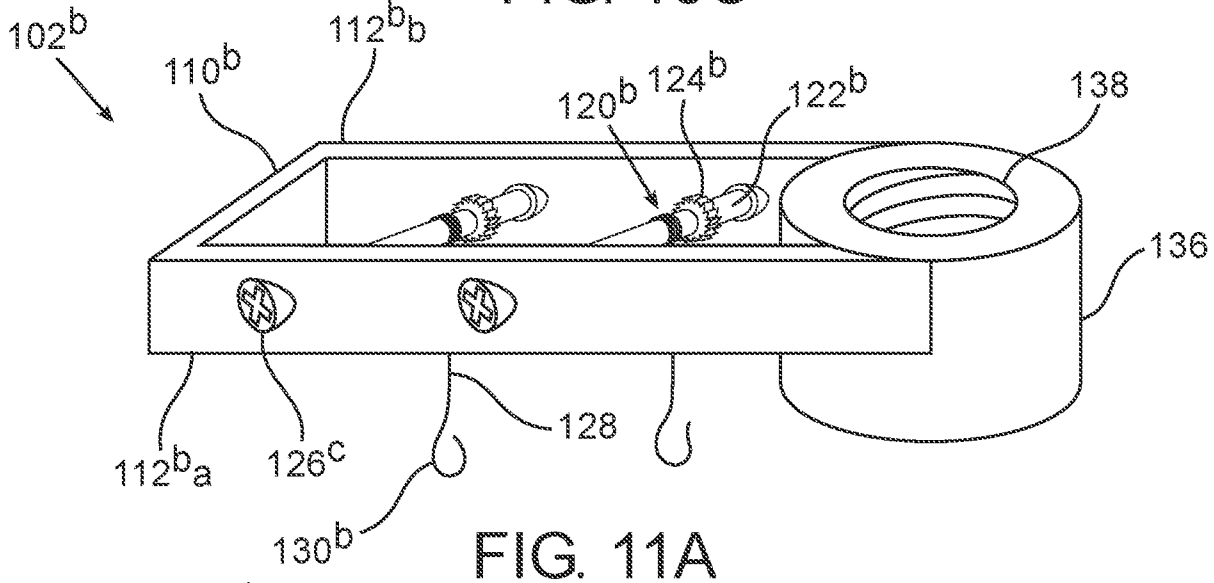


FIG. 11A

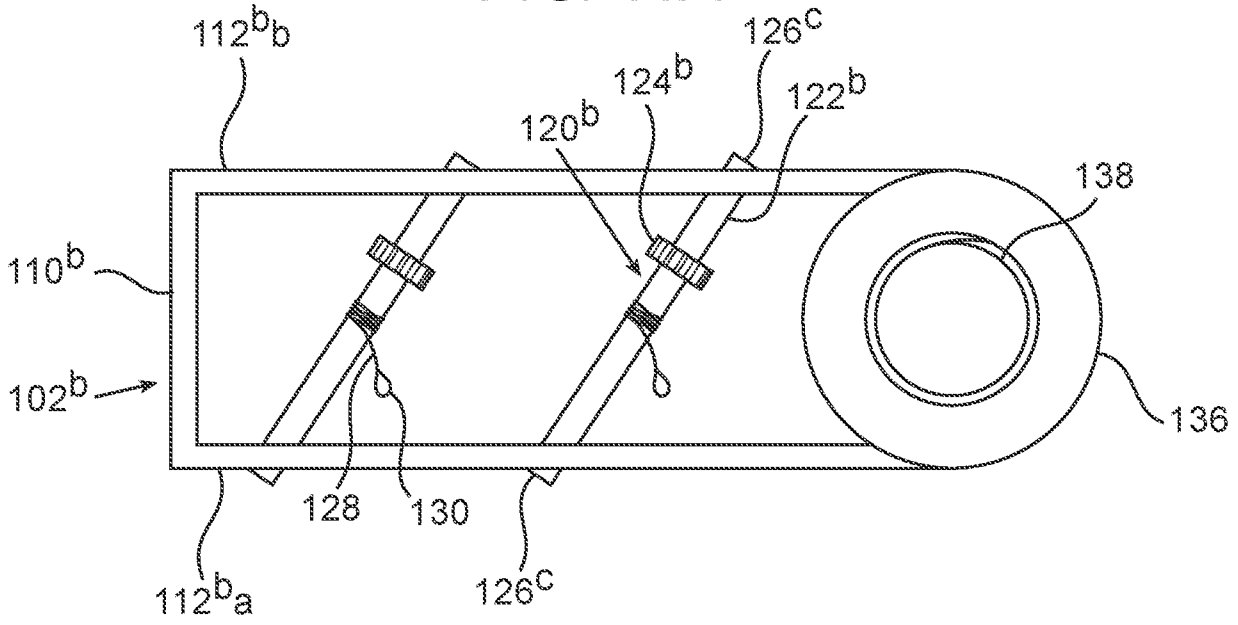


FIG. 11B

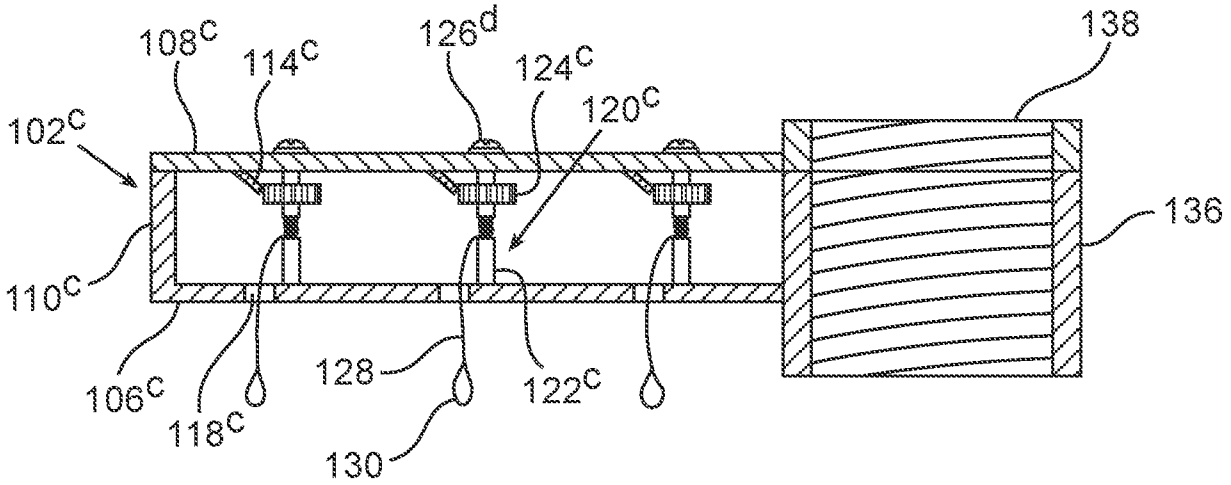


FIG. 12

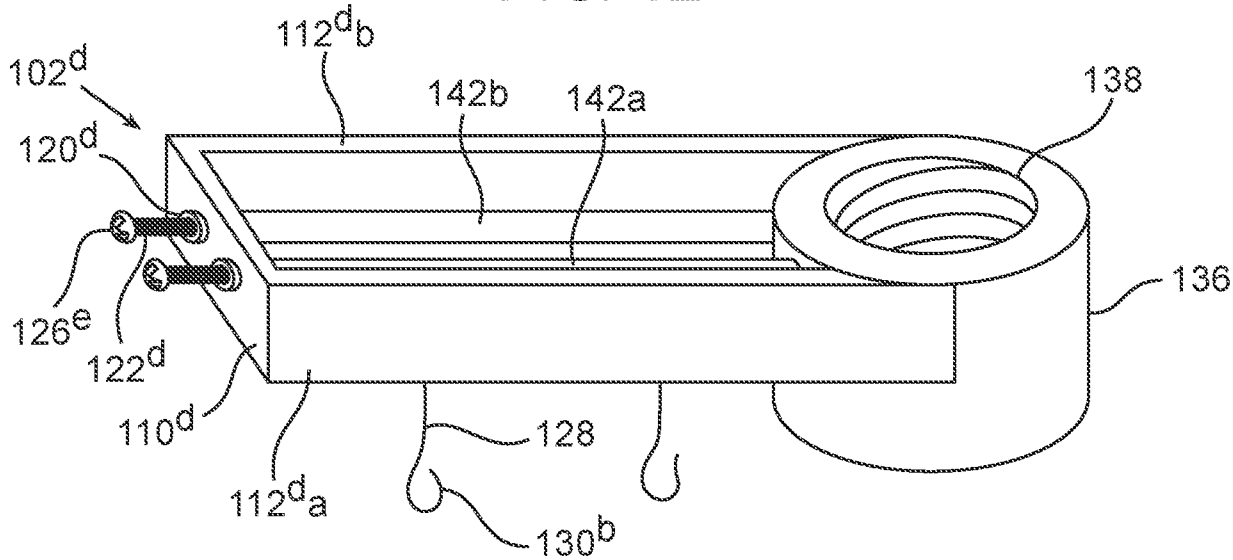


FIG. 13A

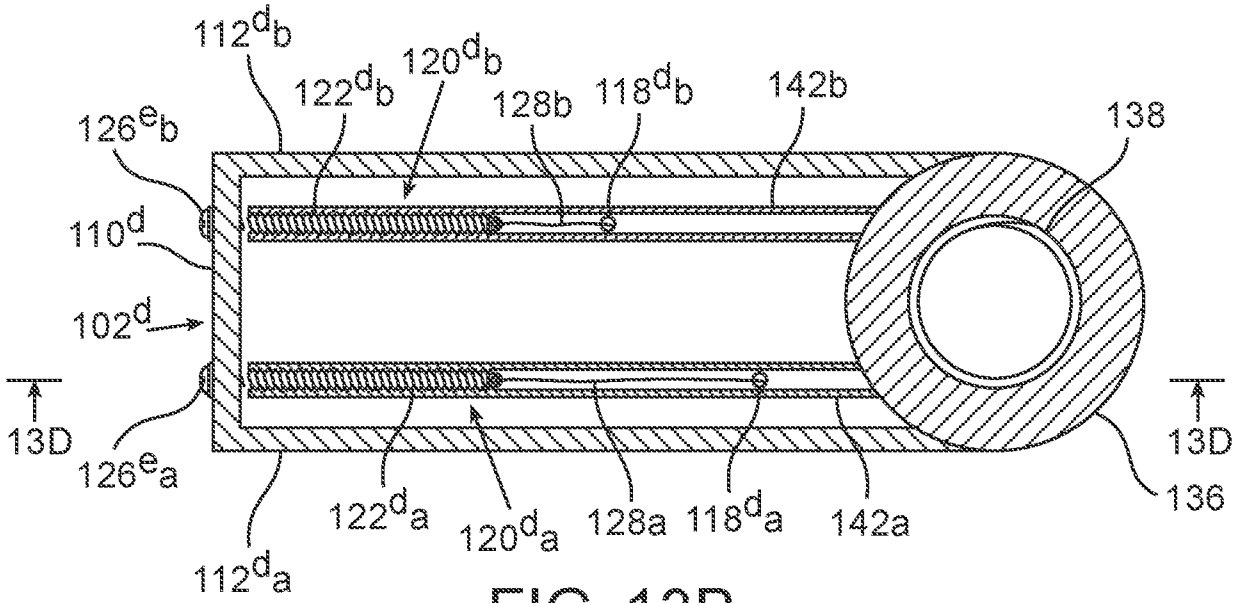


FIG. 13B

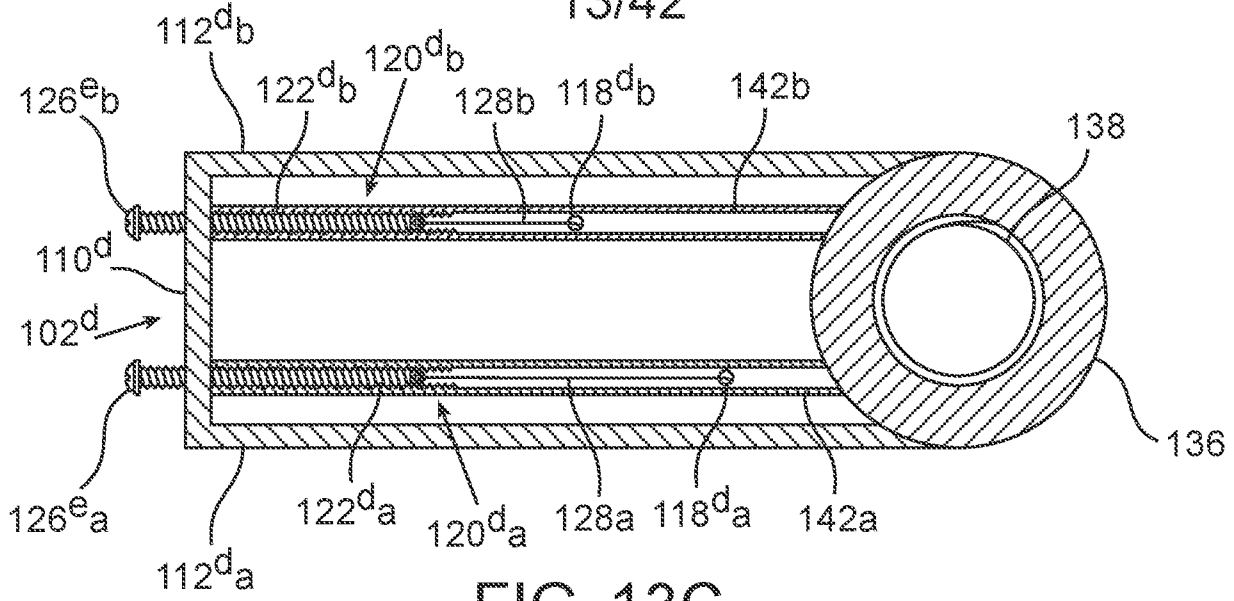


FIG. 13C

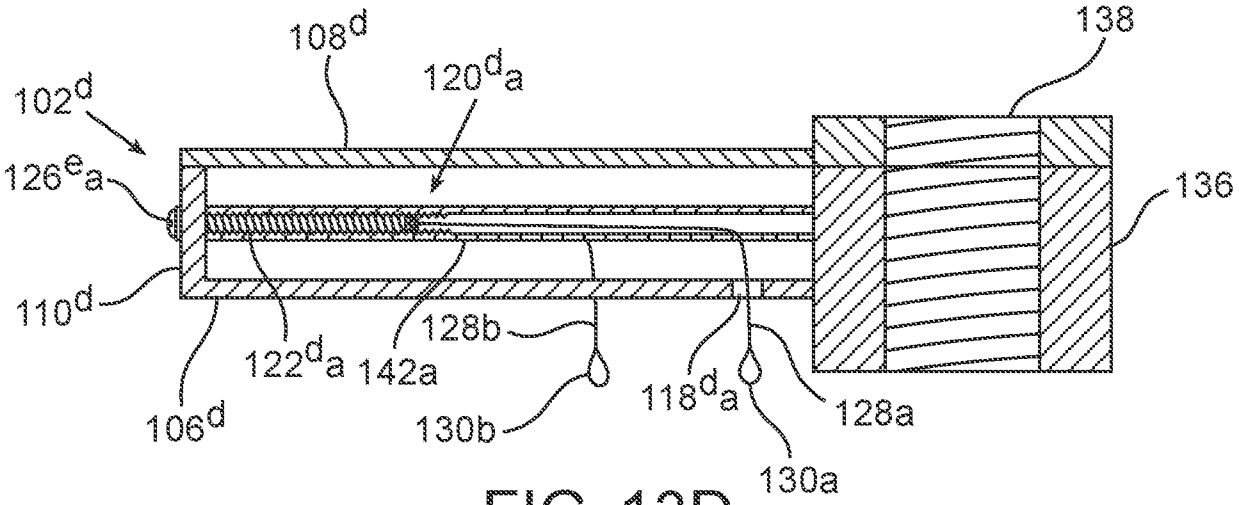


FIG. 13D

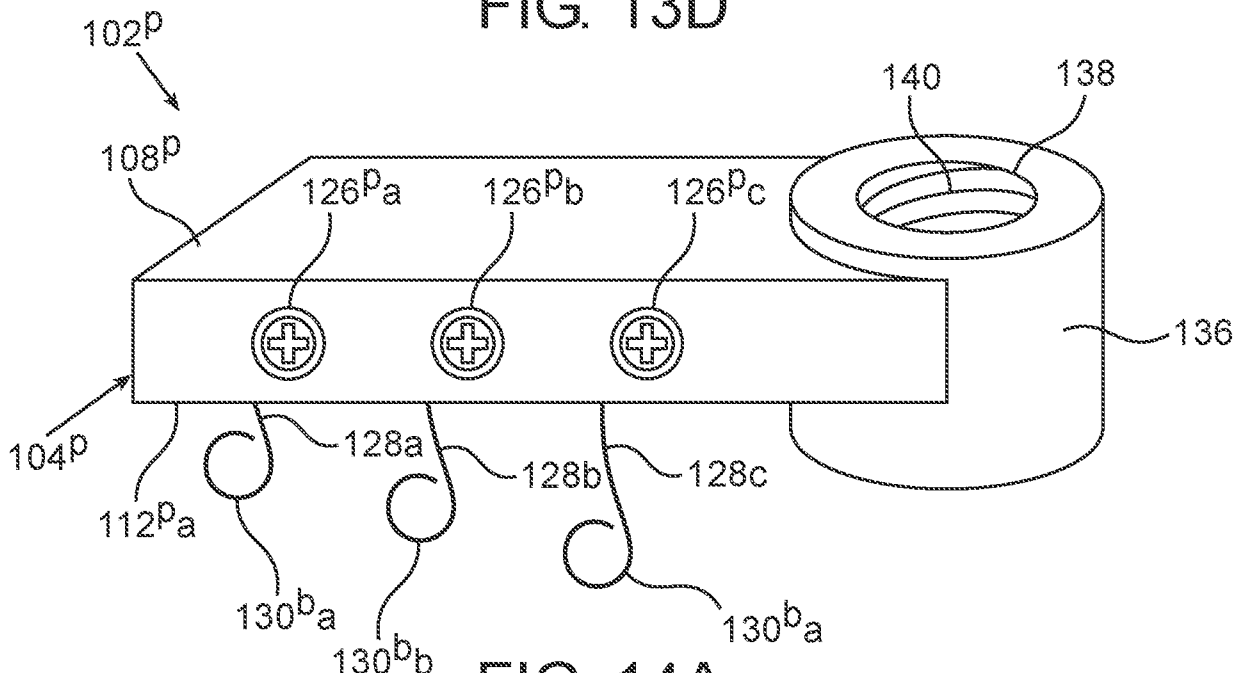


FIG. 14A

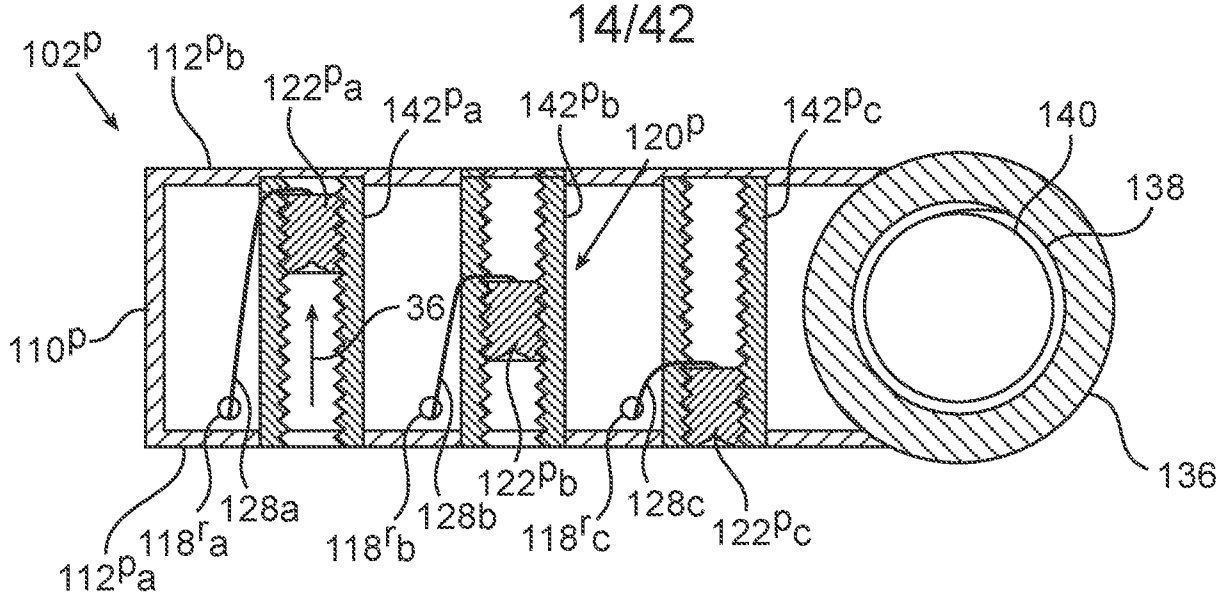


FIG. 14B

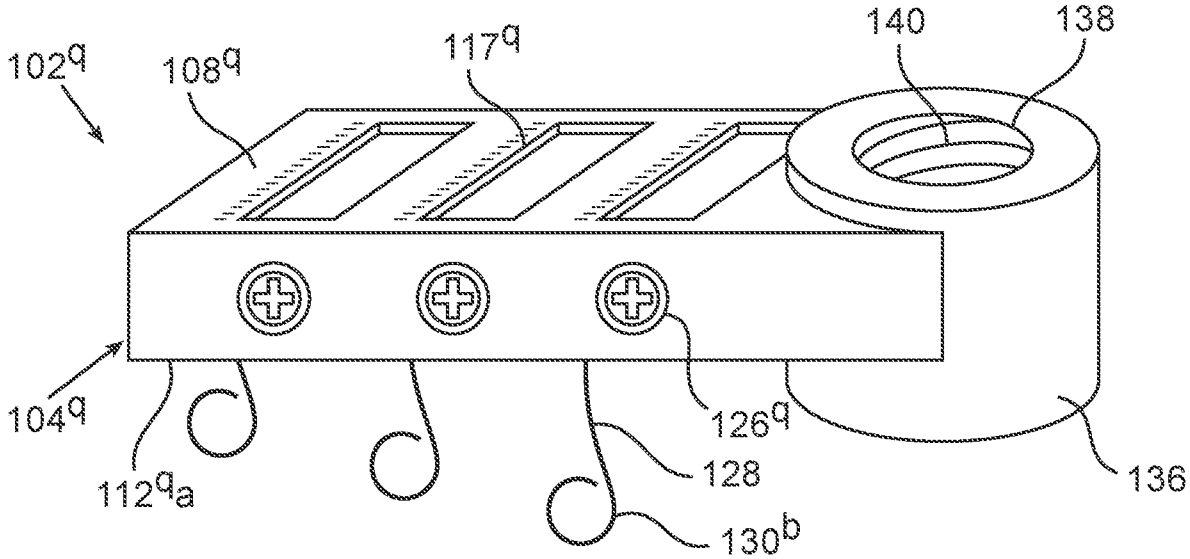


FIG. 14C

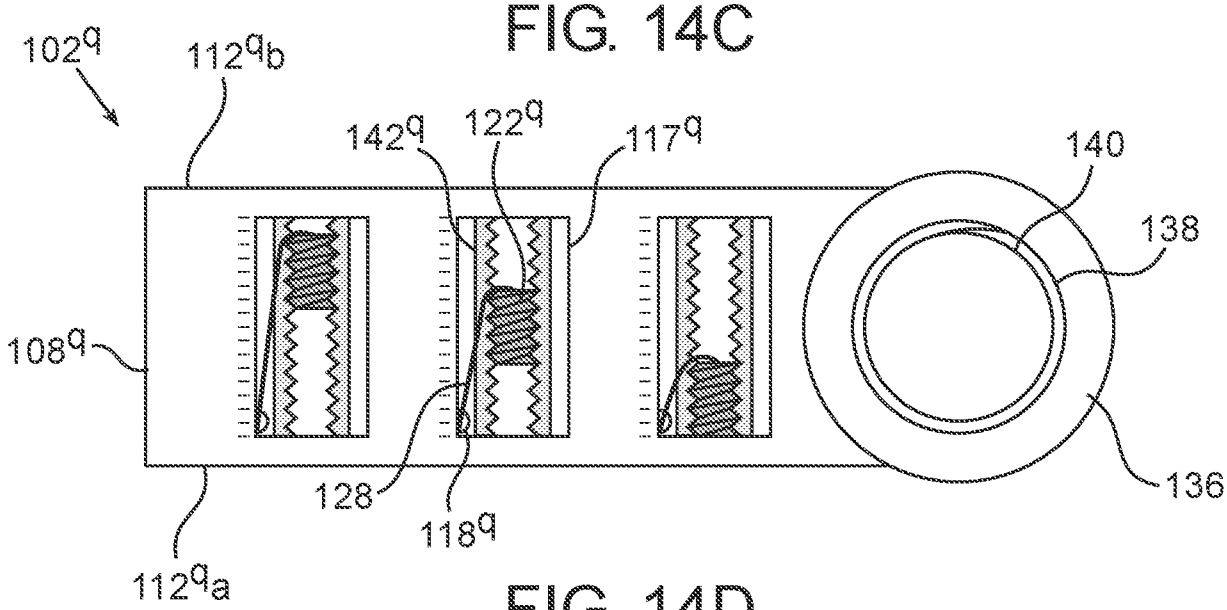


