US009510871B2

(12) United States Patent
Ledet et al.

(10) **Patent No.: US 9,510,871 B2**
(45) **Date of Patent: Dec. 6, 2016**

(54) **DYNAMIC SPINAL FIXATION SYSTEM, METHOD OF USE, AND SPINAL FIXATION SYSTEM ATTACHMENT PORTIONS**

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(73) Assignee: **REVIVO MEDICAL, LLC**, Schenectady, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 55 days.

(21) Appl. No.: **14/237,733**

(22) PCT Filed: **Aug. 8, 2012**

(86) PCT No.: **PCT/US2012/049959**
§ 371 (c)(1),
(2), (4) Date: **May 16, 2014**

(87) PCT Pub. No.: **WO2013/022944**
PCT Pub. Date: **Feb. 14, 2013**

(65) **Prior Publication Data**

US 2014/0257395 A1 Sep. 11, 2014

Related U.S. Application Data

(60) Provisional application No. 61/574,636, filed on Aug. 8, 2011, provisional application No. 61/574,662, filed
(Continued)

(51) **Int. Cl.**

A61B 17/70	(2006.01)
A61B 17/80	(2006.01)
A61B 17/00	(2006.01)

(52) **U.S. Cl.**
CPC ***A61B 17/7059*** (2013.01); ***A61B 17/7007*** (2013.01); ***A61B 17/7011*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61B 17/7062; A61B 17/7067; A61B 17/7068
(Continued)

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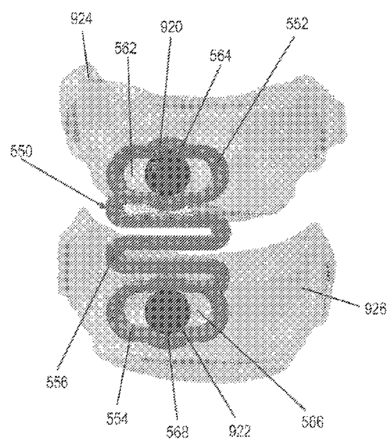
Primary Examiner — Ellen C Hammond
Assistant Examiner — Christina Negrellirodrigue
(74) *Attorney, Agent, or Firm* — Heslin Rothenberg Farley & Mesiti P.C.; John W. Boger

(57) **ABSTRACT**

Dynamic spinal fixation systems including a member, a first attachment portion, a second attachment portion, and an intermediate portion. The first attachment portion is attached at a superior end of the member and includes a first opening. The second attachment portion is attached at an inferior end of the member and includes a second opening. The intermediate portion connects the first and second attachment portions. The dynamic spinal fixation systems may also include a relief in at least one of the first opening and the second opening. The systems may also include a third attachment portion with a third opening and an intermediate portion with a first and a second elastic mechanism. The first elastic mechanism connects the first and third attachment portions and the second elastic mechanism connects the third and second attachment portions. Surgical methods for inserting the dynamic spinal fixation systems in a patient are also disclosed.

20 Claims, 23 Drawing Sheets



Related U.S. Application Data

on Aug. 8, 2011, provisional application No. 61/628,662, filed on Nov. 4, 2011, provisional application No. 61/628,663, filed on Nov. 4, 2011.

(52) **U.S. Cl.**
CPC ***A61B 17/7026*** (2013.01); ***A61B 17/7029*** (2013.01); *A61B 17/701* (2013.01); *A61B 17/7004* (2013.01); *A61B 17/7025* (2013.01); *A61B 17/7028* (2013.01); *A61B 17/8023* (2013.01); *A61B 2017/00004* (2013.01)

(58) **Field of Classification Search**
USPC 606/246–249, 257; 623/17.11–17.16
See application file for complete search history.

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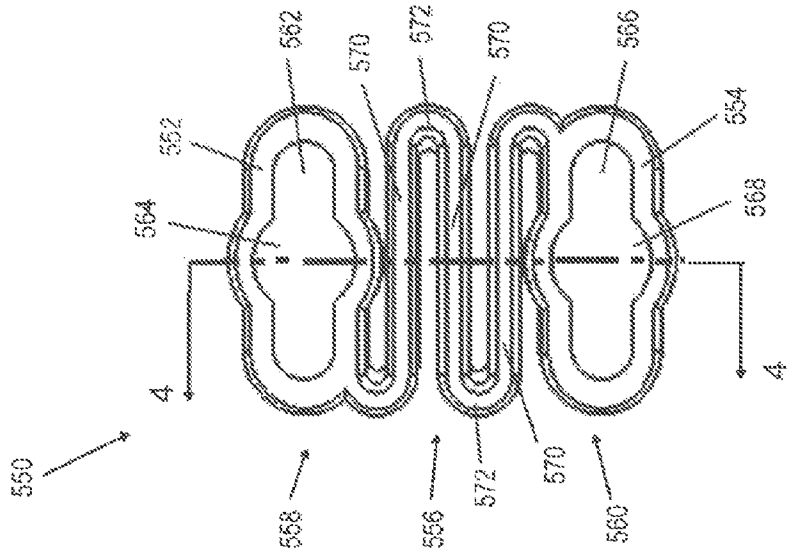
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FIG. 2

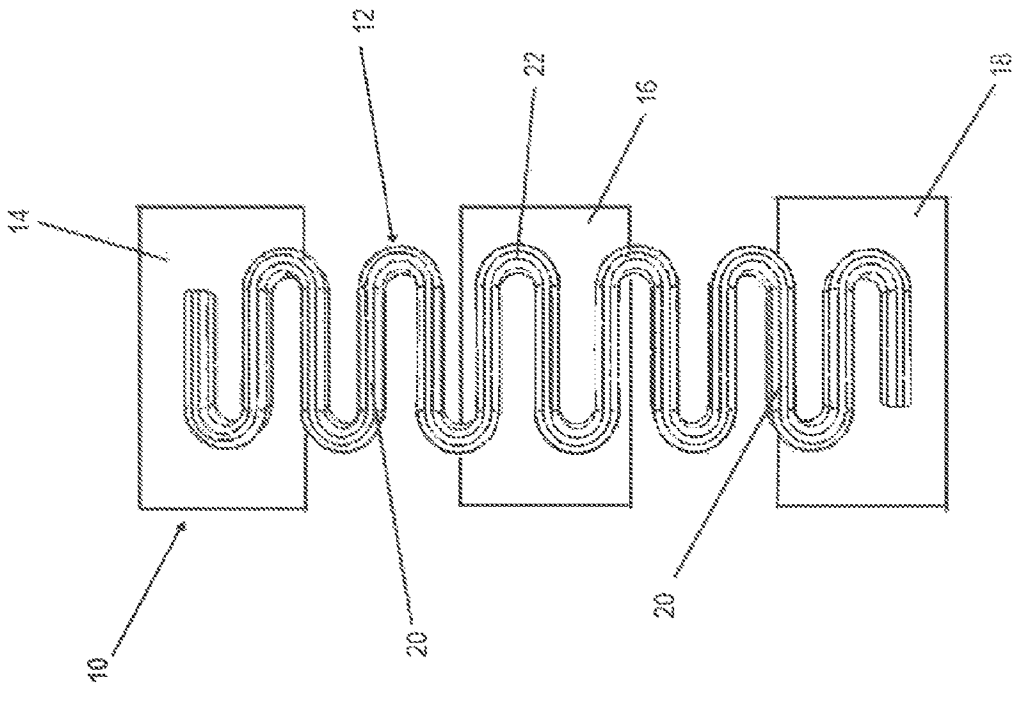
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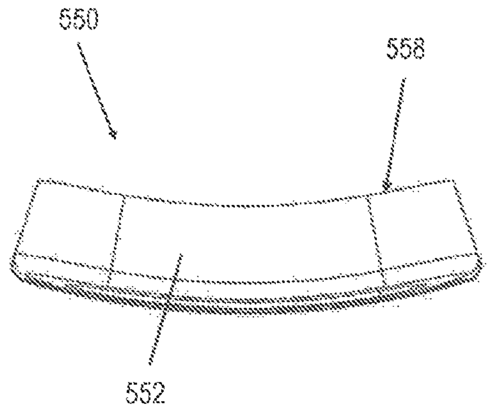
FIG. 1



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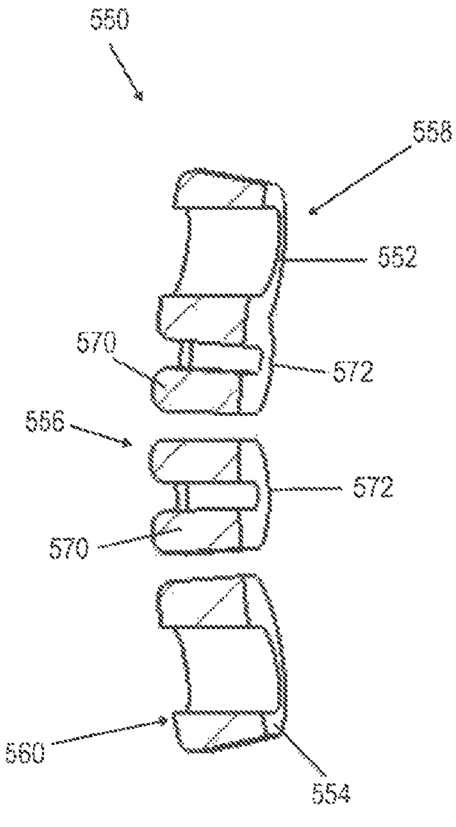

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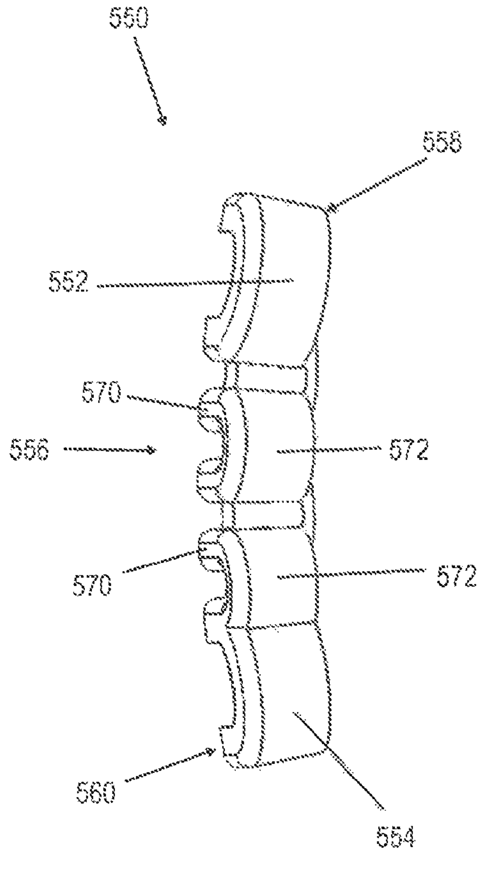

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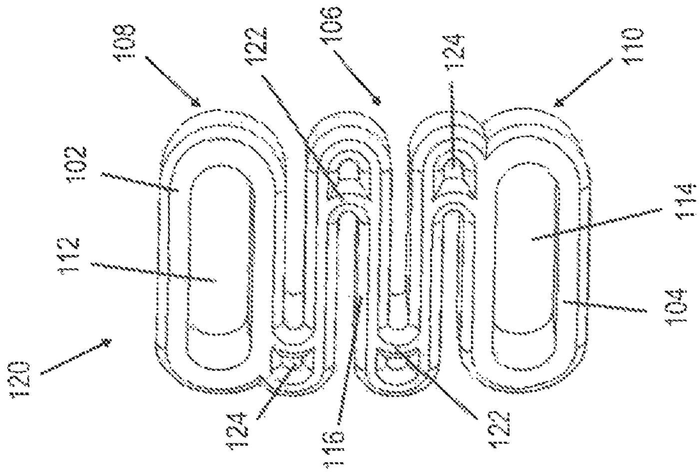

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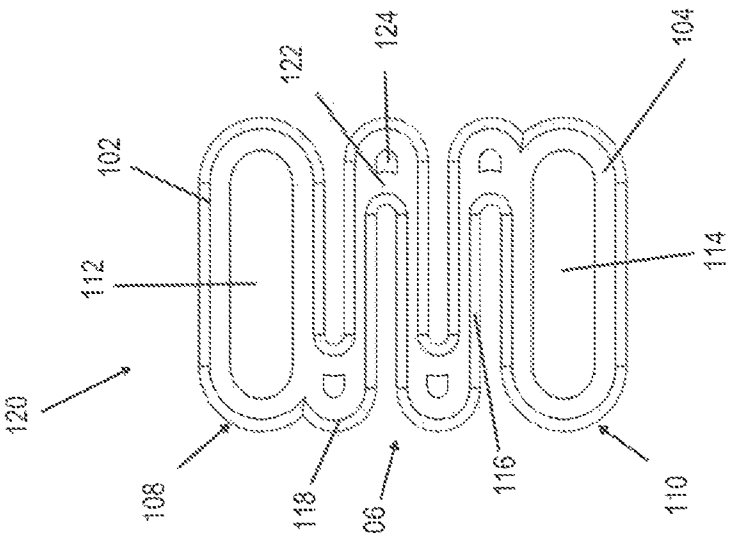

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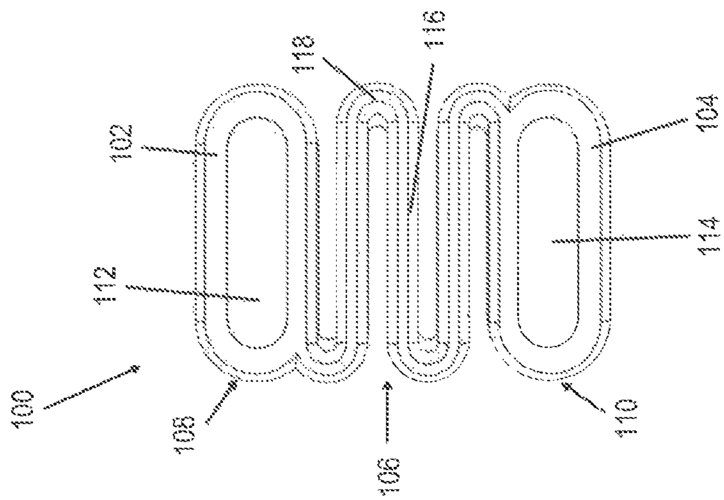

