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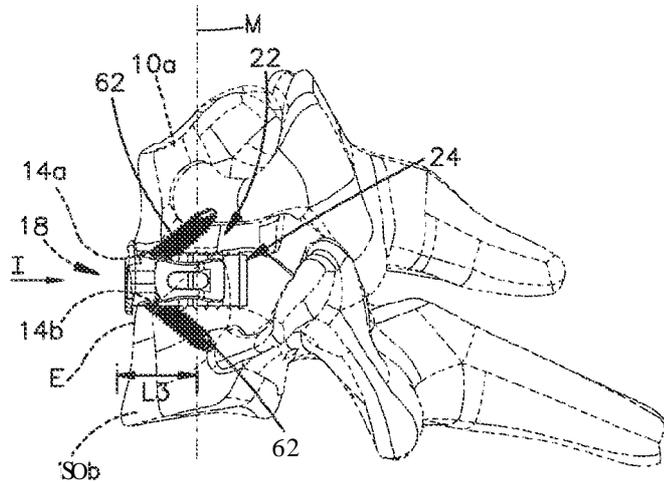


Fig. 1B

(57) **Abstract:** An intervertebral implant frame that is configured to be attached to a spacer body can include a pair of arms that extend longitudinally from a support member such that the arms extend substantially around the spacer body. The arms may be configured to expand, crimp, or otherwise engage the spacer body to thereby hold the spacer body to the frame. The spacer body may be made from bone graft.

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INTERVERTEBRAL IMPLANTS, SYSTEMS, AND METHODS OF USE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Provisional Patent Application Serial No. 61/425,505 filed December 21, 2010 and United States Provisional Patent Application Serial No. 61/425,509 filed December 21, 2010, the contents of each of which are hereby incorporated by reference in their entirety herein.

BACKGROUND

[0002] Implants for spinal fusion typically include a spacer body to allow for growth of bone between adjacent vertebral bodies while restoring and maintaining intervertebral space height that is defined between the vertebral bodies. In some cases, a plate is used to provide stability during healing so as to allow the patient to quickly resume an active lifestyle. The profile of the plate, which is placed on the anterior aspect of the vertebral bodies, however, can lead to dysphasia or patient discomfort which has resulted in various "zero-profile" devices currently being developed. For example, one zero profile device is an intervertebral device that is inserted into the intervertebral space. While the threaded device provides graft retention, stability in flexion and extension is questionable since the device does not positively lock to the vertebral bodies during implantation.

[0003] Other intervertebral implants have been utilized that include a frame shaped in a manner so as to hold a spacer body made from PEEK. Such spacer bodies typically are customized to have complimentary features to the frame so that the spacer bodies may be affixed to the frame. Such frames may not be desirable for spacer bodies made from allograft, however, because allograft spacer bodies may vary in shape, may not include the complimentary features needed to be affixed to the frame, and may degrade or resorb overtime.

SUMMARY

[0004] In accordance with an embodiment, an intervertebral implant frame can be configured to retain a spacer body. The frame can include a support member, a first arm that extends from the support member, and a second arm that extends from the support member. The support member defines an inner surface, and at least two fixation element receiving apertures. Each of the fixation element receiving apertures is configured to receive a respective bone fixation element to thereby attach the intervertebral implant frame to first and second vertebral

bodies, respectively when the intervertebral implant frame is disposed in an intervertebral space defined by first and second surfaces of the first and second vertebral bodies, respectively. The first arm includes a first inner spacer contacting surface, and defines a first terminal end. The second arm includes a second inner spacer contacting surface spaced from the first inner spacer contacting surface along a first direction. The second arm defines a second terminal end. The first and second terminal ends are each spaced from the support member along a second direction that is substantially perpendicular to the first direction so as to define first and second lengths, respectively. The first and second inner spacer contacting surfaces define at least first and second respective contact locations, and at least one of the first and second arms is flexible so as to be movable between a first position, whereby the frame defines a first distance between the first and second contact locations along the first direction, and a second position, whereby the frame defines a second distance between the first and second contact locations along the first direction. The second distance is greater than the first distance, such that when in the second position, the at least one of the first and second arms is biased toward the first position. The first and second lengths are each greater than a length defined between an anterior end of the first vertebral body and a centroid of the first surface.

[0005] In accordance with another embodiment, an intervertebral implant frame includes a support member, a first flexible arm that extends from the support member, and a second flexible arm that extends from the support member. The support member defines an inner surface and at least two fixation element receiving apertures that are each configured to receive a respective bone fixation element to thereby attach the frame to first and second vertebral bodies. The first flexible arm defines a first inner spacer contacting surface. The second flexible arm defines a second inner spacer contacting surface that is spaced from the first inner spacer contacting surface. The inner surface of the support member and the first and second inner spacer contacting surfaces at least partially define a void configured to receive a spacer body that ingrows with the first and second vertebral bodies. The first and second flexible arms include respective first and second engagement members that are configured to receive respective first and second expansion forces from an expansion instrument prior to insertion of the spacer body into the void such that at least one of the first and second flexible arms elastically expands with respect to the other of the first and second arms in response to the expansion force.

[0006] In accordance with another embodiment, an intervertebral implant frame includes a support member, a first flexible arm that extends from the support member, and a second flexible arm that extends from the support member. The support member defines an

inner surface, and at least two fixation element receiving apertures. Each of the fixation element receiving apertures is configured to receive a respective bone fixation element to thereby attach the intervertebral implant frame to first and second vertebral bodies, respectively when the intervertebral implant frame is disposed in an intervertebral space defined by first and second surfaces of the first and second vertebral bodies, respectively. The first flexible arm includes a first inner spacer contacting surface. The first arm has a first distal portion and a first proximal portion. The first distal portion and the first proximal portion each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface. The second flexible arm includes a second inner spacer contacting surface spaced from the first inner spacer contacting surface along a first direction. The second arm has a second distal portion and a second proximal portion. The second distal portion and the second proximal portion each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface. The first and second distal portions are configured to support the first and second vertebral bodies relative to each other on a posterior side of a plane that intersects a centroid of the first surface and the first and second posterior portions are configured to support the first and second vertebral bodies relative to each other on an anterior side of the plane that intersects the centroid of the first surface, when the intervertebral implant frame is disposed in the intervertebral space.

[0007] In accordance with another embodiment, an intervertebral implant frame includes a support member, a first arm that extends from the support member, and a second arm that extends from the support member. The support member defines an inner surface and at least two fixation element receiving apertures that are each configured to receive a respective bone fixation element to thereby affix the frame to superior and inferior vertebral bodies. The first arm includes a first inner spacer contacting surface, and a first crimp member. The second arm includes a second inner spacer contacting surface spaced from the first inner spacer contacting surface along a first direction, and a second crimp member. The inner surface of the support member, and the first and second inner spacer contacting surfaces together define a void that is configured to receive a spacer body. The first crimp member is configured to be bent toward the second arm, and the second crimp member is configured to be bent toward the first arm to thereby engage the spacer body and retain the spacer body within the void.

[0008] In accordance with another embodiment, an intervertebral implant includes a support member, a first arm that extends from the support member, and a second arm that extends from the support member. The support member defines an inner surface, and at least two fixation element receiving apertures. Each of the fixation element receiving apertures is configured to receive a respective bone fixation element to thereby attach the frame to first and

second vertebral bodies, respectively when the frame is disposed in an intervertebral space defined by the first and second vertebral bodies. The first arm includes a first inner spacer contacting surface. The second arm includes a second inner spacer contacting surface spaced from the first inner spacer contacting surface along a first direction. The inner surface of the support member and the first and second inner spacer contacting surfaces at least partially define a void that contains an allograft spacer. The first and second arms are elastically flexible from a first position to a second position, such that when the arms are in the second position, the void defines a cross-sectional dimension greater than that of the allograft spacer such that the void is sized to receive the allograft spacer body. When the first and second arms are in the first position, the first and second inner spacer contacting surfaces apply a retention force against the allograft spacer body along a direction toward the other of the first and second spacer contacting surfaces.

[0009] In accordance with another embodiment, an intervertebral implant system can include an intervertebral implant frame, and an expansion instrument. The intervertebral implant frame is configured to retain a spacer body. The frame has a support member that defines an inner surface, a first arm extending from the support member and defining a first inner spacer contacting surface, and a second arm extending from the support member and defining a second inner spacer contacting surface that is spaced from the first inner spacer contacting surface. The expansion instrument includes a first expansion arm that is configured to couple to the first arm, and a second expansion arm that is configured to couple to the second arm. The first and second arms are pivotally coupled to each other at a first pivot such that rotation of the first and second expansion arms about the first pivot causes the first and second arms to elastically flex away from each other when the first and second expansion arms are coupled to the first and second arms, respectively.

[0010] Also disclosed is a spacer body drill guide constructed in accordance with an embodiment. The drill guide includes a clamp and a cradle. The clamp includes a first jaw and a second jaw that are translatable along a first direction with respect to each other. The first jaw defines a first outer surface, a first inner spacer contacting surface, and a pair of first drill guide apertures that extend from the first outer surface to the first inner spacer contacting surface along a direction that is transverse to the first direction. The second jaw defines a second outer surface, a second inner spacer contacting surface, and a pair of second drill guide apertures that extend from the second outer surface to the second inner spacer contacting surface along a direction that is transverse to the first direction. The cradle includes a base and a mounting portion that extends from the base along a second direction that is substantially perpendicular to the first

direction. The mounting portion includes a body, a channel that extends into the body along the second direction, and a pair of third drill guide apertures that extend through the body and into the channel at a direction that is transverse to the second direction. The channel is configured to receive the first jaw such that the first drill guide apertures align with the third drill guide apertures when the clamp is mounted to the cradle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The foregoing summary, as well as the following detailed description of embodiments of the application, will be better understood when read in conjunction with the appended drawings. For the purposes of illustrating the methods, implants and systems of the present application, there is shown in the drawings preferred embodiments. It should be understood, however, that the application is not limited to the precise methods, implants, and systems shown. In the drawings:

[0012] Fig. 1A is a perspective view of an intervertebral implant assembly that is implanted in an intervertebral space defined by a superior vertebral body and an inferior vertebral body, the intervertebral implant assembly including an intervertebral implant and at least a pair of fixation elements that attach the intervertebral implant to the superior vertebral body and the inferior vertebral body, respectively;

[0013] Fig. 1B is a side elevation view of the intervertebral implant assembly as shown in Fig. 1A, the intervertebral space defining an anterior-posterior midline;

[0014] Fig. 1C is a top plan view of the inferior vertebral body shown in Fig. 1B;

[0015] Fig. 2A is a perspective view of the intervertebral implant illustrated in Figs. 1A and 1B, the intervertebral implant having an intervertebral implant frame and a spacer body retained by the intervertebral implant frame;

[0016] Fig. 2B is a top plan view of the intervertebral implant shown in Fig. 2A;

[0017] Fig. 3A is a perspective view of the intervertebral implant frame shown in Fig. 2, the intervertebral implant frame having a support member, a first arm extending from the support member, and a second arm extending from the support member, the first and second arms configured to elastically flex away from each other;

[0018] Fig. 3B is a front elevation view of the intervertebral implant frame shown in Fig. 3A;

[0019] Fig. 3C is a top plan view of the intervertebral implant frame shown in Fig. 3A;

[0020] Fig. 3D is a side elevation view of the intervertebral implant frame shown in Fig. 3A;

[0021] Fig. 3E is a cross-sectional view of the intervertebral implant frame shown in Fig. 3D through the line 3E-3E;

[0022] Fig. 4A is a perspective view of one of the fixation elements that is configured to affix the intervertebral implant shown in Fig. 2 to a vertebral body as illustrated in Figs. 1A and 1B;

[0023] Fig. 4B is a side elevation view of the of the fixation element shown in Fig. 4A;

[0024] Fig. 5A is a perspective view of a spacer body made from bone graft;

[0025] Fig. 5B is a perspective view of the spacer body shown in Fig. 2;

[0026] Fig. 5C is a top plan view of the spacer body shown in Fig. 5B;

[0027] Fig. 5D is a side elevation view of the spacer body shown in Fig. 5B;

[0028] Fig. 6A is a perspective view of an intervertebral implant system constructed in accordance with an embodiment, the system including an actuation instrument configured as an expansion instrument that includes an actuation grip illustrated as an expansion grip that is configured to actuate the frame shown in Fig. 3A from a first configuration to a second configuration whereby the frame is configured to receive the spacer body shown in Fig. 5B;

[0029] Fig. 6B is a perspective view of the expansion instrument shown in Fig. 6A, the expansion instrument including a first expansion arm and a second expansion arm coupled to the first expansion arm at a first pivot, each expansion arm having a handle portion and a gripping portion that combine to define a handle of the expansion instrument and the expansion grip illustrated in Fig. 6A;

[0030] Fig. 6C is a top plan view of the expansion instrument shown in Fig. 6B;

[0031] Fig. 6D is a detailed view of one of the gripping portions of the expansion instrument shown in Fig. 6B;

[0032] Fig. 6E is an enlarged top plan view of the expansion grip shown in Fig. 6B, coupled to the first and second arms of the frame shown in Fig. 3A, showing the expansion instrument actuated from a first position to a second position, whereby the expansion grip applies an expansion force to the first and second arms of the frame when the expansion instrument is in the second position, the expansion force biasing the first and second arms of the frame to flex away from each other;

[0033] Fig. 7A is a perspective view of an intervertebral implant system constructed in accordance with another embodiment, the system including a intervertebral implant frame, and an actuation instrument configured as an expansion instrument that comprises a pair of clips that engage first and second arms of the frame along a direction that is similar to an insertion direction of the frame;

[0034] Fig. 7B is a top plan view of the intervertebral implant system shown in Fig. 7A;

[0035] Fig. 7C is an exploded view of the intervertebral implant system shown in Fig. 7A;

[0036] Fig. 8A is a perspective view of an intervertebral implant system constructed in accordance with another embodiment, the system including a intervertebral implant frame and an actuation instrument configured as an expansion instrument that comprises a pair of clips that engage first and second arms of the frame along a direction that is opposite to the insertion direction of the frame;

[0037] Fig. 8B is a top plan view of the system shown in Fig. 8A;

[0038] Fig. 8C is an exploded view of the system shown in Fig. 8A;

[0039] Fig. 9A is a perspective view of an intervertebral implant frame constructed in accordance with another embodiment, the frame including a first arm, a second arm, and a respective expansion member that extends out from and is integral to a respective arm of the frame;

[0040] Fig. 9B is a perspective view of an intervertebral implant frame constructed in accordance with another embodiment, the frame including, a support member, a first arm, a second arm, and a respective expansion member that extends out from and is integral to each arm of the frame, the expansion members extending proximate to the support member;

[0041] Fig. 10A is a perspective view of an intervertebral implant frame constructed in accordance with another embodiment, the frame including first and second arms that each include a crimp member configured to be crimped against the spacer body to thereby retain the spacer body to the frame;

[0042] Fig. 10B is a top plan view of the frame shown in Fig. 10A;

[0043] Fig. 11A is a perspective view of an intervertebral implant frame constructed in accordance with another embodiment, the frame including first and second arms that each include a pair of crimp members configured to be crimped against the spacer body to thereby retain the spacer body to the frame;

[0044] Fig. 11B is a top plan view of the frame shown in Fig. 11A;

[0045] Fig. 12A is a perspective view of an intervertebral implant frame constructed in accordance with another embodiment, the frame including first and second arms that each include a crimp member configured as a crimp tab disposed within a window defined by the arm;

[0046] Fig. 12B is a top plan view of the frame shown in Fig. 12A;

[0047] Fig. 13A is a perspective view of an intervertebral implant frame constructed in accordance with another embodiment, the frame including first and second arms that each include at least one crimp member configured as a crimp tab;

[0048] Fig. 13B is a top plan view of the frame shown in Fig. 13A;

[0049] Fig. 14A is a perspective view of an actuation instrument configured as a crimping instrument constructed in accordance with an embodiment, the instrument including gripping members that are configured to crimp the crimp members of the frames shown in Figs. 10A and 11A;

[0050] Fig. 14B is a detailed top plan view of the gripping members of the instrument shown in Fig. 14A, and an intervertebral implant disposed between the gripping members;

[0051] Fig. 14C is a top plan view of the gripping members illustrated in Fig. 14B, shown in a crimped position, whereby the crimp members are crimped onto a spacer body of the intervertebral implant so as to secure the arms to the intervertebral implant;

[0052] Fig. 14D is a detailed view of gripping members of a crimping instrument constructed in accordance with another embodiment, the gripping members including a beaked protrusion configured to crimp the crimp members of the frame shown in Fig. 12A;

[0053] Fig. 15A is a perspective view of an intervertebral implant frame constructed in accordance with another embodiment, the frame defining a four walled structure;

[0054] Fig. 15B is a top plan view of the frame shown in Fig. 15A;

[0055] Fig. 16A is a perspective view of a spacer body drill guide constructed in accordance with an embodiment, the drill guide including a clamp, and a cradle that is configured to mate with and support the clamp;

[0056] Fig. 16B is a perspective view of the clamp shown in Fig. 16A;

[0057] Fig. 16C is a perspective view of the clamp being mounted to the cradle;

[0058] Fig. 16D is a perspective view of the clamp after it has been mounted to the cradle;

[0059] Fig. 16E is a perspective view of a drill bit being inserted into drill guide apertures defined by the clamp to thereby form clearance channels in the spacer body; and

[0060] Fig. 16F is a perspective view of a spacer body after the clearance channels have been formed using the drill guide shown in Fig. 16A.

DETAILED DESCRIPTION

[0061] Referring to Figs. 1A and 1B, a superior vertebral body 10a defines a first or superior vertebral surface 14a of an intervertebral space 18, and an adjacent second or inferior

vertebral body 10b defines an inferior vertebral surface 14b of the intervertebral space 18. Thus, the intervertebral space 18 is disposed between or otherwise defined by the vertebral bodies 10a and 10b. The vertebral bodies 10a and 10b can be anatomically adjacent vertebral bodies, or can remain after a portion of bone has been removed. The intervertebral space 18 can be disposed anywhere along the spine as desired, including at the lumbar, thoracic, and cervical regions of the spine. As illustrated, the intervertebral space 18 is illustrated after a discectomy, whereby the disc material has been removed or at least partially removed to prepare the intervertebral space 18 to receive an intervertebral implant 22 that can achieve height restoration. As shown, the intervertebral implant 22 can be affixed to the superior and inferior vertebral bodies 10a and 10b with respective fixation elements 62. The intervertebral implant 22 and the fixation elements 62 together define an intervertebral implant assembly 24.

[0062] Certain terminology is used in the following description for convenience only and is not limiting. The words "right", "left", "lower" and "upper" designate directions in the drawings to which reference is made. The words "inner" or "distal" and "outer" or "proximal" refer to directions toward and away from, respectively, the geometric center of the implant and related parts thereof. The words, "anterior", "posterior", "superior," "inferior," "medial," "lateral," and related words and/or phrases are used to designate various positions and orientations in the human body to which reference is made and are not meant to be limiting. The terminology includes the above-listed words, derivatives thereof and words of similar import.

[0063] The intervertebral implant 22 is described herein as extending horizontally along a longitudinal direction "L" and lateral direction "A", and vertically along a transverse direction "T". Unless otherwise specified herein, the terms "lateral," "longitudinal," and "transverse" are used to describe the orthogonal directional components of various components. It should be appreciated that while the longitudinal and lateral directions are illustrated as extending along a horizontal plane, and that the transverse direction is illustrated as extending along a vertical plane, the planes that encompass the various directions may differ during use. For instance, when the intervertebral implant 22 is implanted into the intervertebral space 18 along an insertion direction I, the transverse direction T extends vertically generally along the superior-inferior (or caudal-cranial) direction, while the horizontal plane defined by the longitudinal direction L and lateral direction A lies generally in the anatomical plane defined by the anterior-posterior direction, and the medial-lateral direction, respectively. Accordingly, the directional terms "vertical" and "horizontal" are used to describe the intervertebral implant 22 and its components as illustrated merely for the purposes of clarity and illustration.

[0064] As shown in Figs. 1B and 1C, the vertebral surfaces 14a and 14b of the vertebral bodies 10a and 10b can define a geometrical centroid M that is generally located at an anterior-posterior midpoint between an anterior end and a posterior end of the surfaces 14a and 14b. As shown in Fig. 1B, the intervertebral implant 22 is configured to be disposed or otherwise implanted in the intervertebral space 18 such that a portion of the intervertebral implant 22 is located on a posterior side of a medial lateral plane that intersects the centroid M, and a portion of the intervertebral implant 22 is located on an anterior side of the medial lateral plane that intersects the centroid M. Such a configuration can ensure that the height restoration of the intervertebral space 18 remains relatively unchanged over time.

[0065] In reference to Figs. 1A, 1B, 2A and 2B, the intervertebral implant 22 includes an intervertebral implant frame 26 and a spacer body 30 that is retained by the frame 26. The intervertebral implant 22, defines a proximal end P and a distal end D. The frame 26 may be made from any biocompatible material, such as TAN alloy, or PEEK. The spacer body 30 may be composed of a synthetic material such as PEEK or a graft substitute such a tricalcium phosphate or hydroxyapatite. The spacer body 30 may also be composed of a bone graft such as allograft bone, autograft bone or xenograft bone. By using a spacer body 30 composed of bone graft, surface area for fusion can be maximized. Additionally, incorporation of a bone graft spacer body 30 promotes bony on-growth and increased probability and speed of sound fusion. The frame 26 is configured to be attached to various bone graft spacer body footprint geometries, which may or may not conform to the internal footprint of the frame 26.

[0066] As shown in Figs. 3A-3E the frame 26 includes a support member 34, a first arm 38 that extends from the support member 34, and a second arm 42 that extends from the support member 34. In the illustrated embodiment, the first and second arms 38 and 42 are flexible arms that extend from opposed ends of the support member 34 such that the support member 34, the first arm 38, and the second arm 42 together create a three wall structure that retains and secures the spacer body 30 to the frame 26.

[0067] As shown in Figs. 3A-3C, the support member 34 includes a body 46 that defines an inner surface 50, an outer surface 54, and at least one, such as two or such as four, fixation element receiving apertures 58 that extend through the body 46 from the outer surface 54 to the inner surface 50. Each fixation element receiving aperture 58 is configured to receive a respective fixation element, such as fixation element 62 shown in Figs. 4A and 4B. While the fixation elements 62 are illustrated as screws, it should be appreciated that the fixation elements 62 may also be nails or any other fixation element configured to attach the intervertebral implant 22 to the first and second vertebral bodies 10a and 10b. As shown, the support member 34 can

further include at least one, such as three tabs 64 that extend transversely from the body 46. The tabs 64 may sit on an anterior side of the vertebral bodies and prevent over-insertion of the frame 26 into the intervertebral space 18. In the illustrated embodiment, the support member 34 includes two superior tabs 64 and one inferior tab 64 that are each configured to sit flush or slightly proud of an anterior surface of the vertebral bodies depending on the patient's spinal anatomy and/or site preparation. It should be appreciated, however, that the support member 34 can include other configurations for the tabs 64. For example, the support member 34 can include a single superior tab 64 and two inferior tabs 64.

[0068] As shown in Fig. 3B, two of the fixation element receiving apertures 58 are inner apertures 66 that extend through the body 46 at a downward angle relative to the insertion direction I, and two of the fixation element receiving apertures 58 are outer apertures 70 that extend through the body 46 at an upward angle relative to the insertion direction I. The inner apertures 66 are configured to receive respective fixation elements, such as fixation element 62 shown in Figs. 4A and 4B, to thereby attach the intervertebral implant 22 to the inferior vertebral body 10b. Similarly, the outer apertures 70 are configured to receive respective fixation elements 62 to thereby attach the intervertebral implant 22 to the superior vertebral body 10a. It should be appreciated, however, that the inner apertures 66 can extend through the body 46 at an upwards angle and the outer apertures 70 can extend through the body 46 at a downwards angle, as desired. Moreover, it should be appreciated that the support member 34 can define any number of fixation element receiving apertures 58 as desired.