FIG. 14D

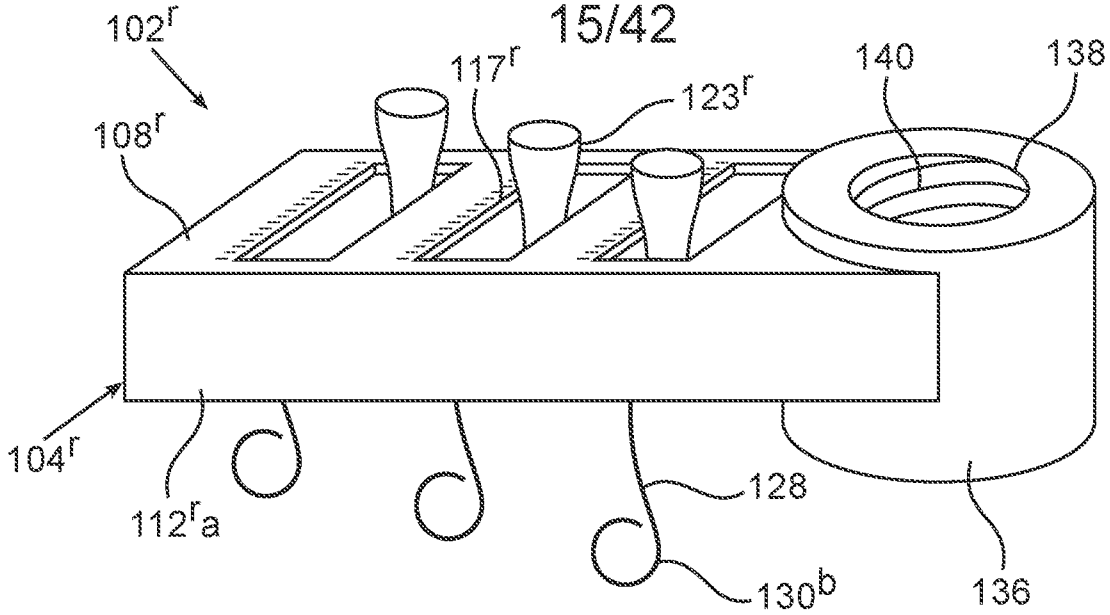


FIG. 14E

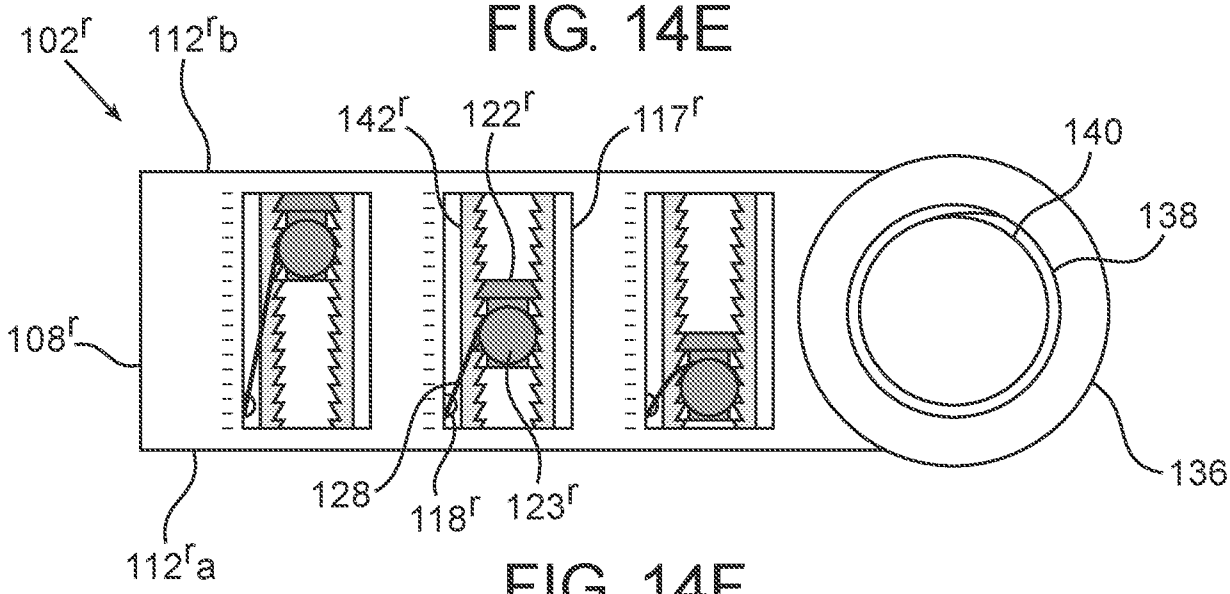


FIG. 14F

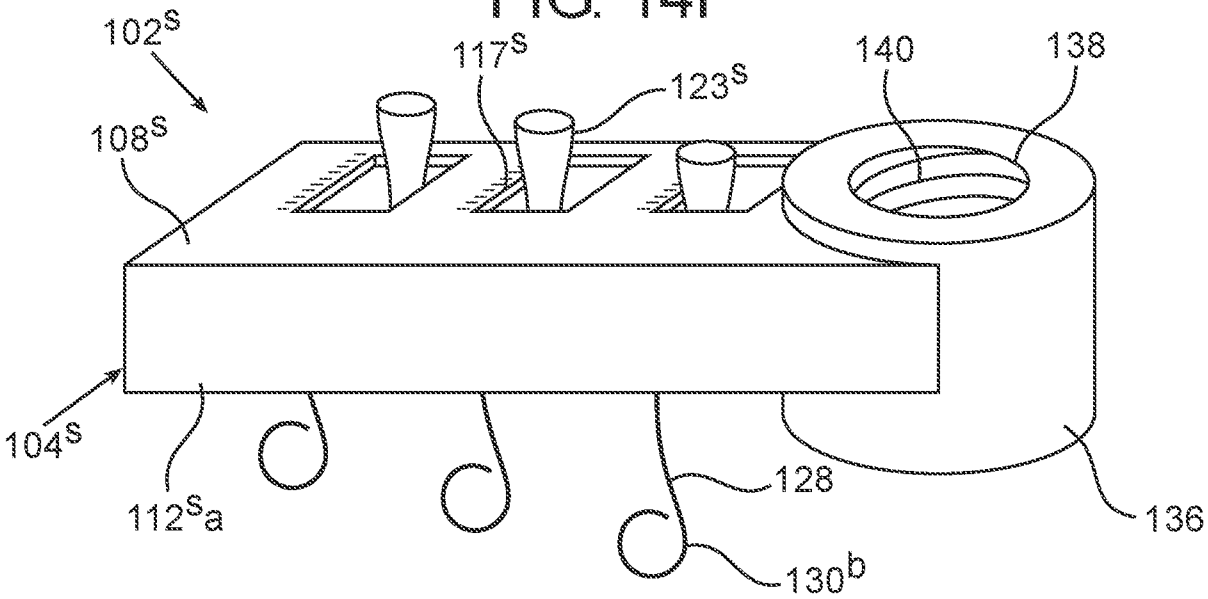


FIG. 14G

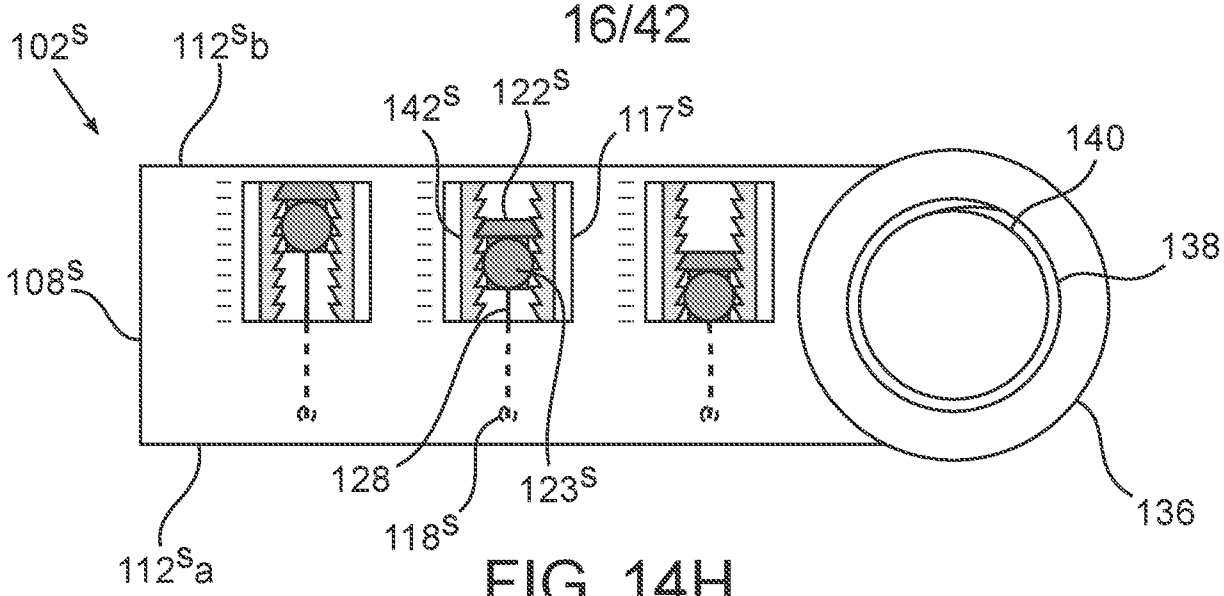


FIG. 14H

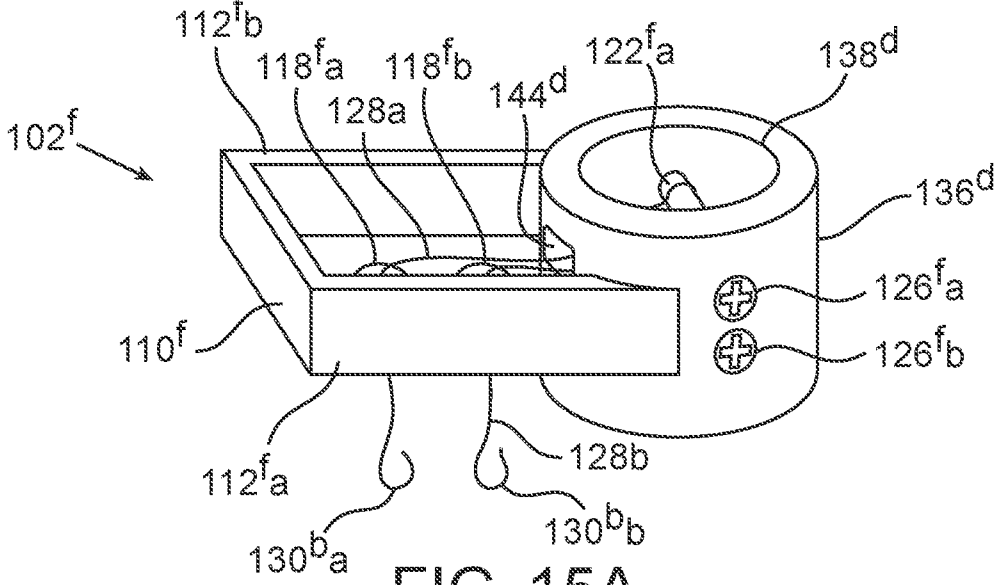


FIG. 15A

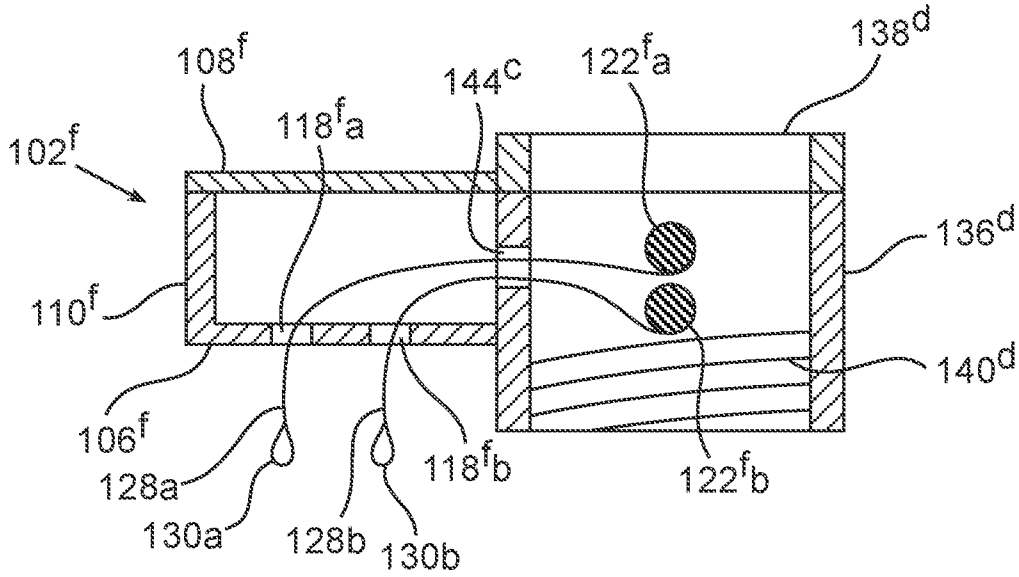


FIG. 15B

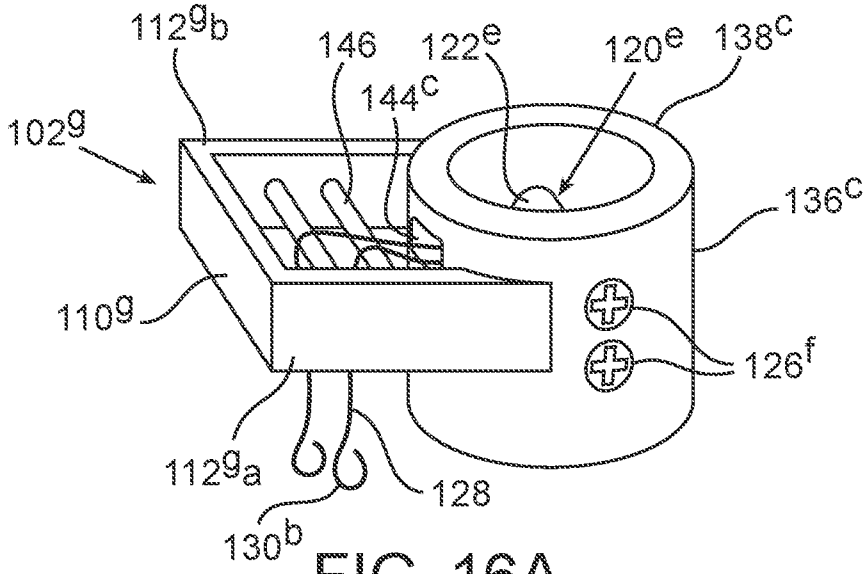


FIG. 16A

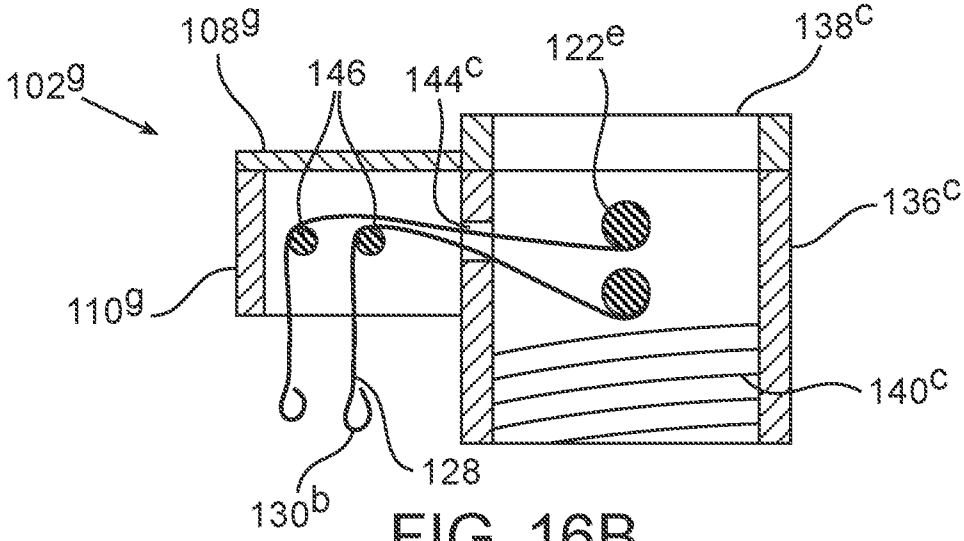


FIG. 16B

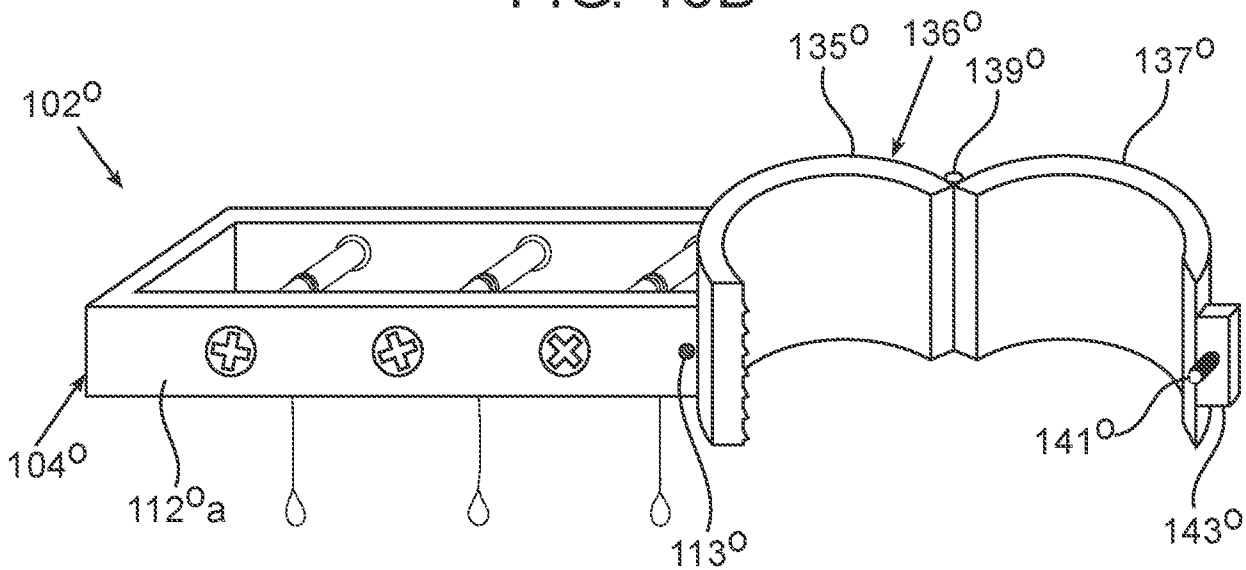


FIG. 17A

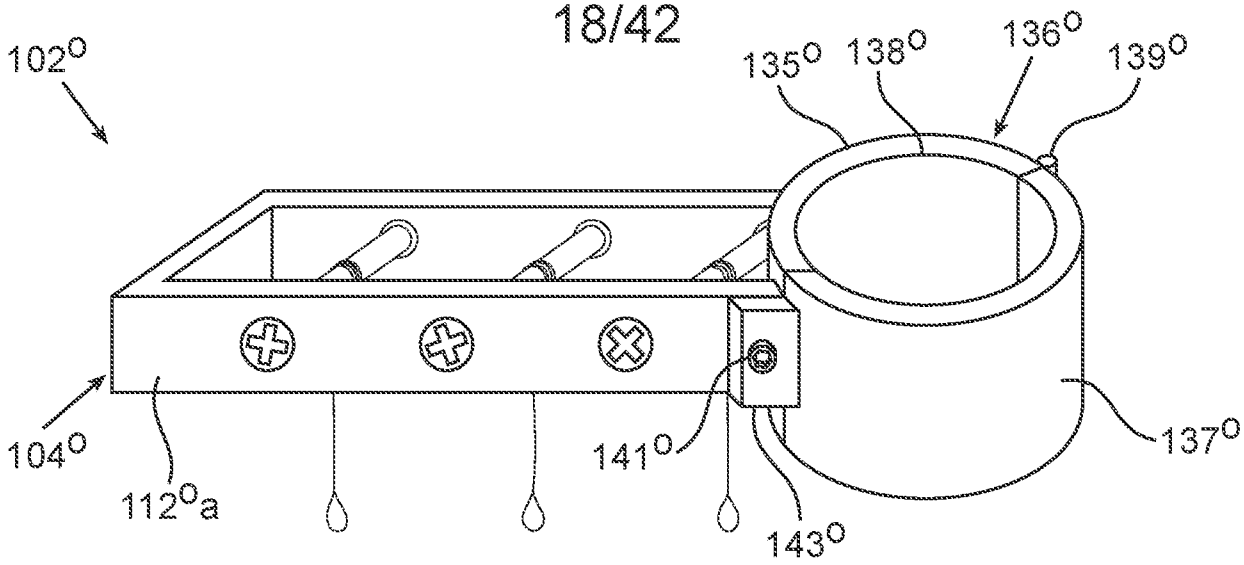


FIG. 17B