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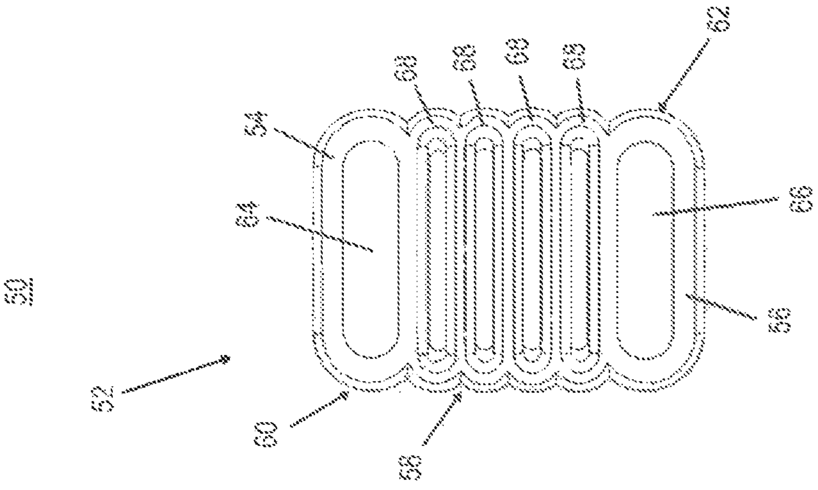

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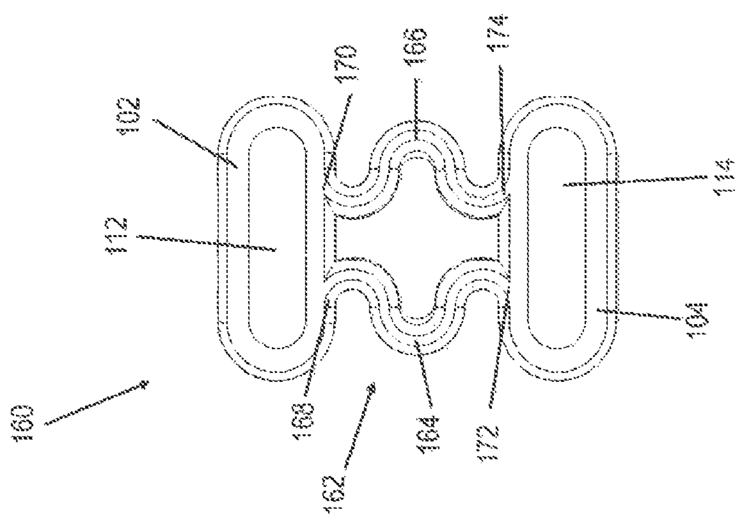

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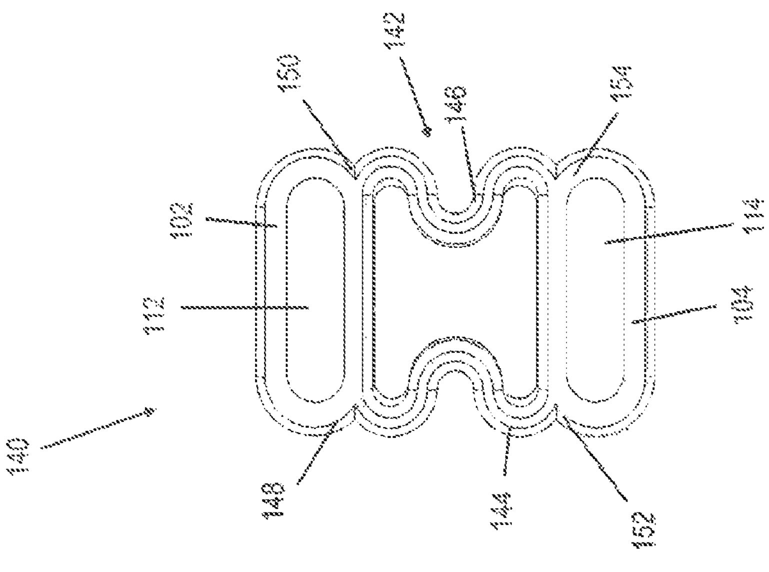

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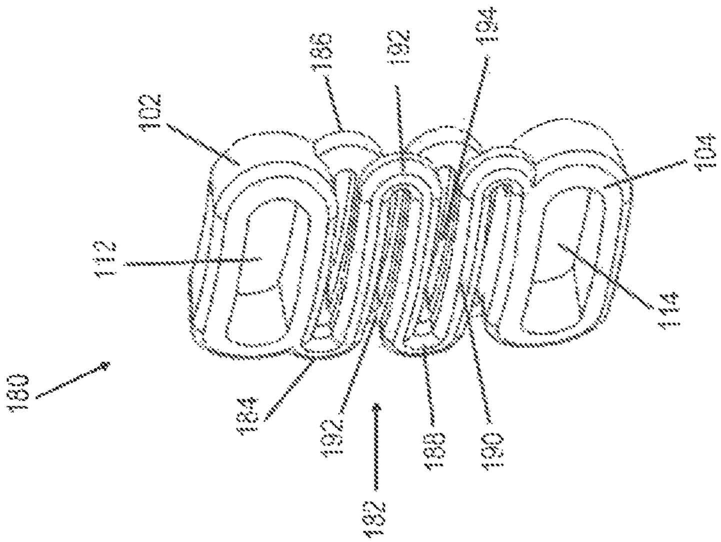
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FIG. 13

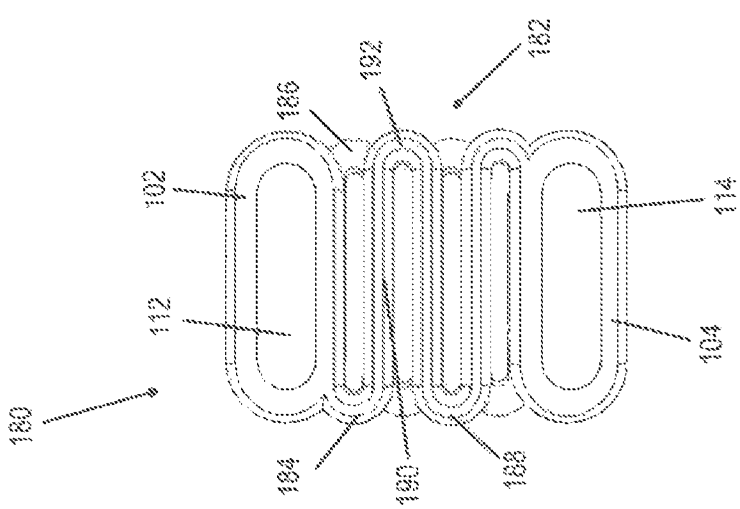
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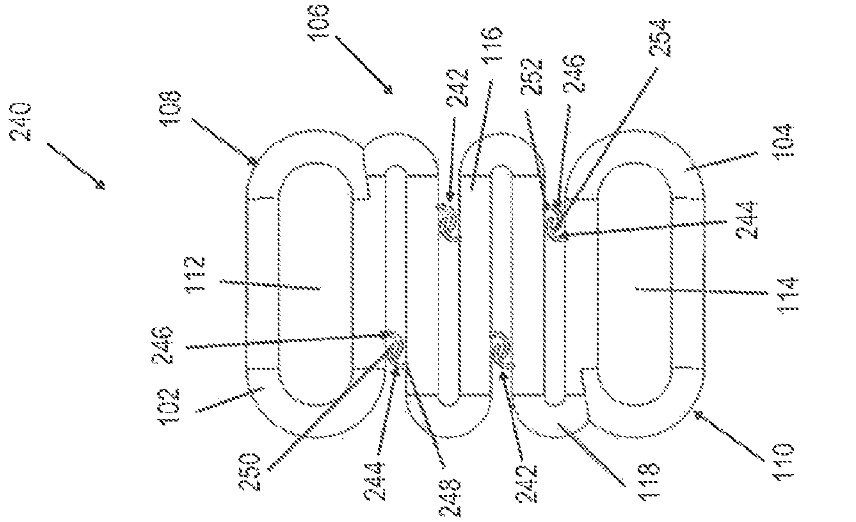
FIG. 12



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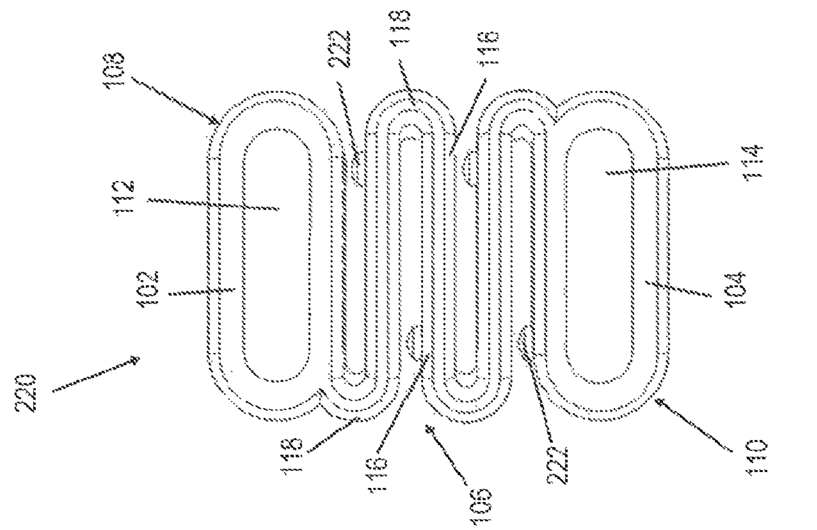

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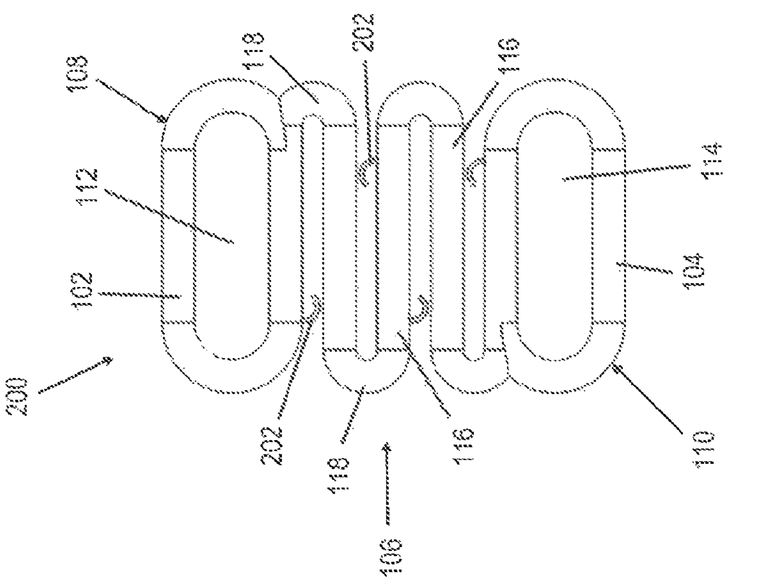

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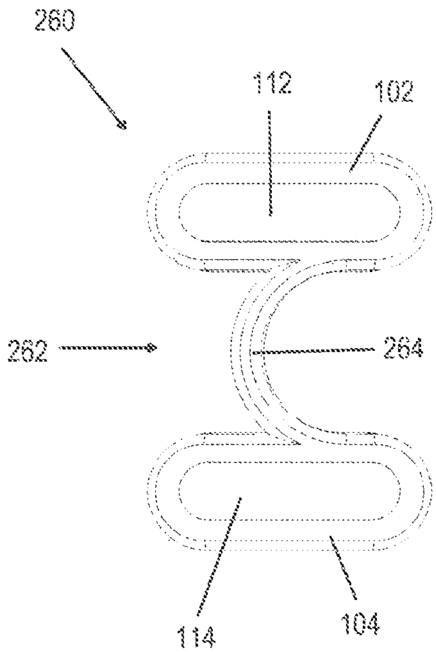

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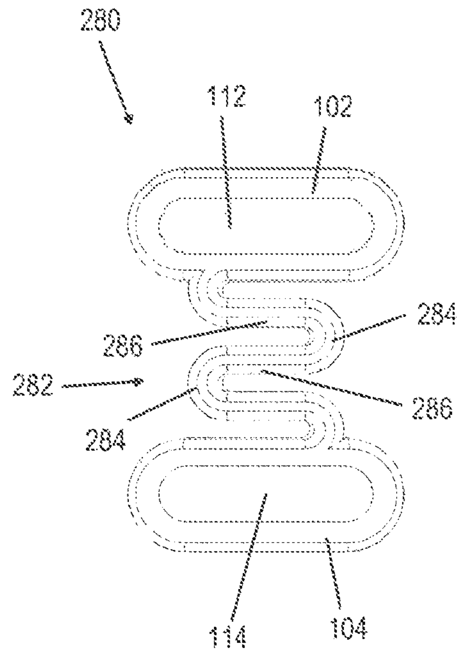

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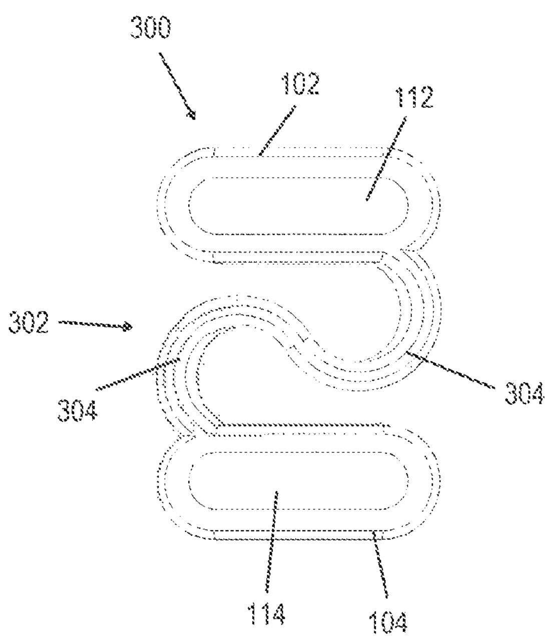