[0069] As shown in Fig. 3B, the apertures 58 each define internal threads 78. The internal threads 78 are configured to engage external threads 80 defined by a head 82 of the respective fixation element 62 that is received within the apertures 58. It should be appreciated, however, that the apertures 58 can be void of threads as desired. The orientation of the apertures 58 may be configured such that the fixation elements that are received by the apertures 58 may have an insertion variance of +/- 5 degrees and do not allow toggling or settling. Once fully received, the fixation elements may lock to the frame 26 to thereby increase the surgeon's reassurance of good screw trajectories and can act as a safety by preventing possibilities of over-insertion during implantation.

[0070] As shown in Fig. 3C, support member 34 can include a retention member 73 that extends from the inner surface 50. The retention member 73 is configured to help retain the spacer body 30 when the spacer body is being supported by the frame 26. The retention member 73 is illustrated as a spike though it should be appreciated, that the retention member 73 can have other configurations. For example, the retention member 73 can be configured as a blade.

[0071] As shown in Figs. 2A, and 3A-3E, the first arm 38 and the second arm 42 each extend from the support member 34 and define a first distal terminal end 83 and a second distal terminal end 84, respectively. The first and second arms 38 and 42 each define gripping portions and support portions. The gripping portions are configured to retain the spacer body 30 while the support portions are configured to support the vertebral bodies 10a and 10b relative to each other. The gripping portions and the support portions can be a single structure or the support portions can be separate structures that extend from the gripping portions. The arms 38 and 42 can be radiolucent so as to increase fluoroscopy visibility. The first arm 38 includes a first inner spacer contacting surface 88 and the second arm 42 includes a second inner spacer contacting surface 92 that is spaced from the first inner spacer contacting surface 88 along a first direction, such as the lateral direction A. The inner surface of the support member 34, the first inner spacer contacting surface 88, and the second inner spacer contacting surface 92 together define a void 94 that is configured to receive and grip the spacer body 30. The terminal ends 83 and 84 are spaced apart from the support member along a second direction, such as the longitudinal direction L that is substantially perpendicular to the first direction so as to define first and second lengths L_1 and L_2 , respectively of the first and second arms 38 and 42. The first and second arms 38 and 42 are sized such that the first and second lengths L_1 and L_2 are each greater than a length L_3 defined between an anterior end E of the inferior vertebral body 10b and the centroid M of the surface 14b of the inferior vertebral body 10b, as shown in Fig. 1C. It should be appreciated, that the first and second arms 38 and 42 can also be sized such that the first and second lengths L_1 and L_2 are greater than a length defined between an anterior end of the superior vertebral body 10a and a centroid of the surface 14a of the superior vertebral body 10a. . The first and second lengths L_1 and L_2 may be between about 3.5 mm and about 12 mm, between about 6.0 mm and about 10 mm, and preferably about 9.5 mm. In some embodiments, the support member 34, the first arm 38, and the second arm 42 extend around at least 51% of the spacer body 30, and preferably around at least 80% of the spacer body 30.

[0072] The flexible arms 38 and 42 can have a transverse height and a lateral width that at least partially define a cross-sectional area of the arms 38 and 42. The arms 38 and 42 can have a cross-sectional area that may vary so long as the arms 38 and 42 are capable of elastically deforming or flexing to thereby allow the frame 26 to receive the spacer body and subsequently apply a retention force to the spacer body 30 after the frame 26 has received the spacer body 30. In that regard, the arms 38 and 42 are configured to elastically flex laterally outwardly away from each other, or otherwise elastically deform from a first position to a second flexed position to allow the frame 26 to receive the spacer body 30. It should be appreciated that the first

position can be a relaxed position of the arms 38 and 42 or a flexed position of the arms 38 and 42 that is outwardly flexed with respect to a relaxed position. At least respective portions of the arms 38 and 42, such as contact locations 320 and 324 (see Fig. 6E), are further spaced from each other in the second position than when in the first position. Once the spacer body 30 is disposed between the arms 38 and 42, the arms 38 and 42 may flex inwardly toward each other to a third or engaged position whereby the arms 38 and 42 engage the spacer body 30 so as to secure the frame 26 to the spacer body 30 as shown in Fig. 2. It should be appreciated that the third position can be outwardly flexed with respect to the first position, and can be substantially equal to the first position. Thus, the respective portions of the arms 38 and 42 can be further spaced from each other when in the third position with respect to the first position, or the respective portions of the arms 38 and 42 can be spaced from each other when in the third position a distance substantially equal to the distance that the respective portions of the arms 38 and 42 are spaced when in the first position. Thus, it can be said that when the arms 38 and 42 are in the third position, at least respective portions of the arms 38 and 42 are spaced apart a distance equal to or greater than (or no less than) the distance that the arms 38 and 42 are spaced when in the first position. It will be further appreciated from the description below in accordance with certain embodiments (see, for instance Fig. 14C) that at least respective portions of the arms 38 and 42 can be spaced apart a distance when in the engaged position that is less than the distance that the respective portions of the arms 38 and 42 are spaced apart when in the first position.

[0073] As shown in Fig. 3C, the first and second arms 38 and 42 extend from the support member 34 such that the first and second arms 38 and 42 are angled toward each other so as to push the spacer body 30 toward the other of the first and second arms 38 and 42 and toward the support member 34. For example, the inner surface of the support member 34 and the first inner spacer contacting surface 88 form an angle θ_1 that is less than 90 degrees, and the inner surface 50 of the support member 34 and the second inner spacer contacting surface 92 form an angle θ_2 that is less than 90 degrees. In the illustrated embodiment, θ_1 and θ_2 are each about 88 degrees, though it should be appreciated that θ_1 and θ_2 may be any angle as desired, and may be different angles with respect to each other.

[0074] As shown in Figs. 3C and 3D, each arm 38 and 42 includes a substantially straight portion 100 that extends from the support member 34, and a distal bent or angled portion 104 that extends from a distal end of the straight portion 100 toward the other of the bent portions 104 such that the bent portions 104 are configured to contact a distal surface of the spacer body 30. As shown, the bent portions 104 at least partially wrap around the spacer body

30 to thereby prevent the spacer body 30 from separating from the frame 26 after the spacer body 30 has been retained by the frame 26. As shown in Fig. 3A, each arm 38 and 42 can include at least one, such as a plurality of retention members 116 that extend out from the first and second inner spacer contacting surfaces 88 and 92. In the illustrated embodiment, the retention members 116 define teeth that extend out of the bent portions 104 so as to form a column of teeth on each bent portion 104. The retention members 116 are configured to engage the spacer body 30 when the frame 22 is retaining the spacer body 30 to thereby ensure that the spacer body 30 remains retained by the frame 22. It should be appreciated, however, that the retention member 116 can have any configuration as desired, so long as the retention member 116 is capable of engaging the spacer body 30. For example, the retention members 116 can be spikes that extend from the inner surfaces 88 and 92 at an angle, elongate blades, or even punches that can be punched into the spacer body 30 by an individual after the spacer body 30 is disposed in the frame 26.

[0075] As shown in Fig. 3D, the arms 38 and 42 may be configured to assist in bearing compressive loads by the vertebral bodies 10a and 10b to thereby mitigate subsidence and settling. As shown, each arm 38 and 42 defines a respective distal portion 110 and a respective proximal portion 114. The distal portions 110 are spaced apart from the proximal portions 114 along the longitudinal direction L such that when the frame 26 is disposed in the intervertebral space 18, the distal portions 110 are on the posterior side of the centroid M of the surface 14b of the inferior vertebral body 10b, and the proximal portions 114 are on the anterior side of the centroid M of the surface 14b of the inferior vertebral body 10b. Each distal portion 110 defines a superior vertebral body contacting surface 118 and an inferior vertebral body contacting surface 122. Similarly, each proximal portion 114 defines a superior vertebral body contacting surface 126 and an inferior vertebral body contacting surface 130. Because of the length of the arms 38 and 42 and because of the transverse height of the arms 38 and 42 at their distal and proximal portions, the frame 26 can bear compressive loads from the vertebral bodies if the spacer body 30 were to subside.

[0076] As shown in Fig. 3D, the arms 38 and 42 may be configured to conform to the lordotic curve of the spine and in particular of the intervertebral space 18 in which the frame 26 is to be disposed. For example, a line drawn between the superior vertebral body contacting surfaces 118 and 126 of the first arm 38 forms an angle that is between about 0 degrees and about -5 degrees with respect to the insertion direction I, and a line drawn between the inferior vertebral body contacting surfaces 122 and 130 of the first arm forms a line that is between about 0 degrees and about 5 degrees with respect to the insertion direction I. Similarly, a line drawn between the superior vertebral body contacting surfaces 118 and 126 of the second arm 42 forms

an angle that is between about 0 degrees and about -5 degrees with respect to the insertion direction, and a line drawn between the inferior vertebral body contacting surfaces 122 and 130 of the second arm 42 forms an angle that is between about 0 degrees and about 5 degrees with respect to the insertion direction I. It should be appreciated, however, that the lines drawn between the superior vertebral body contacting surfaces 118 and 126, and between the inferior vertebral body contacting surfaces 122 and 130 can be any angle as desired. For example, the lines may be parallel to each other. Therefore, it can be said that a first plane is defined by the superior vertebral body contacting surfaces, and a second plane is defined by the inferior vertebral body contacting surfaces. The first plane and the second plane can be parallel to each other or converge toward each other.

[0077] As shown in Fig. 3D, each arm 38 and 42 further includes a superior cut-out 140 and an inferior cut-out 144 to thereby provide visual access to the superior vertebral body 10a and to the inferior vertebral body 10b respectively when the frame 26 is disposed in the intervertebral space 18. The cut-outs 140 and 144 are each disposed between the proximal portions 114 and distal portions 110 of the first and second arms 38 and 42. As shown, the superior cut-outs 140 extend laterally through an upper portion of the arms 38 and 42 so as to define upper curved recesses 148 in the straight portions 100 of the arms 38 and 42. Similarly, the inferior cut-outs 144 extend laterally through a lower portion of the arms 38 and 42 so as to define lower curved recesses 152 in the arms 38 and 42. It should be appreciated that the superior and inferior cut-outs 140 and 144 can have other configurations as desired. For example, the cut-outs 140 and 144 can define rectangular channels that extend through the arms 38 and 42.

[0078] As shown in Figs. 3D and 3E, each arm 38 and 42 can further include a window 156 that extends laterally through the straight portions 100 of the arms 38 and 42 between the superior and inferior cut-outs 140 and 144. The windows 156 are configured to provide visual access to the spacer body 30 through the first and second arms 38 and 42 when the frame 26 is retaining the spacer body 30. As shown, the windows 156 are oval shaped and elongate along the longitudinal direction L. It should be appreciated, however, that the windows 156 can have any shape as desired. For example, the windows 156 can also be rectangular shaped.

[0079] As shown in Figs. 3A, 3D, and 3E, each arm 38 and 42 includes an engagement member 170 that is configured to receive a first and a second external expansion force, respectively, from an expansion instrument prior to insertion of the spacer body 30 into the void 94 such that at least one of the first and second arms 38 and 42 elastically expands or elastically flexes with respect to the other of the first and second arms 38 and 42 in response to

the expansion forces. As shown in Fig. 3A, the engagement members 170 each define a dove-tailed slot 174 that defines an opening 178 at its distal end such that the expansion instrument can engage the dove-tailed slot 174 in a direction that is opposite to the insertion direction I of the frame 26. As shown in Fig. 3D, the dove-tailed slots 174 are wider at the openings 178 and taper as they extend proximally. The wider openings 178 provide a guide for the expansion instrument to engage the engagement members 170. As shown in Fig. 3A, the dove-tailed slots 174 each include a pair of opposed recesses 182 that define angled engagement surfaces 186. It should be appreciated, however, that the engagement members 170 can have any configuration as desired so long as they can receive respective expansion forces.

[0080] Now referring to Fig. 5A, the spacer body 30 that is received within the frame 26 is preferably made from a bone graft material such as allograft bone, autograft bone, or xenograft bone, for example. As shown in Fig. 5A, the spacer body 30 can include cancellous bone 190 that is at least partially surrounded by cortical bone 194. It should be appreciated, however, that the spacer body 30 can be made from only cancellous bone 190 or from only cortical bone 194.

[0081] As shown in Figs. 5B-5D, the spacer body can alternatively be made from a synthetic material. Referring to Figs. 5B-5D, the spacer body 30 is sized and dimensioned to fit within the frame 26. Though not required, the spacer body may have a lateral width of between about 10 mm and about 16 mm, a longitudinal length of between about 10 mm and 17 mm, and a transverse height that is between about 5 mm and about 12 mm. The outer footprint of the spacer body 30 can vary and the frame 26 may still be able to retain the spacer body 30. That is, the frame 26 or at least the arms 38 and 42 are configured to retain a first spacer body 30 having a first maximum width, a first outer footprint, or a first cross-sectional dimension, and a second spacer body having a second maximum width, a second outer footprint, or a second cross-sectional dimension that is different than those of the first spacer body 30. Therefore, the frame 26 and in particular the arms 38 and 42 can retain spacer bodies 30 that are made from bone shaped by the surgeon and not just spacer bodies 30 that are machined to have specific dimensions prior to insertion into the frame 26.

[0082] As shown in Figs. 5B-5D, the spacer body 30 can define a superior or upper or outer bone engaging surface 200 and an opposed inferior or lower or outer bone engaging surface 204. The surfaces 200 and 204 are configured to engage the superior and inferior surfaces 14a and 14b, respectively of the vertebral bodies 10a and 10b. The spacer body 30 can further define side surfaces 208 that are configured to be engaged by the first and second inner

spacer contacting surfaces of the first and second arms 38 and 42 to thereby retain the spacer body 30 within the frame 26.

[0083] As shown in Figs. 6A-6E, the spacer body 30 can be coupled to the frame 26 using an actuation instrument 210 that is configured as an expansion instrument. The instrument 210, the frame 26, and in some cases the spacer body 30 can together define an intervertebral implant system 214. The expansion instrument 210 includes a grip 212 and a handle 213. The grip 212 is configured as an expansion grip and is configured to apply the first and second expansion forces to the engagement members 170 of the first and second arms 38 and 42. The first and second expansion forces will elastically expand the first and second arms 38 and 42 of the frame 26 to thereby allow the spacer body 30 to be received by the void 94 of the frame 26.

[0084] As shown, the instrument 210 includes a first arm 220 that is configured to releasably couple to the first arm 38 of the frame 26, and a second arm 224 that is rotatably coupled to the first arm 220 at a first pivot 228 and is configured to releasably couple to the second arm 42 of the frame 26. The first and second arms 220 and 224 are configured as expansion arms. The first and second expansion arms 220 and 224 are pivotally coupled to each other at the first pivot 228 such that rotation of the first and second expansion arms 220 and 224 about the first pivot 228 causes the first and second arms 38 and 42 of the frame 26 to elastically flex away from each other when the instrument 210 is coupled to the frame 26. Therefore, the instrument 210 is configured to have a first position or configuration whereby the instrument 210 can be coupled to the frame 26, and a second position or configuration whereby the instrument 210 is applying expansion forces to the arms 38 and 42 of the frame 26 so that the frame can receive the spacer body 30.

[0085] As shown in Figs. 6B and 6C, each expansion arm 220 and 224 includes a handle portion 232 that extends proximally from the first pivot 228 and a gripping portion 236 that extends distally from the first pivot 228. The handle portions 232 define the handle 213, and the gripping portions 236 define the grip 212. The handle portions 232 are configured to be gripped by an individual such that the handle portions 232 can be squeezed or otherwise moved toward each other. The expansion instrument 210 can further include a handle locking mechanism 240 that is configured to lock the handle portions 232 relative to each other after the handle portions 232 have been moved toward each other. In the illustrated embodiment, the locking mechanism 240 includes a threaded shaft 244 and a nut 248. As at least one of the handle portions 232 is moved along the shaft 244, the nut 248 can be threaded along the shaft 244 to thereby lock the handle portions 232 relative to each other. It should be appreciated,

however, that the locking mechanism 240 can include other configurations, as desired. For example, the locking mechanism 240 can have a ratchet configuration.

[0086] As shown in Figs. 6C and 6D, the gripping portions 236 are configured to expand the frame arms as the handle portions 232 are moved toward each other. Each gripping portion 236 includes an extension member 250 that extends distally from the first pivot 228, and a gripping member 254 that is pivotally coupled to a distal end of the extension member 250 at a second pivot 258. Each gripping member 254 includes an engagement member 262 that is configured to engage respective engagement members 170 of the first and second arms 38 and 42 of the frame 26. As shown in Fig. 6D, the engagement members 262 are dove-tailed members 266 that are opposed to each other and are configured to mate with the dove-tailed slots of the first and second arms 38 and 42 to thereby couple the expansion instrument 210 to the frame 26. As shown, each dove-tailed member 266 includes a pair of transversely opposed protrusions 280 that each define an angled engagement surface 284 that is configured to abut or otherwise contact a respective angled engagement surface 186 of the slots 174 when the engagement members 262 are mated with the engagement members 170. It should be appreciated that the engagement members 262 can have other configurations as desired. For example, the engagement members 262 and the engagement members 170 can be reversed.

[0087] As shown in Fig. 6D, a proximal end of each engagement member 262 defines a tapered lead-in portion 270 that allows the engagement members 262 to easily be guided into the openings 178 of the engagement members 170. Therefore, the expansion instrument 210 can easily be coupled to the frame 26 along a direction that is opposite the insertion direction I. That is, if the frame 26 is stationary, the expansion instrument 210 can be coupled to the frame 26 by translating the instrument 210 along a direction that is opposite the insertion direction I.

[0088] As shown in Fig. 6C, each gripping member 254 includes a pair of stops 300 that extend proximally toward the extension member 250 and are spaced apart from the extension member 250. As the gripping member 254 rotates about the second pivot 258 the stops 300 will limit the rotation by contacting the extension member 250. Therefore, the angular range in which the gripping members 254 can rotate about the second pivots 258 will depend on the distance in which the stops 300 are spaced apart from the extension members 250.

[0089] As shown in Fig. 6C, each gripping portion 236 further includes a biasing member 304 that is configured to bias the gripping members 254 toward each other. In the illustrated embodiment, the biasing members 304 are leaf springs 308 that are coupled to the extension members 250 and urge against an outer surface of the gripping members 304. By biasing the gripping members 254 toward each other, the expansion instrument 210 can more

easily and more predictably be coupled to the frame 26. It should be appreciated, however, that the biasing members 304 can have other configurations as desired.

[0090] In operation and in reference to Fig. 6E, the expansion instrument 210 is coupled to the frame 26 by placing the engagement members 262 of the instrument 210 distal to the engagement members 170 of the frame 26. By translating or otherwise moving the frame 26 or the instrument 210 toward the other, the engagement members 262 will engage the engagement members 170 to thereby couple the frame 26 to the instrument 210 such that the second pivots 258 of the instrument 210 abut an outer surface of the flexible arms 38 and 42 proximate to the support member 34. By squeezing the handle portions 232 toward each other, the extension member 250 of the first expansion arm 220 will rotate counterclockwise about the first pivot 228 and the gripping member 254 of the first expansion arm 220 will rotate clockwise about the second pivot 258. Conversely, the extension member 250 of the second expansion arm 224 will rotate clockwise about the first pivot 228 and the gripping member 254 of the second expansion arm 224 will rotate counterclockwise about the second pivot 258.

[0091] This rotation will cause at least one of the first and second arms 38 and 42 to elastically flex away from the other. For example, the first and second inner spacer contacting surfaces 88 and 92 of the first and second arms 38 and 42 can define respective first and second respective contact locations 320 and 324, and at least one of the first and second arms 38 and 42 is flexible so as to be movable between a first position, whereby the frame 26 defines a first distance d_1 that extends along the lateral direction A between the first and second contact locations 320 and 324, and a second position, whereby the frame 26 defines a second distance d_2 that extends along the lateral direction A between the first and second contact locations 320 and 324. It should be appreciated that the first and second contact locations 320 and 324 can be located anywhere along the arms 320 and 324 so long as they remain the same when the first and second distances are measured.

[0092] As shown in Fig. 6E, the second distance d_2 is greater than the first distance d_1 such that when in the second position, the void 94 defines a cross-sectional dimension that is greater than that of the spacer body 30 such that the void 94 is sized to receive the spacer body 30. While the arms 38 and 42 are elastically flexed, at least one of the arms 38 and 42 is biased toward the first position. Therefore, when the handle portions 232 of the instrument 210 are released, the arms 38 and 42 will flex back to a third position, and when in the third position, the frame 26 defines a third distance d_3 that extends along the lateral direction A between the first and second contact locations 320 and 324 and is less than the second distance d_2 (See Fig. 2B). When in the third position at least one of the first and second inner contacting surfaces 88 and 92

of the arms 38 and 42 will apply a retention force against the spacer body 30 along a direction toward the other of the first and second inner spacer contacting surfaces 88 and 92.

[0093] In another embodiment and in reference to Figs. 7A-7C, an intervertebral implant system 350 can include an intervertebral implant frame 426, and an actuation instrument 428 that is also configured as an expansion instrument. The frame 426 includes a support member 434, a first arm 438 that extends from the support member 434, and a second arm 442 that extends from the support member 434. The first and second arms 438 and 442 are flexible arms and are configured to elastically flex away from each other so that the frame 426 can receive a spacer body 30. The support member 434, the first arm 438, and the second arm 442 are similar to the support member 34, the first arm 38, and the second arm 42 shown in Fig. 3A, and include like structure unless otherwise described.

[0094] As shown in Fig. 7C, each of the first and second arms 438 and 442 includes a straight portion 446 and a bent portion 450 that extends from a distal end of the straight portion 446 at angle toward the other of the bent portions 450. Each arm 438 and 442 further includes an engagement member 454 that defines a slot 458 that extends through the respective arm 438 and 442. As shown the slots 458 extend through the straight portions 446 at substantially the same angle in which the bent portions 450 extend from the distal end of the straight portions 446. Moreover, the slots 458 extend through the straight portions 446 and into a cavity 460 defined by the bent portions 450. Each bent portion 450 further includes a retention bump 461. The bumps 461 are configured to provide a tactile feedback indicating that the expansion instrument 428 is coupled to the arms 438 and 442.

[0095] As shown in Figs. 7A-7C, the expansion instrument 428 can include a pair of removable clips 470 that are configured to engage the slots 458 defined by the arms 438 and 442 by translating the clips 470 distally or along a direction that has a directional component that is the same as the insertion direction I. As shown, each clip 470 can be a substantially straight elongate member 474 having an engagement member 476 that is defined by a pair of elongate cantilevered beams 478 at its distal end that are separated by a recess 482. An outer beam 478 can include a recess 479 that is configured to receive the retention bump 461 and provide an indication that the clips 470 are properly coupled to the arms 438 and 442. As shown in Fig. 7B, each clip 470 can be attached to a respective arm 438 and 442 by inserting one of the cantilevered beams 478 of a respective clip 470 into a slot 458 of the respective arms 438 and 442. The cantilevered beam 478 that is inserted into the slot 458 will be received by the cavity 460 defined by the bent portion 450.

[0096] Once coupled to the arms 438 and 442, the clips 470 extend out from the arms 438 and 442 at an angle such that the clips 470 diverge from each other as they extend proximally. By squeezing a proximal portion of the clips 470 toward each other, the cantilevered beams 478 apply an expansion force to the engagement members 454 or at least to the bent portions 450 such that the arms 438 and 442 elastically flex away from each other. While flexed, the frame 426 can receive the spacer body 30. By releasing the clips 470, the arms 438 and 442 will apply a retention force to the spacer body 30 to thereby retain the spacer body 30 in the frame 426.