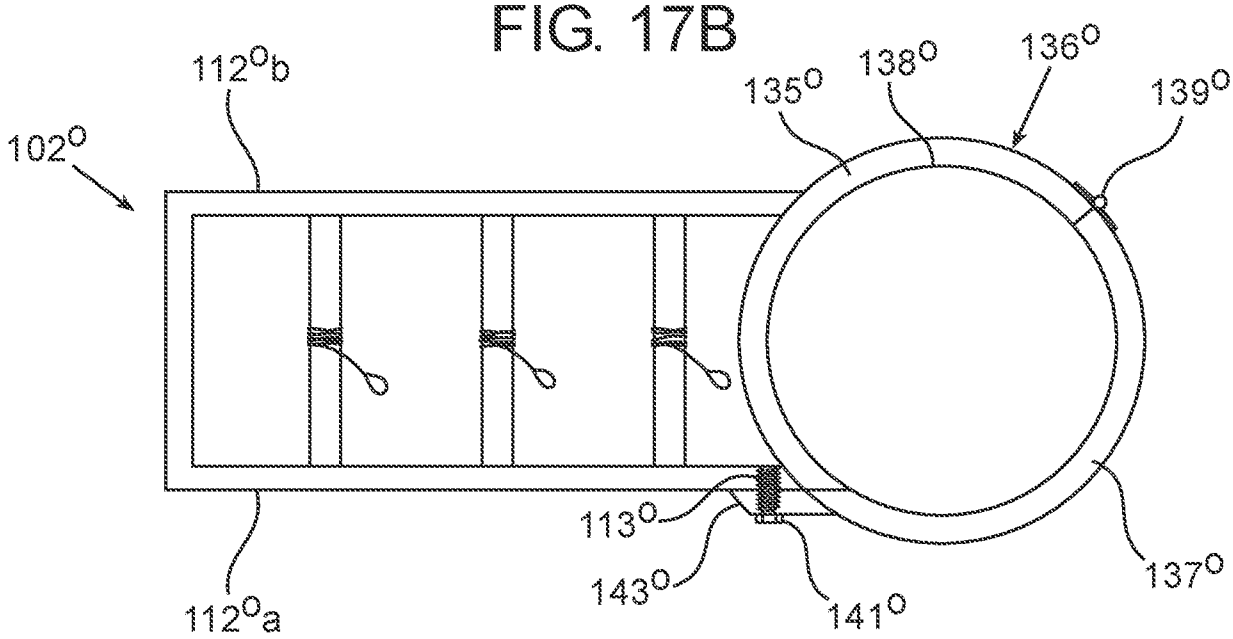


FIG. 17C

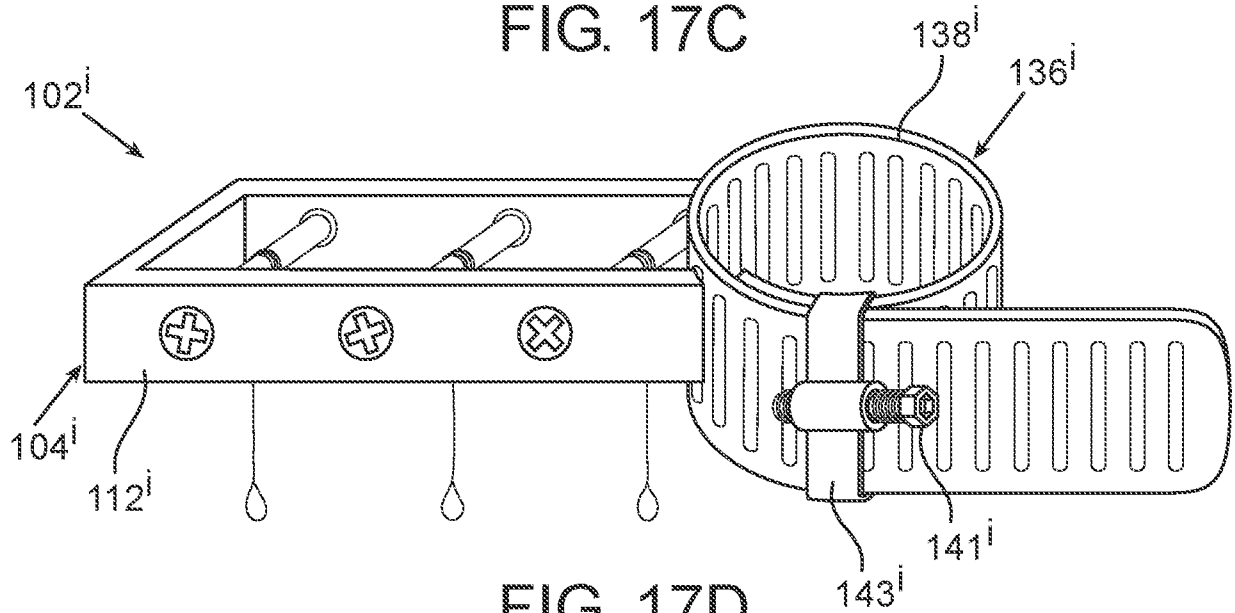


FIG. 17D

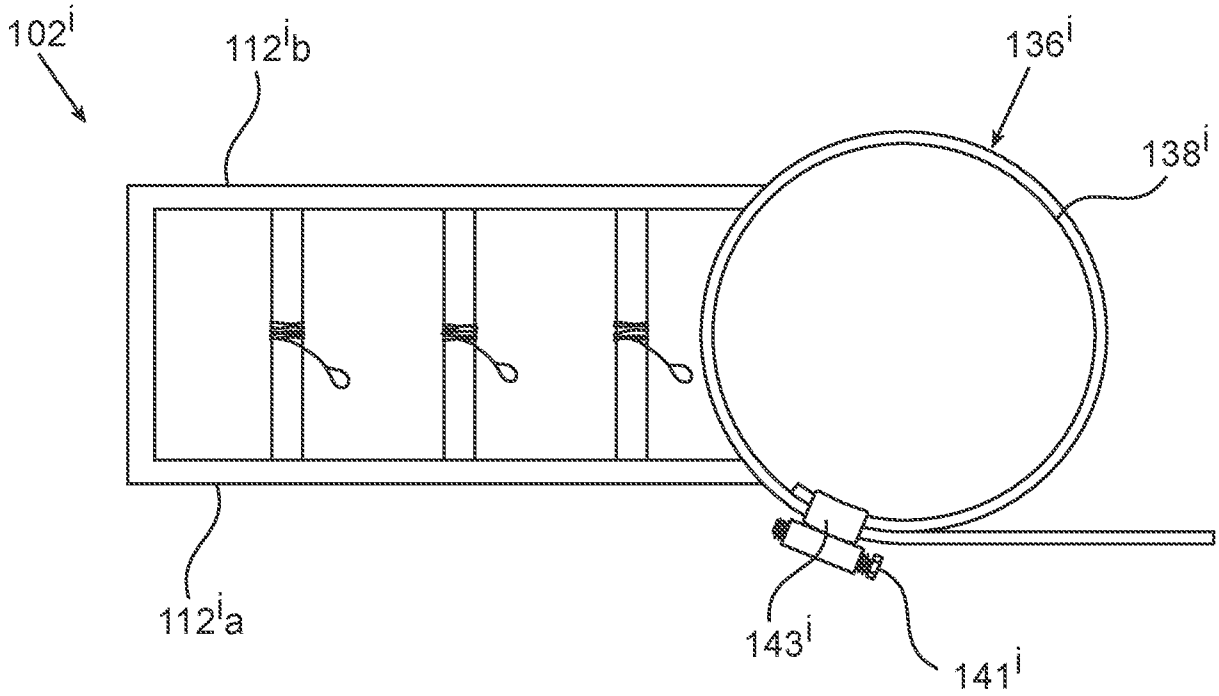


FIG. 17E

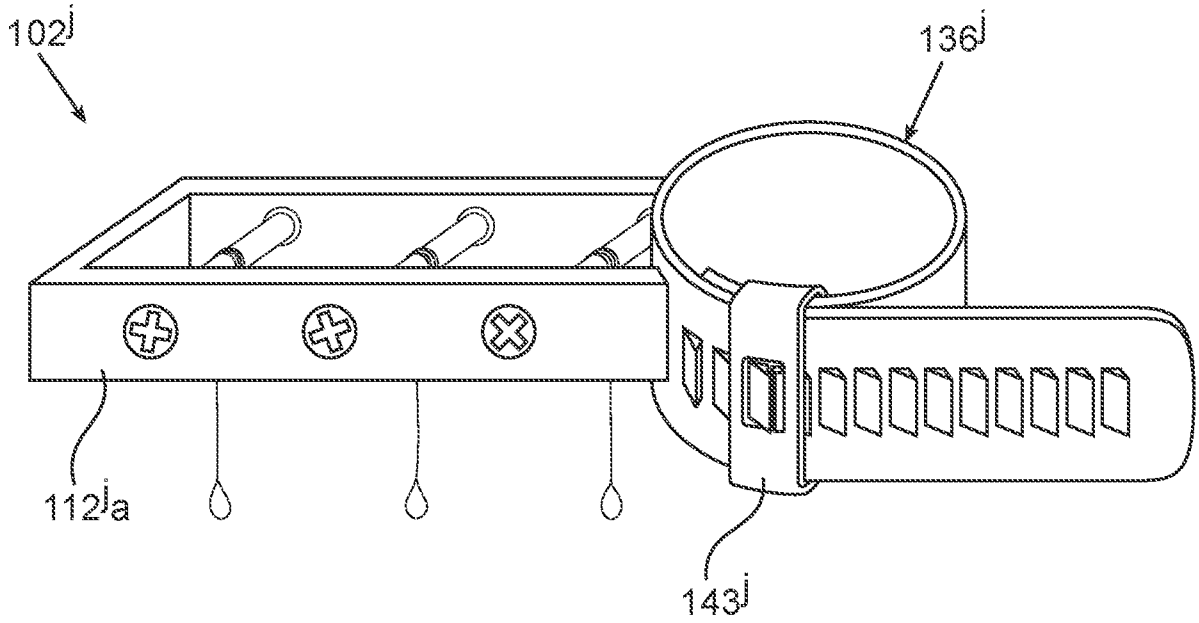


FIG. 17F

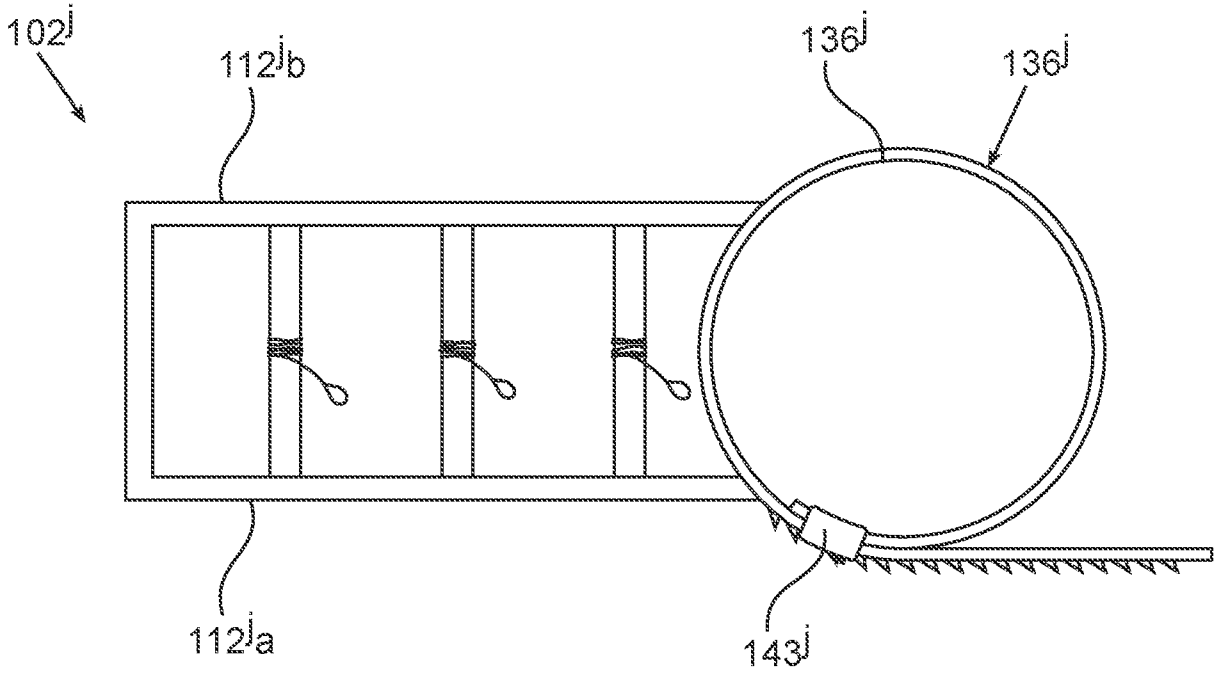


FIG. 17G

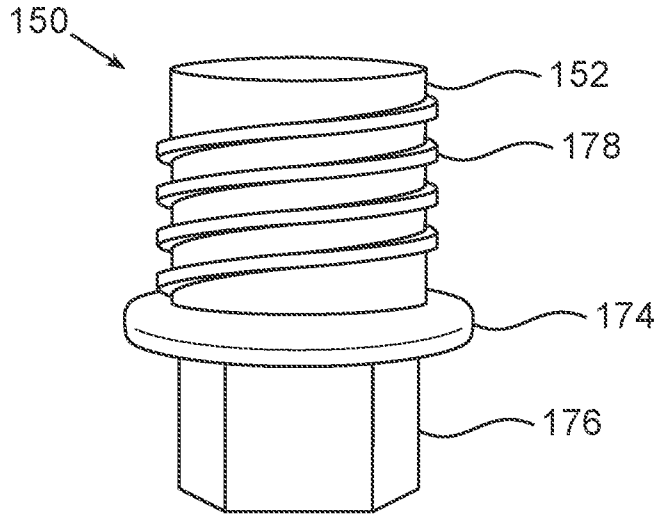


FIG. 18A

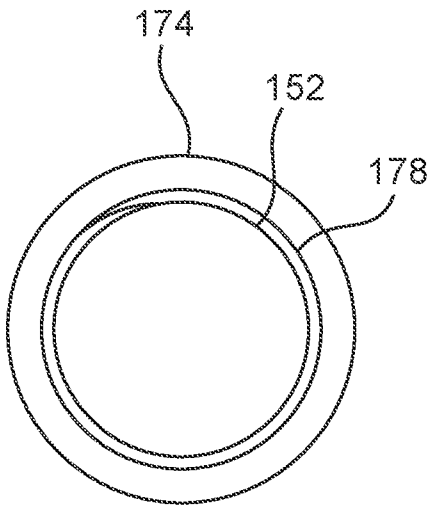


FIG. 18B

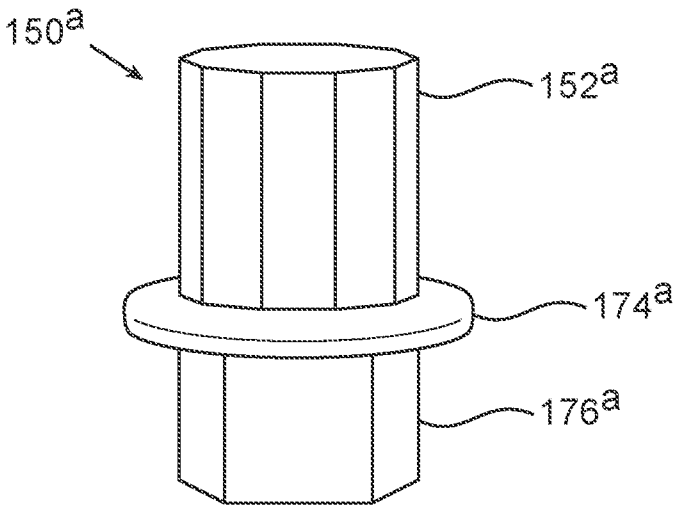


FIG. 18C

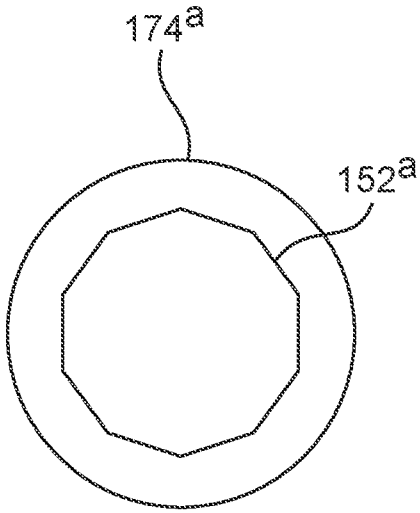


FIG. 18D

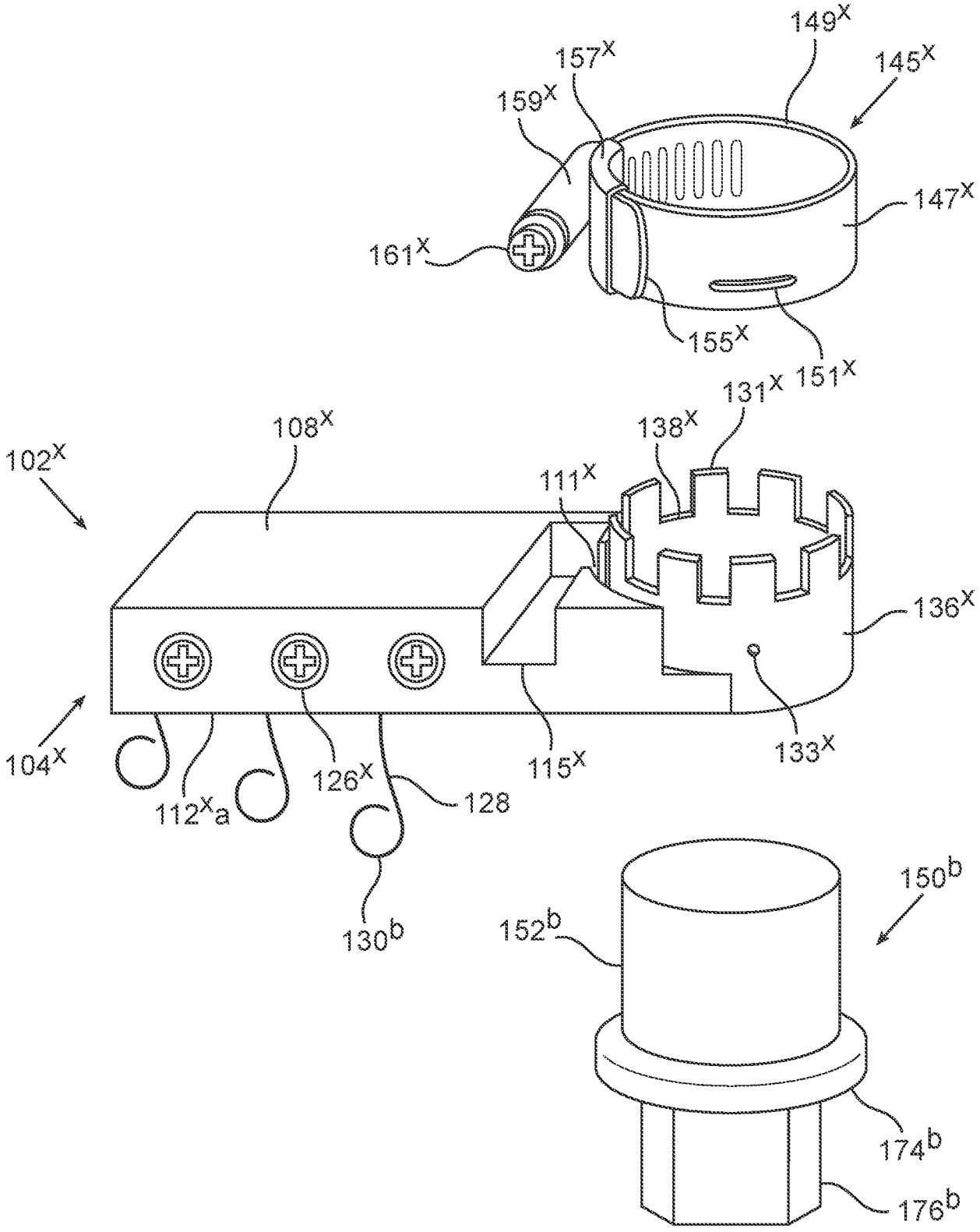

149x
157x
145x
159x
147x
161x
155x
151x
131x
108x