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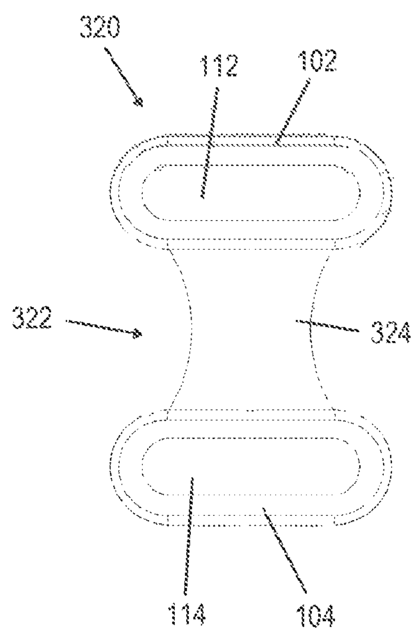

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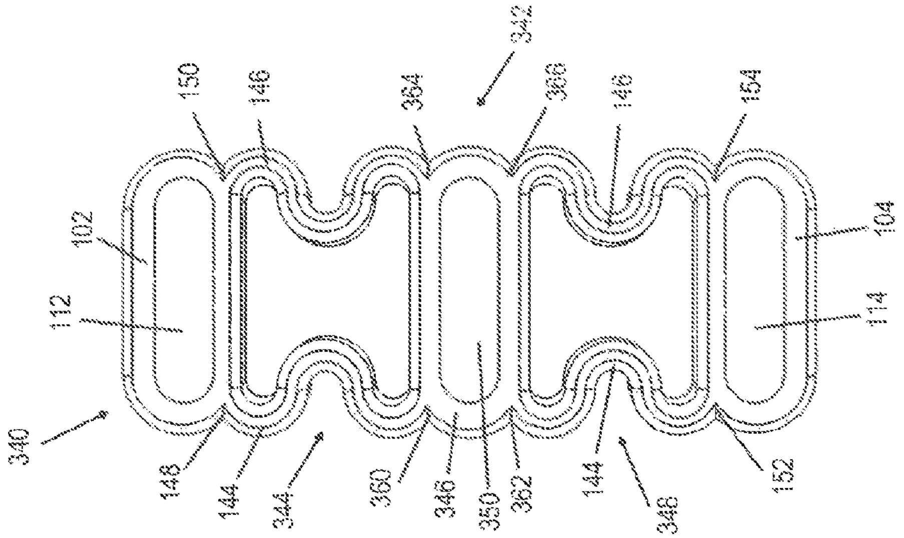

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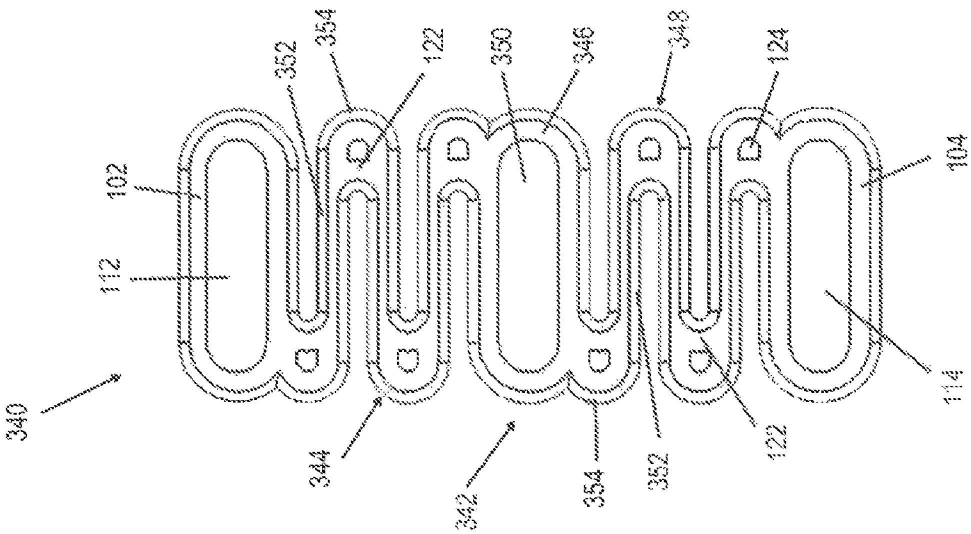

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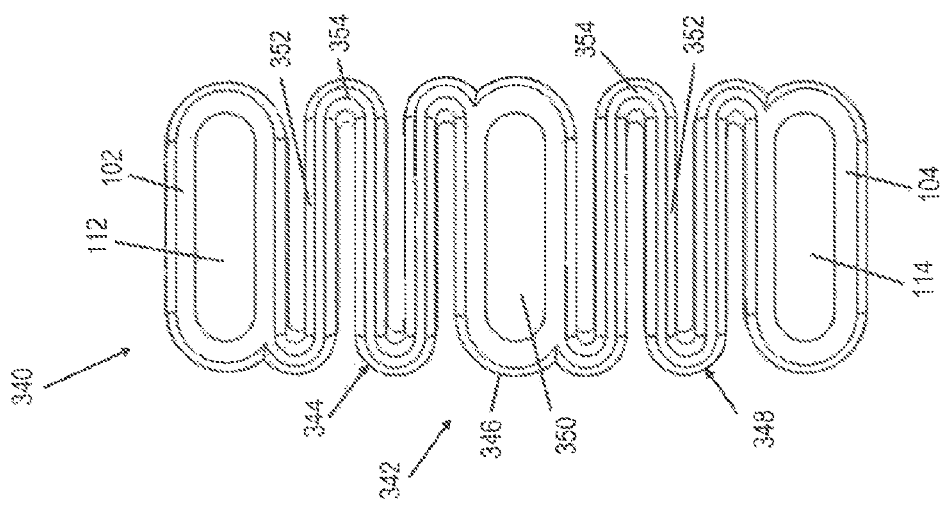

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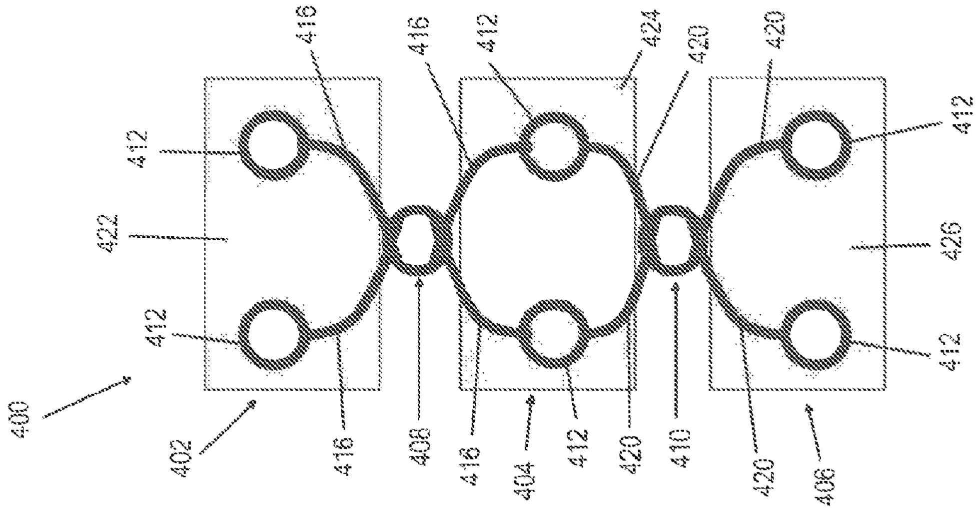

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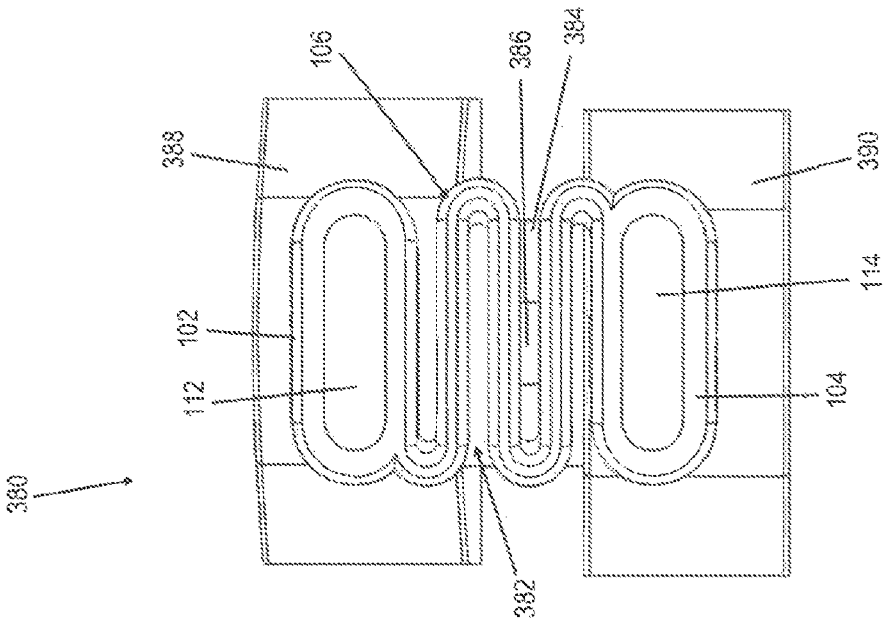

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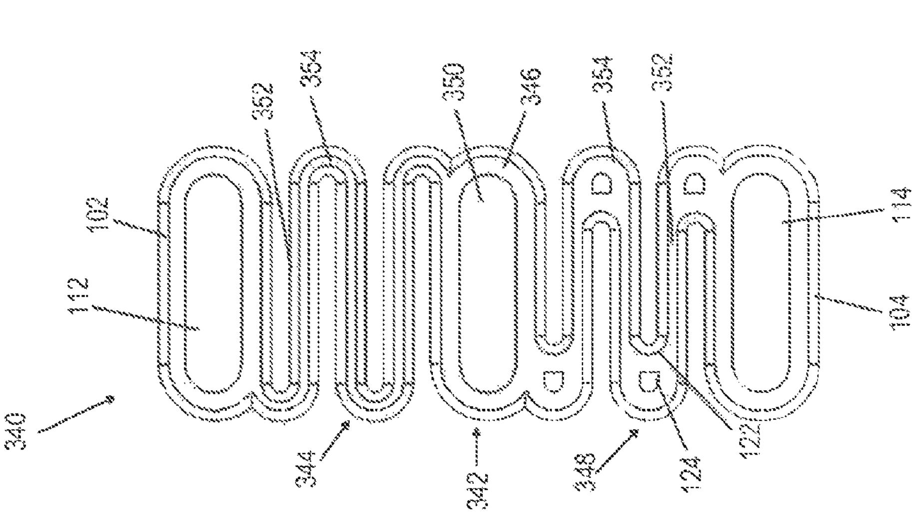

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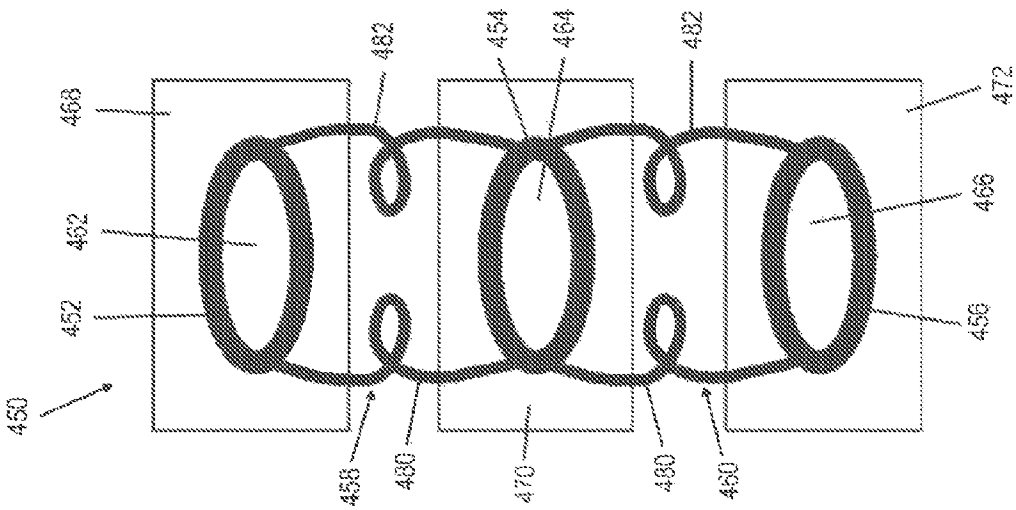

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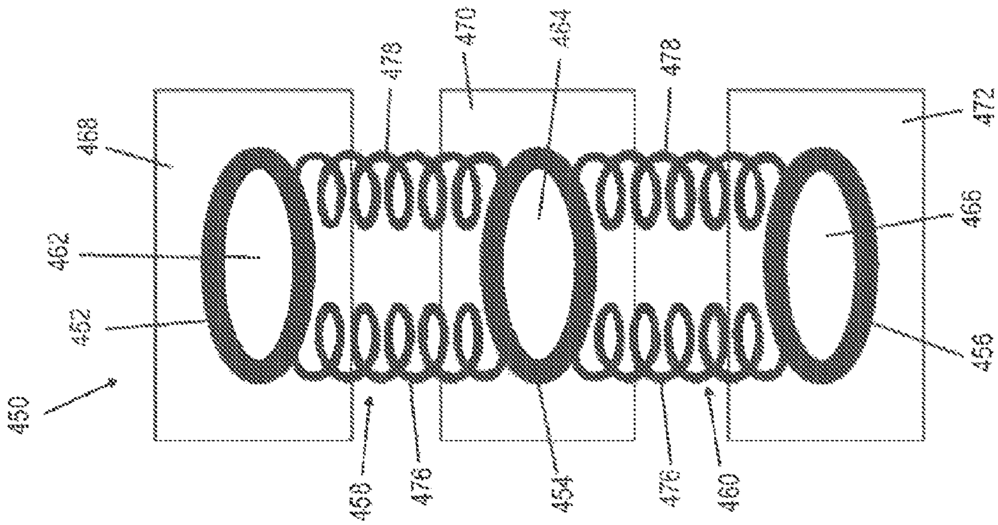