[0097] In another embodiment and in reference to Figs. 8A-8C, an intervertebral implant system 522 can include an intervertebral implant frame 526, and an actuation instrument 528 that is configured as an expansion instrument. The frame 526 includes a support member 534, a first arm 538 that extends from the support member 534, and a second arm 542 that extends from the support member 534. The first and second arms 538 and 542 flexible arms and are configured to elastically flex away from each other so that the frame 526 can receive a spacer body 30. The support member 534, the first arm 538, and the second arm 542 are similar to the support member 34, the first arm 38, and the second arm 42 shown in Fig. 3A, and include like structure unless otherwise described.

[0098] As shown in Fig. 8C, each of the first and second arms 538 and 542 includes a straight portion 546 and a bent portion 550 that extends from a distal end of the straight portion 546 at angle toward the other of the bent portions 550. Each arm 538 and 542 further includes an engagement member 554 that defines a slot 558 that extends through the respective arm 538 and 542. As shown the slots 558 extend through the bent portions 550 along a direction that is opposite the insertion direction I. Moreover, the slots 558 extend into a cavity 560 that is defined by each straight portion 546. Each straight portion 546 further includes a retention bump 561. The bumps 561 are configured to provide a tactile feedback indicating that the expansion instrument 528 is coupled to the arms 538 and 542.

[0099] As shown in Figs. 8A-8C, the expansion instrument 528 can include a pair of removable clips 570 that are configured to engage the slots 558 defined by the arms 538 and 542 by translating the clips 570 proximally or along a direction that is opposite to the insertion direction I. As shown, each clip 570 includes a handle portion 574 and a gripping portion 578 that extends distally from the handle portion 574. Each gripping portion 578 includes a body 582 and an engagement member 584 that extends out from the body 582. As shown, each engagement member 584 defines a proximally extending protrusion 586 that is spaced from the 582 such that a recess 588 is defined between the protrusion 586 and body 582. Each gripping

portion 578 further includes a shoulder 590 that extends out from the body 582 and is configured to abut the arms 538 and 542 proximate to the support member 526 when the clip 570 is coupled to the frame 526. Each clip 570 further includes a recess 579 that is configured to receive the retention bump 561 and provide an indication that the clips 570 are properly coupled to the arms 538 and 542. As shown in Fig. 8B, each clip 570 can be attached to a respective arm 538 and 542 by inserting the protrusion 586 of a respective clip 470 into a slot 558 of a respective arm 538 and 542. The protrusion 586 will be received by the cavity 560 defined by the straight portion 546.

[0100] Once coupled to the arms 538 and 542, the clips 570 extend out from the arms 538 and 542 such that the handle portions 574 are proximal to the front of the frame 526 and the shoulders 590 are abutting the arms 538 and 542 proximate to the support member 526 as shown in Fig. 8B. By squeezing the handle portions 574 toward each other, clips 570 rotate about the shoulders 590 and the protrusions 586 apply an expansion force to the engagement members 554 or to at least the straight portions 546 such that the arms 538 and 542 elastically flex away from each other. While flexed, the frame 526 can receive the spacer body 30. By releasing the clips 570, the arms 538 and 542 will apply a retention force to the spacer body 30 to thereby retain the spacer body 30 in the frame 526.

[0101] It should be appreciated that the engagement members of the frames 26, 426, and 526, and the engagement members of the instruments 210, 428, and 528 are interchangeable. Therefore, for example, frame 26 and instrument 210 can include any of the engagement members 170, 262, 454, 476, 554, and 584 so long as the engagement members of the frame 26 can mate with the engagement members of the instrument 210 to thereby releasably couple the frame 26 to the instrument 210.

[0102] As shown in Figs. 9A and 9B, the actuation instrument can be incorporated into the frame such that the actuation instrument and the frame are a unitary part. In accordance with another embodiment and in reference to Fig. 9A, an intervertebral implant frame 626 can include a support member 634, a first arm 638 that extends from the support member 634, and a second arm 642 that extends from the support member 634. The first and second arms 638 and 642 are flexible arms and are configured to elastically flex away from each other so that the frame 626 can receive a spacer body 30. The support member 634, the first arm 638, and the second arm 642 are similar to the support member 34, the first arm 38, and the second arm 42 shown in Fig. 3A, and include like structure unless otherwise described.

[0103] As shown in Fig. 9A, each of the first and second arms 638 and 642 includes a straight portion 646 and a bent portion 650 that extends from a distal end of the straight portion

646 at angle toward the other of the bent portions 650. Each arm 638 and 642 further includes an expansion member 654 that extends out from the arm at angle. As shown, each expansion member 654 extends out from the proximal end of the bent portion 650 and includes a handle portion 660 that is spaced apart from the straight portion 646. By squeezing the handle portions 660 toward each other, the arms 638 and 642 will elastically flex away from each other so that the frame 626 can receive the spacer body 30. As shown in Fig. 9B, the expansion members 654 can extend proximally such that handle portions 660 are proximal to the arms 638 and 642 to thereby provide more lavage. Once the frame 626 has been coupled to the spacer body 30, the expansion members 654 can be broken off and removed from the frame 626.

[0104] In another embodiment the frame can be configured to have portions of the frame arms crimped toward the spacer body to thereby retain the spacer body. In such embodiments, the frame is capable of receiving the spacer body without flexing the arms of the frame away from each other. The spacer body will then be retained by the frame by crimping the arms toward the spacer body to thereby provide a retention force to the spacer body.

[0105] For example, in reference to Figs. 10A and 10B, an intervertebral implant frame 726 includes a support member 734, a first arm 738 that extends from the support member 734, and a second arm 742 that extends from the support member 734. The first and second arms 734 and 738 are crimpable arms such that the frame 726 is configured to have a first initial position in which the spacer body 30 can be disposed between the arms 738 and 742, and a second crimped or engaged position in which the arms 738 and 742 are crimped toward each other to thereby apply a retention force to the spacer body 30. The support member 734, the first arm 738, and the second arm 742 are similar to the support member 34, the first arm 38, and the second arm 42 shown in Fig. 3A, and include like structure unless otherwise described.

[0106] The first and second arms 738 and 742 are configured to be crimped rather than flexed. As shown, the arms 738 and 742 include first and second inner spacer contacting surfaces 744 and 746, respectively that are configured to contact and retain the spacer body 30. That is, the inner surface of the support member 734, the first inner spacer contacting surface 744 and the second inner spacer contacting surface 746 together define a void 748 that is configured to receive the spacer body 30. Each arm 738 and 742 further includes a substantially straight portion 750 and a crimp member 752 that extends distally from the straight portion 748. As shown, the crimp members 752 are each coupled to the straight portions 750 by a hinge 756. In the illustrated embodiment, the hinges 756 define transverse bending grooves 758 formed in the inner spacer contacting surfaces 744 and 746.

[0107] In operation, the frame 726 can receive the spacer body 30 within the void 748 without expanding the arms 738 and 742 away from each other. Though it should be appreciated some expanding may occur. Once the spacer body 30 is properly positioned, the first crimp member 752 of the first arm 738 can be rotated about the first hinge 756 such that the first crimp member 752 is bent toward the second arm 742. Similarly, the second crimp member 752 of the second arm 742 can be rotated about the second hinge 756 such that the second crimp member 752 is bent toward the first arm 738. After the crimp members 752 have been crimped or otherwise bent, the arms 738 and 742 apply a retention force to the spacer body 30 to thereby retain the spacer body 30 to the frame 726. As shown, each arm 738 and 742 can further include a retention member 760 that extends from the first and second inner spacer contacting surfaces 744 and 746, respectively. The retention members 760 are configured to engage the spacer body 30 to thereby prevent migration of the spacer body 30 from the frame 726.

[0108] In another embodiment and in reference to Figs. 11A and 11B, an intervertebral implant frame 826 can include more than two crimp members. As shown, the frame 826 includes a support member 834, a first arm 838 that extends from the support member 834, and a second arm 842 that extends from the support member 834. The first and second arms 838 and 842 are crimpable arms such that the frame 826 is configured to have a first initial position in which the spacer body 30 can be disposed between the arms 838 and 842, and a second crimped or engaged position in which the arms 838 and 842 are crimped toward each other to thereby apply a retention force to the spacer body 30. The support member 834, the first arm 838, and the second arm 842 are similar to the support member 34, the first arm 38, and the second arm 42 shown in Fig. 3A, and include like structure unless otherwise described.

[0109] The first and second arms 838 and 842 are configured to be crimped rather than flexed. As shown, the arms 838 and 842 include first and second inner spacer contacting surfaces 844 and 846, respectively that are configured to contact and retain the spacer body 30. That is, the inner surface of the support member 834, the first inner spacer contacting surface 844 and the second inner spacer contacting surface 846 together define a void 848 that is configured to receive the spacer body 30. Each arm 838 and 842 further includes a first crimp member 850 and a second crimp member 852 that extends distally from the first crimp member 850. In other words, the first arm 838 can include a first crimp member 850 and a third crimp member 852 of the frame 826, and the second arm 842 can include a second crimp member 850 and a fourth crimp member 852 of the frame 826. As shown, the first crimp member 850 and the second crimp member 850 are each coupled to the support member 834 by first and second hinges 856 respectively. Similarly, the third and fourth crimp members 852 are coupled to the first crimp

members 850 by third and fourth hinges 860 respectively. In the illustrated embodiment, the hinges 856 and 860 define transverse bending grooves 864 formed in the outer surfaces of the first and second arms 838 and 842.

[0110] In operation, the frame 826 can receive the spacer body 30 within the void 848 without expanding the arms 838 and 842 away from each other. Though it should be appreciated some expanding may occur. Once the spacer body 30 is properly positioned, the first crimp member 850 and the second crimp member 852 of the first arm 838 can be rotated about the first and second hinges 856 and 860 respectively such that the crimp members 850 and 852 are bent toward the second arm 842. Similarly, the first crimp member 850 and the second crimp member 852 of the second arm 842 can be rotated about the first and second hinges 856 and 860 respectively such that the crimp members 850 and 852 are bent toward the first arm 838. After the crimp members 850 and 852 have been bent, the arms 838 and 842 apply a retention force to the spacer body 30 to thereby retain the spacer body 30 to the frame 826. As shown, each arm 838 and 842 can further include a retention member 868 that extends from the first and second inner spacer contacting surfaces 844 and 846, respectively. The retention members 868 are configured to engage the spacer body 30 to thereby prevent migration of the spacer body 30 from the frame 826.

[0111] In another embodiment and in reference to Figs. 12A and 12B, an intervertebral implant frame 926 can include crimp members that define crimping tabs. As shown, the frame 926 includes a support member 934, a first arm 938 that extends from the support member 934, and a second arm 942 that extends from the support member 934. The first and second arms 938 and 942 are crimpable arms such that the frame 926 is configured to have a first initial position in which the spacer body 30 can be disposed between the arms 938 and 942, and a second crimped or engaged position in which the arms 938 and 942 are crimped toward each other to thereby apply a retention force to the spacer body 30. The support member 934, the first arm 938, and the second arm 942 are similar to the support member 34, the first arm 38, and the second arm 42 shown in Fig. 3A, and include like structure unless otherwise described.

[0112] The first and second arms 938 and 942 are configured to be crimped rather than flexed. As shown, the arms 938 and 942 include first and second inner spacer contacting surfaces 944 and 946, respectively that are configured to contact and retain the spacer body 30. That is, the inner surface of the support member 934, the first inner spacer contacting surface 944 and the second inner spacer contacting surface 946 together define a void 948 that is configured to receive the spacer body 30. Each arm 938 and 942 further includes a substantially straight portion 950, a bent portion 951 extending from a distal end of the straight portion 950, and a

crimp member 952 that is formed in the straight and bent portion 950 and 951. As shown, the crimp members 952 each define a crimping tab 956 that is attached to one of the straight portion 950 or the bent portion 951 by a hinge 958. In the illustrated embodiment, a proximal edge of the crimping tab 956 is coupled to the straight portion 950 and defines the hinge 958. It should be appreciated, however, that an upper edge, a lower edge, or a distal edge of the crimping tabs 956 could define the hinges 958. As shown, each crimping tab 956 is disposed within a window defined by the respective arm.

[0113] In operation, the frame 926 can receive the spacer body 30 within the void 948 without expanding the arms 938 and 942 away from each other. Though it should be appreciated some expanding may occur. Once the spacer body 30 is properly positioned, the crimping tab 956 of the first arm 938 can be rotated about the hinge 958 such that the crimping tab 956 is bent toward the second arm 942. Similarly, the crimping tab 956 of the second arm 942 can be rotated about the hinge 958 such that the crimping tab 956 is bent toward the first arm 938. After the crimping tabs 956 have been bent, the frame is in the crimped or engaged position such that the arms 938 and 942 apply a retention force to the spacer body 30 to thereby retain the spacer body 30 to the frame 926. It should be appreciated that the first and second arms 938 and 942 can include any number of crimping tabs 956 as desired.

[0114] In another embodiment and in reference to Figs. 13A and 13B, an intervertebral implant frame 1026 can include crimp members that define tabs disposed along upper and lower edges of the arms. As shown, the frame 1026 includes a support member 1034, a first arm 1038 that extends from the support member 1034, and a second arm 1042 that extends from the support member 1034. The first and second arms 1038 and 1042 are crimpable arms such that the frame 1026 is configured to have a first initial position in which the spacer body 30 can be disposed between the arms 1038 and 1042, and a second crimped or engaged position in which the arms 1038 and 1042 are crimped toward each other to thereby apply a retention force to the spacer body 30. The support member 1034, the first arm 1038, and the second arm 1042 are similar to the support member 34, the first arm 38, and the second arm 42 shown in Fig. 3A, and include like structure unless otherwise described.

[0115] The first and second arms 1038 and 1042 are configured to be crimped rather than flexed. As shown, the arms 1038 and 1042 include first and second inner spacer contacting surfaces 1044 and 1046, respectively that are configured to contact and retain the spacer body 30. That is, the inner surface of the support member 1034, the first inner spacer contacting surface 1044 and the second inner spacer contacting surface 1046 together define a void 1048 that is configured to receive the spacer body 30. Each arm 1038 and 1042 further includes a

substantially straight portion 1050, a bent portion 1051 extending from a distal end of the straight portion 1050, and at least one, such as a plurality of crimp members 1052 that are formed in upper and lower edges of the arms 1038 and 1042. As shown, the crimp members 1052 each define a crimping tab 1056 that are each attached to the straight and bent portions 1050 and 1051 by respective horizontal hinges 1058.

[0116] In operation, the frame 1026 can receive the spacer body 30 within the void 1048 without expanding the arms 1038 and 1042 away from each other. Though it should be appreciated some expanding may occur. Once the spacer body 30 is properly positioned, the crimping tabs 1056 of the first arm 1038 can be rotated about the hinges 1058 such that the crimping tabs 1056 are bent toward the second arm 1042. Similarly, the crimping tabs 1056 of the second arm 1042 can be rotated about the hinges 1058 such that the crimping tabs 1056 are bent toward the first arm 1038. After the crimping tabs 1056 have been bent, the frame 1026 is in the crimped or engaged position such that the arms 1038 and 1042 apply a retention force to the spacer body 30 to thereby retain the spacer body 30 to the frame 1026. It should be appreciated that the first and second arms 1038 and 1042 can include any number of crimping tabs 1056 as desired.

[0117] As shown in Figs. 14A-14C, the spacer body 30 can be coupled to the frame 726 using an actuation instrument 1110 that is configured as a crimping instrument. The instrument 1110 and the frame 726 can together define an intervertebral implant system 1114. The crimping instrument 1110 includes an actuation grip 1116 that is configured as a crimping grip so as to apply a crimping force to the frame 726. For instance, in accordance with the illustrated embodiment, the crimping grip 1116 is configured to apply first and second crimping forces to the crimp members 752 of the first and second arms 738 and 742. The first and second crimping forces will permanently deform the crimp members 752 of the frame 726 to thereby retain the spacer body 30 to the frame 726. Therefore, the instrument 1110 is configured to have a first position or configuration whereby the instrument receives the frame 726, and a second position or configuration whereby the instrument applies a crimping force to the frame 726. It should be appreciated that the instrument 1110 can also be used to crimp the frame 726 to the spacer body.

[0118] As shown in Figs. 14A and 14B, the instrument 1110 includes a first arm 1118 and a second arm 1122 rotatably coupled to the first arm 1118 at a first pivot 1126. The first and second arms 1118 and 1122 are configured as crimping arms and each includes a handle portion 1130 that extends proximally of the first pivot 1126 and a gripping portion 1134 that extends distally of the first pivot 1126. The handle portions 1130 are configured to be gripped

by an individual and moved toward each other to thereby crimp the frame 726 to the spacer body 30.

[0119] As shown in Figs. 14A and 14B, the gripping portions 1134 are coupled to the handle portions 1130 at respective second pivots 1138 that are distal to the first pivot 1126. As shown in Fig. 14B, each gripping portion 1134 includes an extension member 1142 that extends from the second pivot 1138, and a gripping member 1146 that extends distally from a distal end of the extension member 1142. As shown, the gripping portions 1134 are coupled to each other at a third pivot 1150 that proximate to the distal ends of the extension members 1142, such that the gripping members 1146 extend distally to the third pivot 1150. Therefore, when the handle portions 1130 are moved toward each other so as to rotate about the first pivot 1126, the extension members 1142 will rotate about their respective second pivots 1138 such that they move away from each other, and the gripping members 1146 will rotate about the third pivot 1150 such that they move toward each other to thereby crimp the frame 726 on to the spacer body 30.

[0120] As shown in Fig. 14B, each gripping member 1146 defines a ribbed contact surface 1156 that is configured to contact and apply a crimping force to the crimp members 752 of the frame 726. As shown, the contact surfaces 1156 are spaced apart from each other so as to define a void 1160 that is configured to receive the frame 726 and spacer body 30. Each gripping member 1146 may further define a lower platform that is configured to support the frame 726 and spacer body 30 while the instrument 1110 is crimping the frame 726 to the spacer body 30. The ribs of the contact surfaces 1156 are configured to allow a portion of the frame 26 between the gripping members 1146.

[0121] In operation and in reference to Fig. 14C, the void 1160 defined between the contact surfaces 1156 receives the frame 726 and spacer body 30 such that the spacer body 30 is loosely disposed within the frame 726. By squeezing the handle portions 1130 toward each other, the contact surfaces 1156 will apply respective crimping forces to the crimp members 752 of the frame 726. Once a sufficient amount of force has been applied, the crimp members 752 will permanently deform toward each other such that the frame 726 will move to the crimped or engaged position and will provide a retention force against the spacer body 30 and retain the spacer body 30 to the frame 726. As shown, when in the crimped or engaged position, respective portions of the arms 738 and 742 are spaced apart from each other by the second distance d_2 which is less than the first distance.

[0122] In another embodiment and in reference to Fig. 14D, the instrument 1110 can also be configured to bend the crimp members 952 of the frame 926. As shown, the instrument

1110 can include beaked protrusions 1170 that are defined by the gripping members 1146 and are configured to engage the crimp members 952 when the handle portions 1130 are squeezed together. The beaked protrusions 1170 can be anywhere along the gripping members 1146 so long as they align with the crimp members 952. Moreover, the gripping members 1146 can define any number of beaked protrusions 1170, as desired. Therefore, if the frame 926 includes four crimping tabs 956 (i.e. crimp members 952) then the gripping members 1146 can each define two beaked protrusions 1170 that align with the crimping tabs 956.

[0123] In another embodiment and in reference to Figs. 15A and 15B frame may include a fully enclosed endplate that supports the spacer body with a multi-walled, such as a six walled structure. As shown, an intervertebral implant frame 1226 includes a support member 1234, a first arm 1238 that extends from the support member 1234, a second arm 1242 that extends from the support member 1234, and an end plate 1244 that connects the distal ends of the first and second arms 1238 and 1242 together. The support member 1234, the first arm 1238, the second arm 1242, and the end plate 1244 together define a six wall structure that supports the spacer body 30.

[0124] Now in reference to Figs. 16A-16E, the spacer body 30 can be pre-drilled to make channels in the spacer body 30 using a spacer body drill guide 1300. The channels are configured to provide clearance for the fixation elements 62 when the intervertebral implant is affixed to the superior and inferior vertebral bodies. Therefore, when the fixation elements are inserted into the fixation element apertures of the frame and then subsequently affixed to the vertebral bodies, the fixation elements will not be interfered with by the spacer body 30. The channels can be made either before or after the spacer body has been retained by the frame. If the channels are made prior to the spacer body being retained by the frame, then the channels can have a dimension that is greater than a dimension of the fixation element receiving apertures of the frame.

[0125] As shown in Figs. 16A and 16B, the spacer body drill guide 1300 includes a clamp 1304 configured to hold the spacer body 30, and a cradle 1308 that is configured to support the clamp 1304 while the channels are drilled using a drill bit 1312. The clamp 1304 includes a first clamp arm assembly 1316 and a second clamp arm assembly 1320 that is rotatably coupled to the first clamp arm assembly 1316 at a first pivot 1324. The first clamp arm assembly 1316 includes a first handle 1328, a first extension member 1332, and a first jaw 1344 removeably coupled to the first extension member 1332. Similarly, the second clamp arm assembly 1320 includes a second handle 1352, a second extension member 1356, and a second jaw 1358 removeably coupled to the second extension member 1356. As shown, a proximal end

of the first extension member 1332 is coupled to a middle portion of the first handle 1328 at a respective second pivot 1336, and a middle portion of the first extension member 1332 is coupled to a distal end of the second handle 1352 at the third pivot 1340. Similarly, a proximal end of the second extension member 1356 is coupled to a middle portion of the second handle 1352 at a respective second pivot 1336, and a middle portion of the second extension member 1356 is coupled to a distal end of the first handle 1352 at a respective third pivot 1340.

[0126] The first and second extension members 1332 and 1356 are substantially parallel to each other and remain substantially parallel to each other as the first and second handles 1328 and 1352 are rotated about the first pivot 1324. This allows the first and second jaws 1344 and 1358 to translate rather than rotate relative to each other as the first and second handles 1328 and 1352 are rotated about the first pivot 1324. As shown in Figs. 16A and 16B, each extension member 1332 and 1356 includes an elongate mounting portion 1370 at its distal end. Each mounting portion 1370 defines a fixation element receiving aperture 1364 that is configured to receive a respective fixation element 1374. As shown, the first and second jaws 1344 and 1358 are configured to be mounted to the removeably mounting portions 1370 with the fixation elements 1374.

[0127] As shown in Figs. 16A and 16B, the first jaw 1344 includes an elongate body 1380 that has a proximal mounting portion 1384 and a distal gripping portion 1388. The mounting portion 1384 defines an elongate channel 1392 that is configured to receive the mounting portion 1370 of the first extension member 1332. The mounting portion 1384 further defines an outer slot or aperture 1396 that extends into the channel 1392 and is configured to receive the fixation element 1374 to thereby couple the first jaw 1344 to the first extension member 1332. The mounting portion 1384 further includes an engagement rail 1397 that is configured to engage the cradle 1308 when the clamp 1304 is mounted to the cradle 1308.

[0128] As shown in Figs. 16A and 16B, the gripping portion 1388 includes an inner spacer contacting surface 1402, an outer surface 1406 and at least one such as two, guide holes 1410 that extend from the outer surface 1406 through to the inner spacer contacting surface 1402 at a downward angle. The guide holes 1410 are configured to receive the drill bit 1312 and guide the drill bit 1312 to the spacer body 30. As shown, a lower portion of the inner spacer contacting surface 1402 defines a pair of cut outs 1412 that provide clearance for the drill bit 1312 as it extends through the holes 1410.

[0129] As shown in Fig. 16B, the gripping portion 1388 can further include a mating member 1414, such as a bore 1418 that extends into the gripping portion 1388. The bore 1418 is configured to receive a mating member of the cradle 1308 to thereby properly align the clamp

within the cradle. It should be appreciated that the mating member 1414 can have other configurations as desired. For example, the mating member 1414 can define a peg or protrusion.