138x
102x
111x
136x
104x
133x
115x
126x
128
112xa
130b
150b
152b
174b
176b

FIG. 19A

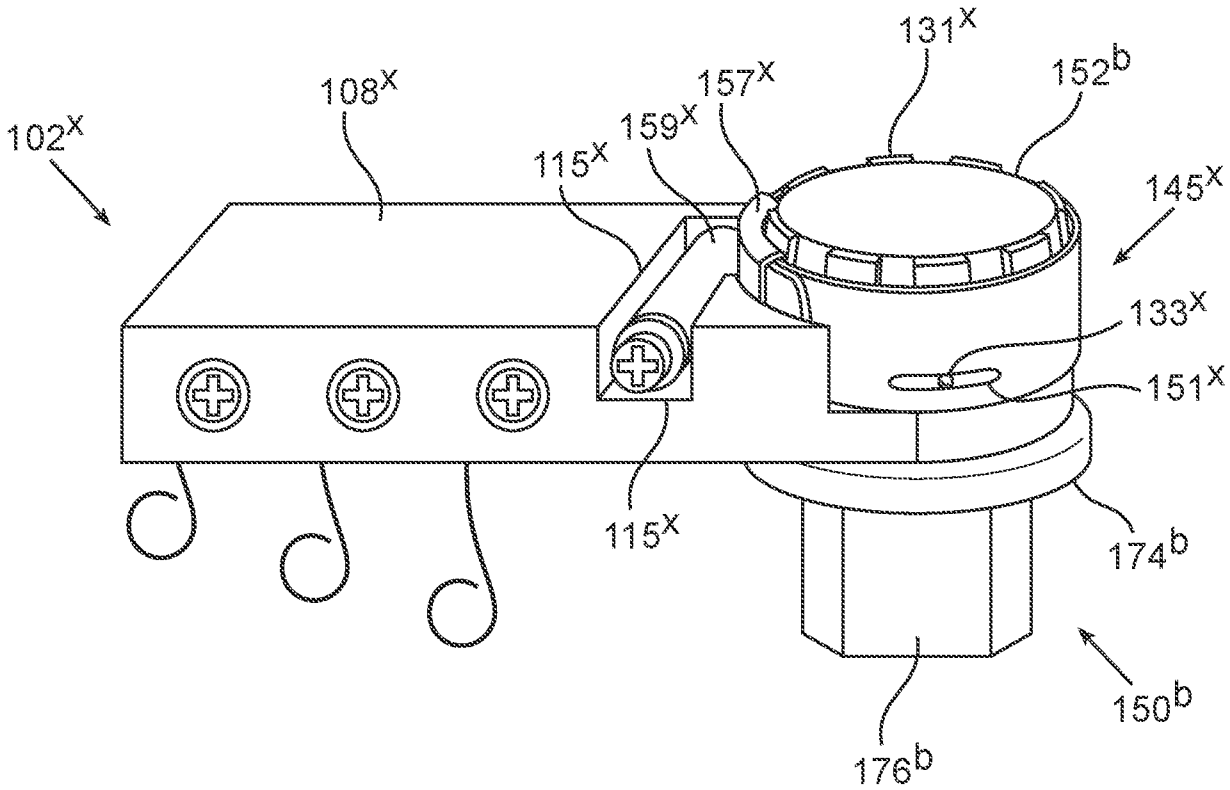
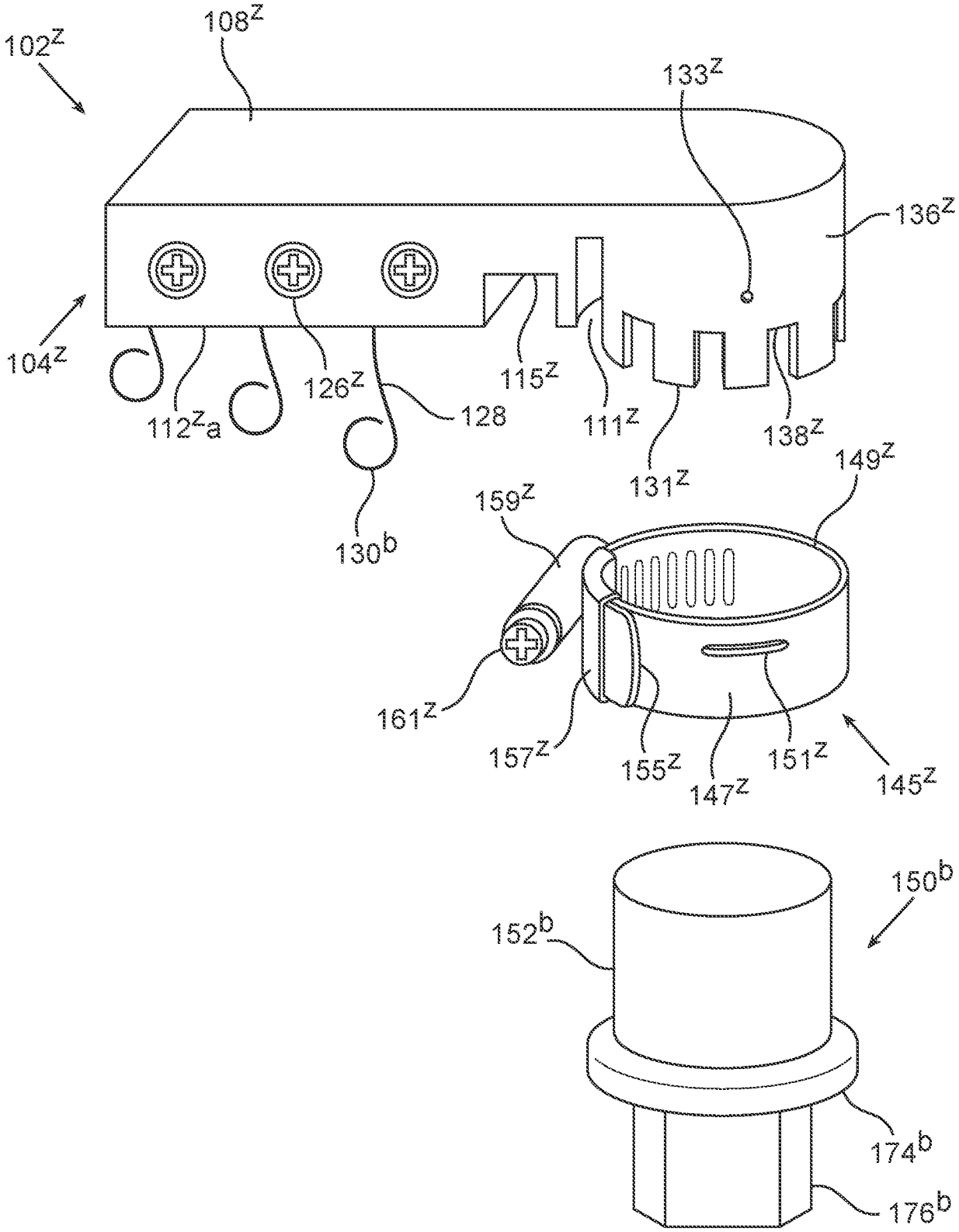

102x
108x
115x
159x
157x
131x
152b
145x
133x
151x
115x
174b
150b
176b

FIG. 19B


102z
108z
133z
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104z
112za
126z
128
115z
111z
138z
131z
130b
159z
149z
161z
157z
155z
147z
151z
145z
150b
152b
174b
176b

FIG. 20A

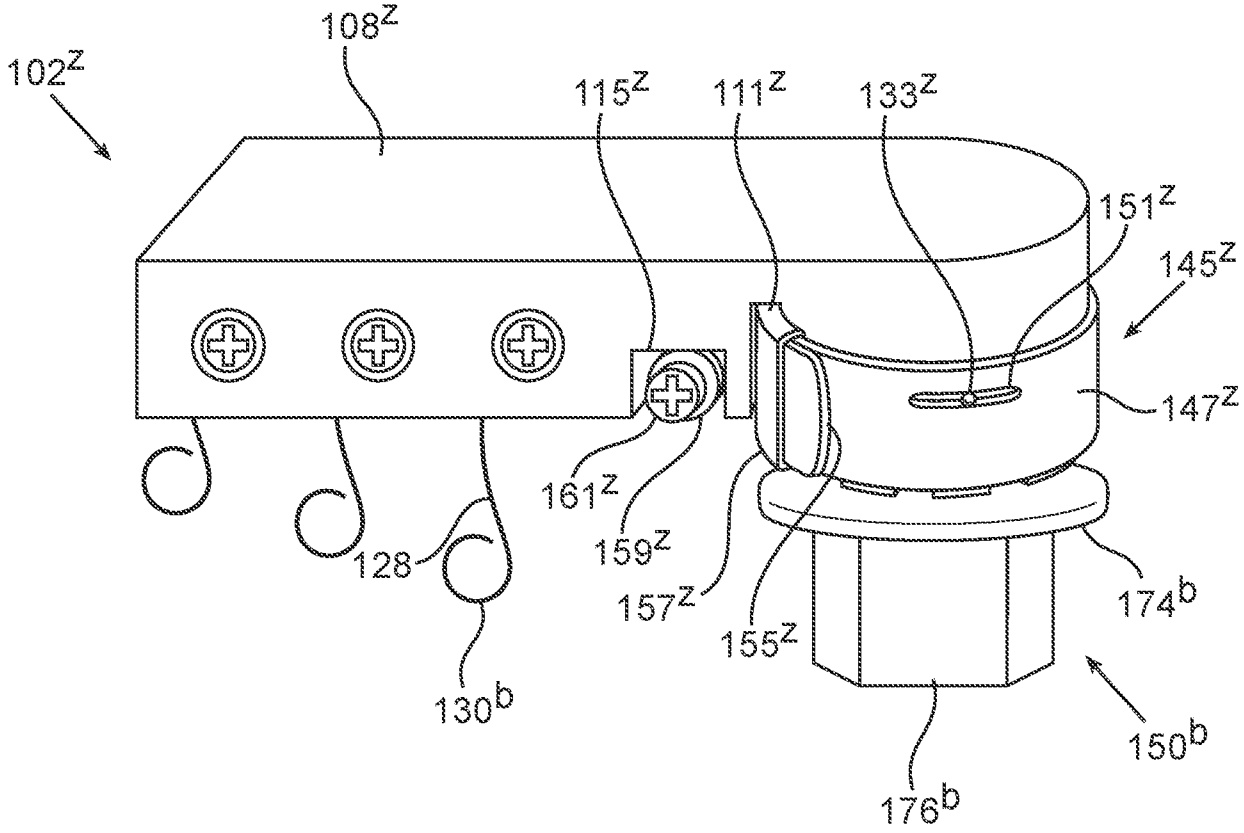

102z
108z
115z
111z
133z
151z
145z
147z
161z
159z
157z
155z
128
130b
174b
150b
176b