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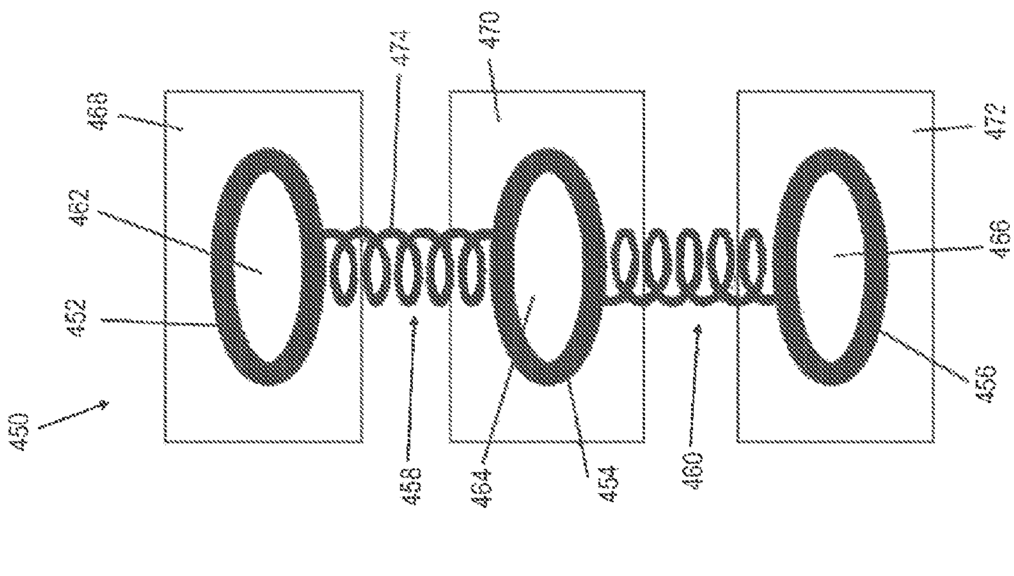

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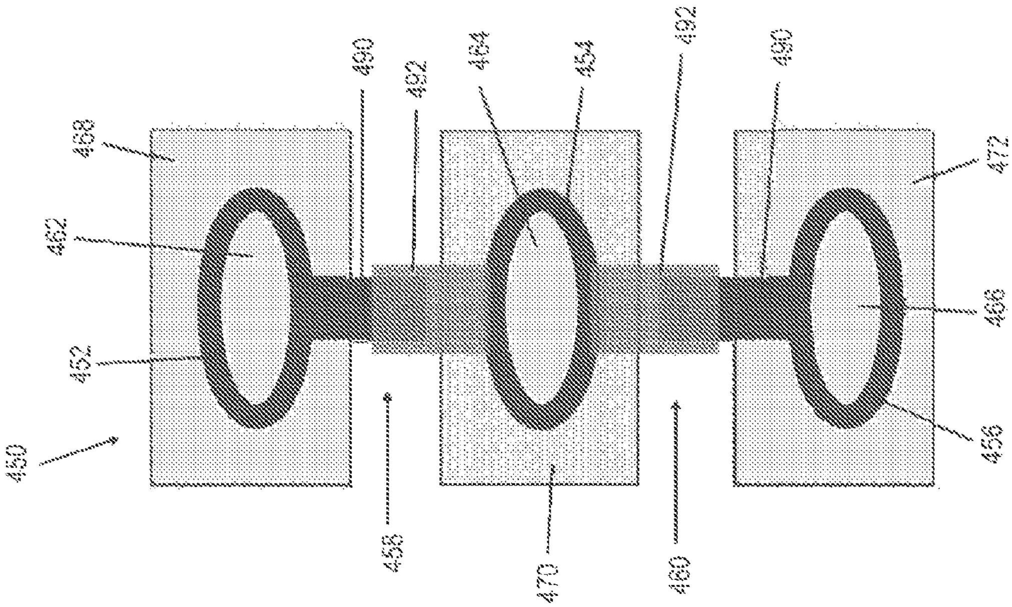
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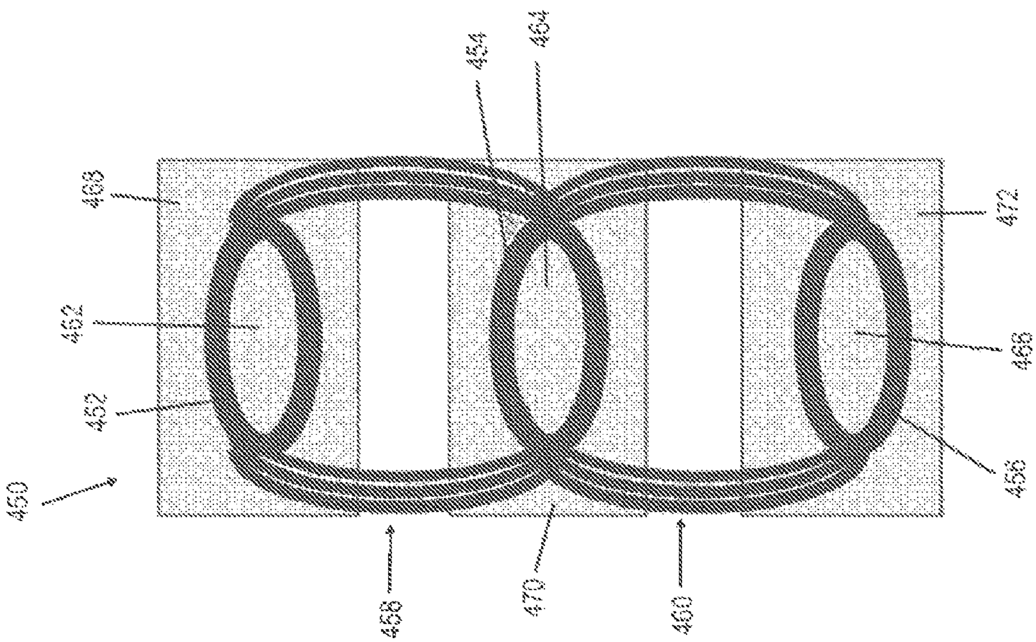
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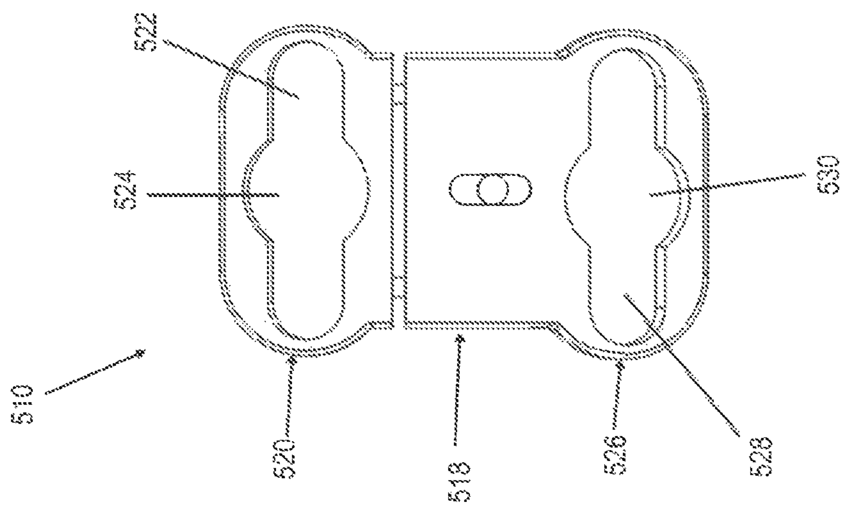

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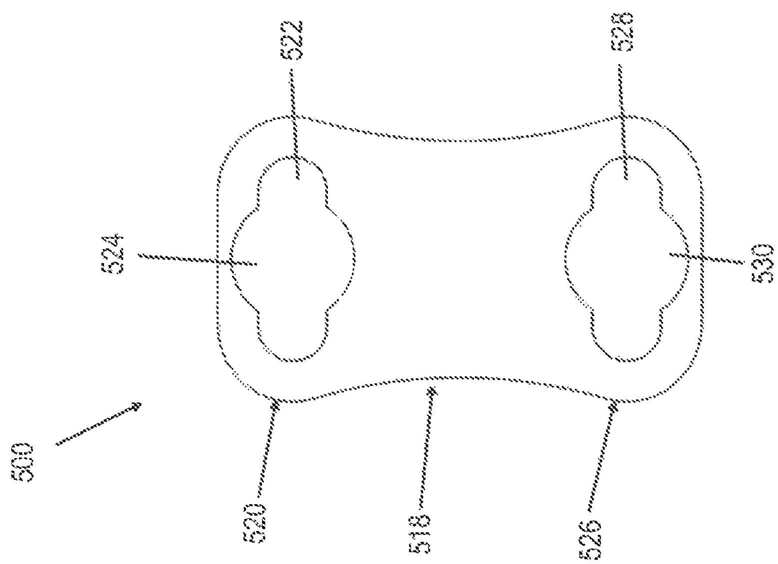

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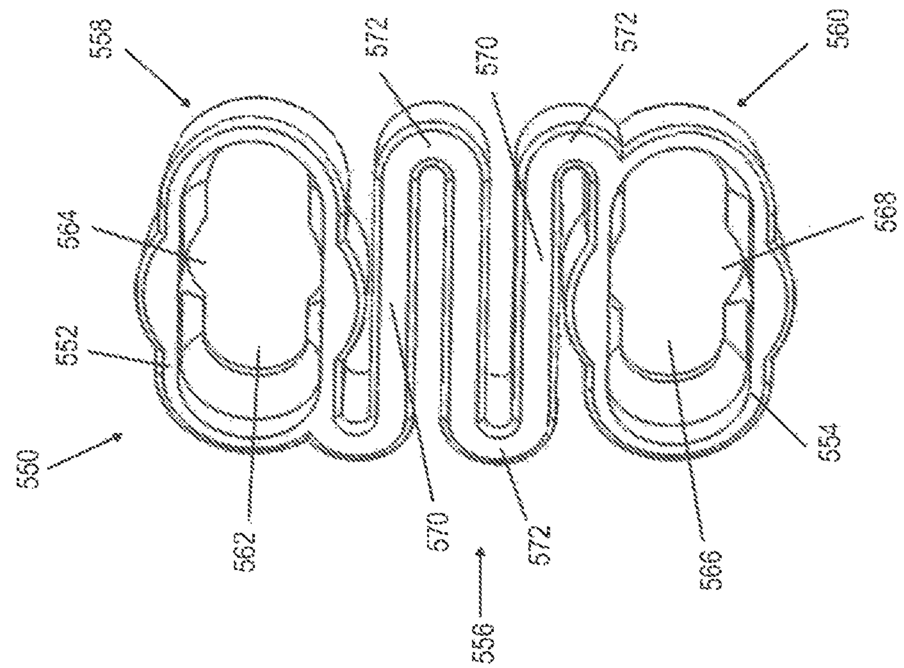
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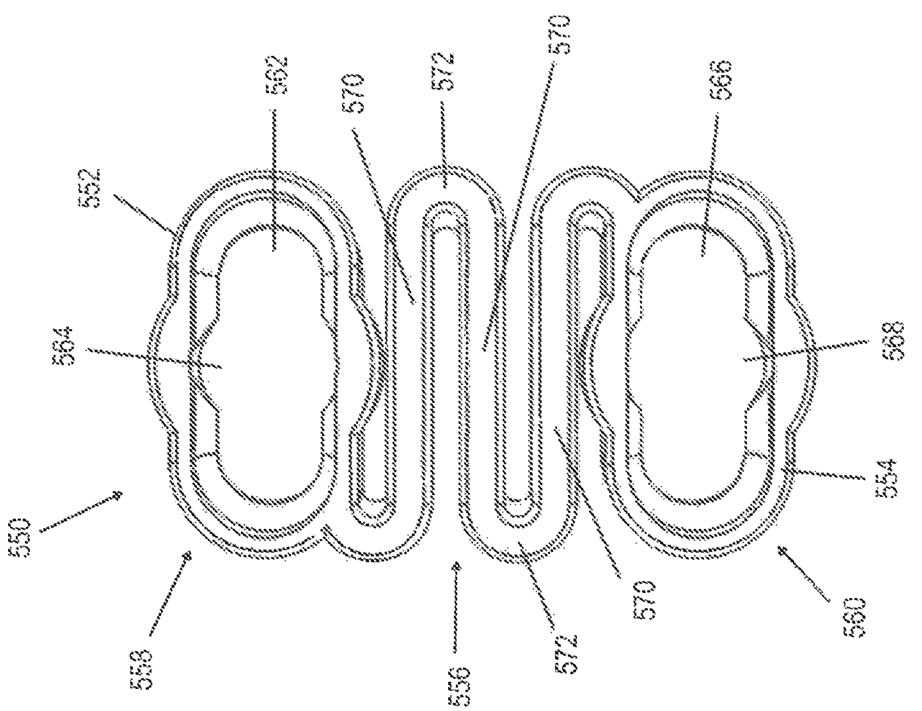
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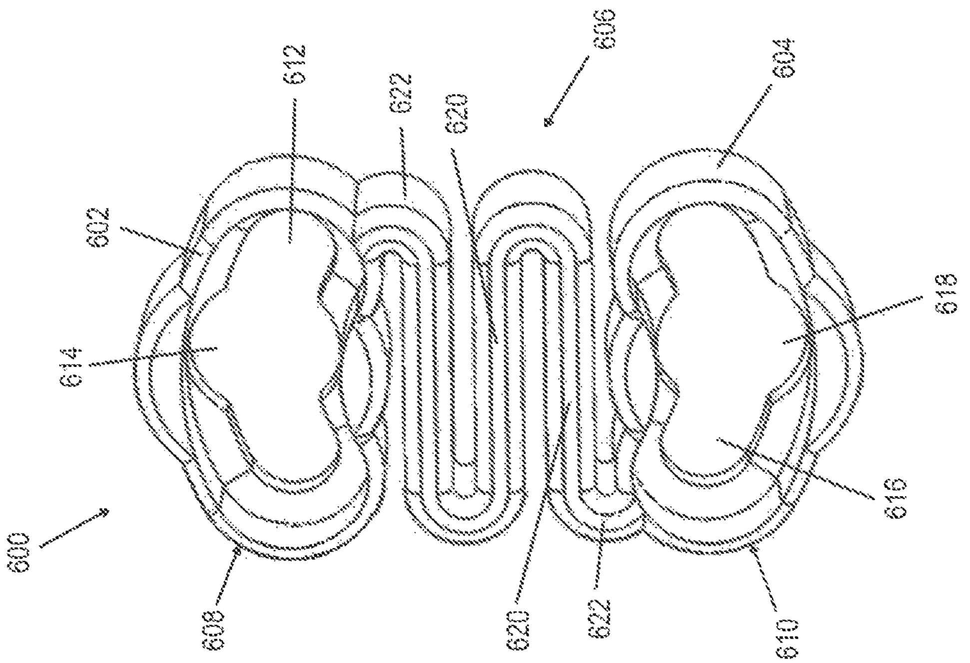
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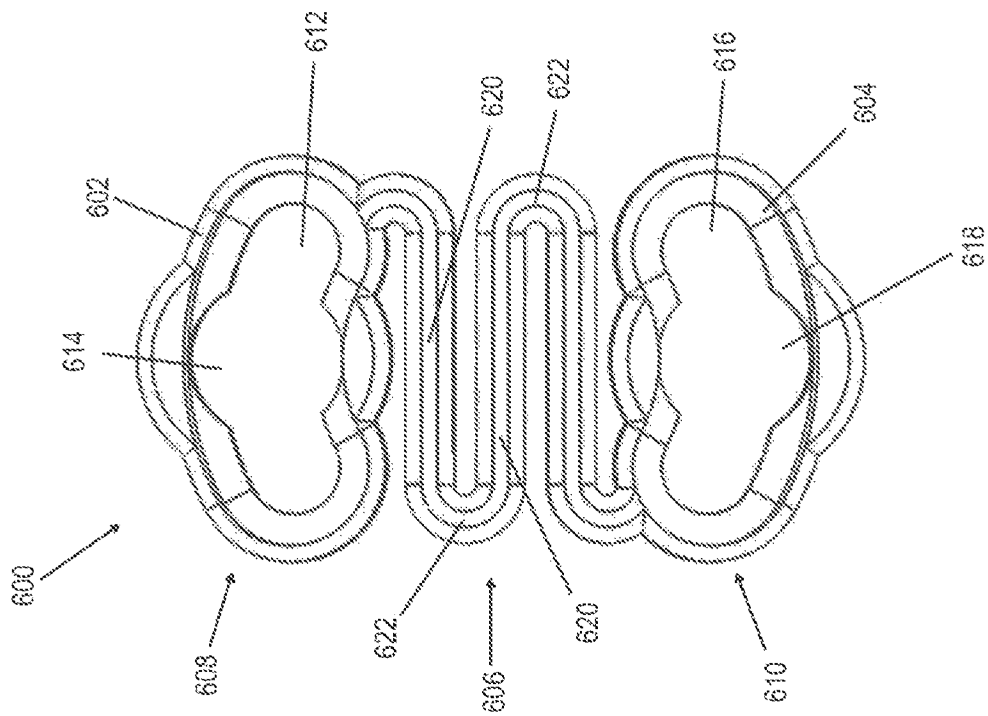
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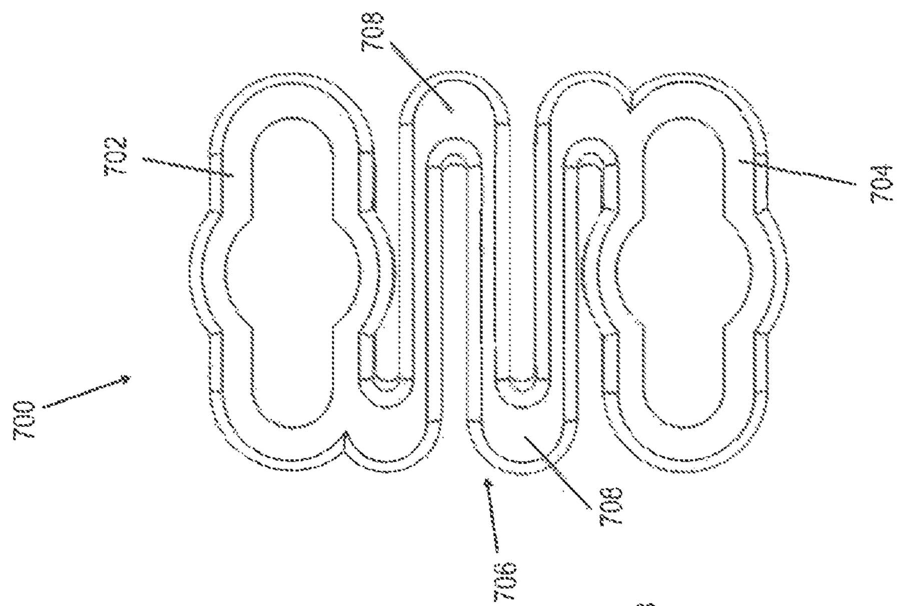