[0130] As shown in Figs. 16A and 16B, the second jaw 1358 includes an elongate body 1430 that has a proximal mounting portion 1434 and a distal gripping portion 1438. The mounting portion 1434 defines an elongate channel 1442 that is configured to receive the mounting portion 1370 of the first extension member 1332. The mounting portion 1434 further defines an outer slot or aperture 1446 that extends into the channel 1442 and is configured to receive the fixation element 1374 to thereby couple the second jaw 1358 to the second extension member 1356.

[0131] As shown in Figs. 6A and 6B, the gripping portion 1438 includes an inner spacer contacting surface 1452, an outer surface 1456 and at least one such as two, guide holes 1460 that extend from the outer surface 1456 through to the inner spacer contacting surface 1452 at a downward angle. The guide holes 1460 are configured to receive the drill bit 1312 and guide the drill bit 1312 to the spacer body 30. As shown, a lower portion of the inner spacer contacting surface 1402 defines a pair of cut outs 1462 that provide clearance for the drill bit 1312 as it extends through the holes 1460.

[0132] As shown in Fig. 16B, each gripping portion 1388 and 1438 can further include a plurality of retention members 1470 that extend out from the inner spacer contacting surfaces 1402 and 1452. In the illustrated embodiment the retention members 1470 define spikes that are configured to engage the spacer body 30. It should be appreciated, however, that the retention members 1470 can include other configuration, or the gripping portions 1388 and 1438 can be void of retention members 1470.

[0133] As shown in Fig. 16A, the cradle 1308 includes a base 1480 and a mounting portion 1484 that extends up from the base 1480. The base 1480 is sized and configured to sit on a surface and support the clamp 1304 while the drill bit 1312 drills the channels into the spacer body 30. The mounting portion 1484 includes a transverse elongate body 1488 and a channel 1492 that extends transversely into the body 1488. The channel 1492 is configured to receive the first jaw 1344 along a transverse direction such that when the first jaw 1344 is received by the channel 1492 the first jaw 1344 is fully supported by the cradle 1308.

[0134] The mounting portion 1484 further includes a pair of drill guide apertures 1500 that extend through body 1488 and into the channel 1492. The drill guide apertures 1500 of the mounting portion 1484 are configured to align with the drill guide apertures 1410 of the first jaw 1344 when the first jaw 1344 is received by the channel 1492. The mounting portion 1484 further includes a first platform 1504 that a distal end of the channel 1492 terminates into, and a

mating member 1508 that is defined by the first platform 1504. In the illustrated embodiment, the mating member 1508 is a peg 1512 that is configured to mate with the bore 1418 of the first jaw 1344. It should be appreciated, however, that the mating member 1508 can have other configurations as desired so long as the mating members of the mounting portion 1484 and the first jaw 1344 can mate with each other.

[0135] As shown in Fig. 16A, the cradle 1308 further includes a second platform 1516 that extends from the base 1480 and is spaced apart from the first platform 1504. The second platform 1516 defines a pair of cutouts 1520 that align with the drill guide apertures 1460 of the second jaw 1358 when the second jaw 1358 is resting on the second platform 1516.

[0136] In operation and in reference to Figs. 16C-16F, the clamp 1304 is configured to hold a spacer body 30 by moving the handle portions 1328 and 1352 toward each other. The clamp 1304 is then translated toward the cradle 1308 subsequently along the transverse direction T such that the first jaw 1344 of the clamp 1304 is mounted within the channel 1492 of the cradle 1408. When mounted and as shown in Fig. 16D, the peg 1512 engages the bore 1418, and the first and second jaws 1344 and 1358 rest on the first and second platforms 1504 and 1516 respectively, such that the drill guide apertures 1410 of the first jaw 1344 are aligned with the drill guide apertures 1500 of the cradle 1308.

[0137] As shown in Fig. 16E, the drill bit 1312 may then be inserted into the drill guide apertures 1410 and 1460 to thereby form the channels in the spacer body 30. As shown in Fig. 16F, the spacer body 30 will have two upper channels 1600, and two lower channels 1614. After the channels have been formed, the spacer body 30 may be coupled to a frame such as one of the frames described, using any of the instruments described. When the spacer body 30 is retained by the frame the fixation element receiving apertures of the frame will align with the channels 1600 and 1614 of the spacer body 30. The channels 1600 and 1614 can have a dimension have a dimension such as a diameter d_4 that is greater than the diameter of the fixation element receiving apertures of the frame. It should be appreciated, however, that the diameter d_5 can be equal to or even less than the diameter of the fixation element receiving apertures of the frame, as desired.

[0138] It should be appreciated, that the drill guide 1300 can be part of a kit that also includes at least one of an intervertebral implant frame, an actuation instrument, and a drill bit. Moreover it should be appreciated, that the kit can also include the spacer body 30 and at least one fixation element 62.

[0139] It will be appreciated by those skilled in the art that changes could be made to the embodiments described above without departing from the broad inventive concept thereof.

Furthermore, it should be appreciated that the structure, features, and methods as described above with respect to any of the embodiments described herein can be incorporated into any of the other embodiments described herein unless otherwise indicated. For example, the frame 26 can also include crimp members as shown in Figs. 10A, 11A, 12A, and 13A. It is understood, therefore, that this invention is not limited to the particular embodiments disclosed, but it is intended to cover modifications within the spirit and scope of the present disclosure.

What is Claimed:

1. An intervertebral implant frame comprising:
 - a support member that defines an inner surface, and at least two fixation element receiving apertures, each of the fixation element receiving apertures configured to receive a respective bone fixation element to thereby attach the intervertebral implant frame to first and second vertebral bodies, respectively when the intervertebral implant frame is disposed in an intervertebral space defined by first and second surfaces of the first and second vertebral bodies, respectively;
 - a first arm that extends from the support member and includes a first inner spacer contacting surface, the first arm defining a first terminal end; and
 - a second arm that extends from the support member and includes a second inner spacer contacting surface spaced from the first inner spacer contacting surface along a first direction, the second arm defining a second terminal end, wherein the first and second terminal ends are each spaced from the support member along a second direction that is substantially perpendicular to the first direction so as to define first and second lengths, respectively; andwherein 1) the first and second inner spacer contacting surfaces define at least first and second respective contact locations, and at least one of the first and second arms is flexible so as to be movable between a first position, whereby the frame defines a first distance between the first and second contact locations along the first direction, and a second position, whereby the frame defines a second distance between the first and second contact locations along the first direction, the second distance greater than the first distance, such that when in the second position, the at least one of the first and second arms is biased toward the first position, and 2) the first and second lengths are each sized to be greater than a length between an anterior end of the first vertebral body and a centroid of the first surface.
2. The intervertebral implant frame of claim 1 wherein the first and second lengths are each between about 3.5 mm and about 12 mm.
3. The intervertebral implant frame of claim 2, wherein the first and second lengths are each between about 6.0 mm and about 10 mm.
4. The intervertebral implant frame of claim 1, wherein the first and second arms have first and second lengths, respectively such that the support member, the first arm, and the second arm

extend around at least 51% but no more than 99% of a spacer body when the spacer body is retained by the intervertebral implant frame.

5. The intervertebral implant frame of claim 4, wherein the first and second arms have first and second lengths, respectively such that the support member, the first arm, and the second arm extend around at least 80% of the spacer body but no more than 99% of the spacer body when the spacer body is retained by the intervertebral implant frame.

6. The intervertebral implant frame of claim 1, wherein the first and second arms are capable of retaining a spacer body consisting of cancellous bone.

7. The intervertebral implant frame of claim 1, wherein the first and second arms each include at least one retention member that extends out of the spacer contacting surface, and is configured to engage a spacer body.

8. The intervertebral implant frame of claim 1, wherein the first arm and the second arm are angled toward each other such that the inner surface of the support member and the first inner spacer contacting surface forms an angle that is less than 90°, and the inner surface of the front plate and the second inner spacer contacting surface forms an angle that is less than 90°.

9. The intervertebral implant frame of claim 1, wherein the first and second lengths are between about 50% and 100% of an anterior-posterior length of the intervertebral space.

10. The intervertebral implant frame of claim 1, wherein the first and second arms each include a substantially straight portion that extends from the support member, and a distal bent portion that extends inward from a distal end of the substantially straight portion at an angle such that the bent portions are configured to contact a distal surface of a spacer body when the intervertebral implant frame is retaining the spacer body to thereby prevent the spacer body from separating from the intervertebral implant frame.

11. The intervertebral implant frame of claim 1, wherein the first and second arms each define a respective distal portion and a respective proximal portion, the distal portions each define a superior vertebral body contacting surface and an inferior vertebral body contacting

surface, the proximal portions each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface.

12. The intervertebral implant frame of claim 11, wherein a line drawn between the superior vertebral body contacting surfaces of the first arm forms an angle between about 0° and about -5° with respect to an insertion direction of the intervertebral implant frame, and a line drawn between the superior vertebral body contacting surfaces of the second arm forms an angle between about 0° and about -5° with respect to the insertion direction of the intervertebral implant frame.

13. The intervertebral implant frame of claim 12, wherein a line drawn between the inferior vertebral body contacting surfaces of the first arm forms an angle between about 0° and about 5° with respect to the insertion direction of the intervertebral implant frame, and a line drawn between the inferior vertebral body contacting surfaces of the second arm forms an angle between about 0° and about 5° with respect to the insertion direction of the intervertebral implant frame.

14. The intervertebral implant frame of claim 1, wherein the first and second arms each include a superior cut-out and an inferior cut-out to thereby provide visual access to the superior vertebral body and to the inferior vertebral body respectively when the intervertebral implant frame is disposed in the intervertebral space.

15. The intervertebral implant frame of claim 14, wherein the first and second arms each include a window that extends through the first and second arms to thereby provide visual access to a spacer body through the first and second arms when the intervertebral implant frame is retaining the spacer body.

16. The intervertebral implant frame of claim 1, wherein the first and second arms each include an expansion instrument engagement member.

17. The intervertebral implant frame of claim 16, wherein the expansion instrument engagement members each define a dove-tailed slot.

18. The intervertebral implant frame of claim 17, wherein the dove-tailed slots are each open at their distal ends, such that an expansion instrument can engage the dove-tailed slots in a direction that is opposite to an insertion direction of the intervertebral implant frame.
19. The intervertebral implant frame of claim 16, wherein the expansion instrument engagement members each define a slot that extends through the first and second arms.
20. The intervertebral implant frame of claim 1, wherein the arms are configured to retain a first spacer body having a first maximum width and a second spacer body having a second maximum width that is different than the first maximum width.
21. The intervertebral implant frame of claim 1, wherein at least one of the first and second arms is flexible so as to be movable between the second position to a third position whereby the frame defines a third distance between the first and second contact locations along the first direction, the third distance less than the second distance.
22. A intervertebral implant frame comprising:
- a support member that defines an inner surface and at least two fixation element receiving apertures that are each configured to receive a respective bone fixation element to thereby attach the frame to first and second vertebral bodies when the intervertebral implant frame is disposed in an intervertebral space defined by the superior and inferior vertebral bodies;
 - a first flexible arm that extends from the support member and defines a first inner spacer contacting surface;
 - a second flexible arm that extends from the support member and defines a second inner spacer contacting surface that is spaced from the first inner spacer contacting surface, wherein the inner surface of the support member and the first and second inner spacer contacting surfaces at least partially define a void configured to receive a spacer body that ingrows with the first and second vertebral bodies when the spacer is disposed in the intervertebral space;
- wherein the first and second flexible arms include respective first and second engagement members that are configured to receive respective first and second expansion forces from an expansion instrument prior to insertion of the spacer body into the void, such that at least one of the first and second flexible arms elastically expands with respect to the other of the first and second arms in response to the expansion force.

23. The intervertebral implant frame of claim 22 wherein the first and second arms each have a length that is between about 3.5 mm and about 12 mm.
24. The intervertebral implant frame of claim 23, wherein the first and second arms each have a length that is between about 6.0 mm and about 10 mm.
25. The intervertebral implant frame of claim 22, wherein the first and second arms each have a length such that the support member, the first arm, and the second arm extend around at least 51% but no more than 99% of the spacer body when the spacer body is retained by the intervertebral implant frame.
26. The intervertebral implant frame of claim 22, wherein the first and second arms are capable of retaining a spacer body consisting of cancellous bone, cortical bone, or both cancellous and cortical bone.
27. The intervertebral implant frame of claim 22, wherein the first and second arms each include at least one retention member that extends out of the first and second spacer contacting surfaces, respectively, and is configured to engage the spacer body.
28. The intervertebral implant frame of claim 27, wherein the first arm and the second arm are angled toward each other such that the inner surface of the support member and the first inner spacer contacting surface forms an angle that is less than 90°, and the inner surface of the support member and the second inner spacer contacting surface forms an angle that is less than 90°.
29. The intervertebral implant frame of claim 22, wherein the first and second arms each define a respective distal portion and a respective proximal portion, the distal portions each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface, the proximal portions each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface.
30. The intervertebral implant frame of claim 29, wherein a line drawn between the superior vertebral body contacting surfaces of the first arm forms an angle between about 0° and about -5° with respect to an insertion direction of the intervertebral implant frame, and a line drawn between the superior vertebral body contacting surfaces of the second arm forms an angle

between about 0° and about -5° with respect to the insertion direction of the intervertebral implant frame.

31. The intervertebral implant frame of claim 30, wherein a line drawn between the inferior vertebral body contacting surfaces of the first arm forms an angle between about 0° and about 5° with respect to the insertion direction of the intervertebral implant frame, and a line drawn between the inferior vertebral body contacting surfaces of the second arm forms an angle between about 0° and about 5° with respect to the insertion direction of the intervertebral implant frame.

32. The intervertebral implant frame of claim 22, wherein the first and second arms each include a superior cut-out and an inferior cut-out to thereby provide visual access to the superior vertebral body and inferior vertebral body when the intervertebral implant frame is disposed in the intervertebral space.

33. The intervertebral implant frame of claim 32, wherein the first and second arms each include a window that extends through the first and second arms to thereby provide visual access to the spacer body through the first and second arms when the intervertebral implant frame is retaining the spacer body.

34. The intervertebral implant frame of claim 22, wherein the engagement members each define a dove-tailed slot.

35. The intervertebral implant frame of claim 34, wherein the dove-tailed slots are each open at their distal ends, such that the expansion instrument engages the dove-tailed slots in a direction that is opposite to an insertion direction of the intervertebral implant frame.

36. The intervertebral implant frame of claim 22, wherein the engagement members each define a slot that extends through the first and second arms.

37. The intervertebral implant frame of claim 22, wherein the first and second arms are configured to retain a first spacer body having a first maximum width and a second spacer body having a second maximum width that is different than the first maximum width.

38. An intervertebral implant system comprising

an intervertebral implant frame configured to retain a spacer body, the frame having a support member that defines an inner surface, a first elastically flexible arm extending from the support member and defining a first inner spacer contacting surface, and a second elastically flexible arm extending from the support member and defining a second inner spacer contacting surface that is spaced from the first inner spacer contacting surface; and

an expansion instrument including a first expansion arm that is configured to couple to the first arm, and a second expansion arm that is configured to couple to the second arm, wherein the first and second arms are pivotally coupled to each other such that rotation of the first and second expansion arms relative to each other causes the first and second arms to elastically flex away from each other when the first and second expansion arms are coupled to the first and second arms, respectively.

39. The intervertebral implant system of claim 38, wherein the first and second expansion arms are pivotally coupled at a first pivot and each include a handle portion that extends proximally from the first pivot, and a gripping portion that extends distally from the first pivot.

40. The intervertebral implant system of claim 39, wherein each gripping portion includes an extension member and a gripping member that is coupled to a distal end of the extension member at a respective second pivot.

41. The intervertebral implant system of claim 40, wherein the extension member of the first expansion arm is configured to rotate clockwise about the first pivot and the gripping member of the first expansion arm is configured to rotate counterclockwise about the second pivot of the first expansion arm, and the extension member of the second expansion arm is configured to rotate counterclockwise about the first pivot and the gripping member of the second expansion arm is configured to rotate clockwise about the second pivot of the second expansion arm.

42. The intervertebral implant system of claim 41, wherein each gripping member includes an engagement member that is configured to engage the first and second arms of the intervertebral implant frame.

43. The intervertebral implant system of claim 42, wherein the engagement members are dovetailed members.

44. The intervertebral implant system of claim 43, wherein each dovetailed member includes a tapered proximal end.
45. The intervertebral implant system of claim 41, wherein the first and second expansion arms each include a biasing member that applies a force to the gripping members.
46. The intervertebral implant system of claim 41, wherein each gripping member includes at least one stop that limits the rotation of the gripping member about the second pivot.
47. The intervertebral implant system of claim 41, wherein the first and second arms of the intervertebral implant frame each define an outer surface, and the second pivots of the first and second expansion arms are configured to abut the outer surface proximate to the support member when the expansion instrument is coupled to the intervertebral implant frame.
48. The intervertebral implant system of claim 38, wherein the first and second arms of the intervertebral implant frame each have a length that is between about 6.0 mm and about 10 mm.
49. The intervertebral implant system of claim 38, wherein the first and second arms of the intervertebral implant frame are capable of retaining a spacer body consisting of cancellous bone, cortical bone, or both cancellous and cortical bone.
50. The intervertebral implant system of claim 38, wherein the first and second arms each define a respective distal portion and a respective proximal portion, the distal portions each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface, the proximal portions each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface.
51. The intervertebral implant system of claim 50, wherein a line drawn between the superior vertebral body contacting surfaces of the first arm forms an angle between about 0° and about -5° with respect to an insertion direction of the intervertebral implant frame, and a line drawn between the superior vertebral body contacting surfaces of the second arm forms an angle between about 0° and about -5° with respect to the insertion direction of the intervertebral implant frame.

52. The intervertebral implant system of claim 51, wherein a line drawn between the inferior vertebral body contacting surfaces of the first arm forms an angle between about 0° and about 5° with respect to the insertion direction of the intervertebral implant frame, and a line drawn between the inferior vertebral body contacting surfaces of the second arm forms an angle between about 0° and about 5° with respect to the insertion direction of the intervertebral implant frame.

53. The intervertebral implant system of claim 38, wherein the first and second arms each include an engagement member that is configured to be engaged by the first and second expansion arms respectively of the expansion instrument.

54. The intervertebral implant system of claim 53, wherein the engagement members of the first and second arms each define a dove-tailed slot.

55. The intervertebral implant system of claim 54, wherein the dove-tailed slots are each open at their distal ends, such that the expansion instrument engages the dove-tailed slots in a direction that is opposite to an insertion direction of the intervertebral implant frame.

56. The intervertebral implant system of claim 38, further comprising a spacer body that is retained by the first and second arms of the intervertebral implant frame.

57. An intervertebral implant frame comprising:

a support member that defines an inner surface, and at least two fixation element receiving apertures, each of the fixation element receiving apertures configured to receive a respective bone fixation element to thereby attach the intervertebral implant frame to first and second vertebral bodies, respectively when the intervertebral implant frame is disposed in an intervertebral space defined by first and second surface of the first and second vertebral bodies, respectively;

a first flexible arm that extends from the support member and includes a first inner spacer contacting surface, the first arm having a first distal portion and a first proximal portion, the first distal portion and the first proximal portion each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface; and

a second flexible arm that extends from the support member and includes a second inner spacer contacting surface spaced from the first inner spacer contacting surface along a first

direction, the second arm having a second distal portion and a second proximal portion, the second distal portion and the second proximal portion each define a superior vertebral body contacting surface and an inferior vertebral body contacting surface,

wherein first and second distal portions are configured to support the first and second vertebral bodies relative to each other on a posterior side of a plane that intersects a centroid of the first surface and the first and second posterior portions are configured to support the first and second vertebral bodies relative to each other on an anterior side of the plane that intersects the centroid of the first surface, when the intervertebral implant frame is disposed in the intervertebral space.

58. The intervertebral implant frame of claim 57, wherein the superior vertebral body contacting surfaces of the first and second flexible arms define a first plane, and the inferior vertebral body contacting surfaces of the first and second flexible arms define a second plane.

59. The intervertebral implant system of claim 57, wherein a line drawn between the superior vertebral body contacting surfaces of the first arm forms an angle between about 0° and about -5° with respect to an insertion direction of the intervertebral implant frame, and a line drawn between the superior vertebral body contacting surfaces of the second arm forms an angle between about 0° and about -5° with respect to the insertion direction of the intervertebral implant frame.

60. The intervertebral implant system of claim 59, wherein a line drawn between the inferior vertebral body contacting surfaces of the first arm forms an angle between about 0° and about 5° with respect to the insertion direction of the intervertebral implant frame, and a line drawn between the inferior vertebral body contacting surfaces of the second arm forms an angle between about 0° and about 5° with respect to the insertion direction of the intervertebral implant frame.

61. The intervertebral implant frame of claim 57 wherein the first and second arms each have a length that is between about 3.5 mm and about 12 mm.

62. The intervertebral implant frame of claim 61, wherein the lengths of the first and second arms are each between about 6.0 mm and about 10 mm.

63. An intervertebral implant comprising:

a support member that defines an inner surface, and at least two fixation element receiving apertures, each of the fixation element receiving apertures configured to receive a respective bone fixation element to thereby attach the frame to first and second vertebral bodies, respectively when the frame is disposed in an intervertebral space defined by the first and second vertebral bodies;

a first arm that extends from the support member and includes a first inner spacer contacting surface; and

a second arm that extends from the support member and includes a second inner spacer contacting surface spaced from the first inner spacer contacting surface along a first direction, wherein inner surface of the support member and the first and second inner spacer contacting surfaces at least partially define a void that contains a bone graft spacer body; and

wherein 1) the first and second arms are elastically flexible away from each other from a first position to a second position, such that when the arms are in the second position, the void defines a cross-sectional dimension greater than that of the bone graft spacer body such that the void is sized to receive the bone graft spacer body, and 2) the first and second arms can flex toward each other to a third position, such that when the arms are in the third position the first and second inner spacer contacting surfaces apply a retention force against the bone graft spacer body along a direction toward the other of the first and second spacer contacting surfaces.

64. An intervertebral implant frame comprising:

a support member that defines an inner surface and at least two fixation element receiving apertures that are each configured to receive a respective bone fixation element to thereby affix the frame to superior and inferior vertebral bodies when the intervertebral implant frame is disposed in an intervertebral space that is defined by the superior and inferior vertebral bodies;

a first arm that extends from the support member and includes a first inner spacer contacting surface, and a first crimp member; and

a second arm that extends from the support member and includes a second inner spacer contacting surface spaced from the first inner spacer contacting surface along a first direction, and a second crimp member,

wherein the inner surface of the support member, and the first and second inner spacer contacting surfaces together define a void that is configured to receive a spacer body, and the first crimp member is configured to be bent toward the second arm, and the second crimp

member is configured to be bent toward the first arm to thereby engage the spacer body and retain the spacer body within the void.

65. The intervertebral implant frame of claim 64, wherein (i) the first arm includes a first hinge and the second arm includes a second hinge, and (ii) the first crimp member is configured to rotate about the first hinge and the second crimp member is configured to rotate about the second hinge.

66. The intervertebral implant frame of claim 64, wherein the first arm includes a third crimp member, and the second arm includes a fourth crimp member.

67. The intervertebral implant frame of claim 66, wherein (i) the first arm includes a third hinge and the second arm includes a fourth hinge, and (ii) the third crimp member is configured to rotate about the third hinge and the fourth crimp member is configured to rotate about the fourth hinge.

68. The intervertebral implant frame of claim 64, wherein the first and second crimp members define crimping tabs that are configured to engage respective side surfaces of the spacer body.

69. The intervertebral implant frame of claim 64, wherein the crimping tabs are disposed along an upper and lower edge of the first and second arms.