FIG. 20B

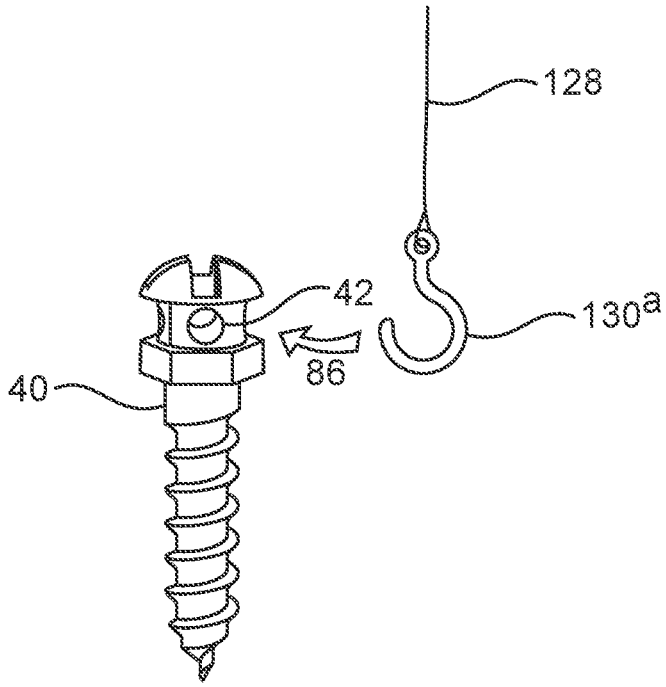


FIG. 21A

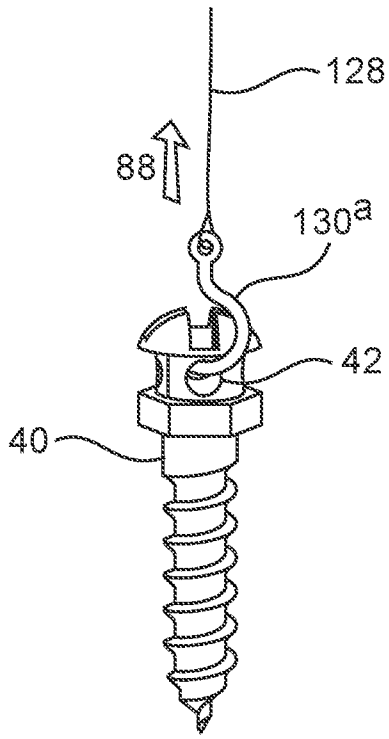


FIG. 21B

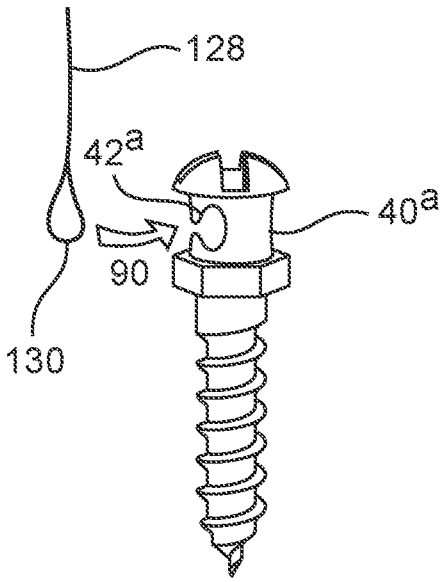


FIG. 21C

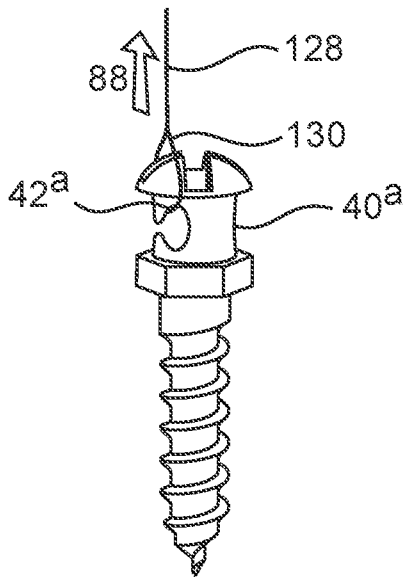


FIG. 21D

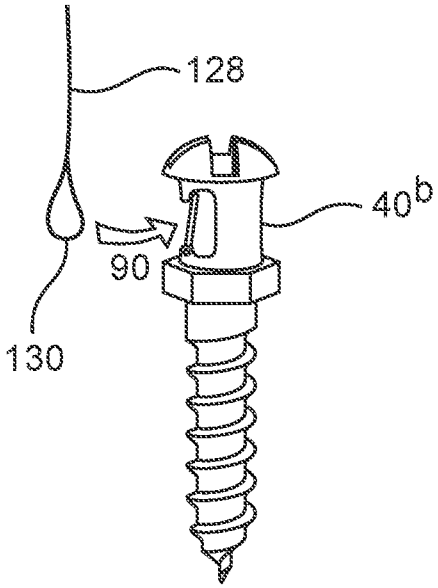


FIG. 21E

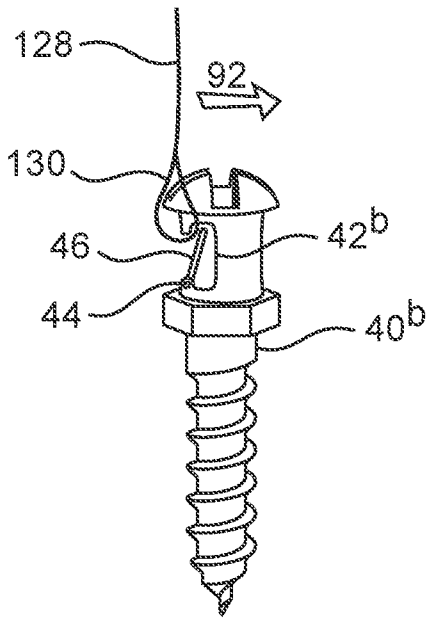


FIG. 21F

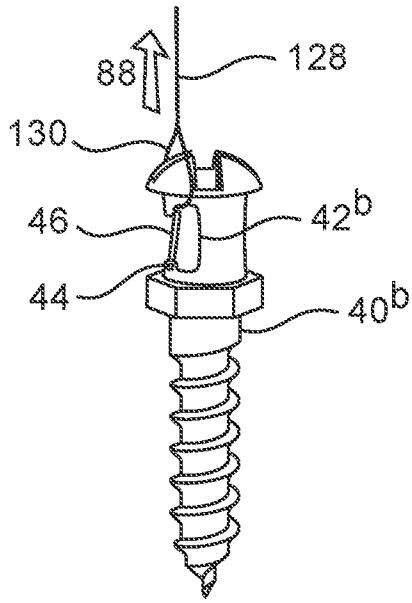


FIG. 21G

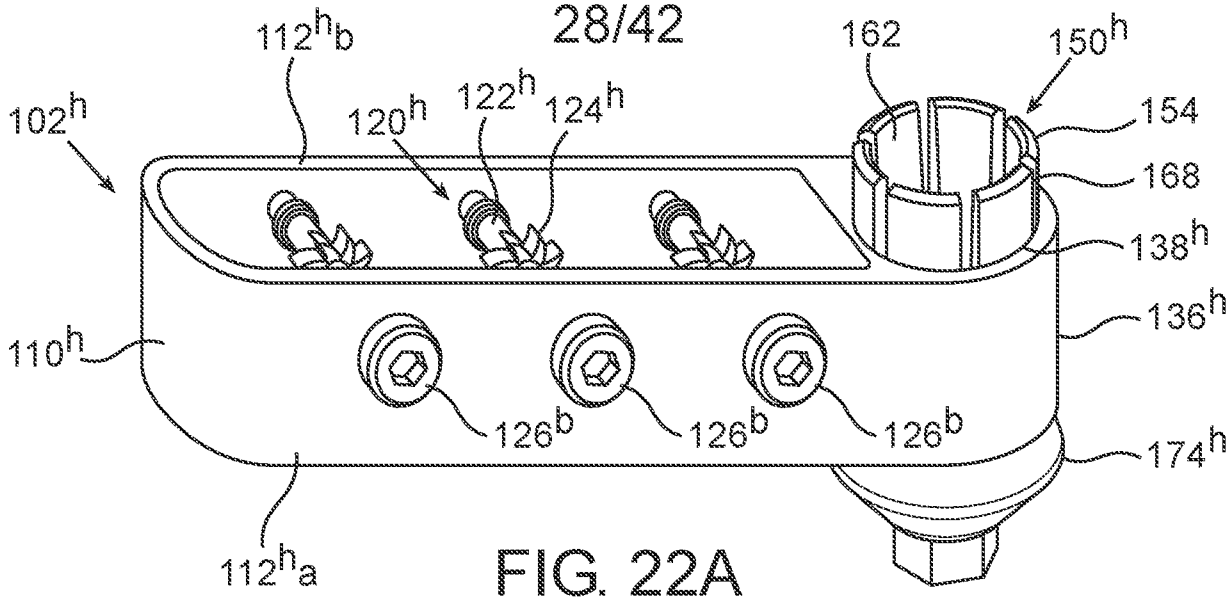


FIG. 22A

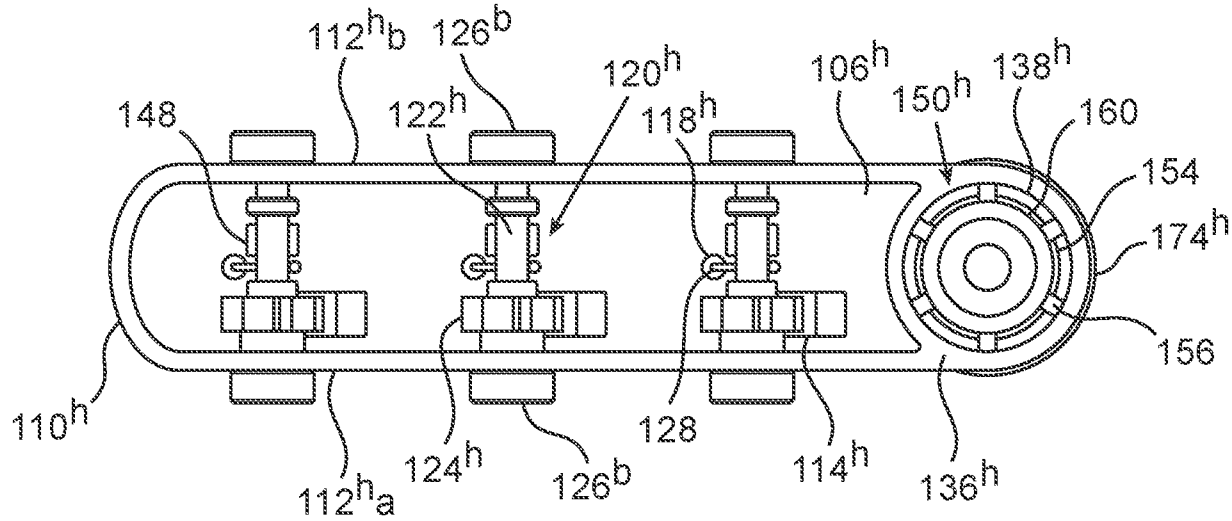


FIG. 22B

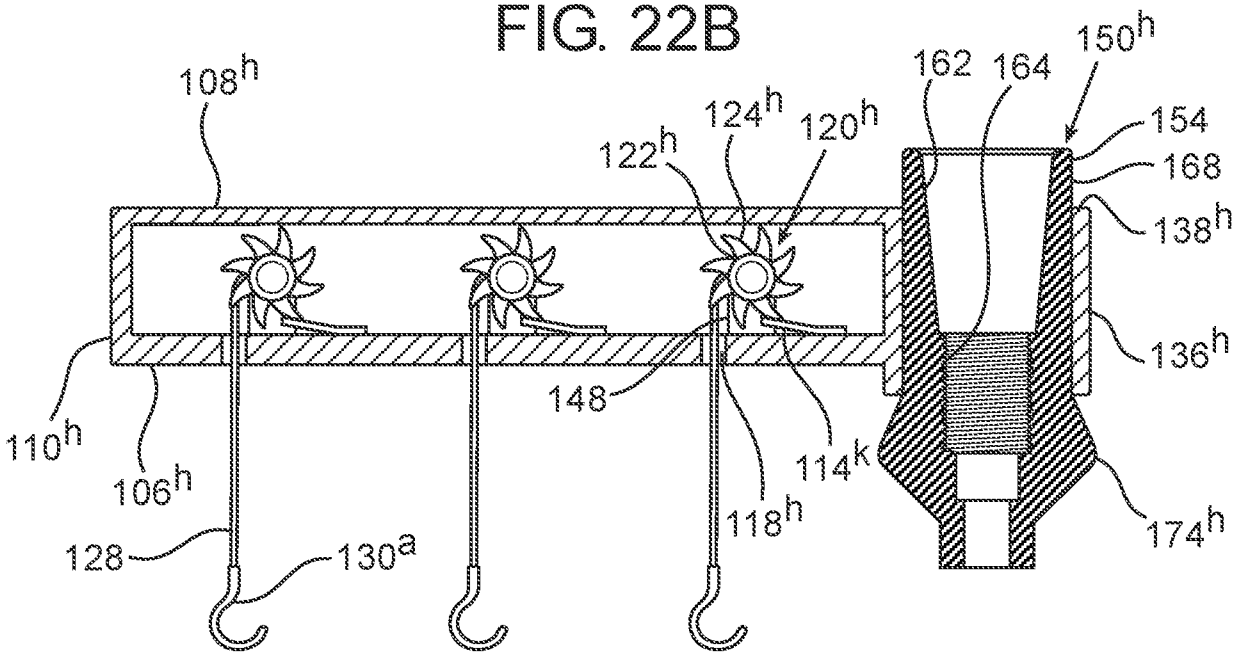


FIG. 22C

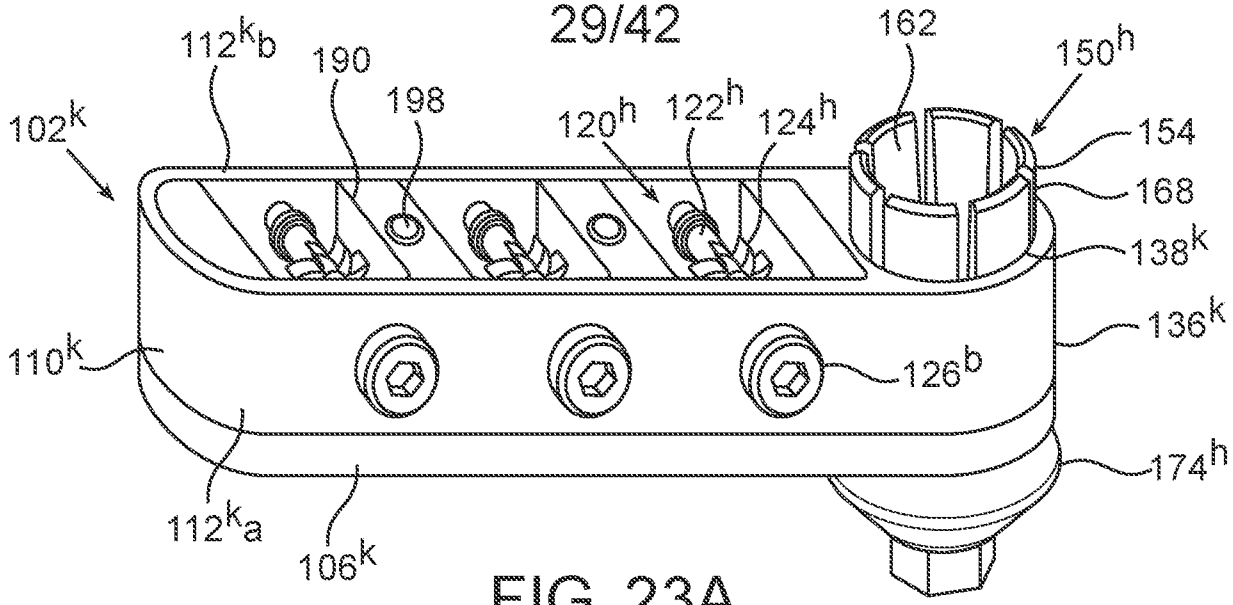


FIG. 23A

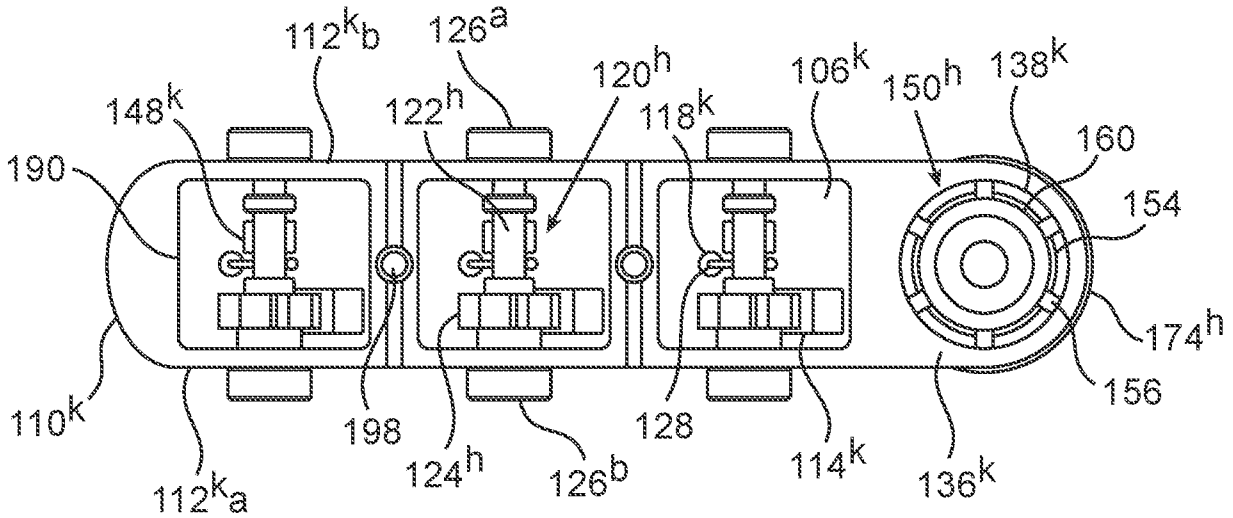


FIG. 23B

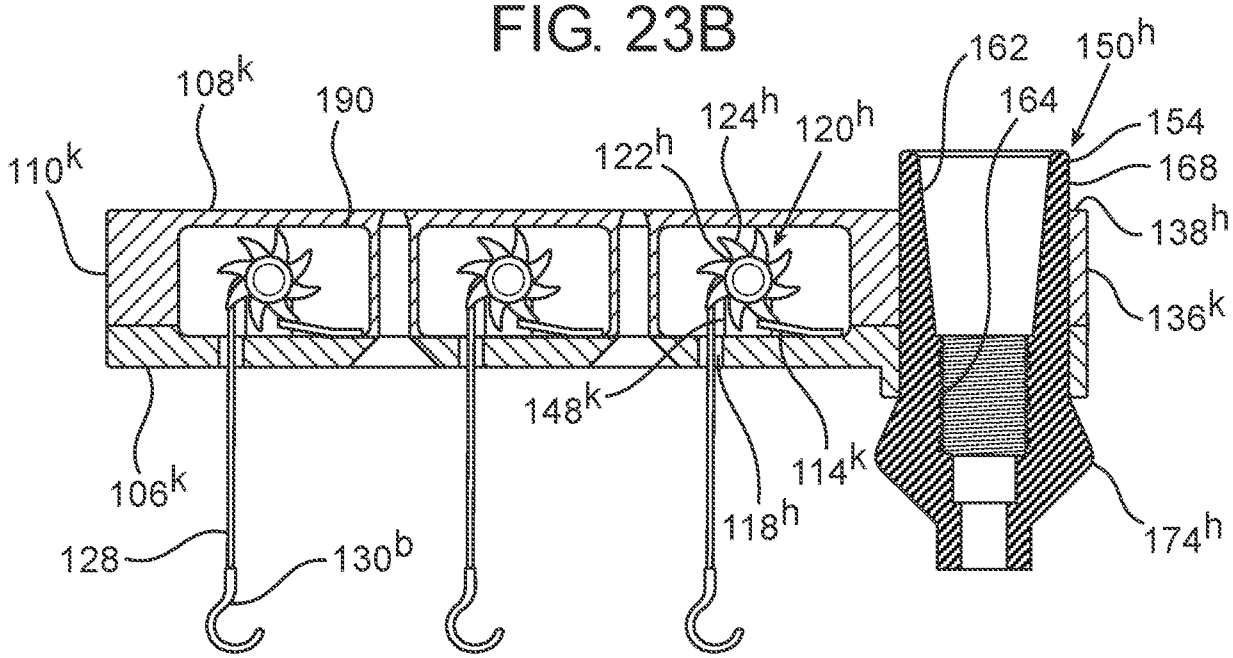


FIG. 23C

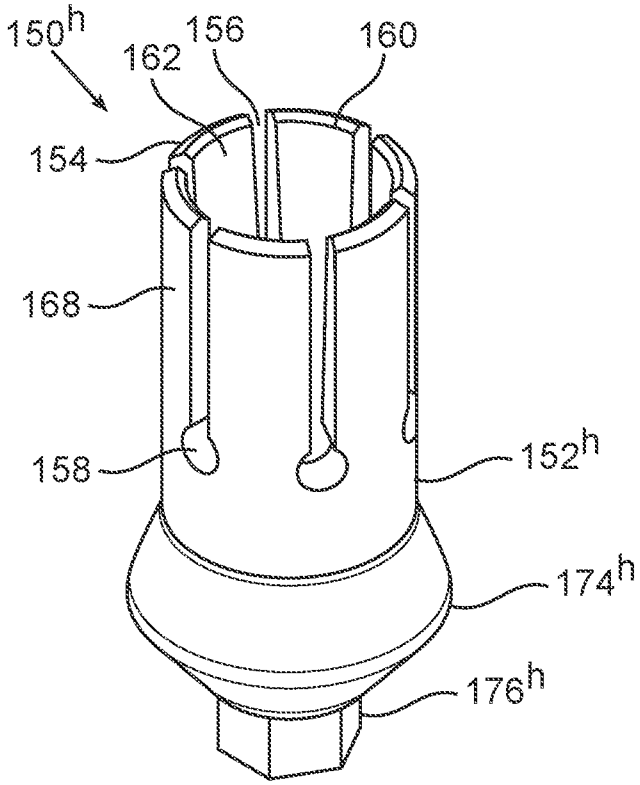


FIG. 24A

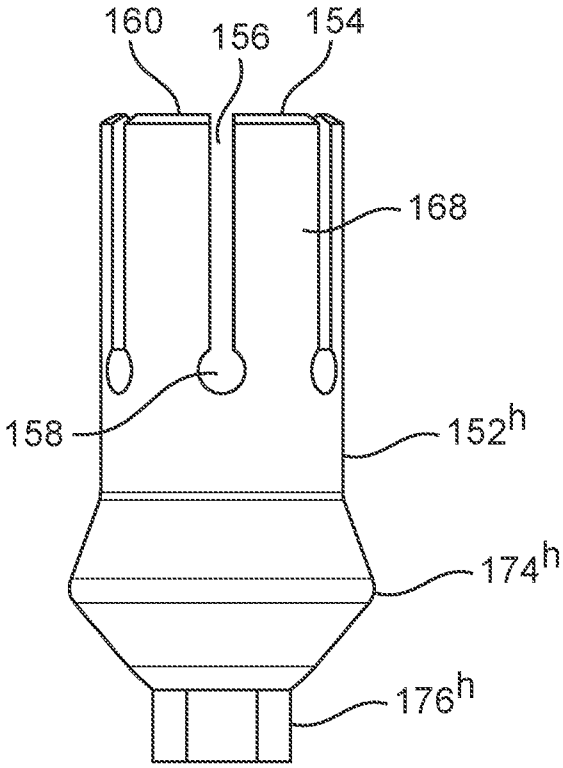


FIG. 24B

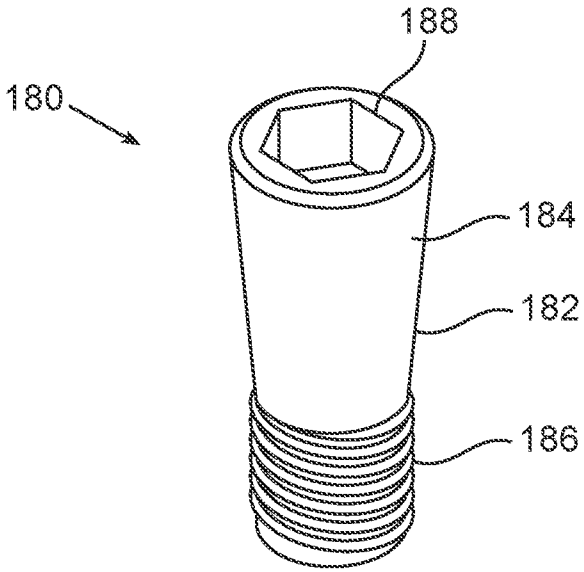


FIG. 25

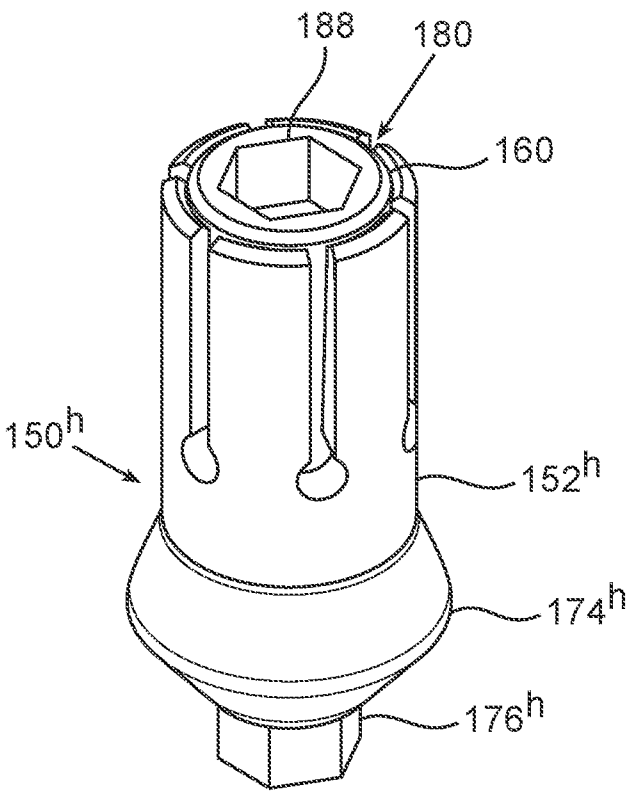


FIG. 26A

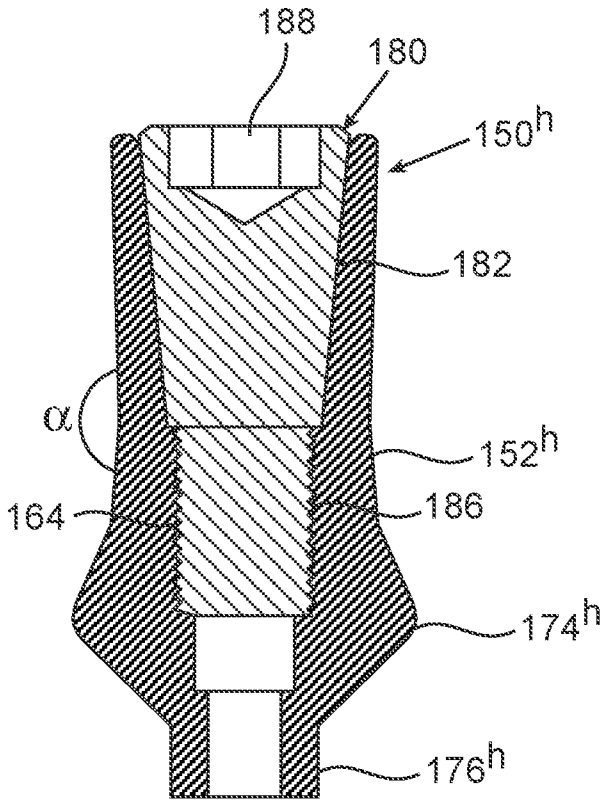
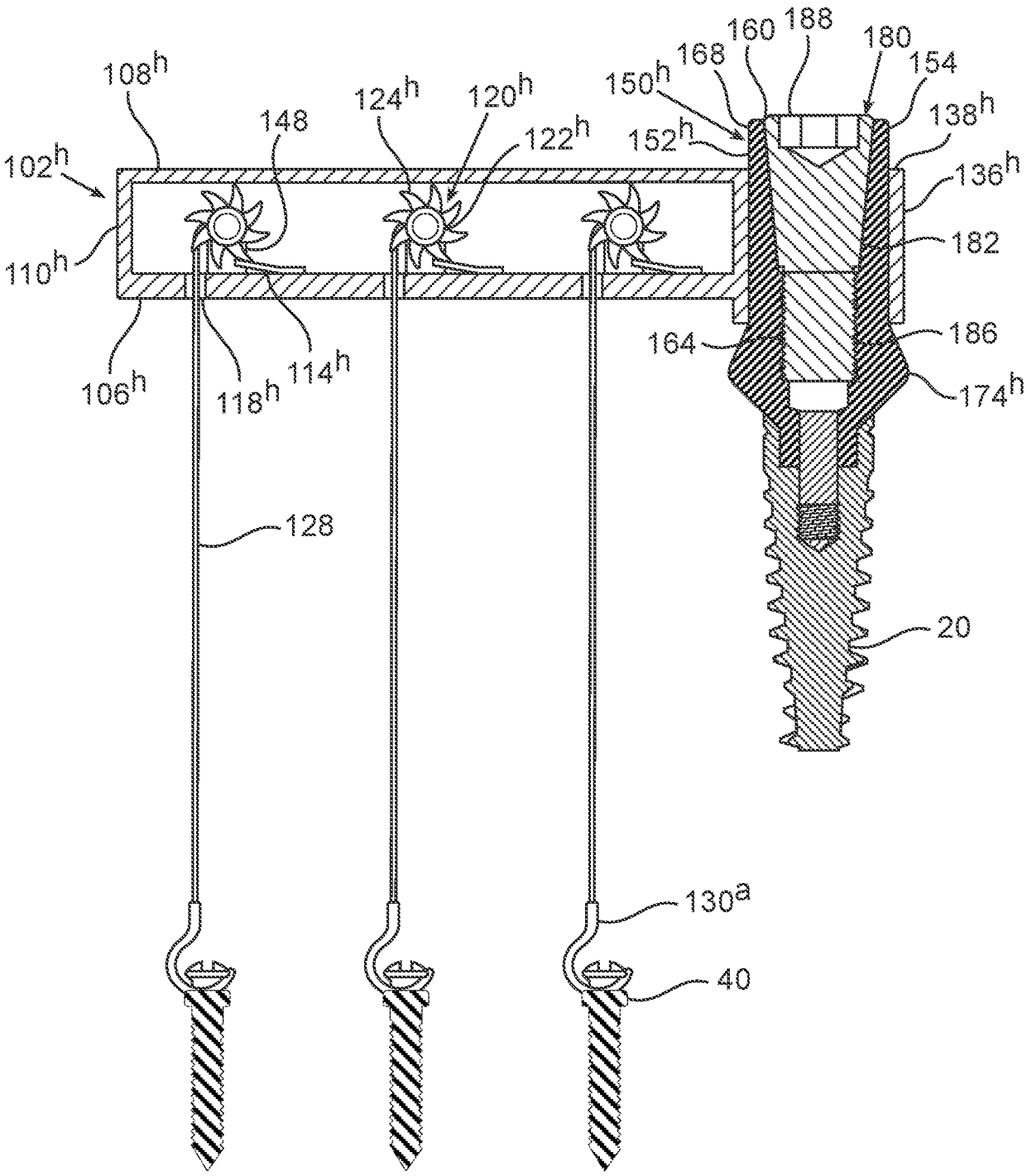


FIG. 26B


108h
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120h
150h
168
160
188
180
154
102h
122h
152h
138h
136h
110h
182
164
186
106h
118h
114h
174h
128
20
130a
40