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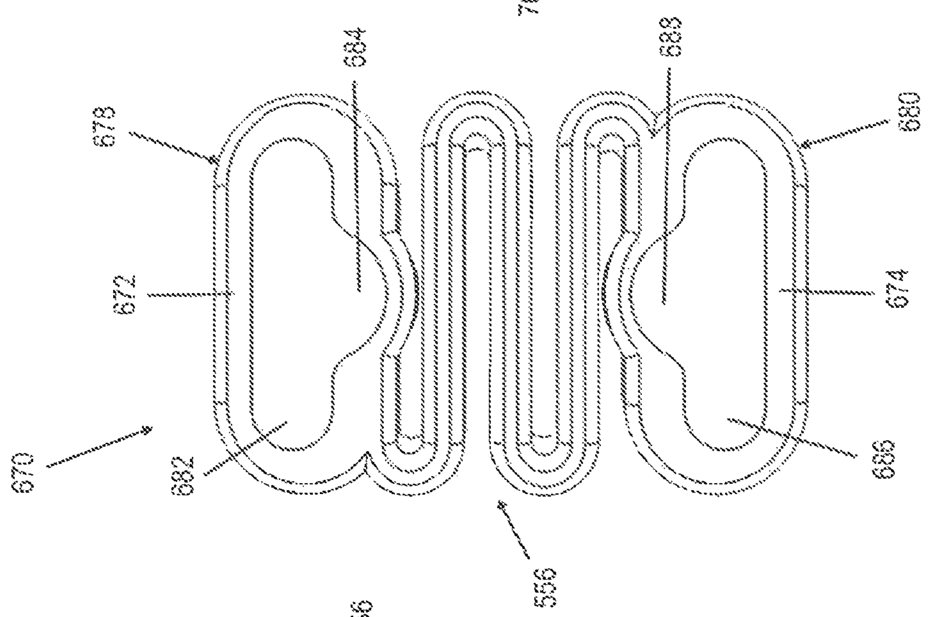

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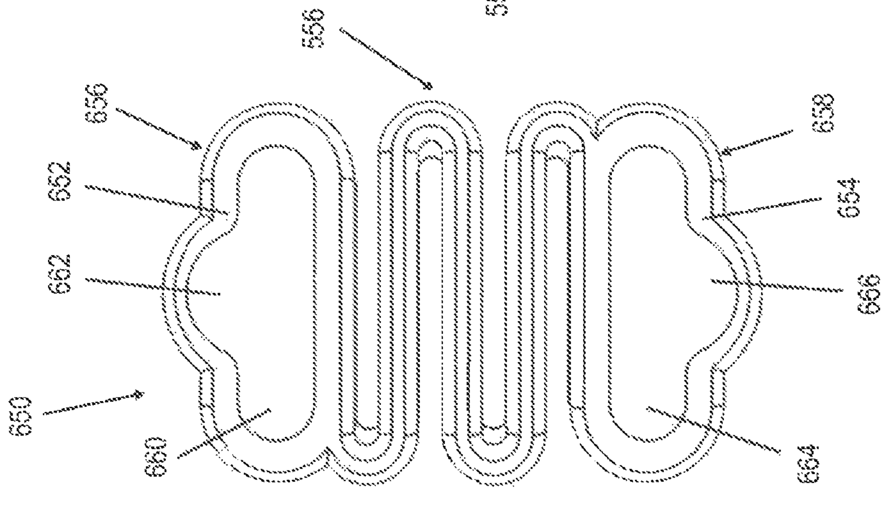

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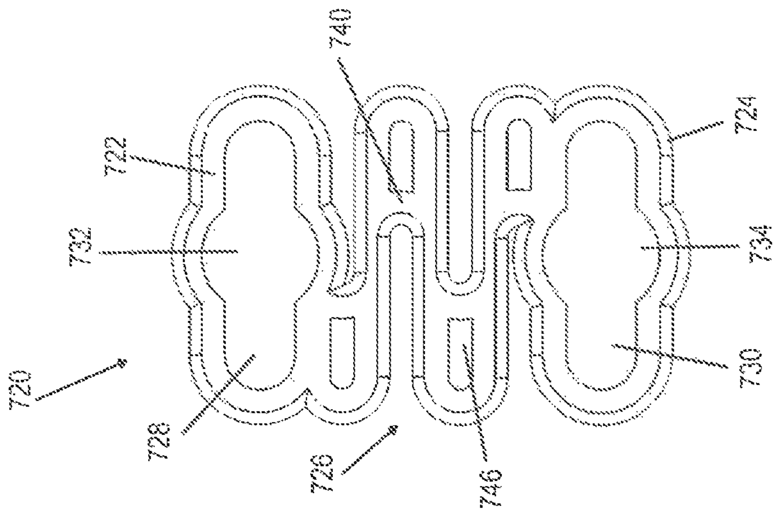

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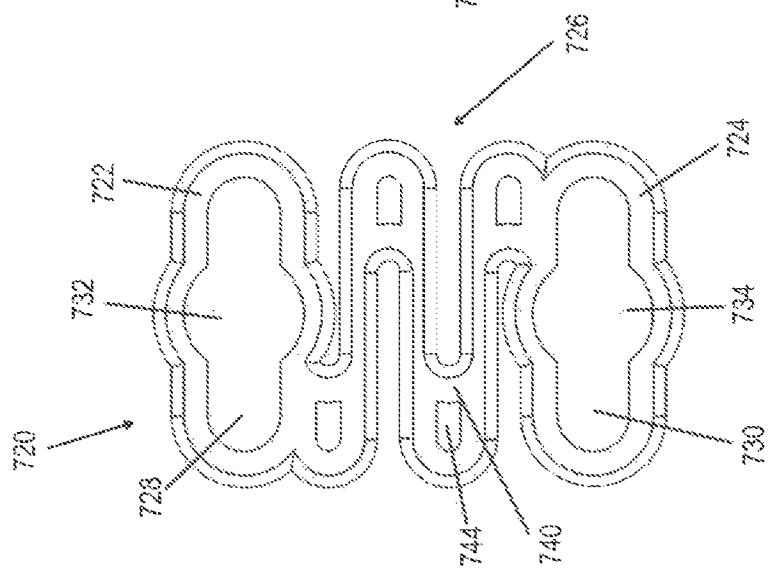

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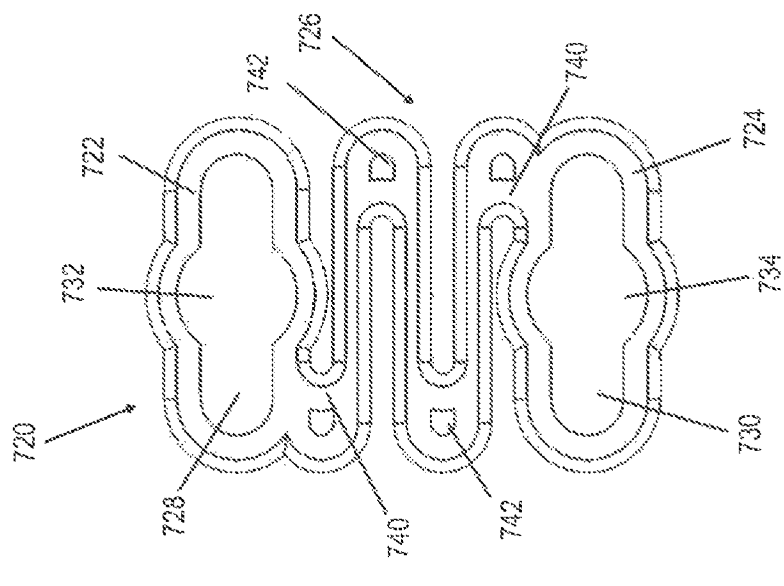