70. A spacer body drill guide comprising:

a clamp including a first jaw and a second jaw that are translatable along a first direction with respect to each other, the first jaw defining a first outer surface, a first inner spacer contacting surface, and a pair of first drill guide apertures that extend from the first outer surface to the first inner spacer contacting surface along a direction that is transverse to the first direction, and the second jaw defining a second outer surface, a second inner spacer contacting surface, and a pair of second drill guide apertures that extend from the second outer surface to the second inner spacer contacting surface along a direction that is transverse to the first direction; and

a cradle including a base and a mounting portion that extends from the base along a second direction that is substantially perpendicular to the first direction, the mounting portion

including a body, a channel that extends into the body along the second direction, and a pair of third drill guide apertures that extend through the body and into the channel at a direction that is transverse to the second direction,

wherein the channel is configured to receive the first jaw such that the first drill guide apertures align with the third drill guide apertures when the clamp is mounted to the cradle.

71. The spacer body drill guide of claim 70, wherein the mounting portion includes a first platform, and the cradle includes a second platform that extends from the base and is spaced apart from the first platform.

72. The spacer body drill guide of claim 71, wherein the mounting portion further includes a mating member, and the first jaw includes a mating member that is configured to engage the mating member of the mounting portion when the clamp is mounted to the cradle.

73. The spacer body drill guide of claim 70, wherein the clamp further includes a first handle and a second handle that is rotatably coupled to the first handle at a first pivot.

74. The spacer body drill guide of claim 73, wherein the clamp further includes a first extension member, and a second extension member, the first extension member is coupled to the first handle at a respective second pivot and to the second handle at a respective third pivot, and the second extension member is coupled to the second handle at a respective second pivot and to the first handle at a respective third pivot.

75. A method of implanting an intervertebral implant into an intervertebral space defined by first and second vertebral bodies, the method comprising:

moving first and second arms of an intervertebral implant frame from a first position to a second position, whereby first and second spacer contacting surfaces of the first and second arms, respectively, are spaced apart by a first distance when in the first position, and are spaced apart by a second distance that is greater than the first distance when in the second position;

inserting an allograft spacer body into the frame between the first and second arms when the first and second arms are in the second position;

moving the first and second arms to a third position, whereby the first and second spacer contacting surfaces are spaced apart by a third distance when in the third position, the third

distance is less than the second distance such that the arms apply a retention force against the allograft spacer body to thereby retain the allograft spacer body in the frame;

implanting the frame and allograft spacer body into an intervertebral space such that a portion of the first and second arms is disposed on an anterior side of an anterior-posterior midline of the intervertebral space and a portion of the first and second arms is disposed on a posterior side of the anterior-posterior midline of the intervertebral space.

76. The method of claim 75, further comprising drilling clearance channels in the allograft spacer body using a drill guide.

77. The method of claim 76, wherein the step of drilling the clearance channels is performed prior to the step of inserting the allograft spacer body into the frame.

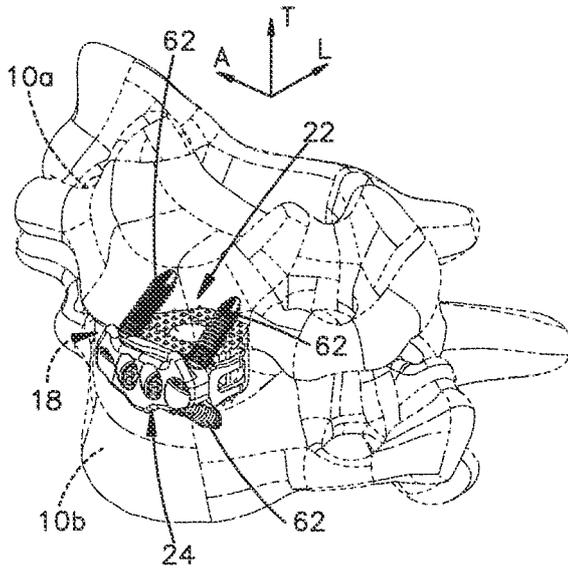


Fig.1A

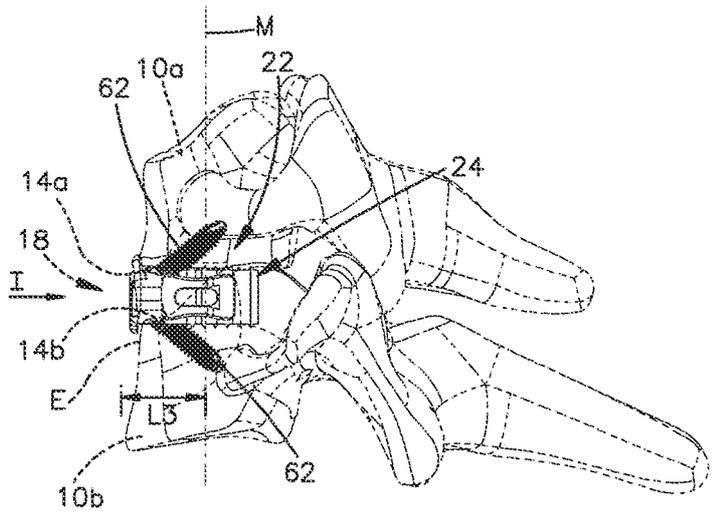


Fig.1B

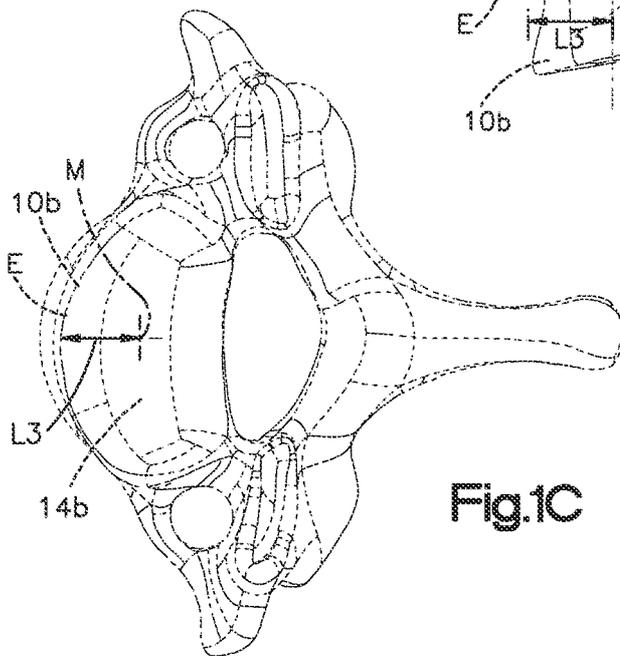
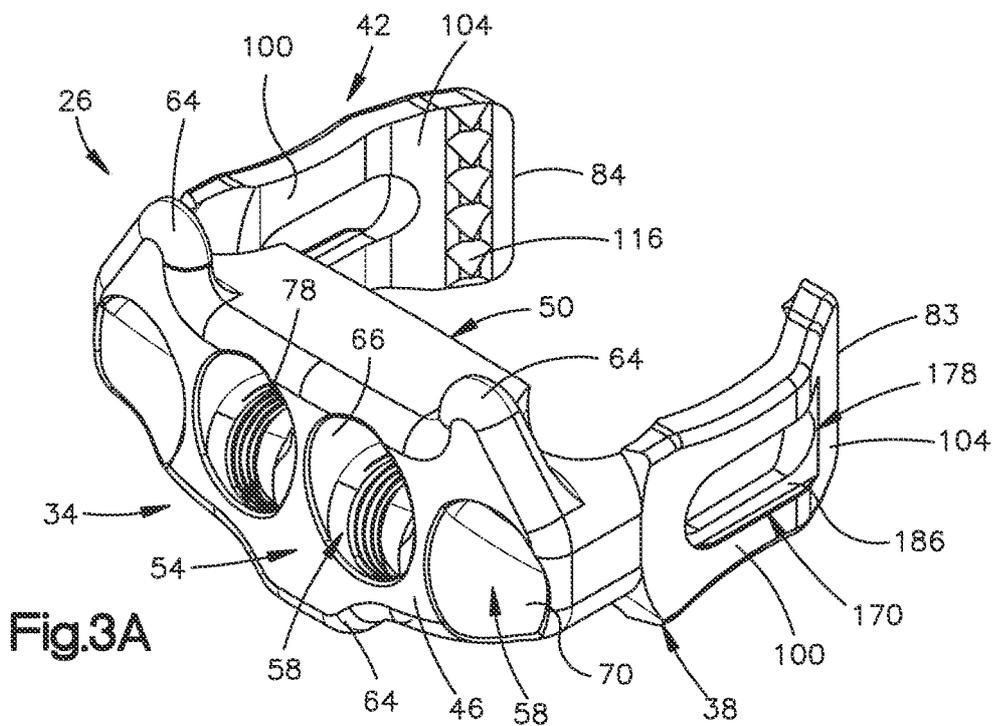
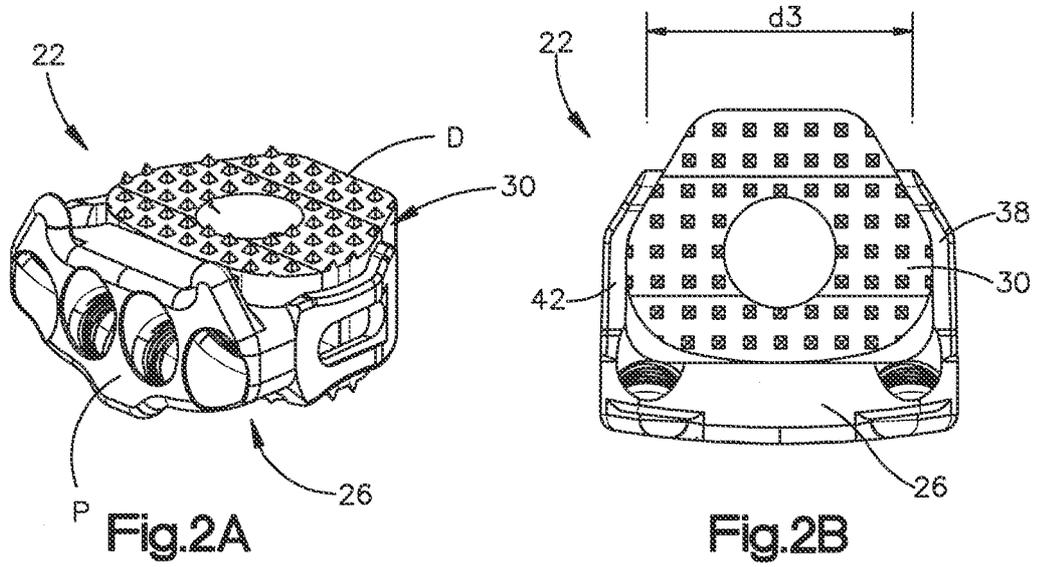