FIG. 27

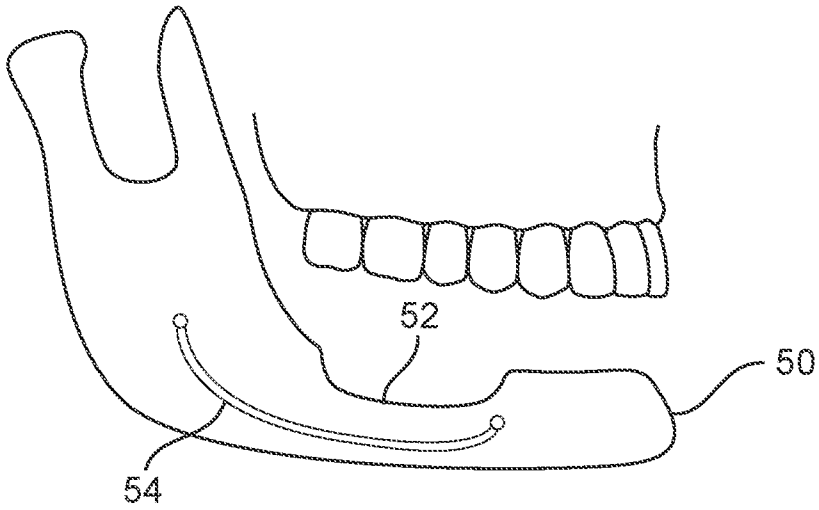


FIG. 28A

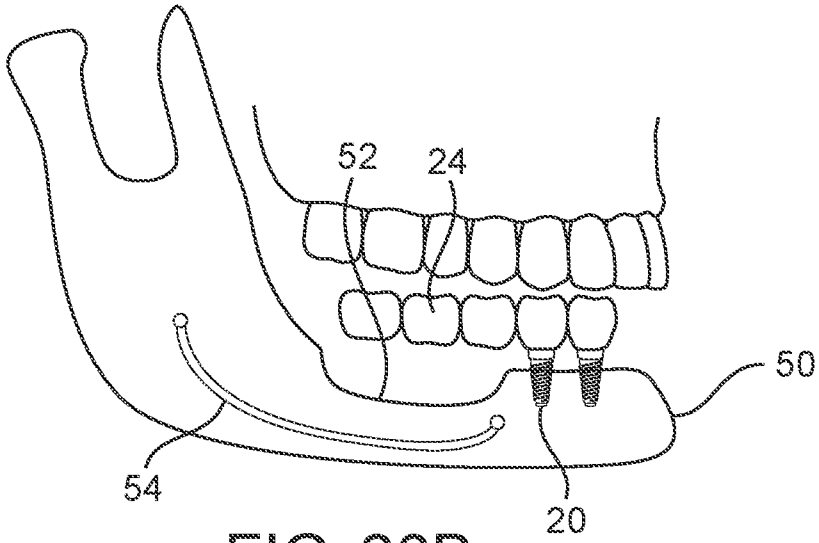


FIG. 28B

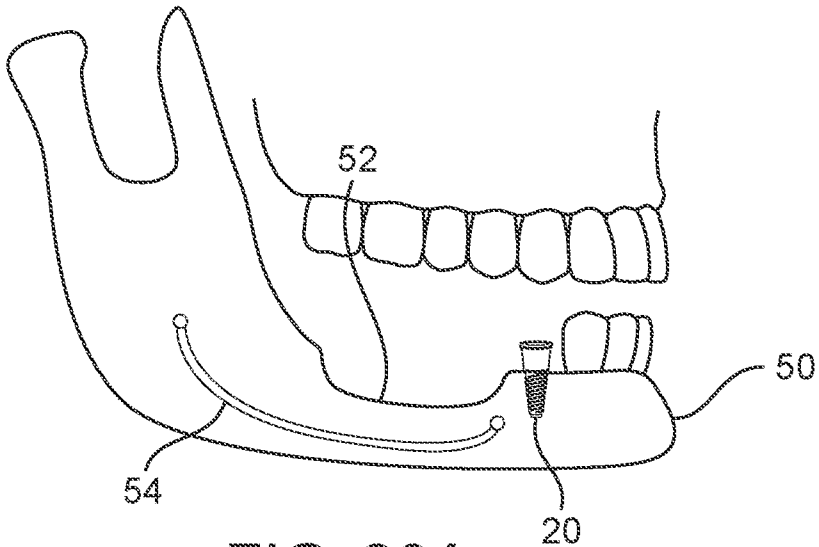


FIG. 29A

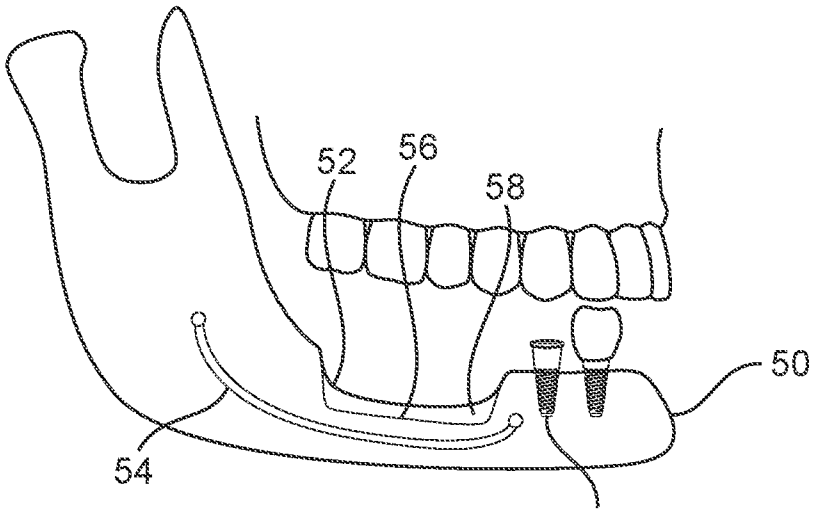


FIG. 29B

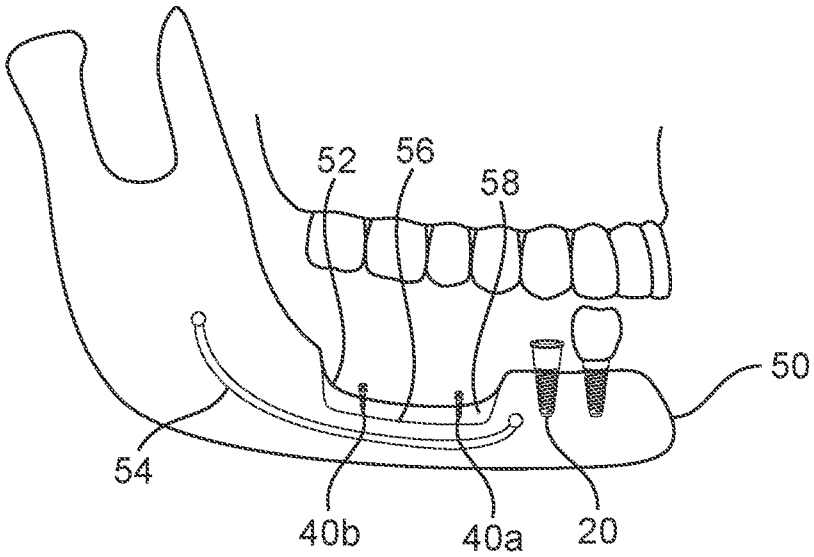


FIG. 29C

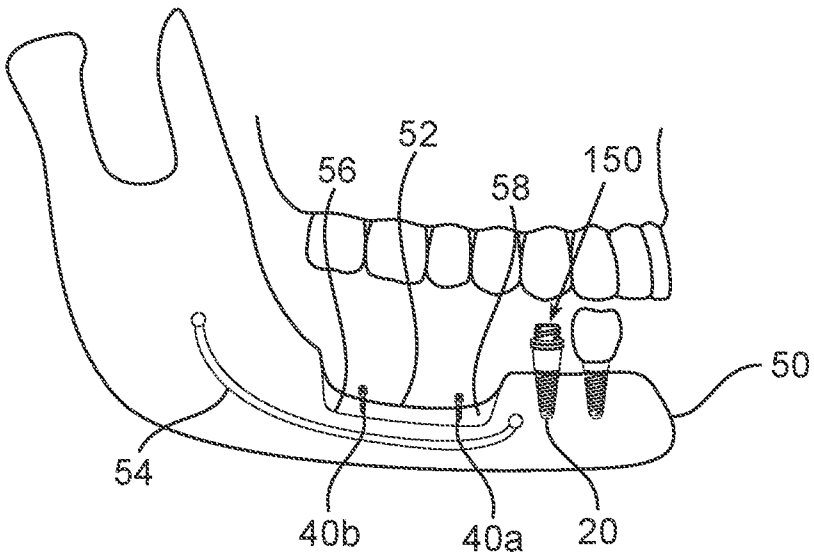


FIG. 29D

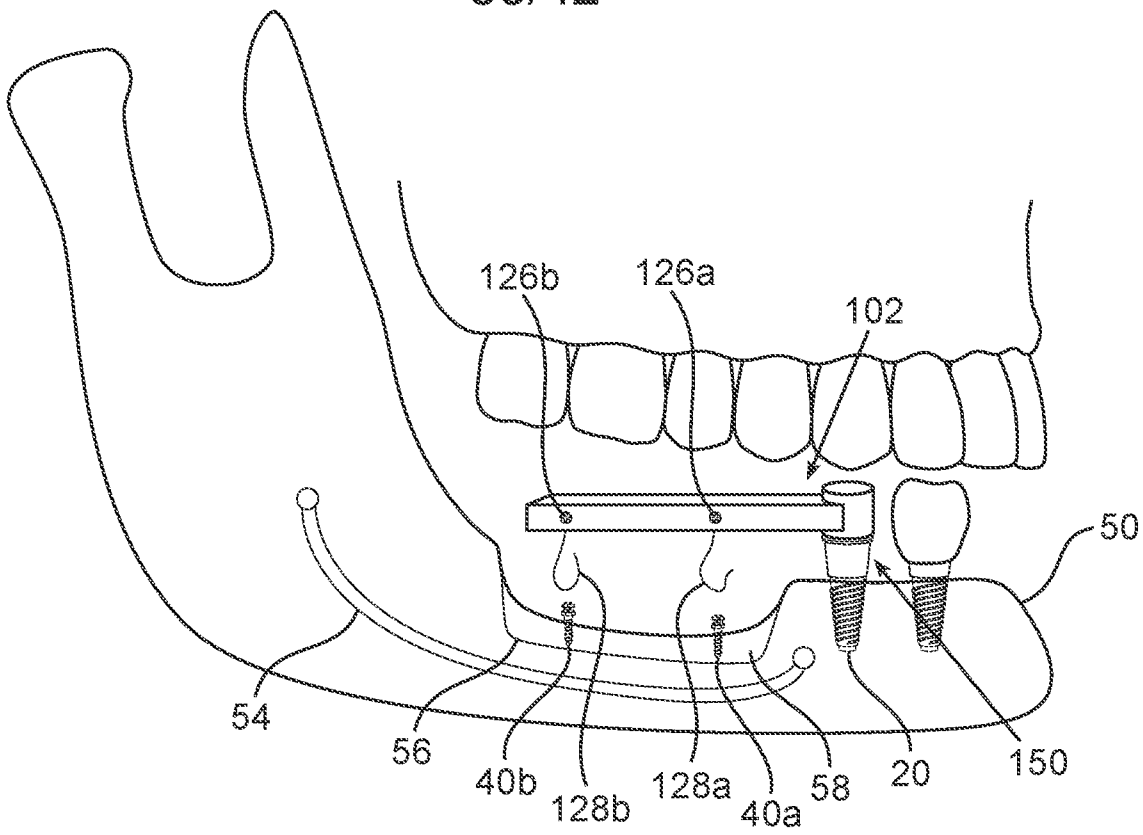


FIG. 29E

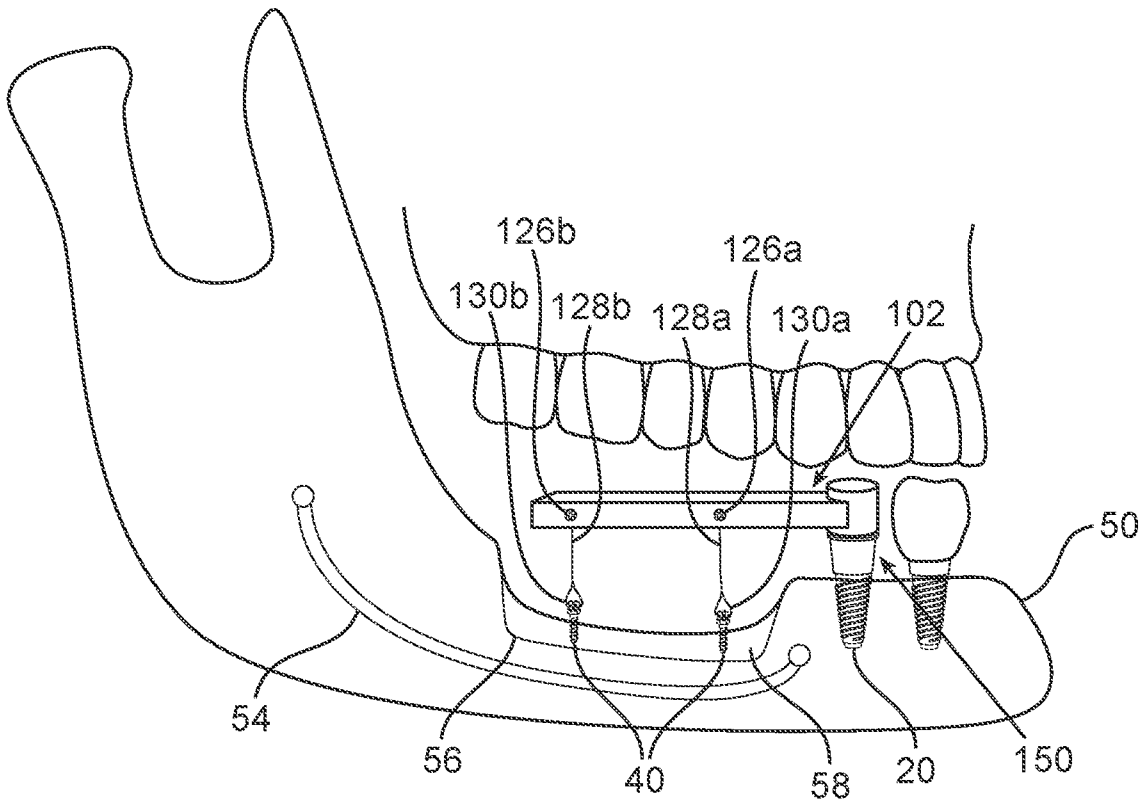


FIG. 29F

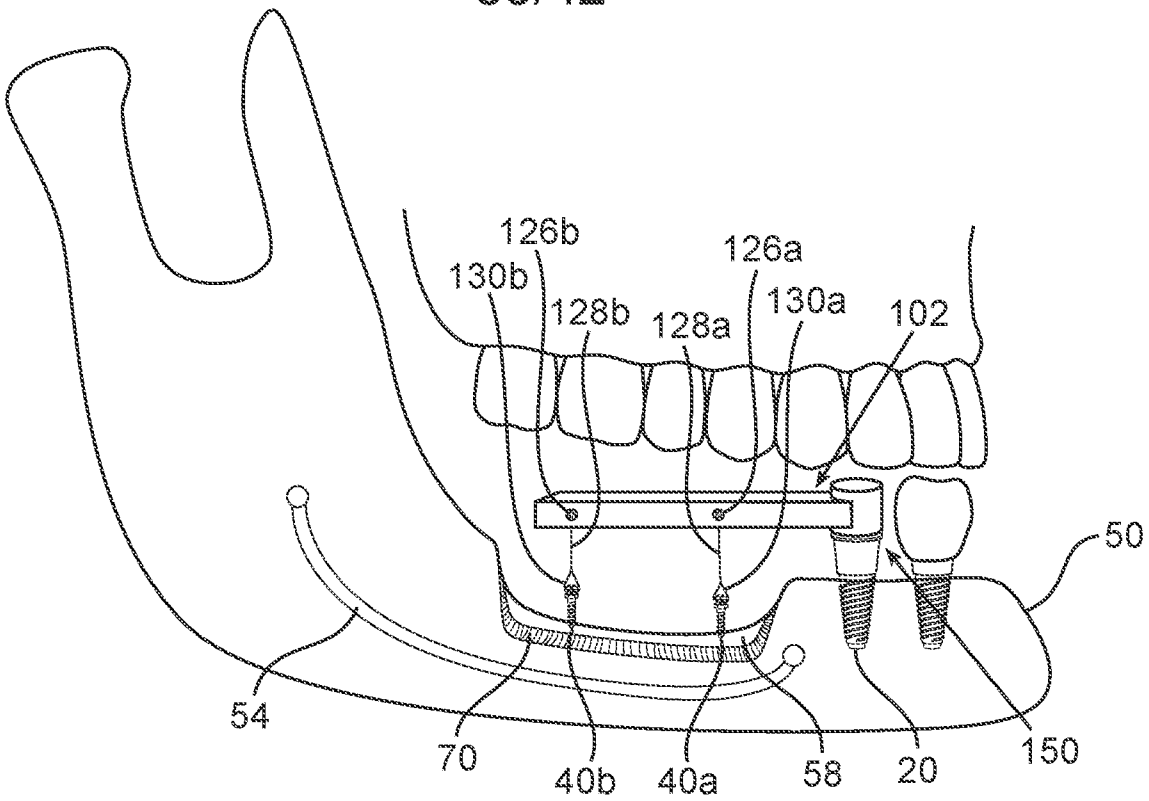


FIG. 29G

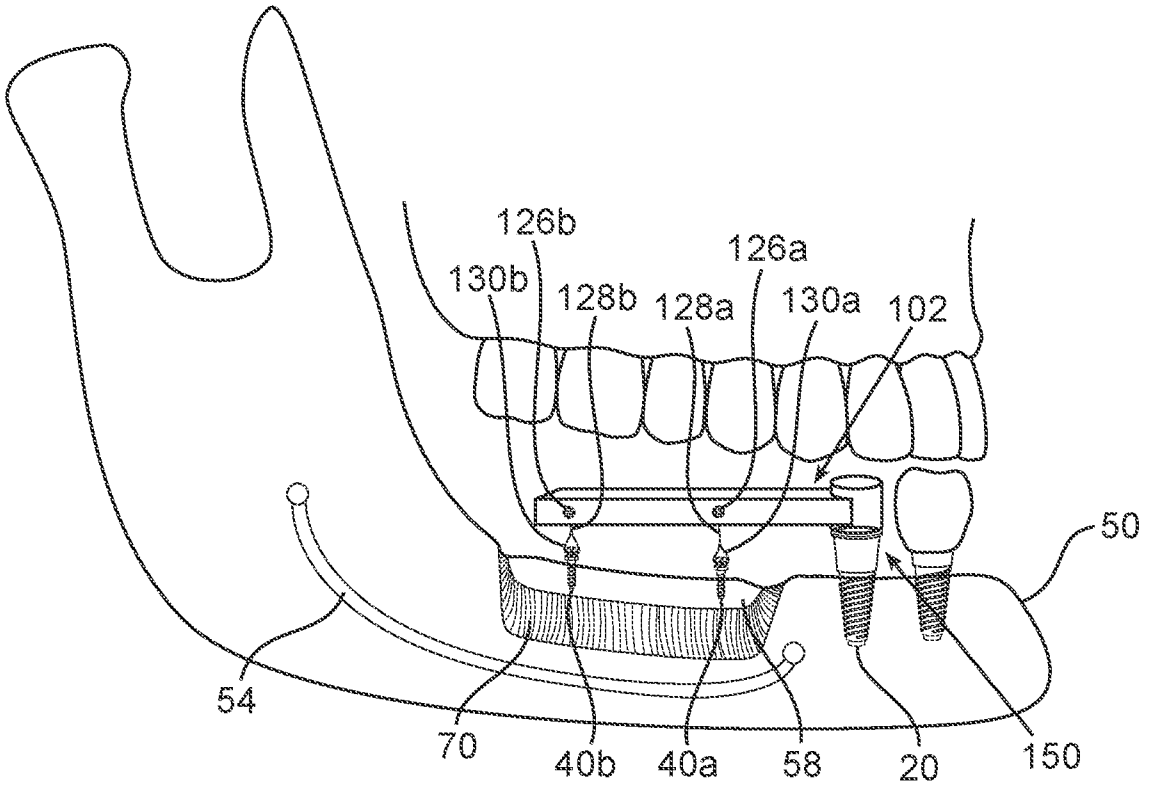


FIG. 29H

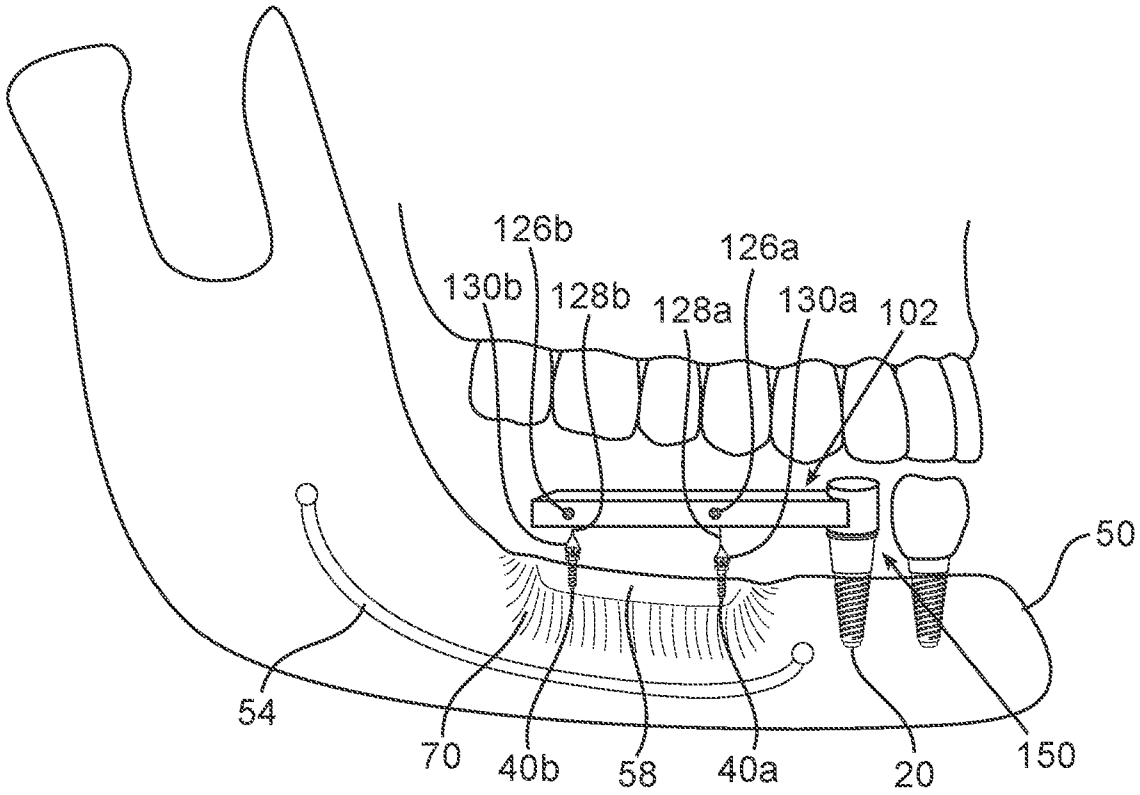


FIG. 29I

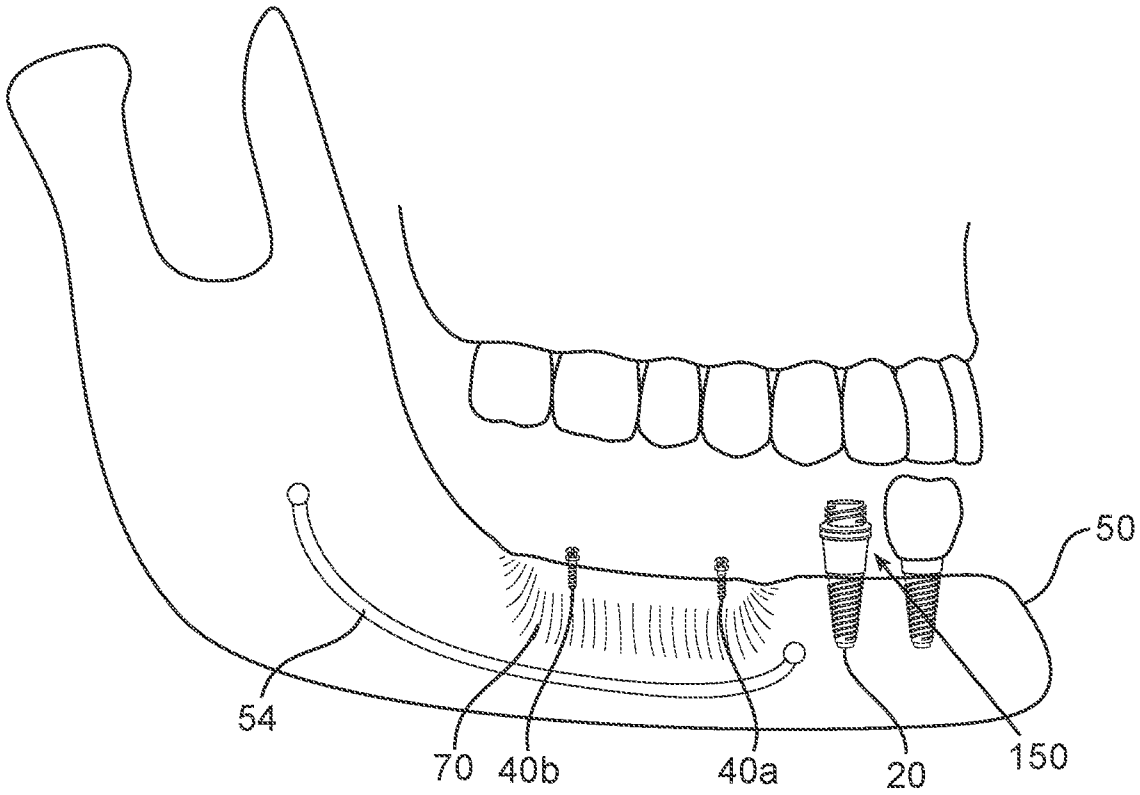


FIG. 29J

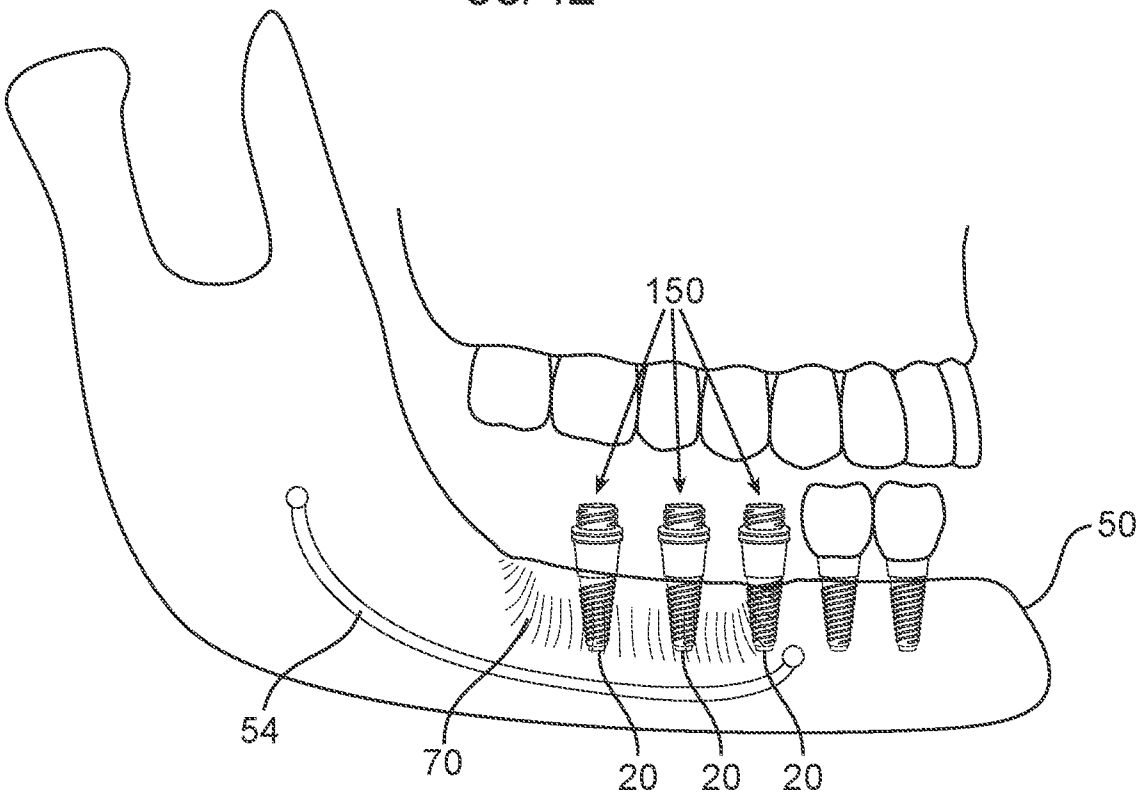


FIG. 29K

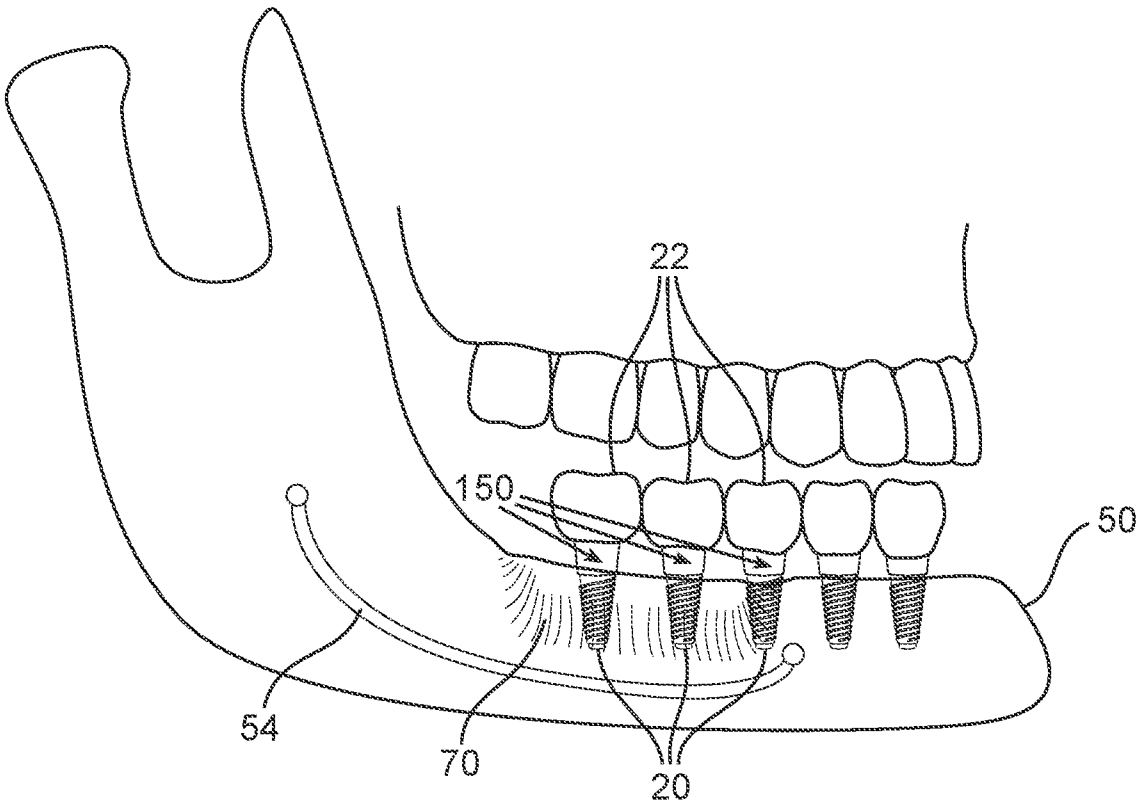


FIG. 29L

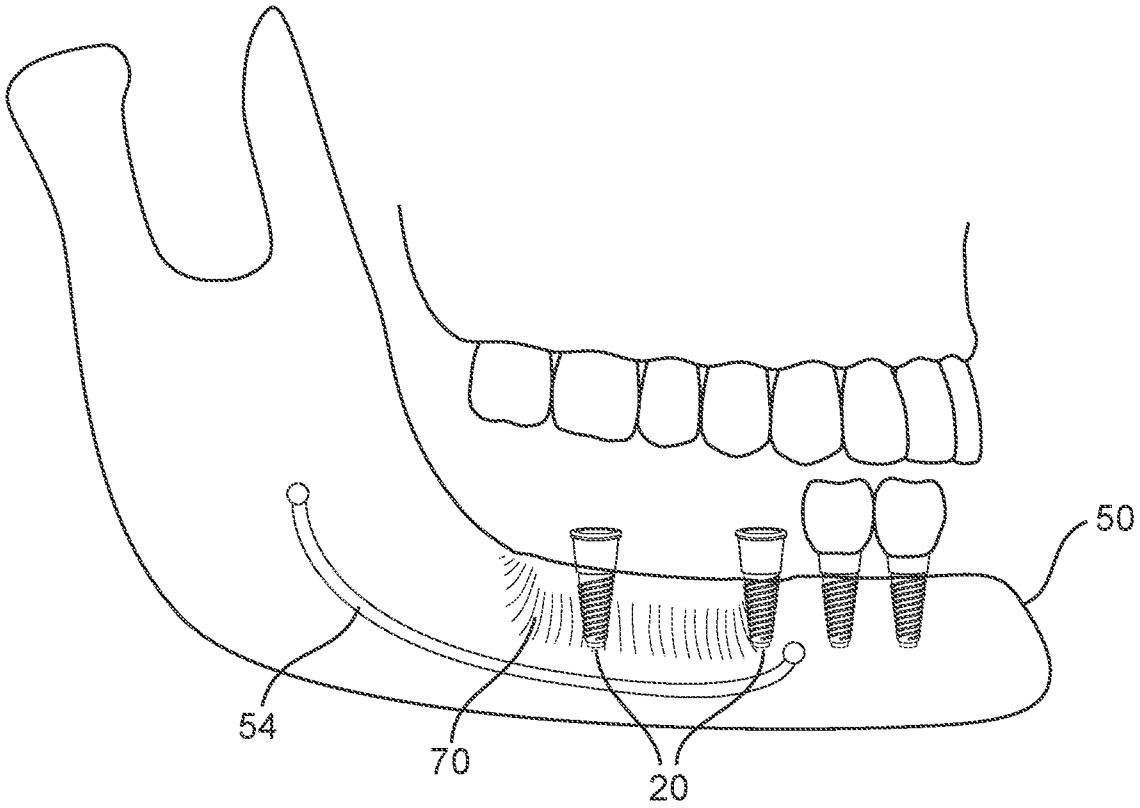


FIG. 30A

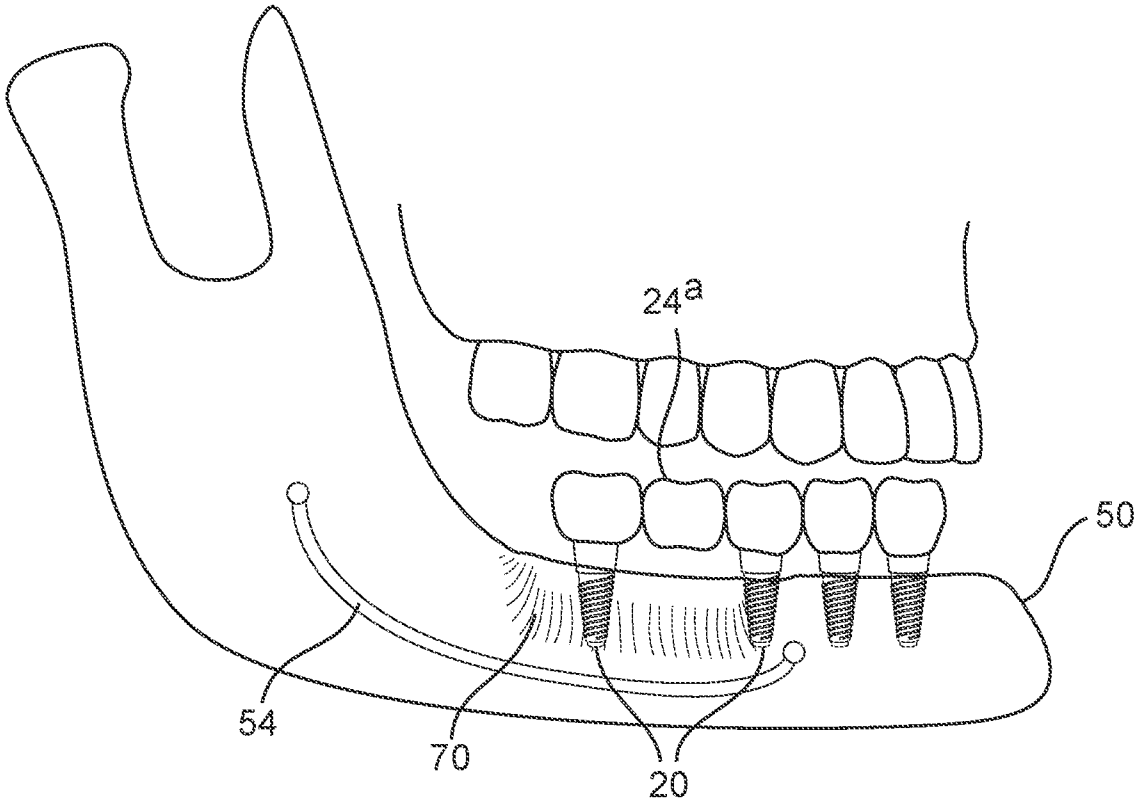


FIG. 30B

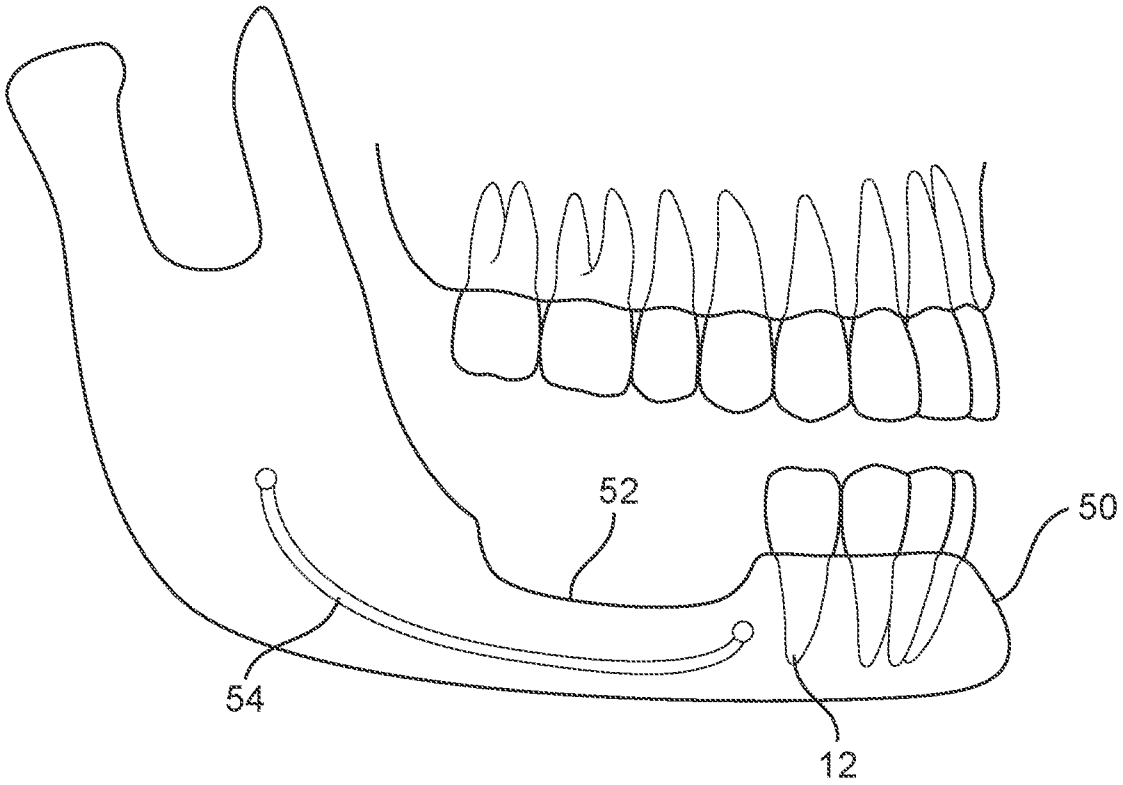


FIG. 31A

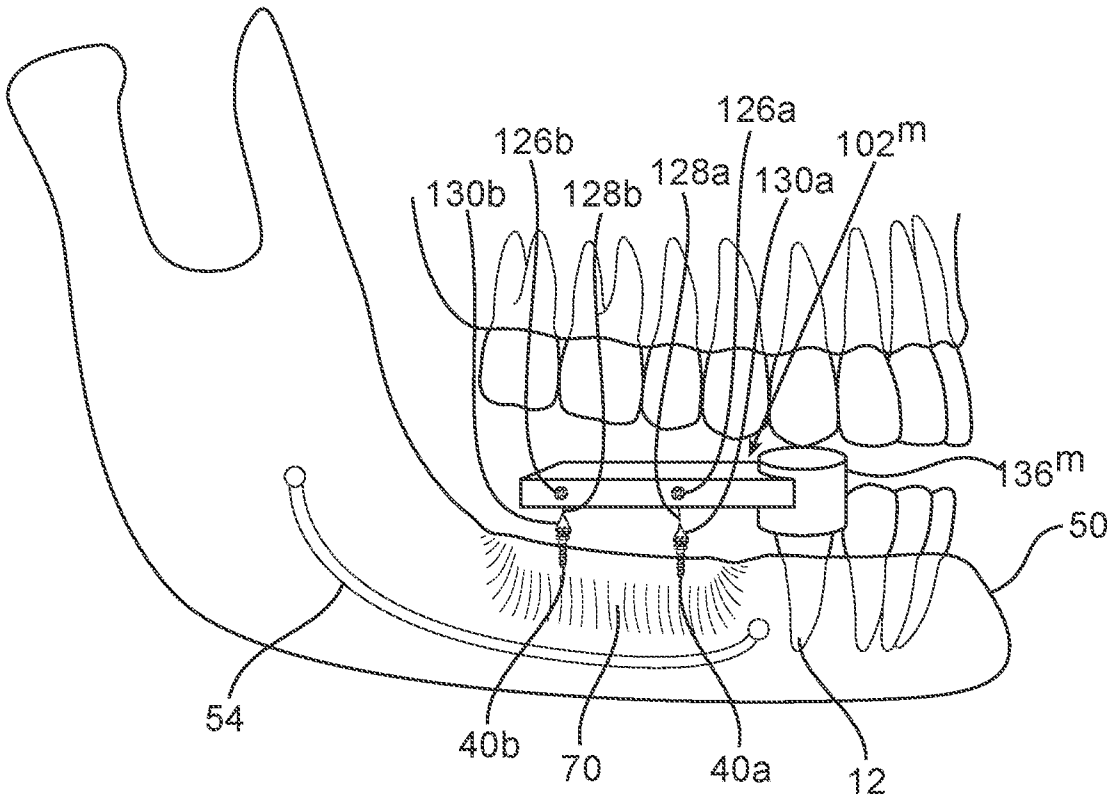
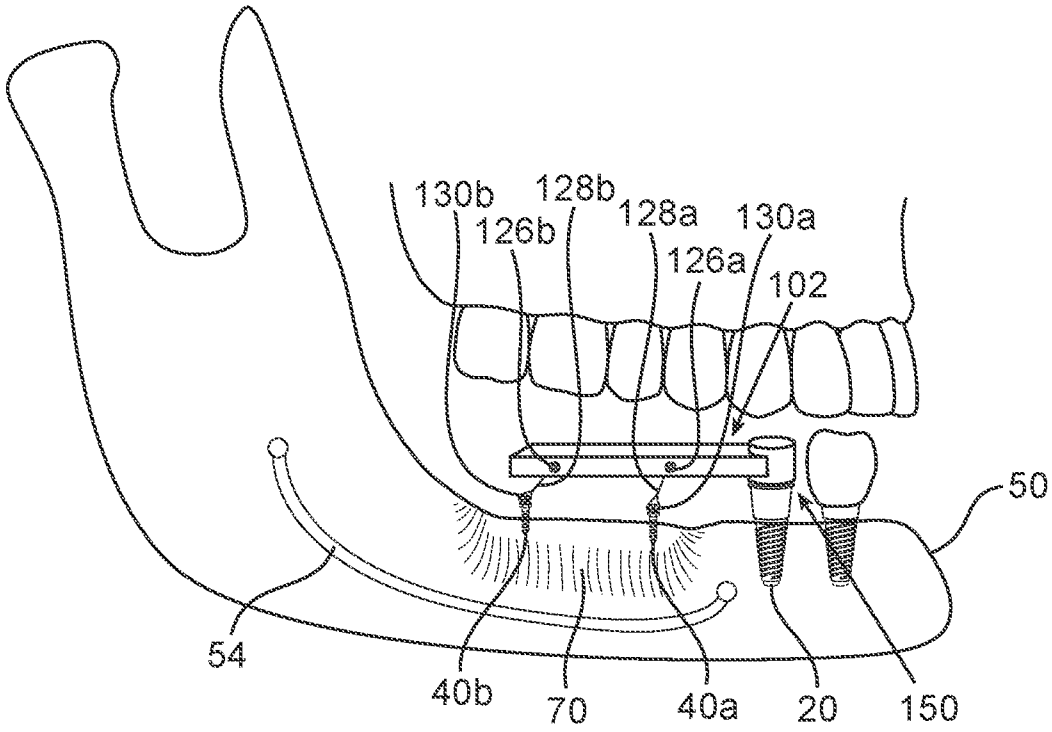


FIG. 31B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126a
102
50
54
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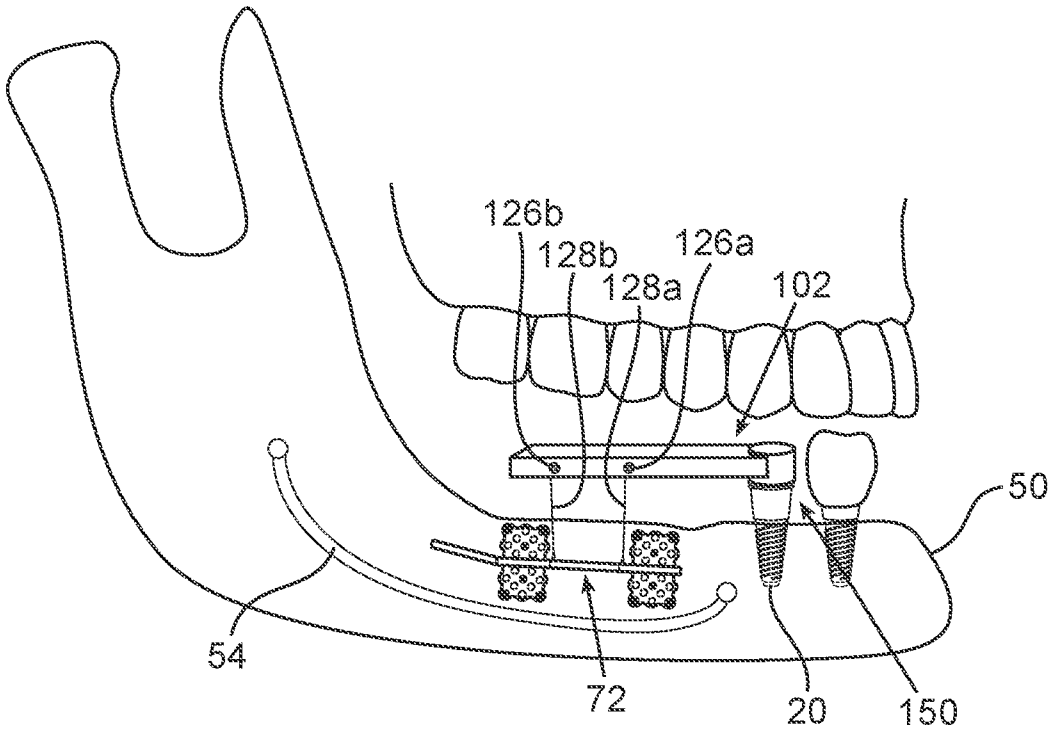