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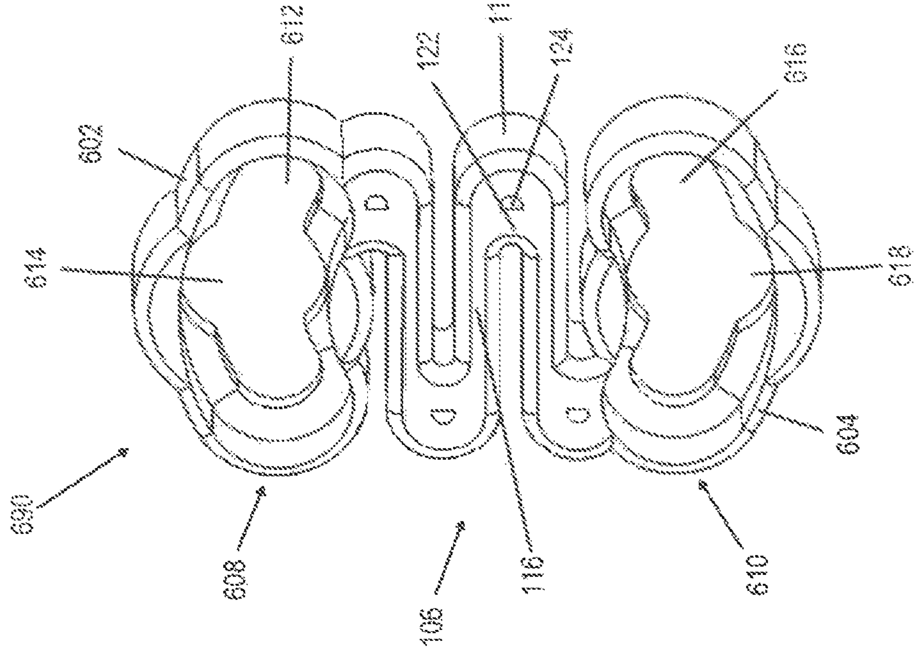
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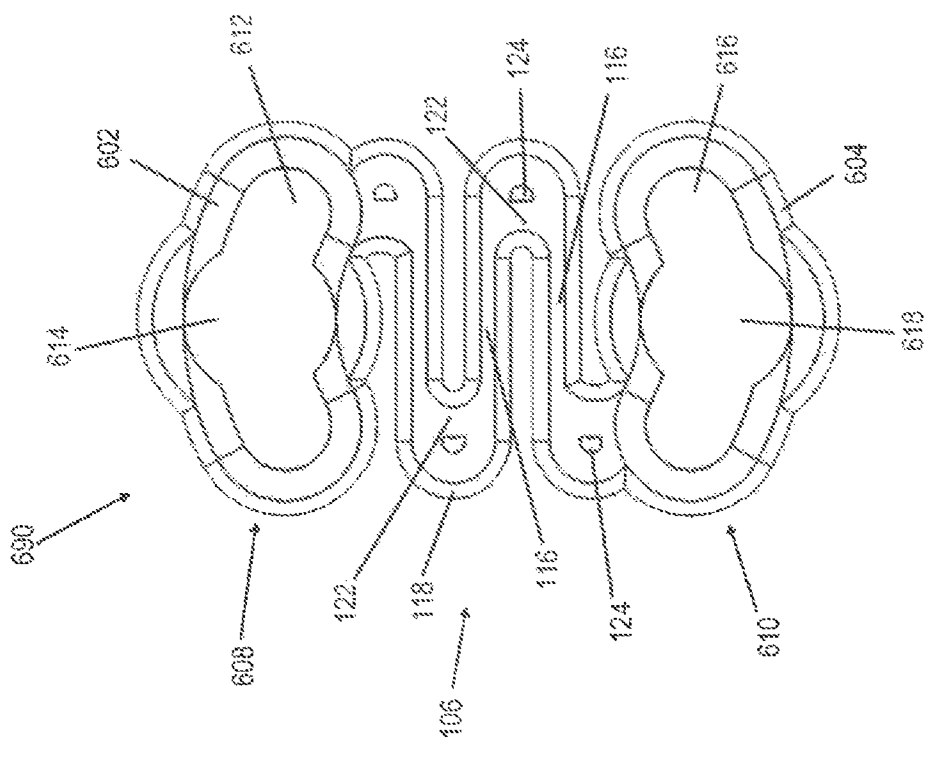
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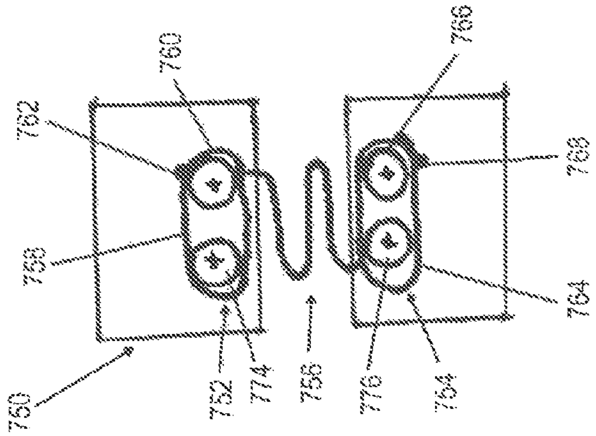
FIG. 44



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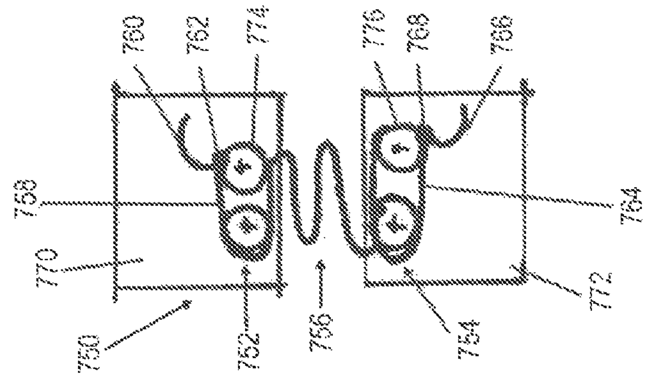

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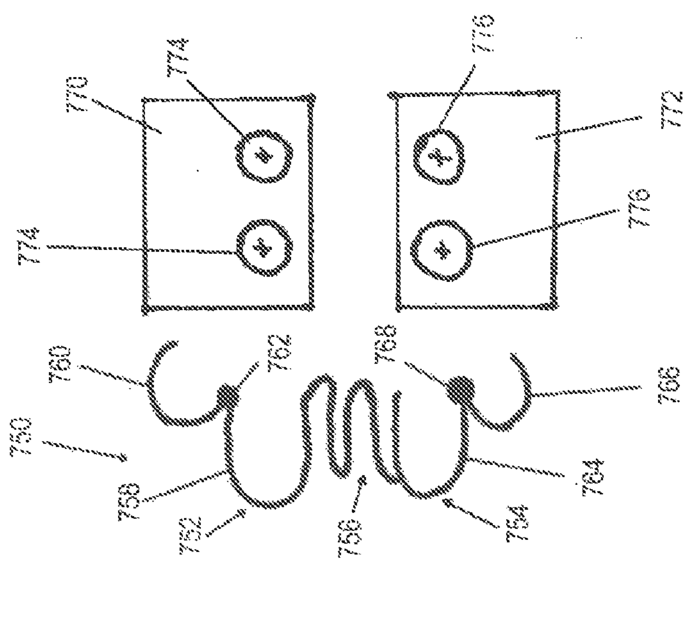

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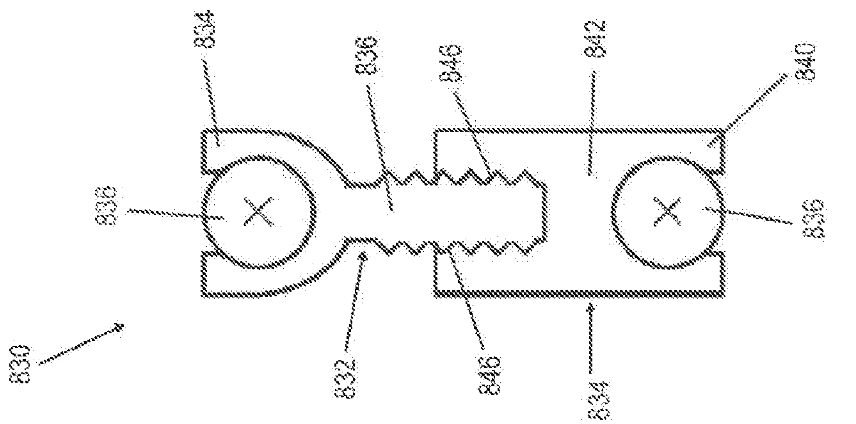
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FIG. 50

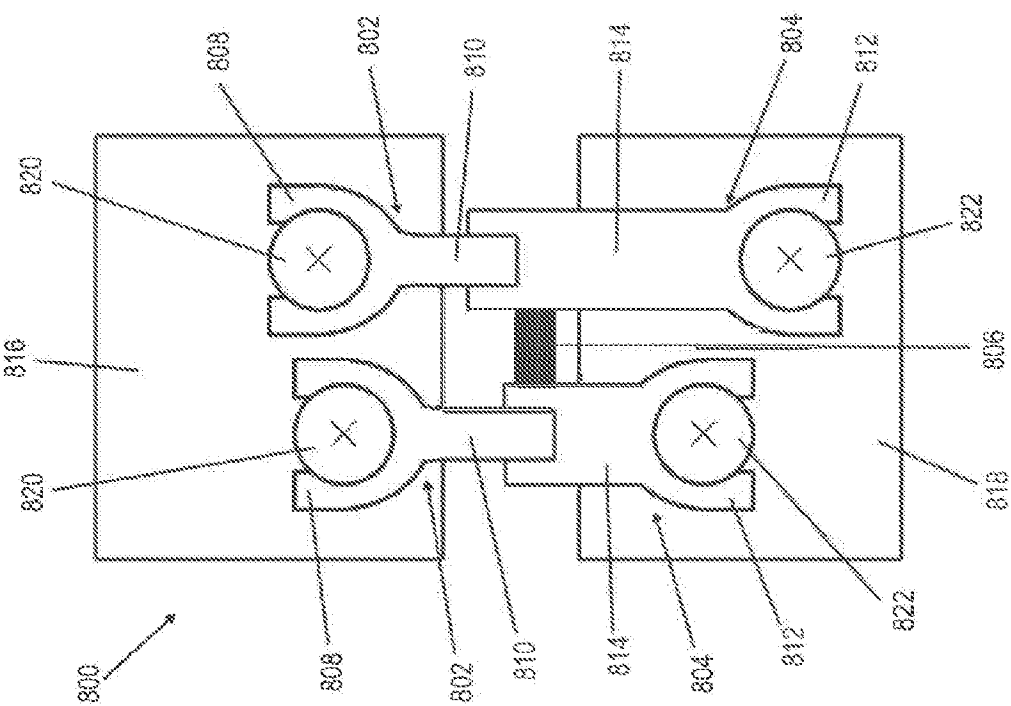
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FIG. 49

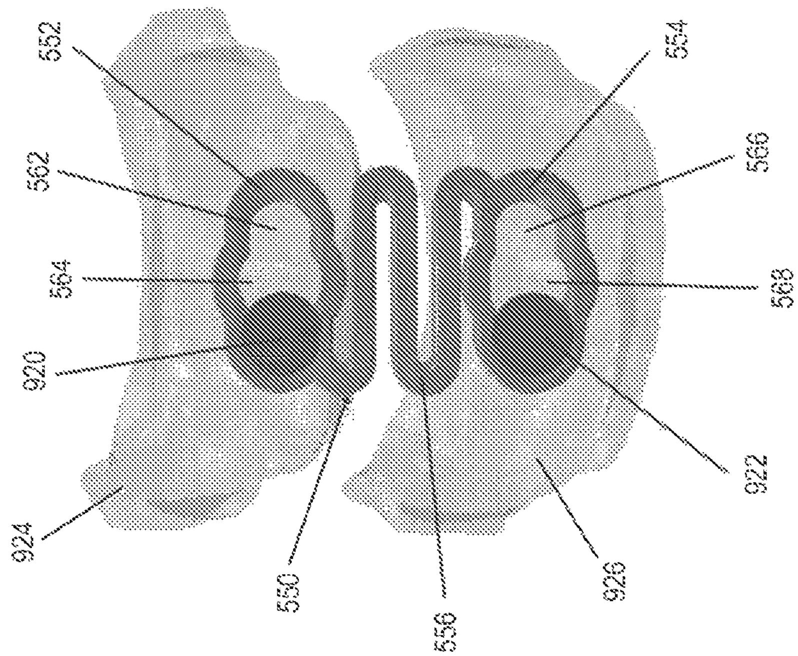
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FIG. 52

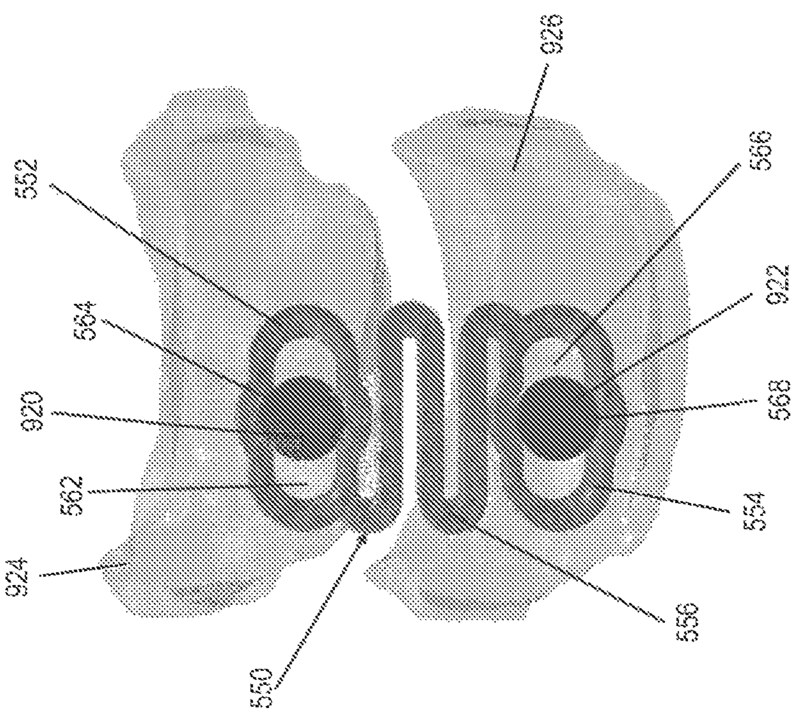
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FIG. 51

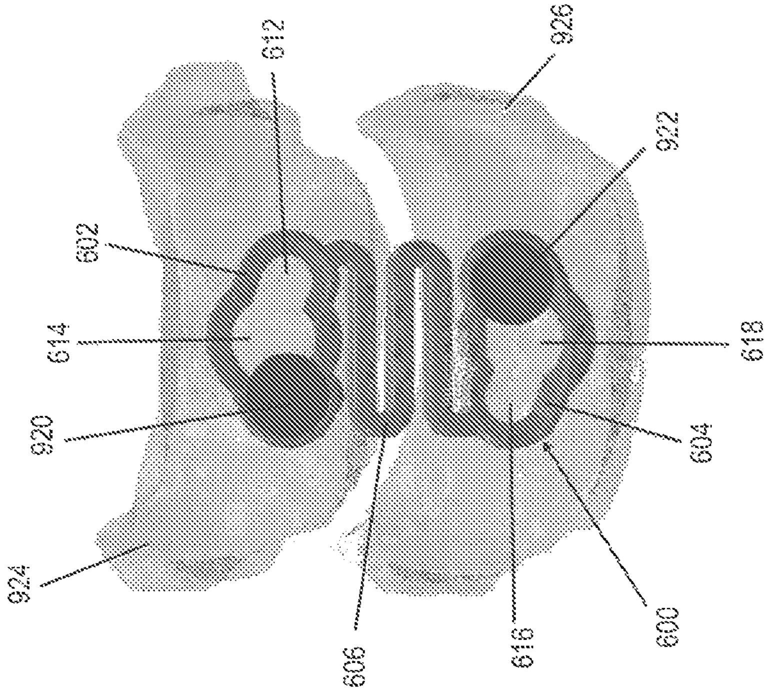
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FIG. 54