Fig.1C



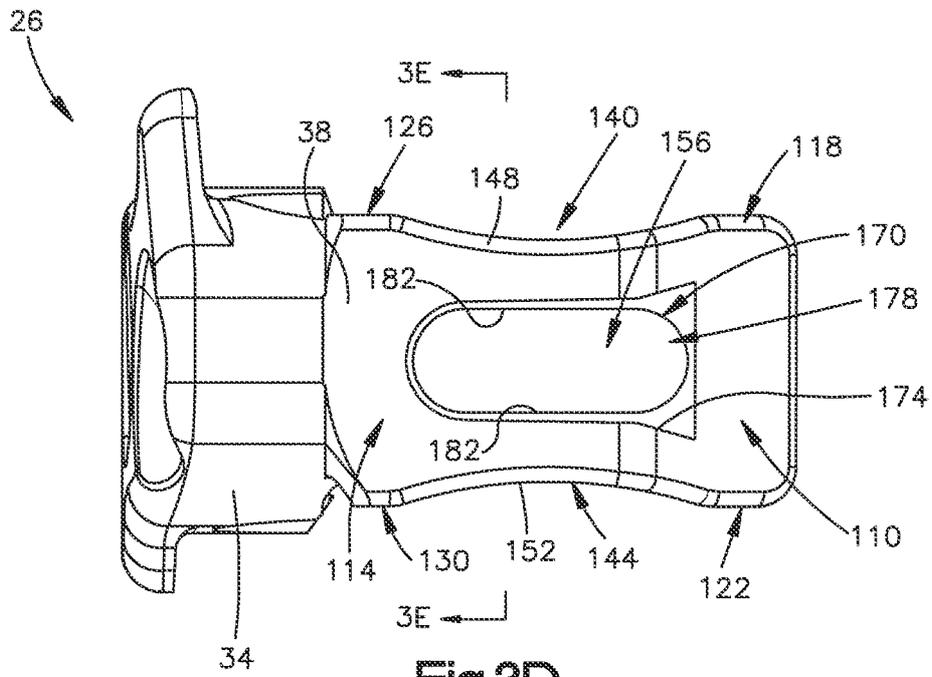


Fig.3D

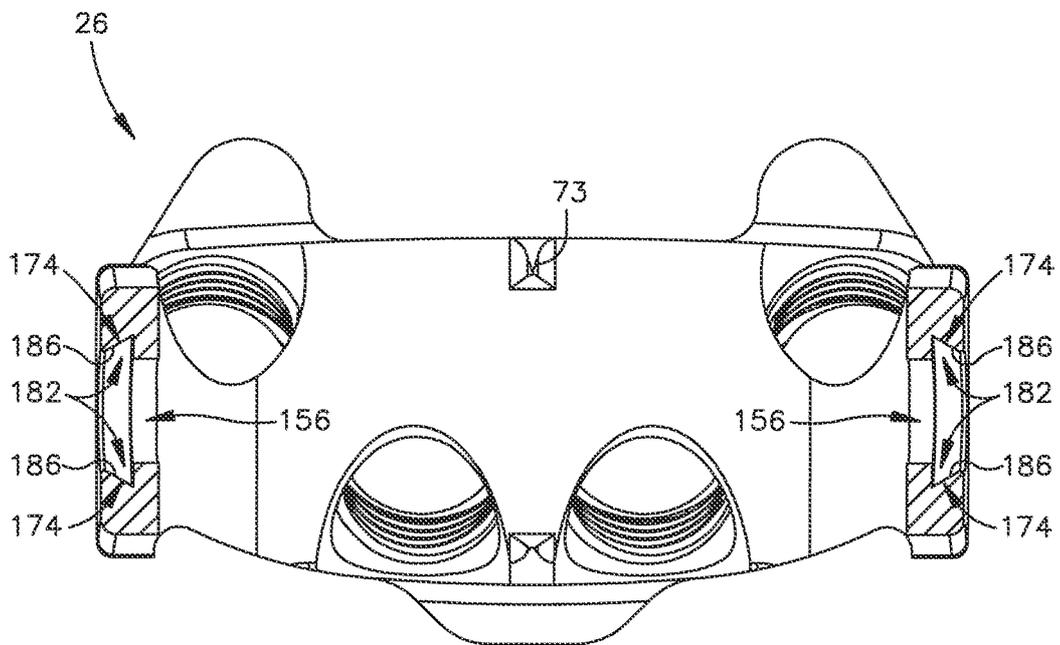


Fig.3E

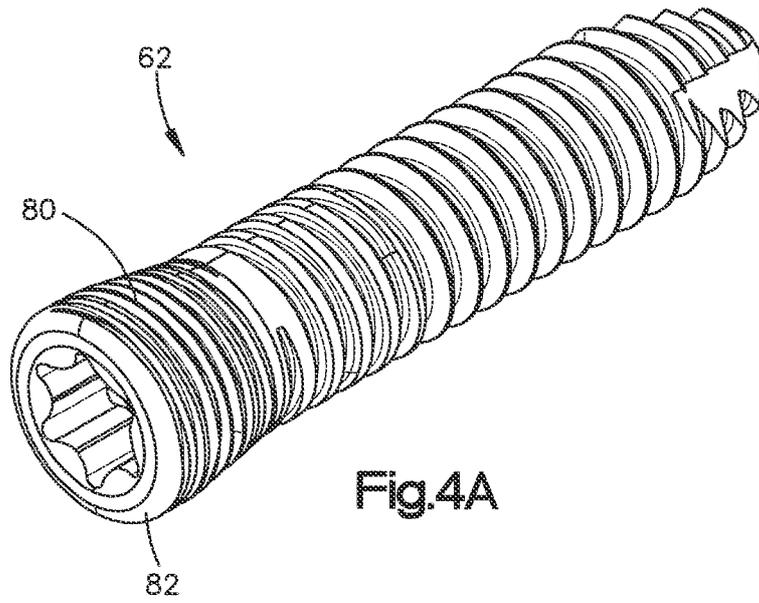


Fig.4A

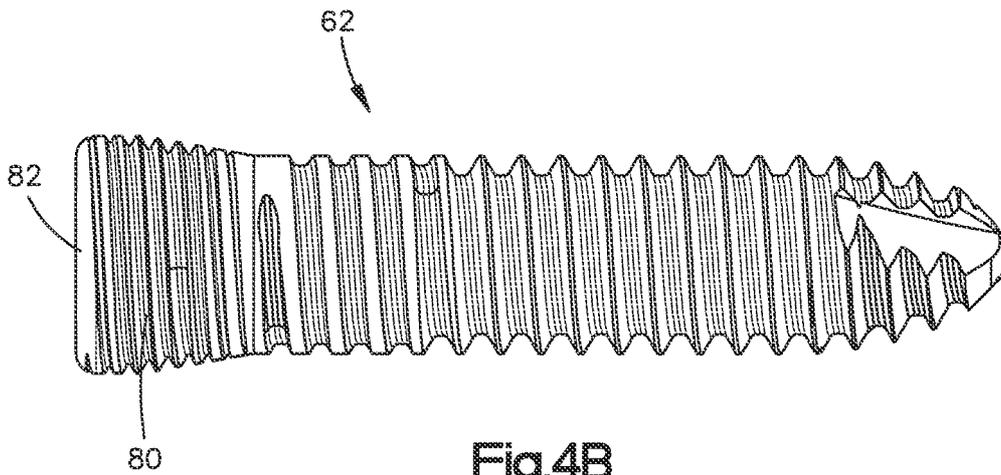


Fig.4B

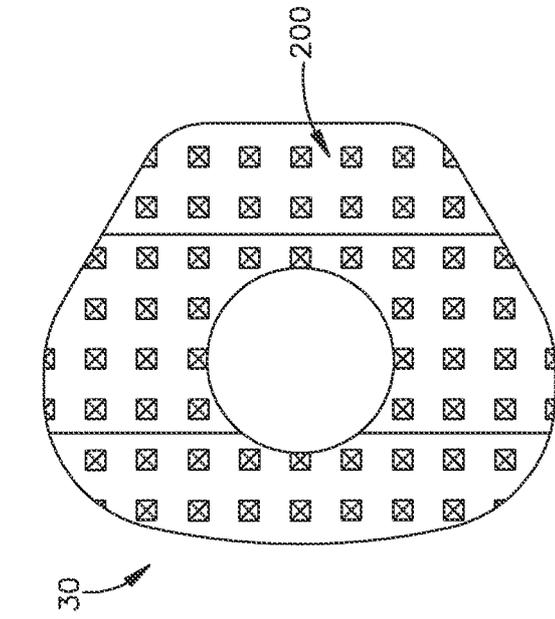


Fig. 5C

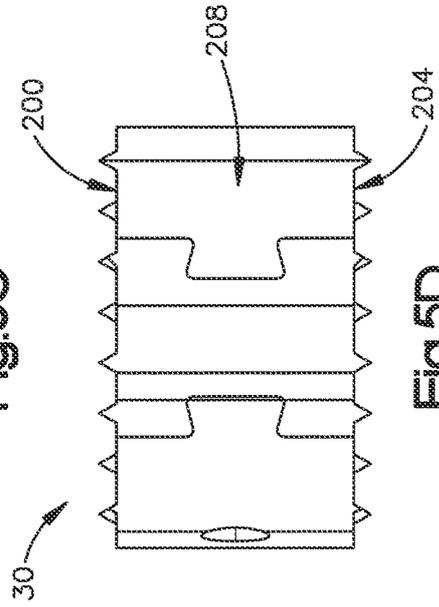


Fig. 5D

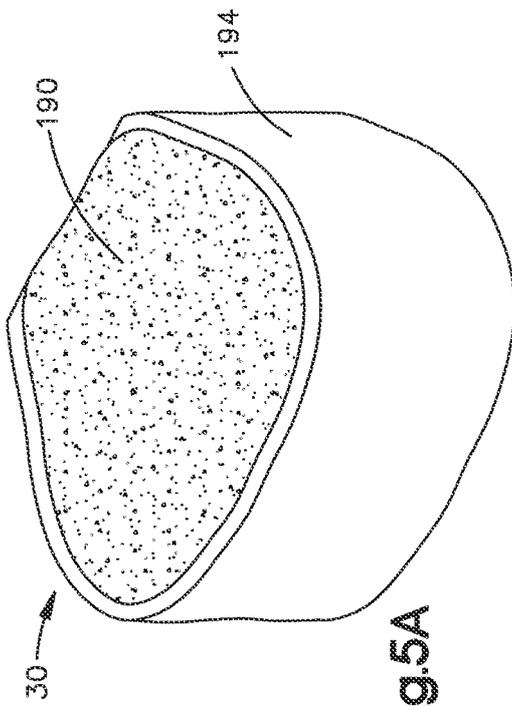


Fig. 5A

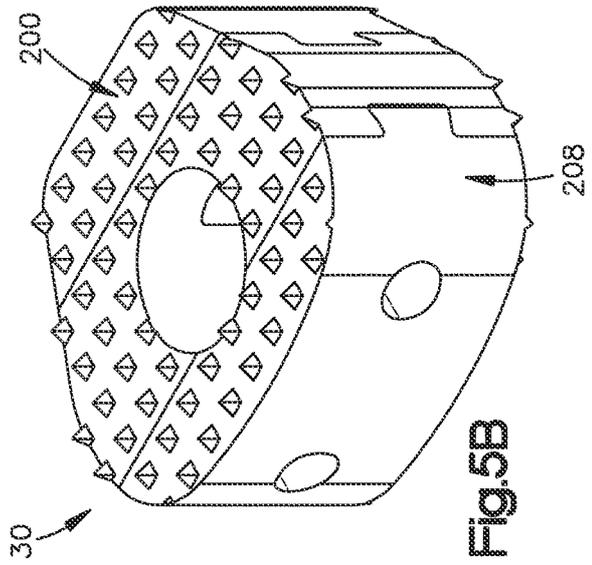


Fig. 5B

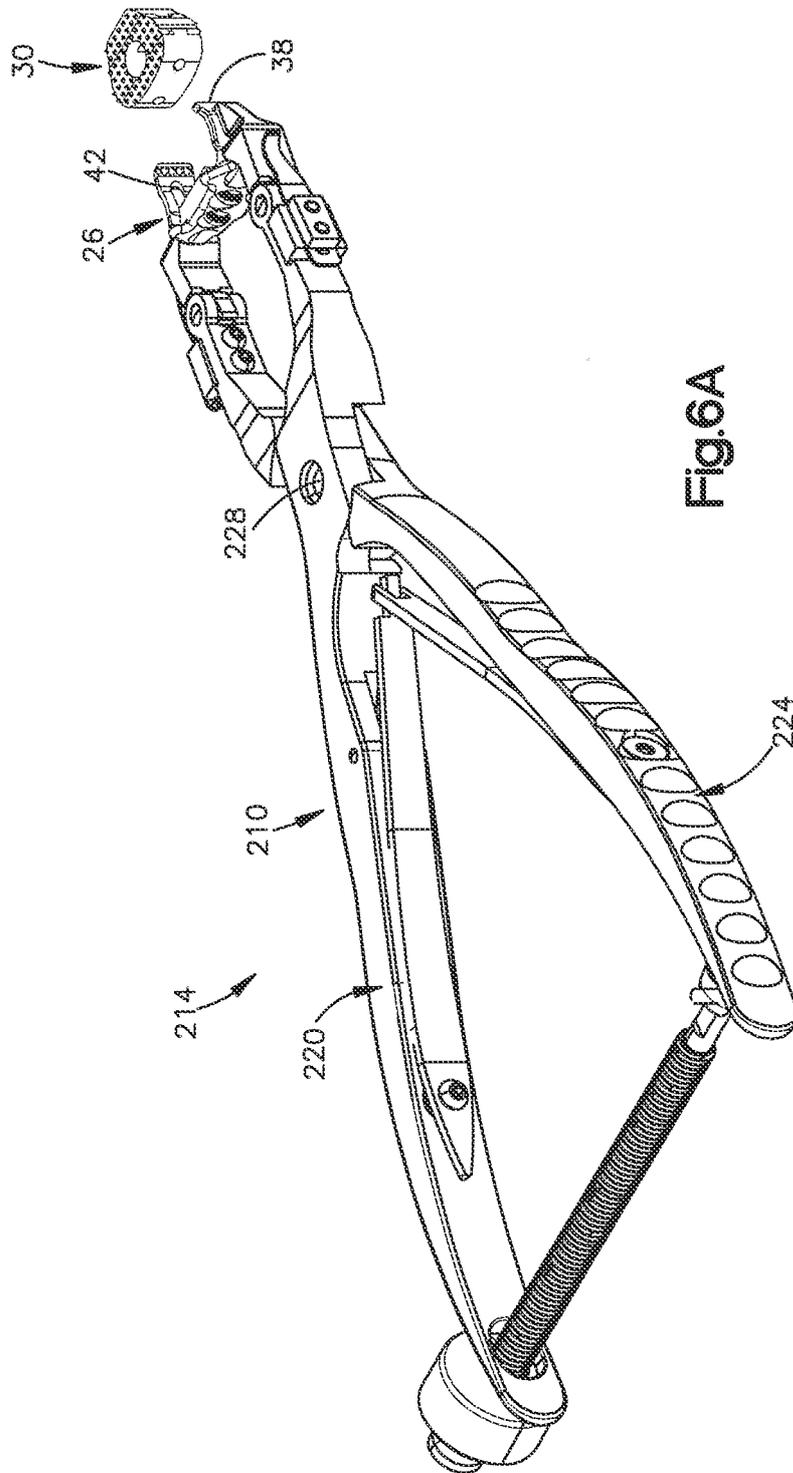


Fig.6A

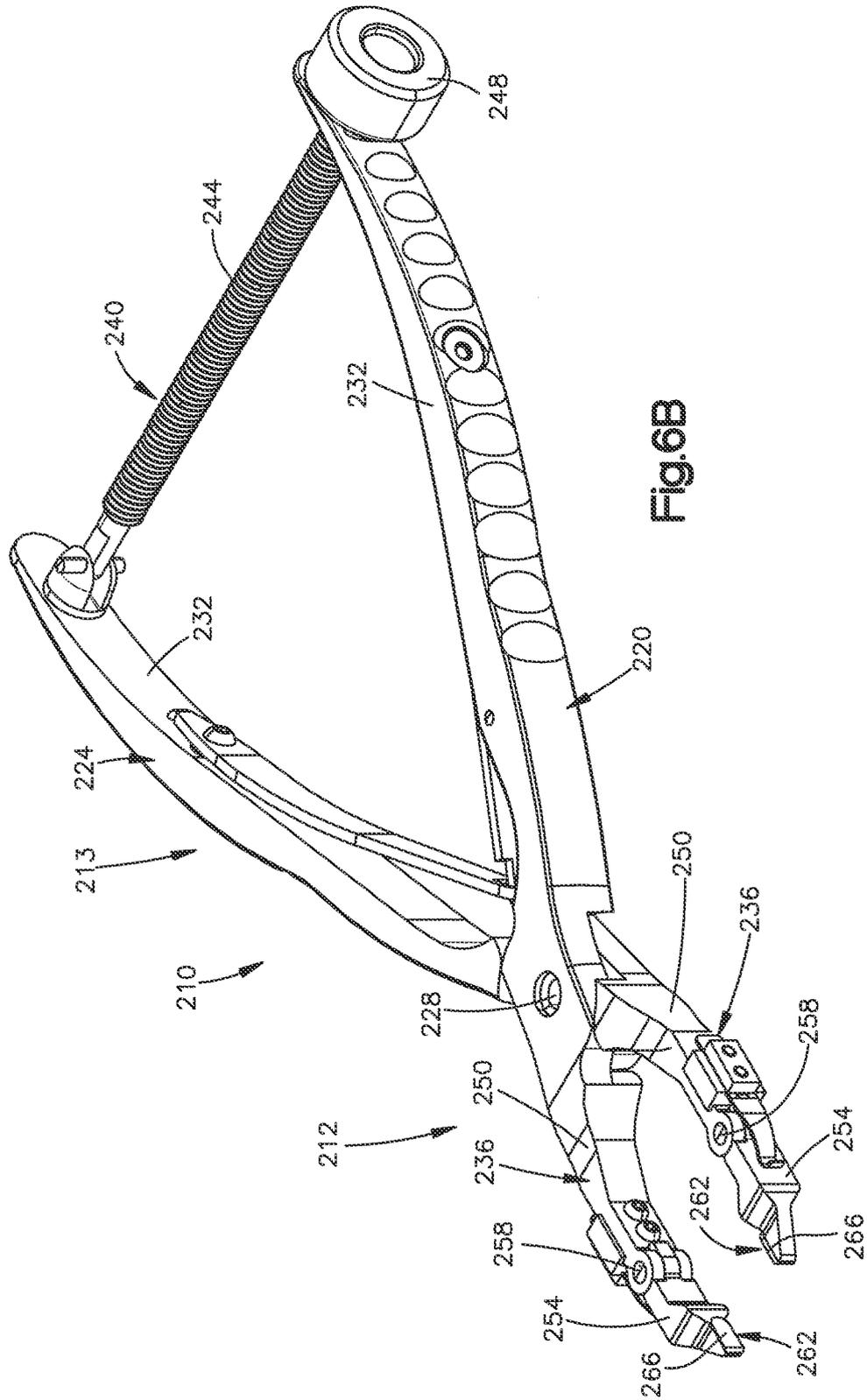


Fig. 6B

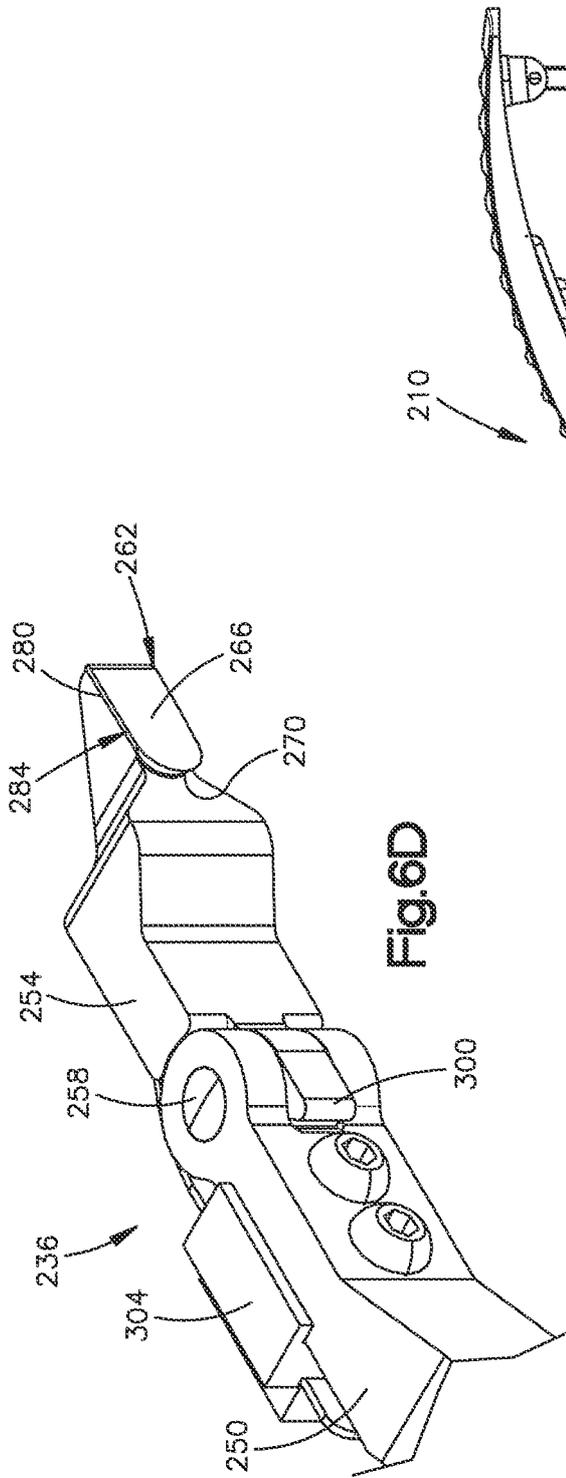


Fig. 6D

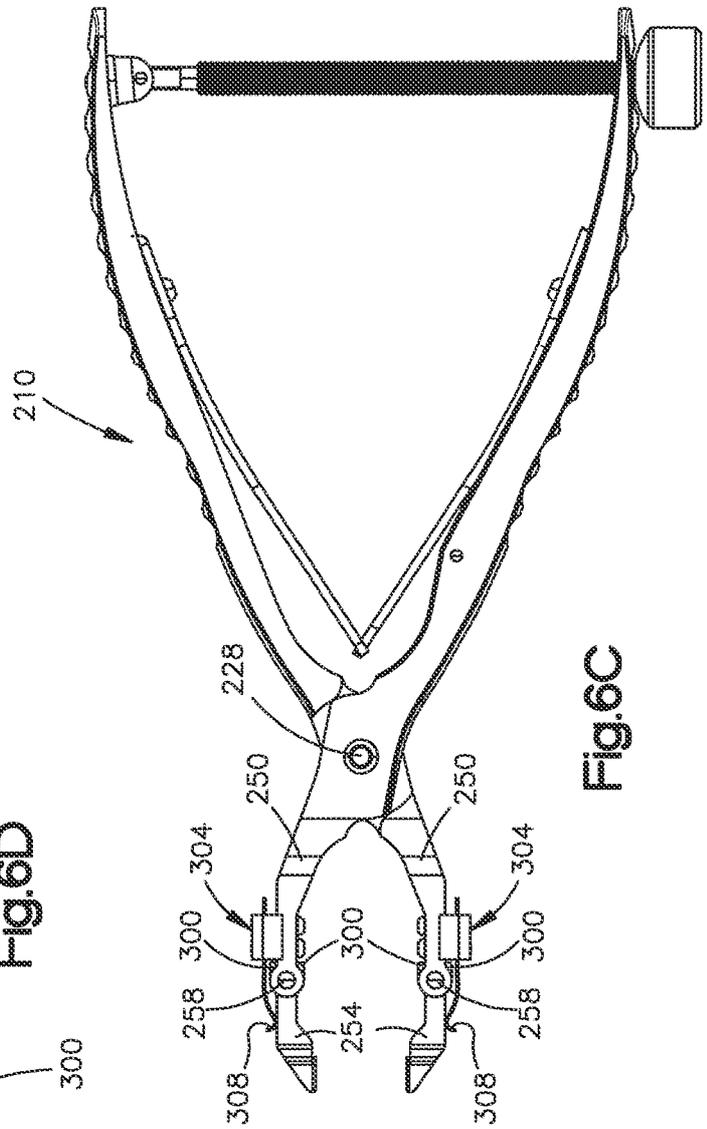


Fig. 6C