70
40a
20
150

FIG. 32


126b
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128a
102
50
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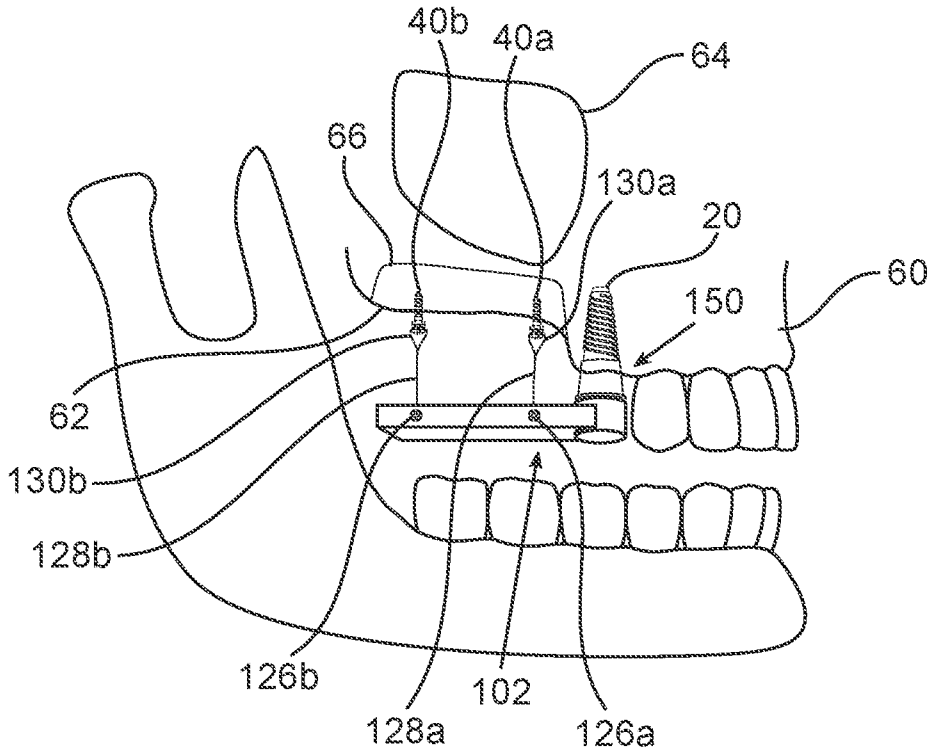
72
20
150

FIG. 33


40b
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66
130a
20
60
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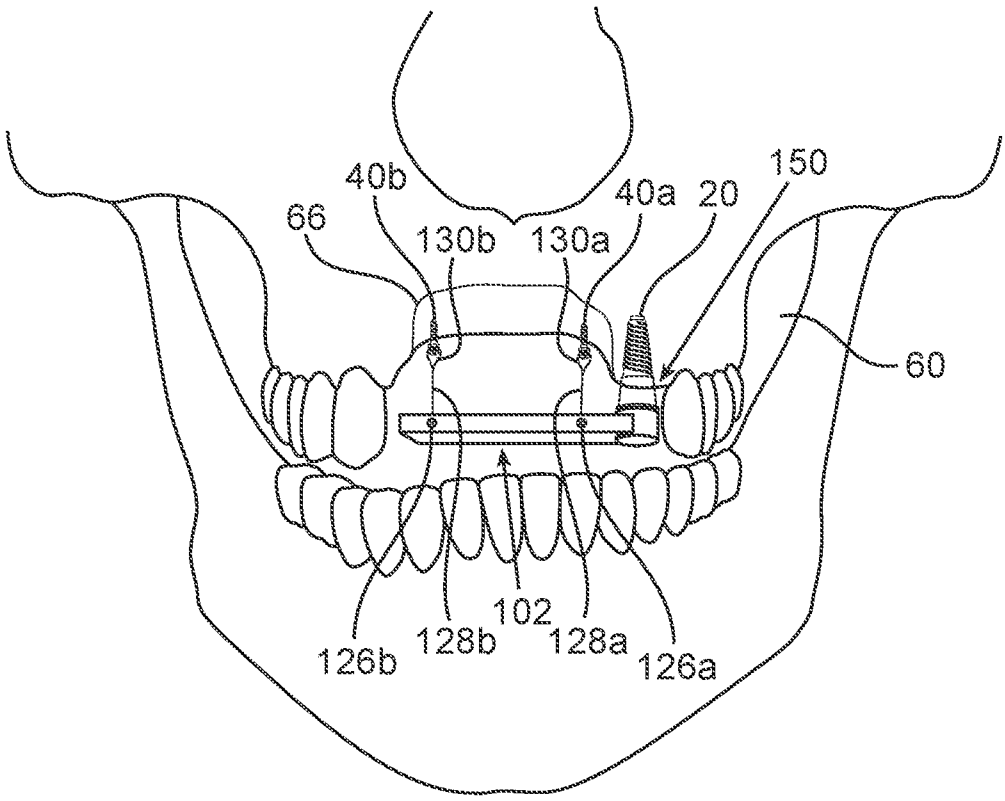
62
130b
128b
126b
102
128a
126a

FIG. 34


40b
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126b
128b
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128a
126a

FIG. 35

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2019/050722

A. CLASSIFICATION OF SUBJECT MATTER
IPC (20190101) A61B 17/66, A61C 8/02, A61C 8/00
CPC (20130101) A61B 17/663, A61B 17/666, A61C 8/0006, A61C 8/0027, A61C 8/0083
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC (20190101) A61B 17/66, A61C 8/02, A61C 8/00
CPC (20130101) A61B 17/663, A61B 17/666, A61C 8/0006, A61C 8/0027, A61C 8/0083

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Databases consulted: Esp@cenet, Derwent Innovation, Orbit
Search terms used: frame, border, support, adaptor, ring, annular, abutment

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1088520 A2 RAZDOLSKY 04 Apr 2001 (2001/04/04) para.[0038], [0043]-[0047], fig. 8, 15, 16	1-45
Y	US 2013209956 A1 MID CORP. 15 Aug 2013 (2013/08/15) para.[0207]-[0208], [0231], fig. 6A, 6B, 13B	1-45
A	CN 1044043 A KURGANSKY NIIEX I KLINICHESKOI 25 Jul 1990 (1990/07/25) * the whole document *	1-45

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

☒ See patent family annex.

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

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"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 Oct 2019	24 Oct 2019

Name and mailing address of the ISA:	Authorized officer
Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. pctoffice@justice.gov.il	AHARONY Meytal Telephone No. 972-73-3927138

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2019/050722

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2019/050722

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CN 1044043 A	25 Jul 1990	CN 1044043 A	25 Jul 1990