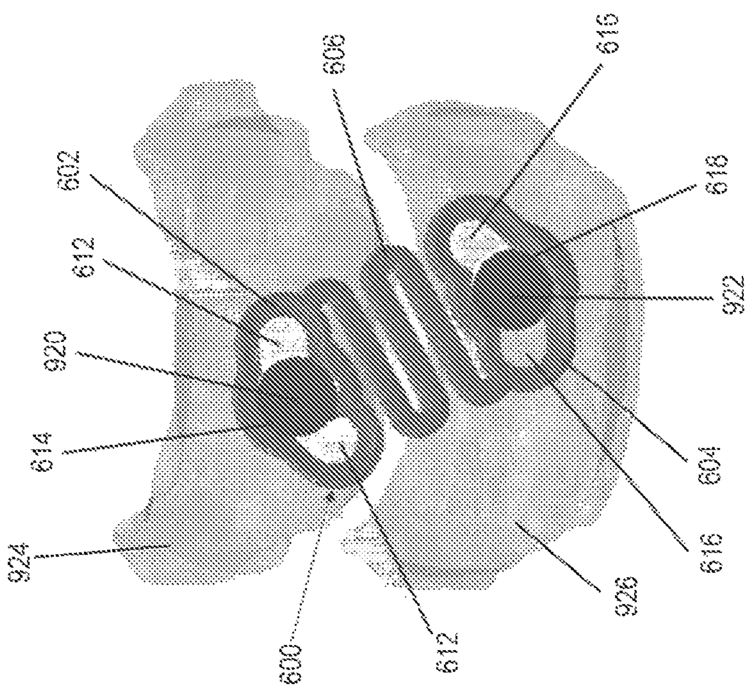
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FIG. 53

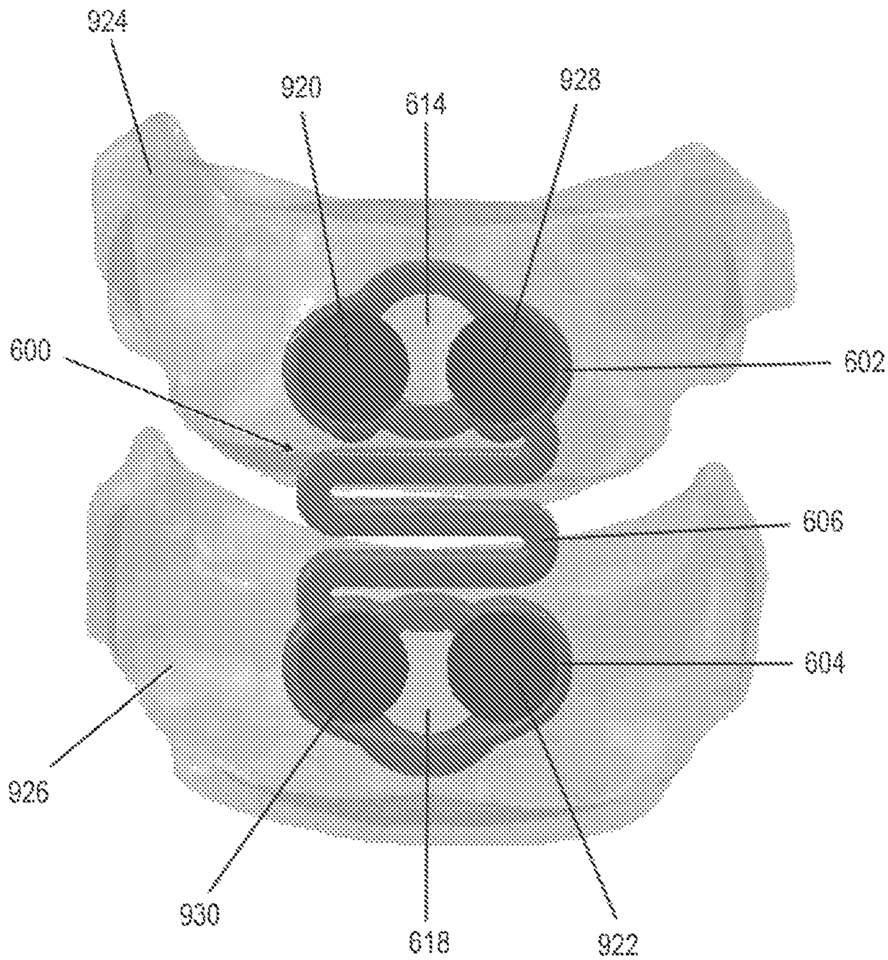

FIG. 55

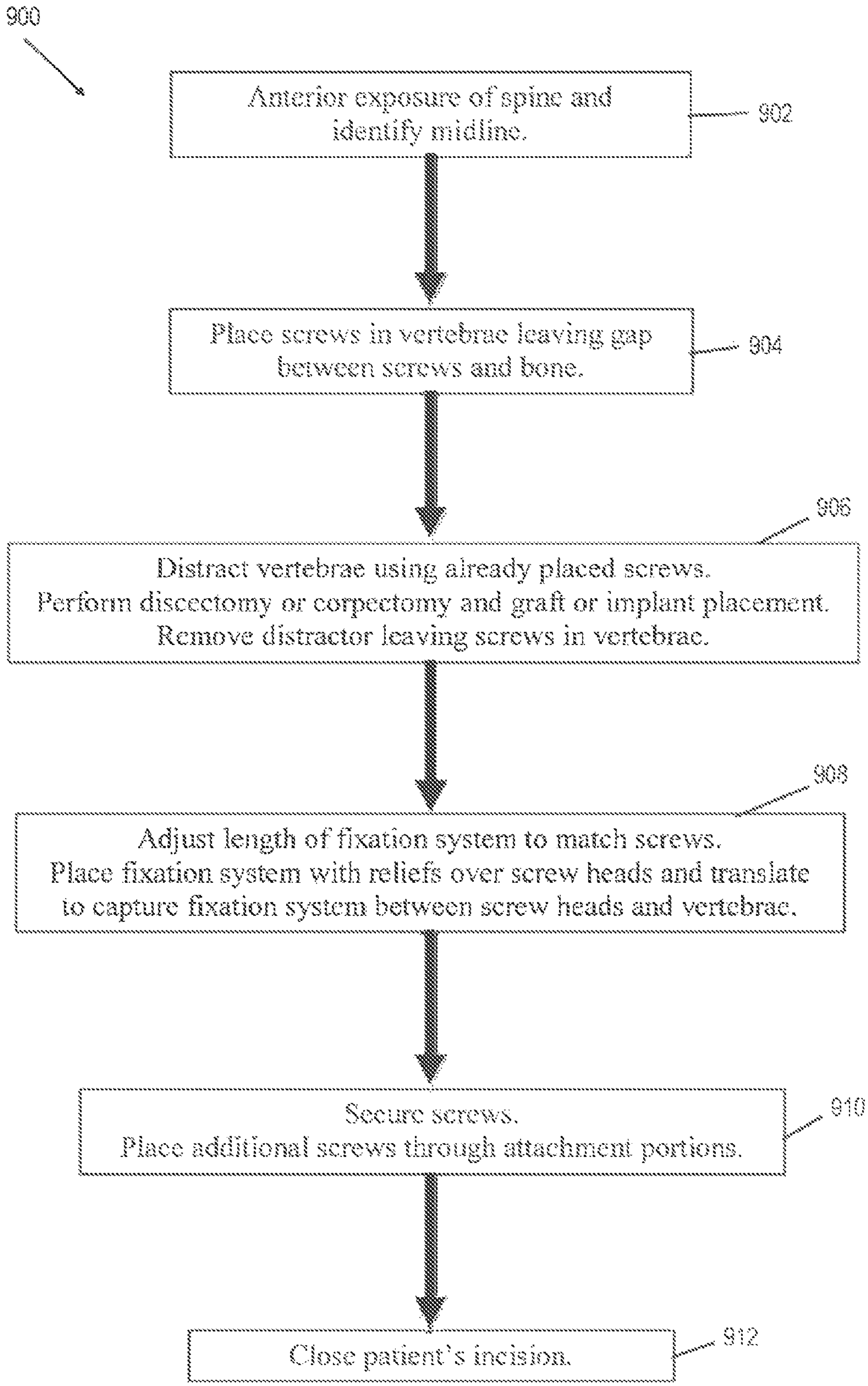
900
Anterior exposure of spine and identify midline.
902
Place screws in vertebrae leaving gap between screws and bone.
904
906
Distract vertebrae using already placed screws.
Perform discectomy or corpectomy and graft or implant placement.
Remove distractor leaving screws in vertebrae.
908
Adjust length of fixation system to match screws.
Place fixation system with reliefs over screw heads and translate to capture fixation system between screw heads and vertebrae.
Secure screws.
Place additional screws through attachment portions.
910
Close patient's incision.
912

FIG. 56

DYNAMIC SPINAL FIXATION SYSTEM, METHOD OF USE, AND SPINAL FIXATION SYSTEM ATTACHMENT PORTIONS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a national stage filing under section 371 of International Application No. PCT/US2012/049959 filed on Aug. 8, 2012, and published in English on Feb. 14, 2013 as WO 2013/022944 A1 and claims priority benefit under 35 U.S.C. §119(e) of U.S. provisional patent application Nos. 61/574,662 and 61/574,636 filed Aug. 8, 2011 and U.S. provisional patent application Nos. 61/628,662 and 61/628,663 filed Nov. 4, 2011, which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

The present disclosure relates generally to a spinal fixation device and, in particular, to a dynamic spinal fixation system and method of use for stabilizing one or more levels of the cervical spine or lumbar spine as well as to a spinal fixation system including attachment portions with reliefs. When non-surgical treatments of spinal injuries, diseases, and trauma fail, anterior spinal surgery is often performed to access the cervical or lumbar vertebrae or intervertebral discs. The anterior spinal surgery that is performed may be an anterior cervical discectomy and fusion ("ACDF"). During an ACDF procedure a bone graft or interbody implant is often used to replace the removed disc and a spinal fixation plate is then attached to adjacent vertebrae to stabilize the spine and foster arthrodesis. Current procedures employ placement of the plate first and the screws to fix that plate to vertebrae second. Most commonly, spinal fixation plates are affixed to the vertebrae using bone screws.

The currently available spinal fixation plates or devices limit visualization of the vertebrae during placement. In addition, currently available spinal fixation devices are difficult to place along the midline. The currently available spinal fixation devices also create an inability to align intervening segments for fixation. Finally, the currently available spinal fixations devices make it difficult to pull the vertebrae up into a more lordotic position when significant kyphosis exists.

Accordingly, the present invention contemplates new and improved spinal fixation systems which overcome the above-referenced problems and others.

SUMMARY OF THE INVENTION

The present invention is directed toward devices and methods for use in stabilizing one or more levels of the cervical spine or lumbar spine.

In one aspect of the present invention provided herein, is a dynamic spinal fixation system. The dynamic spinal fixation system includes a member with a superior end and an inferior end. The member includes a first attachment portion with a first opening at the superior end and a second attachment portion with a second opening at the inferior end. An intermediate portion connects the first attachment portion and the second attachment portion.

In another embodiment of the present invention provided herein, is a dynamic spinal fixation system. The dynamic spinal fixation system includes a member with a top end and a bottom end. The member includes a first attachment portion with a first opening at the top end and a second

attachment portion with a second opening at the bottom end. An intermediate portion connects the first attachment portion and the second attachment portion. At least one of the first and second openings includes a relief.

In a further aspect of the present invention provided herein, is a surgical method for fusing a spine. The method includes obtaining a dynamic spinal fixation system. The dynamic spinal fixation system includes a member with a superior end and an inferior end. The member includes a first attachment portion at the inferior end which includes a first opening with a first relief and a second attachment portion which includes a second opening with a second relief. An intermediate portion connects the first attachment portion and the second attachment portion. A first bone fastener is inserted into a first vertebra of a patient and a second bone fastener is inserted into a second vertebra of the patient. The first vertebra is superior the second vertebra. The first relief is then aligned with the first fastener and the second relief is aligned with the second fastener. The member is moved into alignment with the first vertebra and the second vertebra for fixation by sliding the member to engage the first fastener in the first opening and second fastener in the second opening. The first fastener is tightened to the first vertebra and the second fastener is tightened to the second vertebra to secure the dynamic spinal fixation system to at least the first vertebra and the second vertebra of a patient's spine. The method is advantageous because it provides a surgeon with the ability to place the bone fasteners into the spine prior to placement of the dynamic spinal fixation system which assists in placing the system in the midline of the spine while also allowing for ideal fastener placement with respect to the vertebrae.

These and other objects, features and advantages of this invention will become apparent from the following detailed description of the various aspects of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and together with the detailed description herein, serve to explain the principles of the invention. It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion. The drawings are only for purposes of illustrating preferred embodiments and are not to be construed as limiting the invention.