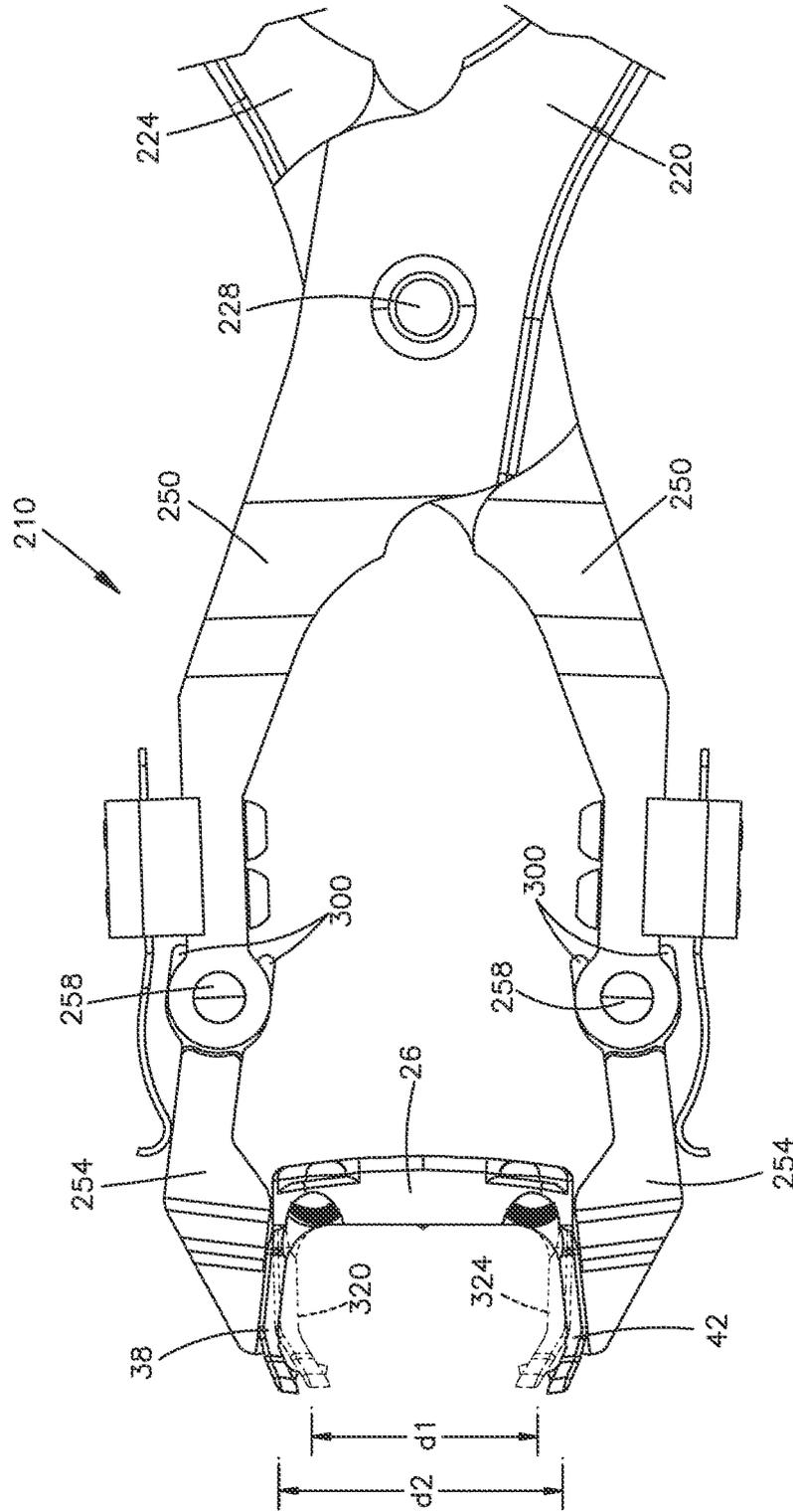


Fig.6E

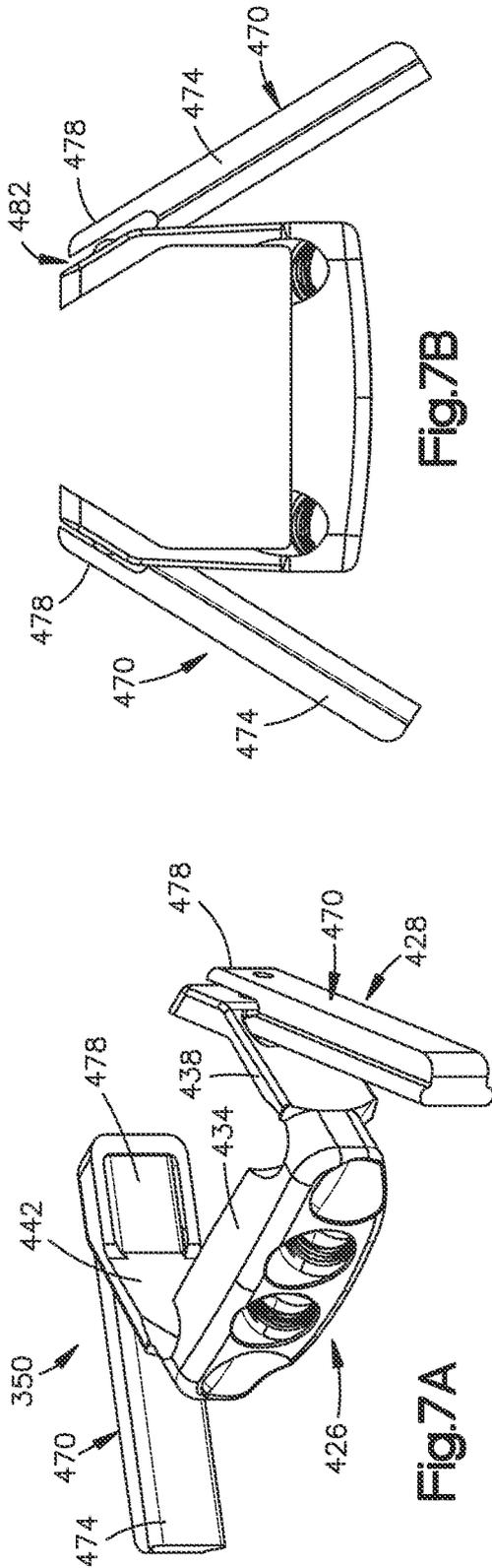


Fig.7B

Fig.7A

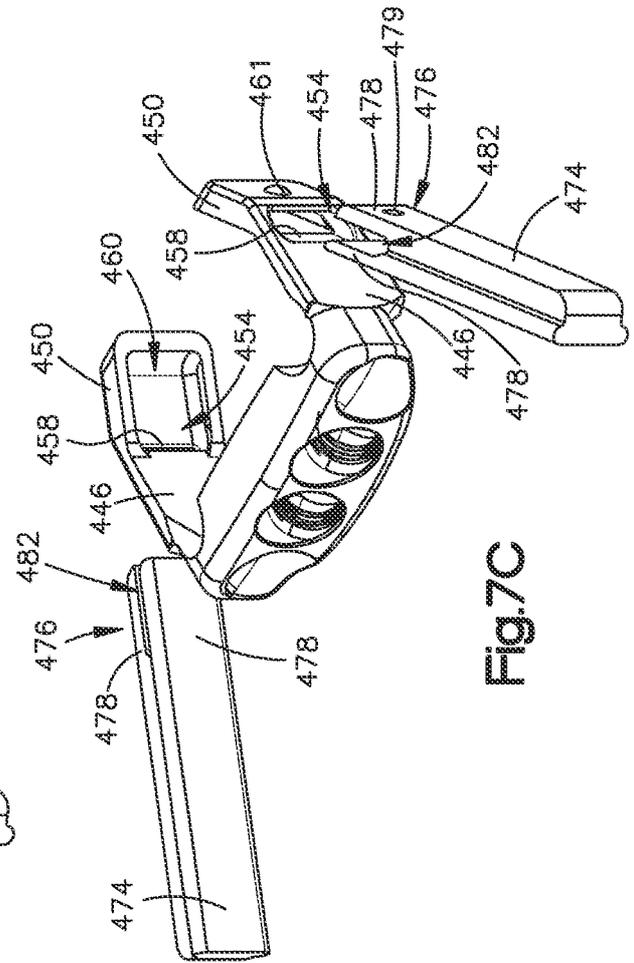


Fig.7C

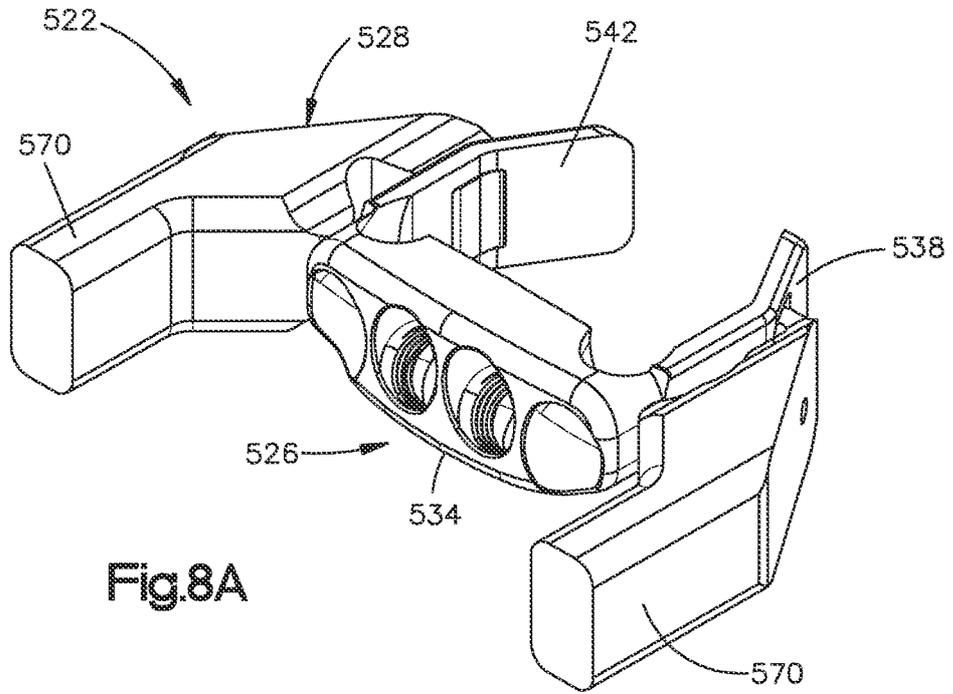


Fig.8A

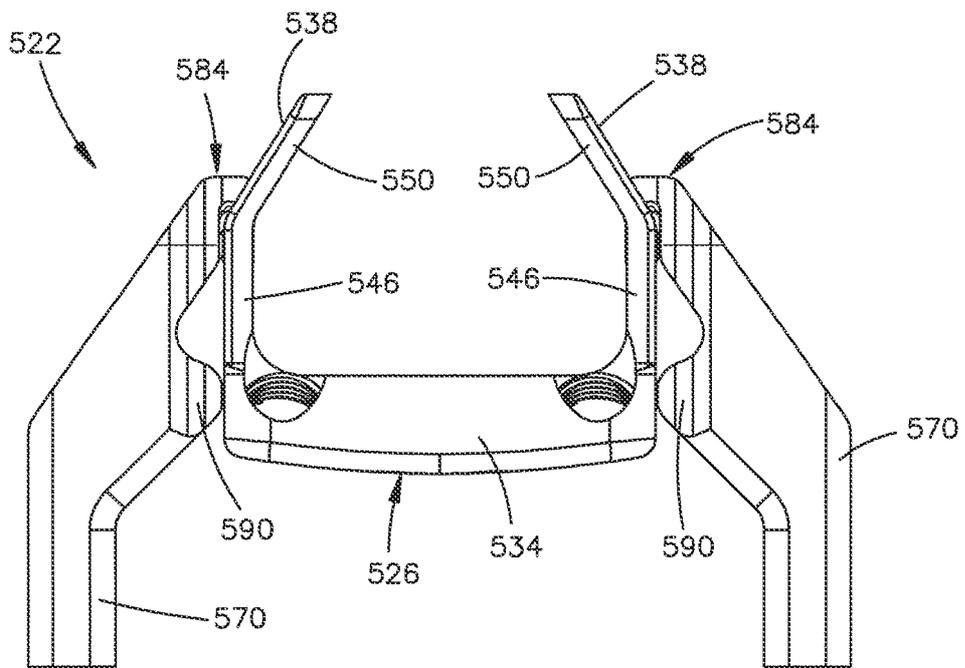


Fig.8B

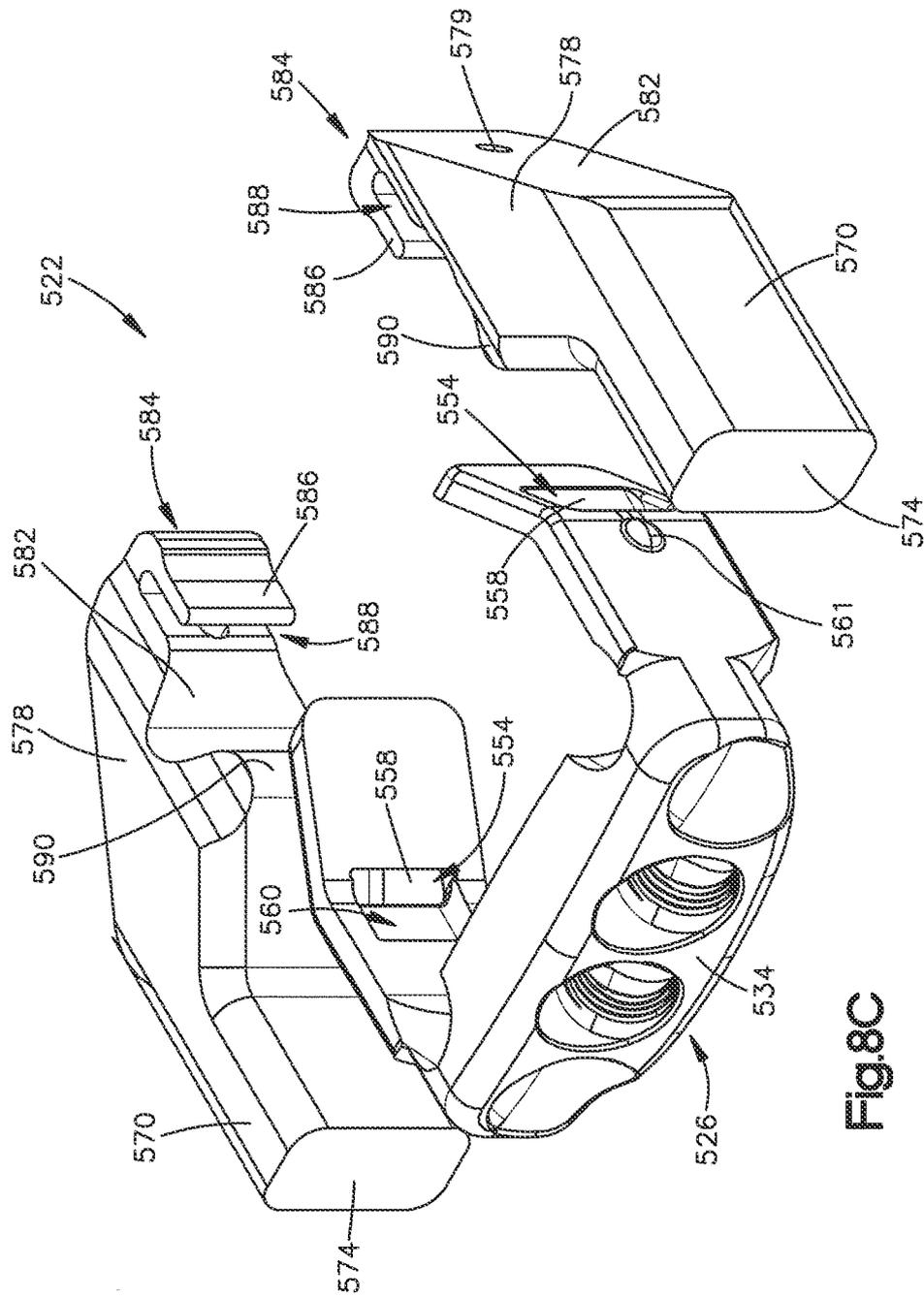
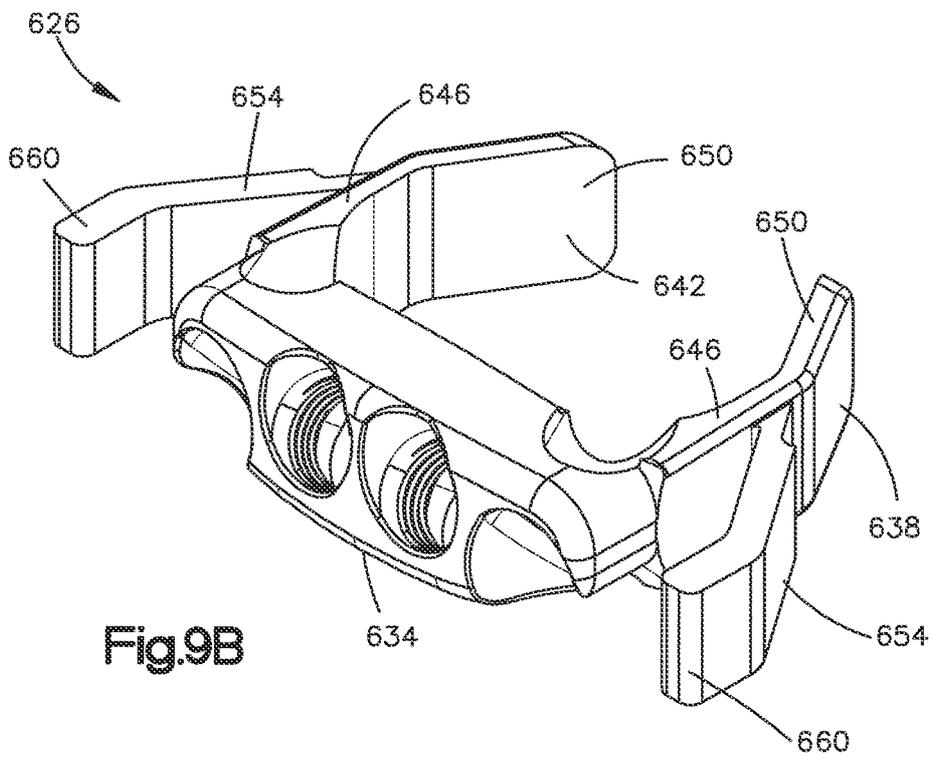
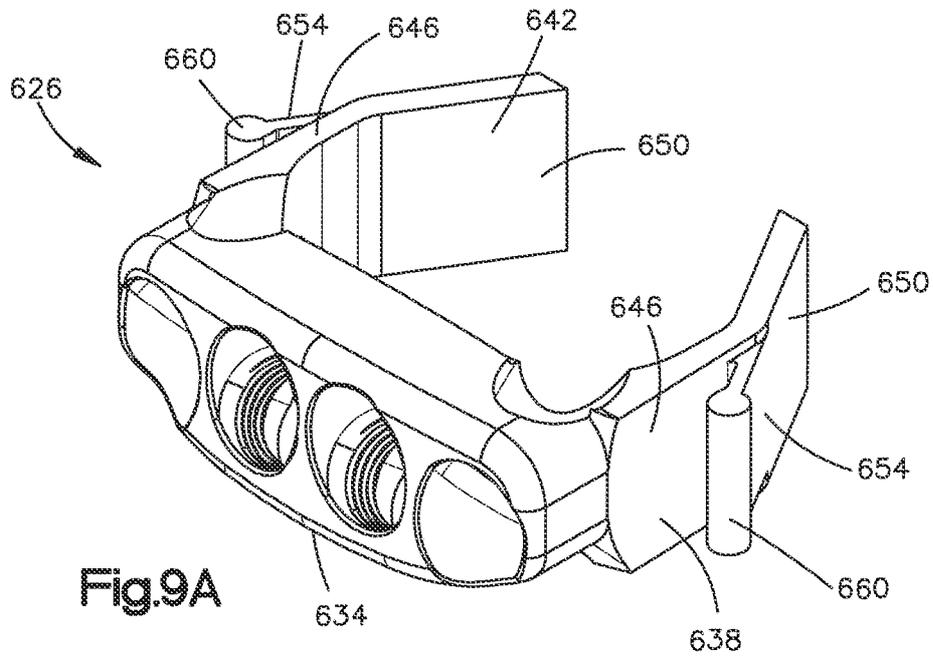


Fig.8C



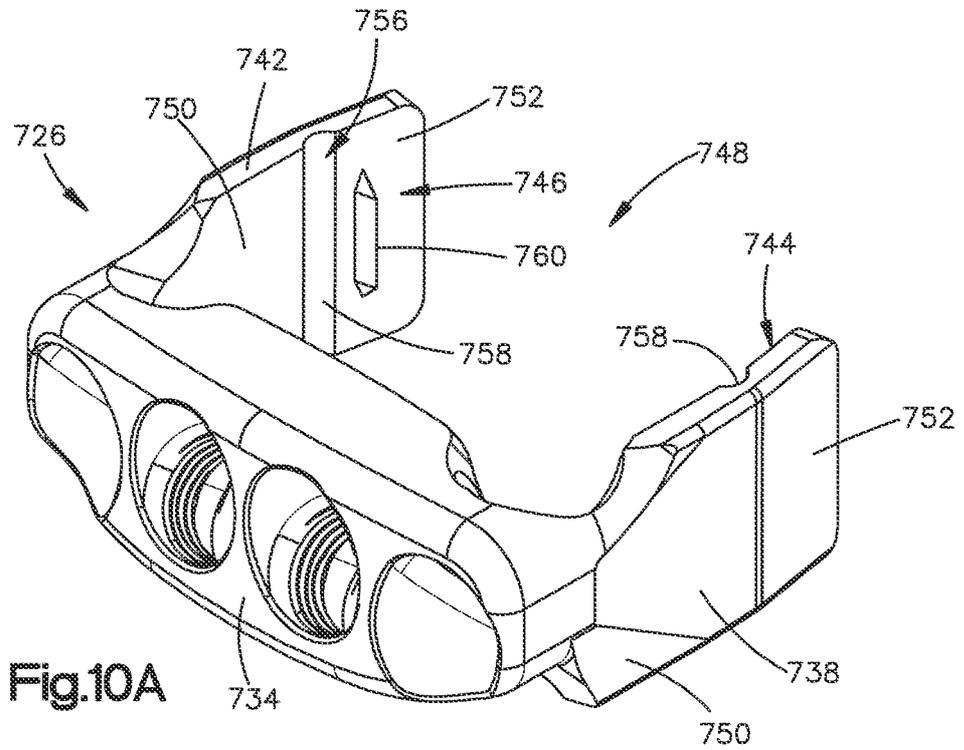


Fig.10A

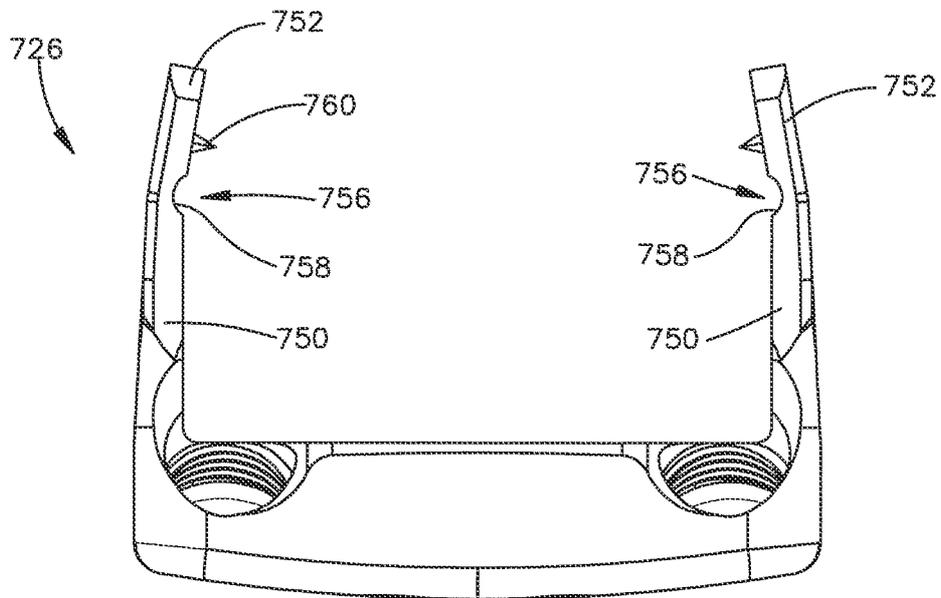
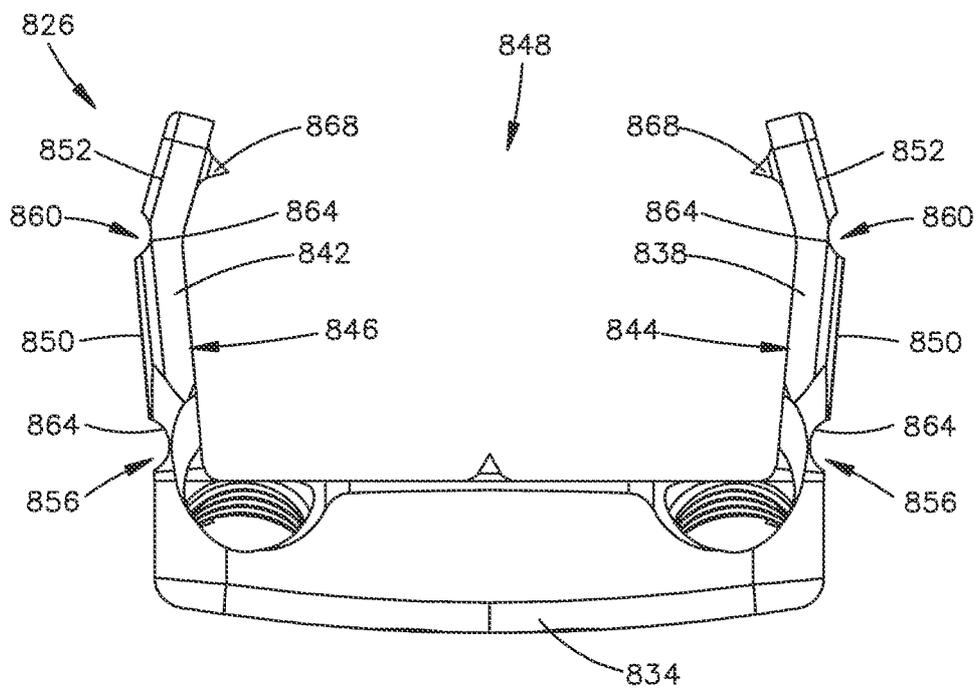
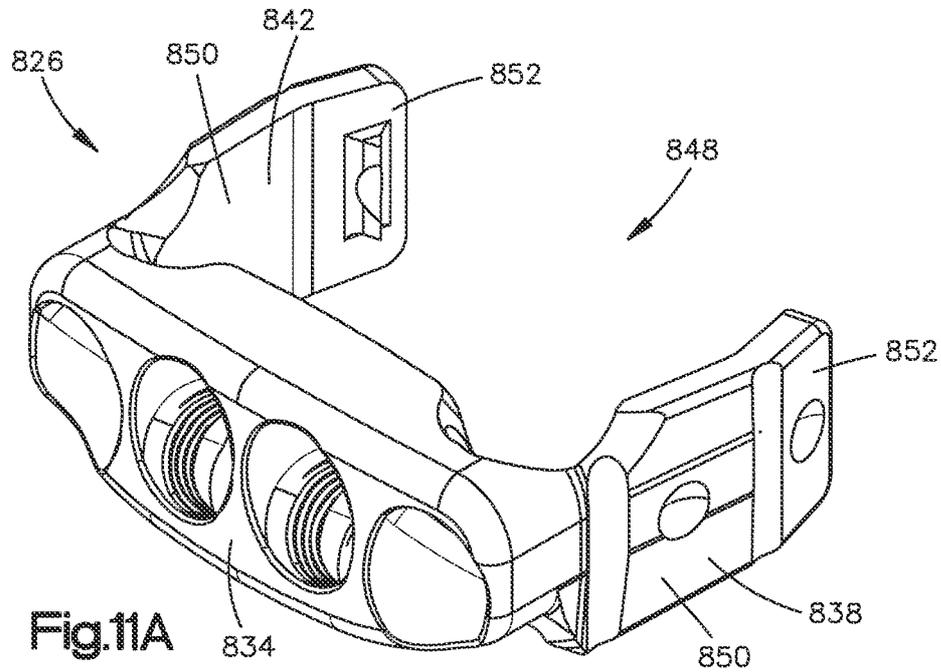
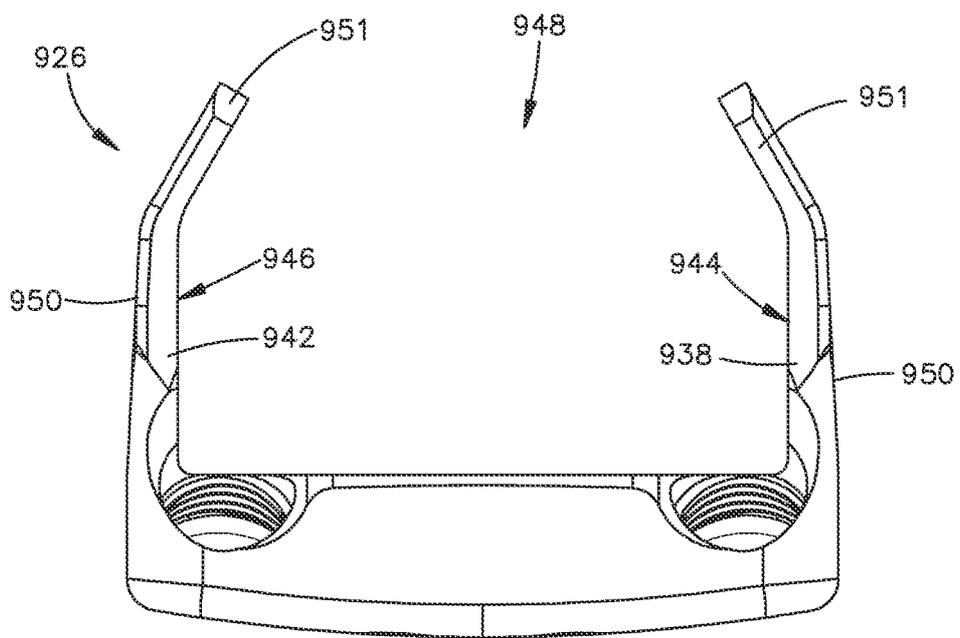
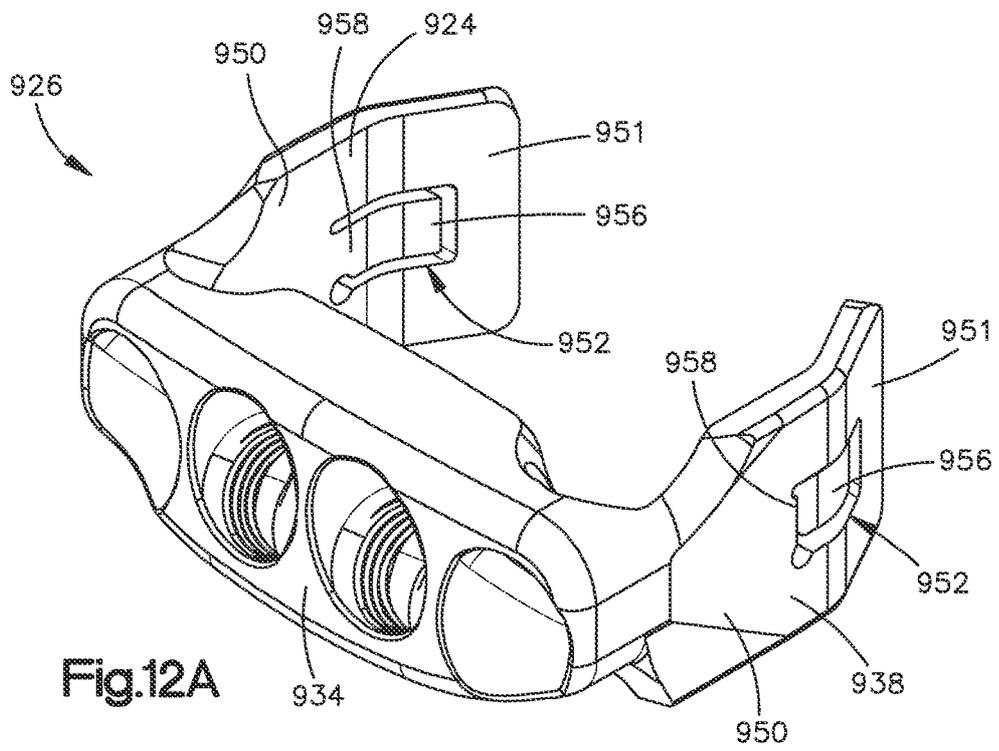


Fig.10B





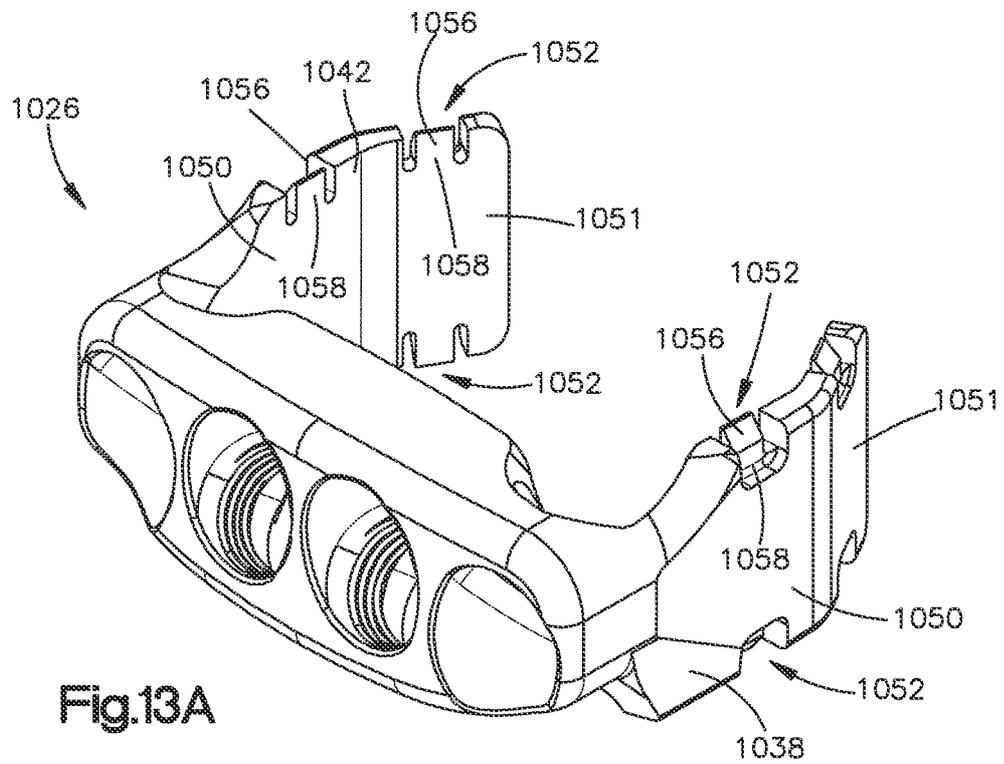


Fig.13A

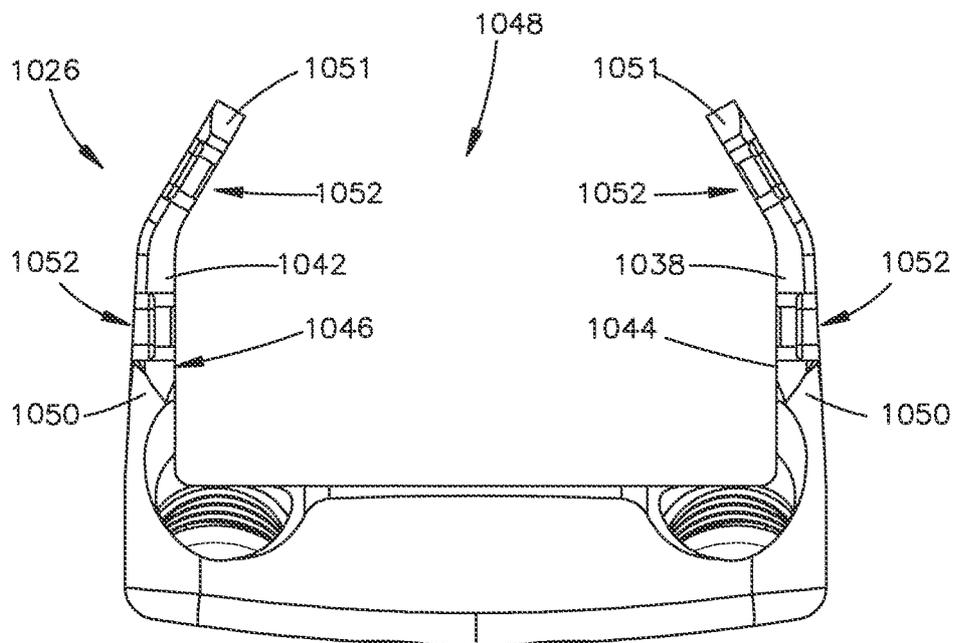
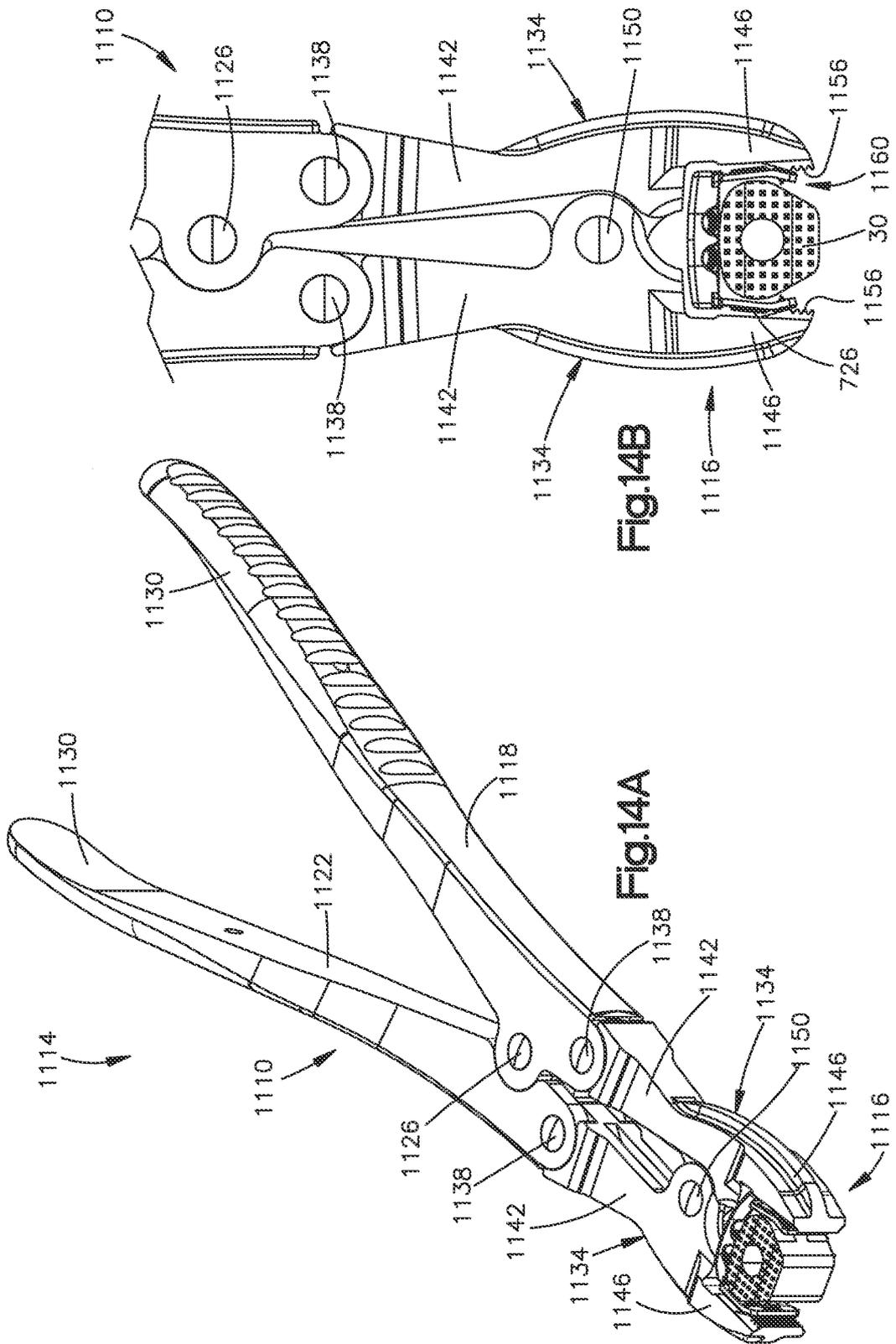


Fig.13B



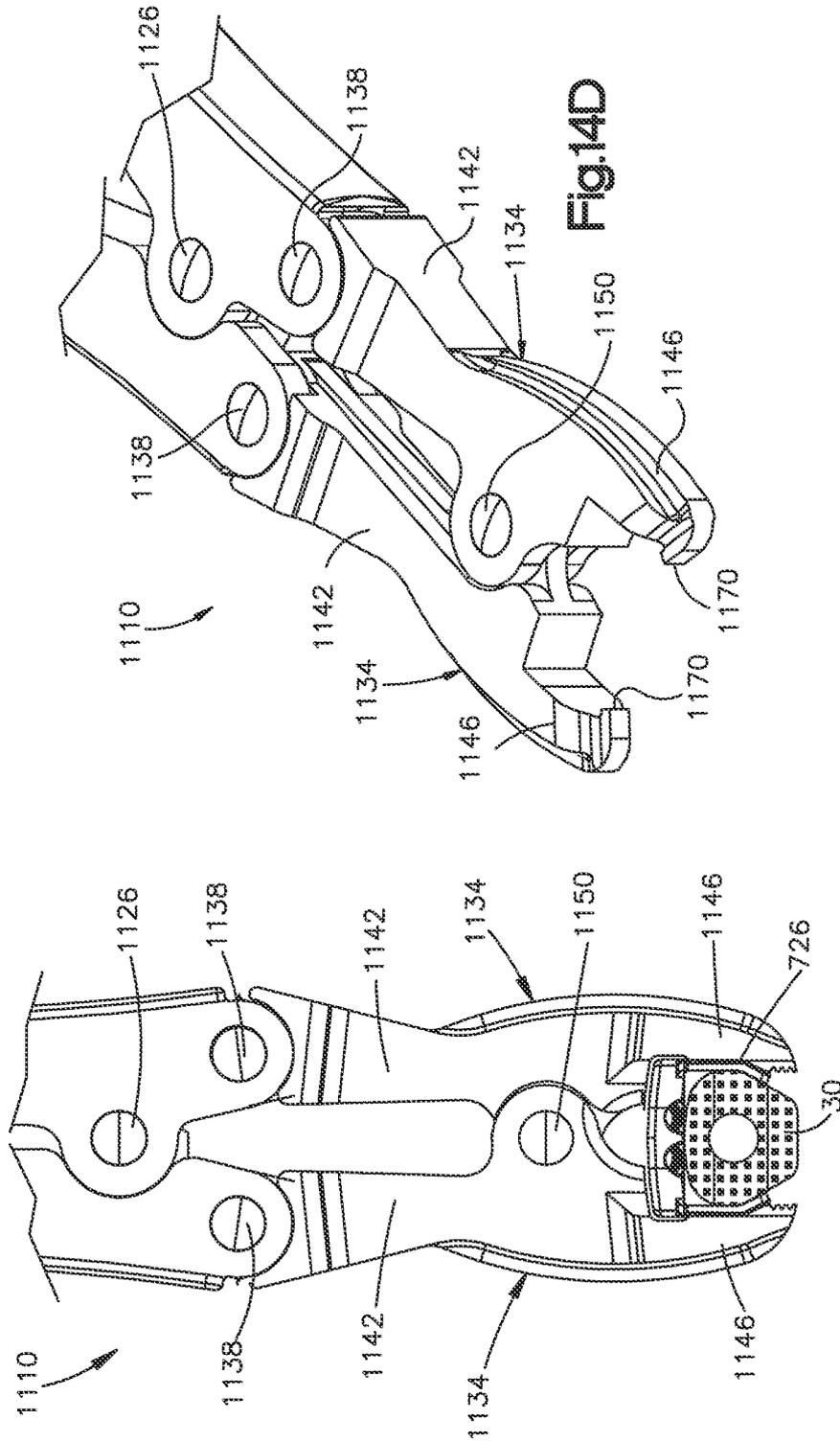
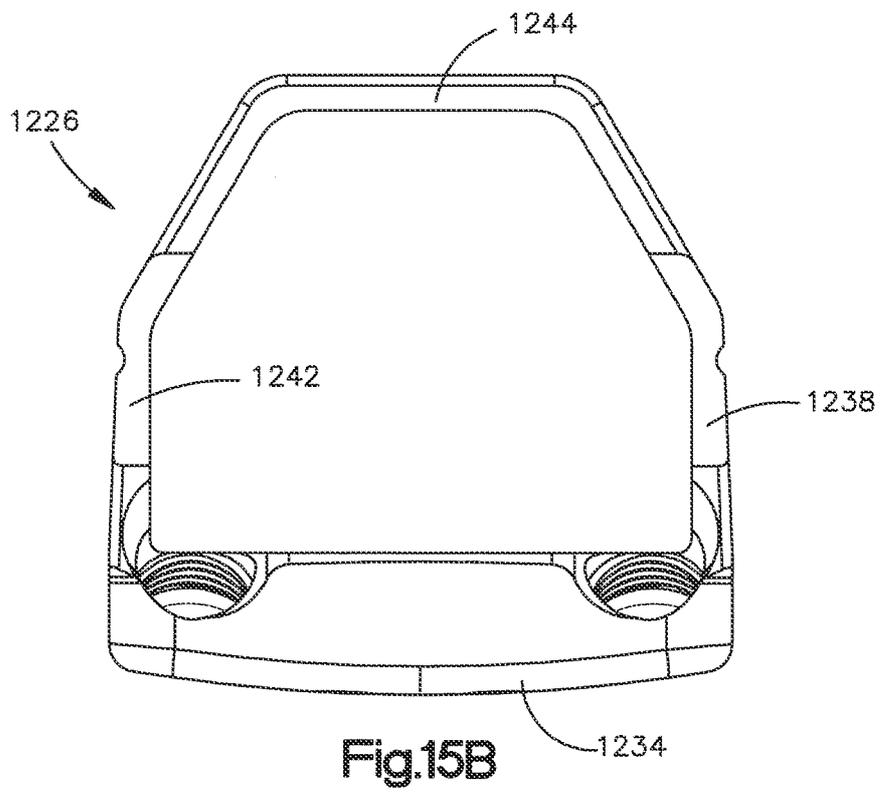
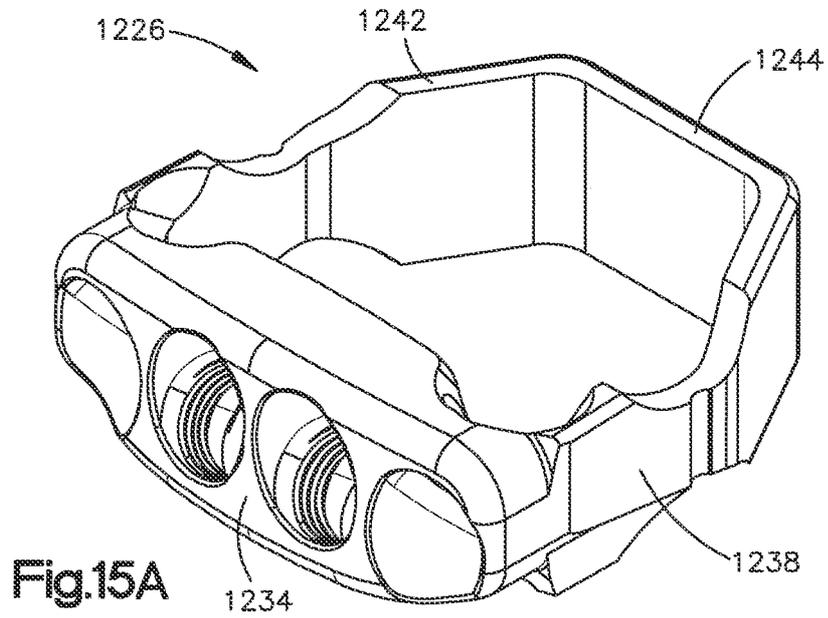


Fig.14C

Fig.14D



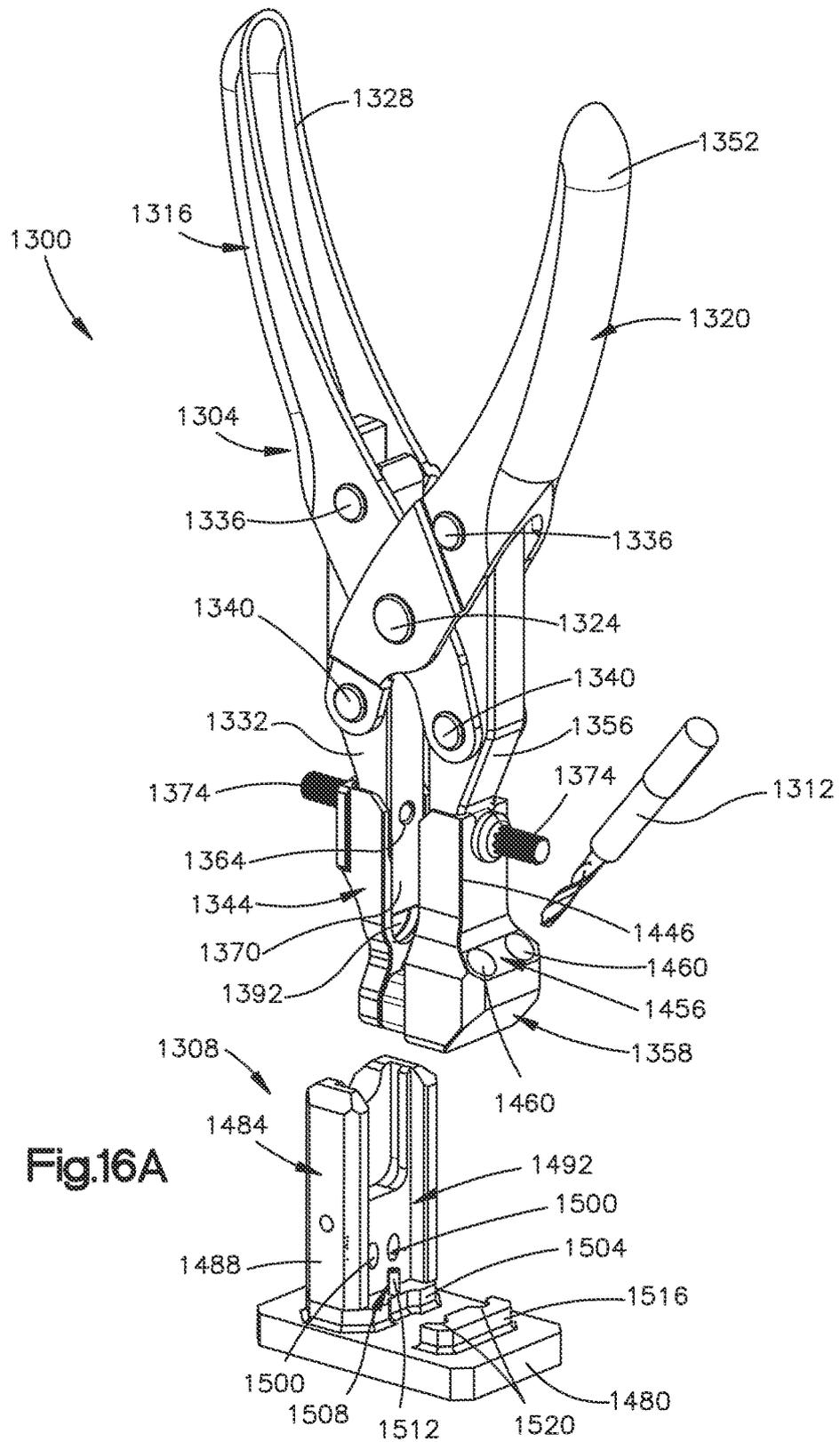
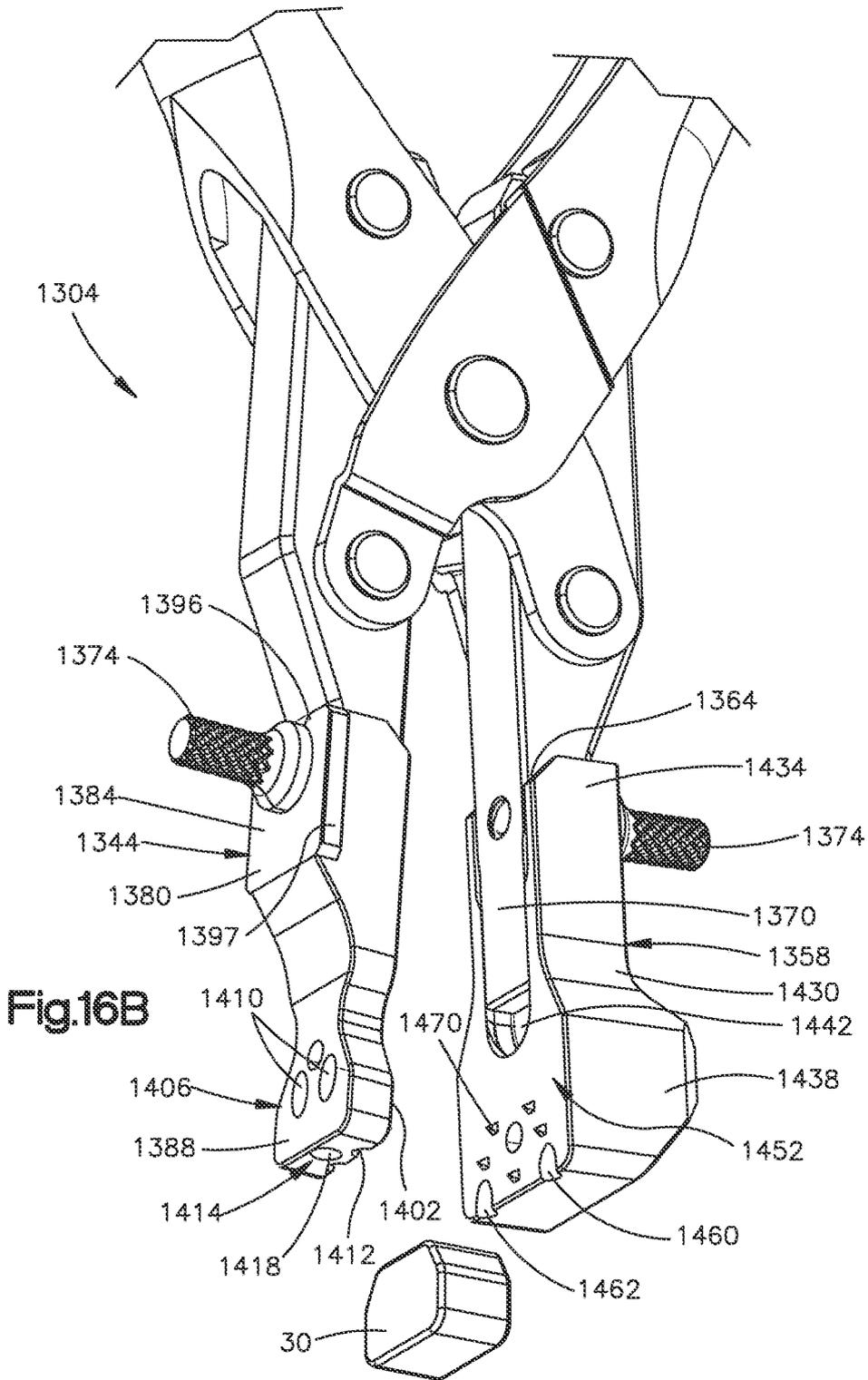


Fig.16A



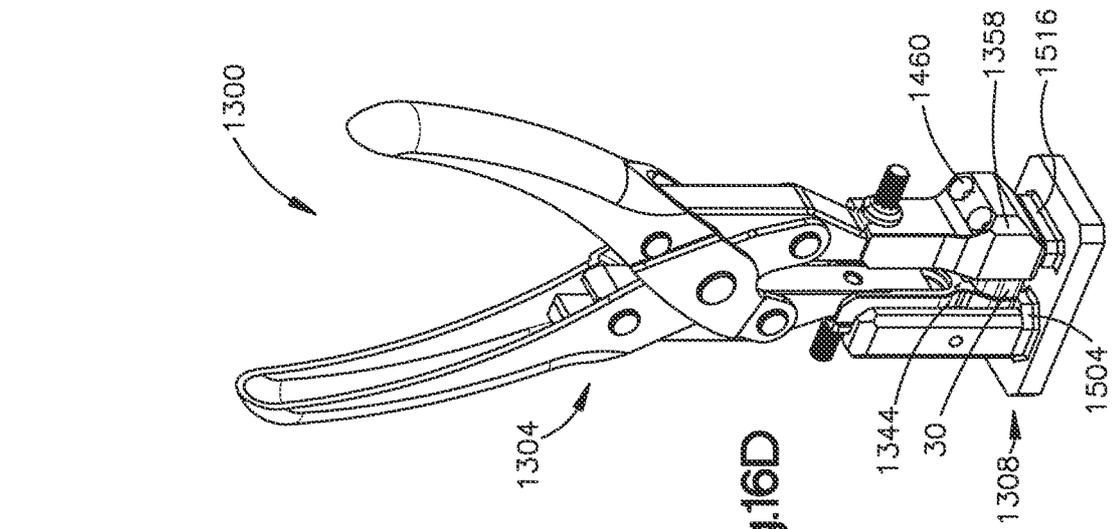


Fig.16D

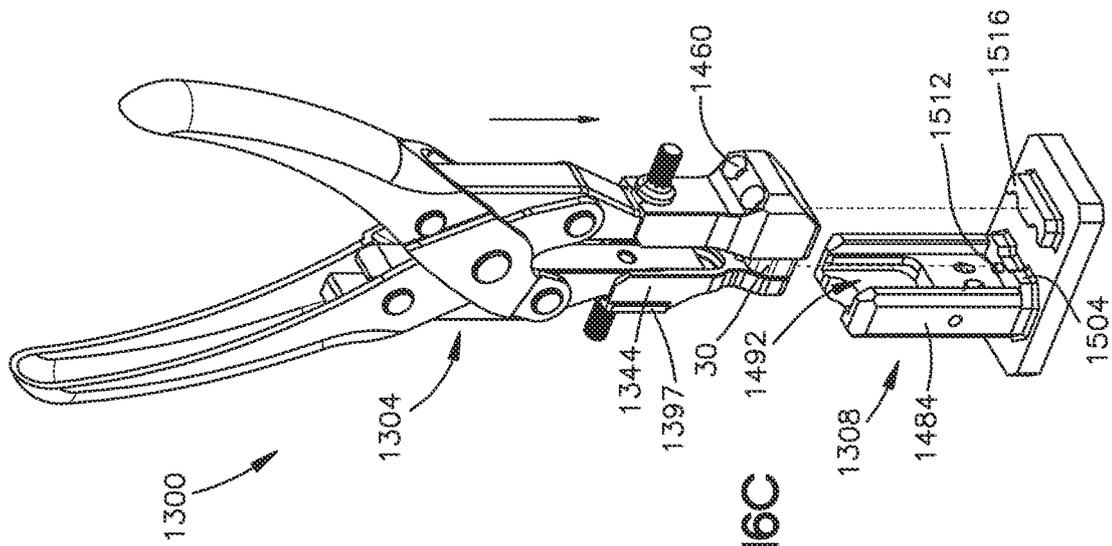


Fig.16C