FIG. **1** shows a front view of one embodiment of a two level dynamic spinal fixation system, in accordance with an aspect of the present invention;

FIG. **2** shows a front view of one embodiment of a one level dynamic spinal fixation system including reliefs, in accordance with an aspect of the present invention;

FIG. **3** shows a top view of the dynamic spinal fixation system of FIG. **2**, in accordance with an aspect of the present invention;

FIG. **4** is a cross-sectional perspective view of the dynamic spinal fixation system shown in FIG. **2** as viewed along section line **4-4** in FIG. **2**, in accordance with an aspect of the present invention;

FIG. **5** is a side perspective view of the dynamic spinal fixation system shown in FIG. **4**, in accordance with an aspect of the present invention;

FIG. 6 is another embodiment of a one level dynamic spinal fixation system from a front view, in accordance with an aspect of the present invention;

FIG. 7 shows a front view of yet another embodiment of a one level dynamic spinal fixation system, in accordance with an aspect of the present invention;

FIG. 8 is a perspective view of the dynamic spinal fixation system embodiment of FIG. 7, in accordance with an aspect of the present invention;

FIG. 9 is an additional embodiment of a one level dynamic spinal fixation system from a front view, in accordance with an aspect of the present invention;

FIG. 10 shows a further embodiment of a one level dynamic spinal fixation system from a front view, in accordance with an aspect of the present invention;

FIG. 11 shows a front view of yet another embodiment of a one level dynamic spinal fixation system, in accordance with an aspect of the present invention;

FIG. 12 is another embodiment of a one level dynamic spinal fixation system shown from a front view, in accordance with an aspect of the present invention;

FIG. 13 is a perspective view of the dynamic spinal fixation system embodiment of FIG. 12, in accordance with an aspect of the present invention;

FIG. 14 shows another embodiment of a one level dynamic spinal fixation system with a hard stop from a front view, in accordance with an aspect of the present invention;

FIG. 15 is a front view of a further embodiment of a one level dynamic spinal fixation system with an alternative hard stop, in accordance with an aspect of the present invention;

FIG. 16 is a front view of yet another embodiment of a one level dynamic spinal fixation system with a further alternative hard stop, in accordance with an aspect of the present invention;

FIG. 17 shows a front view of an additional embodiment of a one level dynamic spinal fixation system, in accordance with an aspect of the present invention;

FIG. 18 shows another embodiment of a one level dynamic spinal fixation system from a front view, in accordance with an aspect of the present invention;

FIG. 19 shows a front view of still another embodiment of a one level dynamic spinal fixation system, in accordance with an aspect of the present invention;

FIG. 20 shows a further embodiment of a one level dynamic spinal fixation system from a front view, in accordance with an aspect of the present invention;

FIG. 21 is a front view of a two level embodiment of the dynamic spinal fixation system of FIG. 8, in accordance with an aspect of the present invention;

FIG. 22 is a front view of a two level embodiment of the dynamic spinal fixation system of FIG. 9, in accordance with an aspect of the present invention;

FIG. 23 is a front view of a two level embodiment of the dynamic spinal fixation system of FIG. 10, in accordance with an aspect of the present invention;

FIG. 24 is a front view of a two level dynamic spinal fixation system embodiment that combines the dynamic fixation systems of FIG. 8 and FIG. 9, in accordance with an aspect of the present invention;

FIG. 25 is a front view of the one level dynamic spinal fixation system embodiment of FIG. 8 integrated with an interbody cage, in accordance with an aspect of the present invention;

FIG. 26 is a front view of another embodiment of a two level dynamic spinal fixation system, in accordance with an aspect of the present invention;

FIG. 27 is another embodiment of a two level dynamic spinal fixation system with at least one coil spring-like member shown from a front view, in accordance with an aspect of the present invention;

FIG. 28 is a front view of yet another embodiment of a two level dynamic spinal fixation system with at least two parallel coil spring-like members, in accordance with an aspect of the present invention;

FIG. 29 is a further embodiment of a two level dynamic spinal fixation system with at least two parallel torsional spring members shown from a front view, in accordance with an aspect of the present invention;

FIG. 30 is a front view of another embodiment of a two level dynamic spinal fixation system with at least two elastic members, in accordance with an aspect of the present invention;

FIG. 31 is a further embodiment of a two level dynamic spinal fixation system with piston members shown from a front view, in accordance with an aspect of the present invention;

FIG. 32 is a front view of a static spinal fixation system embodiment with attachment portions including openings with reliefs, in accordance with an aspect of the present invention;

FIG. 33 is a front view of another embodiment of a dynamic spinal fixation system with attachment portions including openings with reliefs; in accordance with an aspect of the present invention;

FIG. 34 is a front view of a further embodiment of a dynamic spinal fixation system with attachment portions including openings with reliefs, in accordance with an aspect of the present invention;

FIG. 35 is a perspective view of the dynamic spinal fixation system embodiment of FIG. 34, in accordance with an aspect of the present invention;

FIG. 36 is a front view of yet another embodiment of a dynamic spinal fixation system with curved attachment portions including openings with reliefs, in accordance with an aspect of the present invention;

FIG. 37 is a perspective view of the dynamic spinal fixation system embodiment of FIG. 36, in accordance with an aspect of the present invention;

FIG. 38 is a front view of another dynamic spinal fixation system embodiment with attachment portions including openings with off center reliefs, in accordance with an aspect of the present invention;

FIG. 39 is a front view of a further embodiment of a dynamic spinal fixation system with attachment portions including openings with reliefs, in accordance with an aspect of the present invention;

FIG. 40 is yet another embodiment of a dynamic spinal fixation system with attachment portions including openings with reliefs shown from a front view, in accordance with an aspect of the present invention;

FIG. 41 is a front view of an additional embodiment of a dynamic spinal fixation system with attachment portions including openings with reliefs, in accordance with an aspect of the present invention;

FIG. 42 is another embodiment of a dynamic spinal fixation system with attachment portions including openings with reliefs from a front view, in accordance with an aspect of the present invention;

FIG. 43 is a front view of still a further embodiment of a dynamic spinal fixation system with attachment portions including openings with reliefs, in accordance with an aspect of the present invention;

FIG. **44** is a front view of the embodiment dynamic spinal fixation system of FIG. **41** wherein the openings are curved, in accordance with an aspect of the present invention;

FIG. **45** is a perspective view of the dynamic spinal fixation system embodiment of FIG. **44**, in accordance with an aspect of the present invention;

FIG. **46** is an exploded view of another embodiment of a dynamic spinal fixation system with attachment portions including openings with reliefs and two vertebrae with four fasteners secured to the vertebrae, in accordance with an aspect of the present invention;

FIG. **47** is a front view of the embodiment of FIG. **46** wherein the dynamic spinal fixation system with attachment portions including openings with reliefs is inserted over the fasteners and the arms are in an open position, in accordance with an aspect of the present invention;

FIG. **48** is a front view of the dynamic spinal fixation system of FIGS. **46** and **47** secured to the two vertebrae with closed arms, in accordance with an aspect of the present invention;

FIG. **49** is a front view of another embodiment dynamic spinal fixation system with curved attachment portions secured to two vertebrae, in accordance with an aspect of the present invention;

FIG. **50** is a front view of yet another embodiment of a dynamic spinal fixation system with curved attachment portions secured to two vertebrae, in accordance with an aspect of the present invention;

FIG. **51** is a front view of the dynamic spinal fixation system of FIGS. **34** and **35** with the reliefs of the fixation system mating with two aligned fasteners secured to two vertebrae, in accordance with an aspect of the present invention;

FIG. **52** is a front view of the dynamic spinal fixation system of FIG. **51** after sliding the fixation system along the openings to secure the fasteners, in accordance with an aspect of the present invention;

FIG. **53** is a front view of the dynamic spinal fixation system of FIGS. **36** and **37** with the reliefs of the fixation system mating with two offset fasteners secured to two vertebrae, in accordance with an aspect of the present invention;

FIG. **54** is a front view of the dynamic spinal fixation system of FIG. **53** after rotation of the fixation system, in accordance with an aspect of the present invention;

FIG. **55** is a front view of the dynamic spinal fixation system embodiment of FIGS. **53** and **54** secured to two vertebrae with four fasteners, in accordance with an aspect of the present invention; and

FIG. **56** depicts one embodiment of a surgical method for implanting a dynamic spinal fixation system into a patient's body, in accordance with an aspect of the present invention.

DETAILED DESCRIPTION FOR CARRYING OUT THE INVENTION

In this application, the words proximal, distal, anterior, posterior, medial and lateral are defined by their standard usage for indicating a particular part or portion of a bone or prosthesis coupled thereto, or directional terms of reference, according to the relative disposition of the natural bone. For example, "proximal" means the portion of a bone or prosthesis nearest the torso, while "distal" indicates the portion of the bone or prosthesis farthest from the torso. As an example of directional usage of the terms, "anterior" refers to a direction towards the front side of the body, "posterior" refers to a direction towards the back side of the body, "medial" refers to a direction towards the midline of the body and "lateral" refers to a direction towards the sides or away from the midline of the body.

Referring to the drawings, wherein like reference numerals are used to indicate like or analogous components throughout the several views and referring now to FIG. **1** which depicts a dynamic spinal fixation plate or system **10**. The dynamic spinal fixation system **10** includes a single member **12**. The single member **12** is aligned with a first vertebra **14** at a superior end, a second vertebra **16** at a mid-point, and a third vertebra **18** at an inferior end. The system **10** may be secured to the vertebrae **14**, **16**, **18** using bone fasteners, not shown.

The single member **12** may be comprised of a single elastic component with a plurality of straight and curved portions. The single member **12** may be a wire, rod, tube, or other curvilinear spring-like element and may be made of a metallic, polymer, ceramic, or composite material. The single member **12** or elastic component may include a plurality of straight portions **20** and a plurality of curved portions **22** to facilitate fixation of a bone fastener, such as a screw, nail, staple, wire, pin, and the like, to the vertebrae **14**, **16**, **18**. The plurality of straight portions **20** may preferably range from one to fifteen per level and the plurality of curved portions **22** may preferably range from one to sixteen per level. More preferably the plurality of straight portions **20** may range from one to six per level and the plurality of curved portions **22** may range from one to seven per level. In the depicted embodiment, the single member **12** includes thirteen straight portions **20** and twelve curved portions **22**. The bone fasteners may be placed through the single member **12** to engage the vertebrae, specifically the bone fasteners may be placed through any two horizontal sections of the single member **12**. In alternative embodiments, the single member **12** may include attachment portions at the positions where the single member **12** is secured to the vertebrae and the attachment portions may have closed geometries of the types described in greater detail below.

In addition, the shape of the single member **12** may also facilitate controlled deformation in axial compression and in flexion/extension while maintaining a high level of rigidity in lateral bending and in the anterior/posterior direction. The single member **12** of the dynamic spinal fixation system **10** may be comprised of at least one spring-like elastically deformable element. The spring-like element may be curvilinear in shape and allow for elastic deformation when loaded. The deformation of the spring-like element is primarily in the axial direction allowing for controlled or limited flexion and extension. Further, the single member **12** may be shaped to match the curvature of the spine in the sagittal and transverse planes. Alternative shapes that are advantageous to promote stability or arthrodesis of the spine are also contemplated.

The single member **12** may have a cross-section that is circular, elliptical, square, rectangular, or another uniform or non-uniform geometric shape. In addition, the single member **12** may have a uniform geometry along the sagittal and/or transverse planes. Alternatively, the single member **12** may have a non-uniform geometry along the sagittal and/or transverse planes, whereby the single member **12** changes in thickness becoming either thicker or thinner along the sagittal and/or transverse planes. For example, the single member **12** may be thicker near the lateral aspects of the dynamic spinal fixation system **10** and may be thinner near the midline of the dynamic spinal fixation system **10**. A system **10** with thicker lateral aspects and thinner near the midline gives the single member **12** a larger cross-section dimension at the lateral sides of the system **10** and a smaller cross-section dimension near the midline of the system **10**. The single member **12** may also be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes.

The system **10** provides for a high proportion of open area between plurality of straight and curved portions of the single member **12** allowing for easy visualization through the single member **12**. The system **10** also provides elastic compliance allowing the single member **12** to be pre-compressed or pre-distracted prior to attachment to the vertebrae **14**, **16**, **18**. By pre-compressing the single member **12**, the system **10** can facilitate pre-distraction of one or more motion segments of the spine when attached to the vertebrae **14**, **16**, **18**. Alternatively, by pre-distracting the single member **12**, the system **10** can facilitate pre-compression of one or more motion segments of the spine when attached to the vertebrae **14**, **16**, **18**.

Referring now to FIGS. **2-5**, an alternative embodiment of a dynamic spinal fixation system or plate **550** is shown. The system **550** includes a superior end **558** and an inferior end **560**. A first attachment portion **552** is at the superior end **558** of the system **550** and a second attachment portion **554** is at the inferior end **560** of the system **550**. An intermediate portion **556** connects the first attachment portion **552** and the second attachment portion **554**. The first attachment portion **552** and second attachment portion **554** or platform sections may have a generally closed geometry such as a circle, ellipse, square, rectangle, or other closed geometry to facilitate placement of bone fasteners, such as bone screws, nails, staples, wires, pins, and the like. The first attachment portion **552** includes a first opening or slot **562** which is oriented in a transverse direction and further includes a relief **564** or a larger aperture creating a "key hole" slot. Likewise, second attachment portion **554** includes a second opening or slot **566** which is oriented in a transverse direction and further includes a relief **568** or larger aperture creating a "key hole" slot. The reliefs **564**, **568** are centered in the first and second openings **562**, **566**, respectively. In alternative embodiments, the openings **562**, **566** could also include additional reliefs allowing for additional bone fasteners to be inserted into the vertebrae before placement of the system **550** onto a patient's spine. In other alternative embodiments, the openings **562**, **566** could also be oriented vertically or in any other direction. Multiple openings or tracks **562**, **566** in each attachment portion **552**, **554** may also be included in alternative embodiments.

The reliefs **564**, **568** allow the first attachment portion **552** and second attachment portion **554** to be placed over the bone fastener heads, such as screw heads, that are already fixed to a vertebral body. The bone fasteners could also be pins, wires, nails, or any other method for fixing system **550** to a bone. The first and second openings **562**, **566** are smaller than the geometry of the head of the bone fastener and the reliefs **564**, **568**. Thus, the geometry of the first and second openings **562**, **566**, respectively, allows the first and second attachment portions **552**, **554** to be captured between the bone fastener heads and the underlying vertebra when the system **550** is slid into position between the head of the bone fasteners and the vertebra. Once the system **550** is in a desired position the surgeon may insert additional bone fasteners to secure the system **550** to the patient's spine

The intermediate portion **556** may be comprised of an elastic mechanism that includes a plurality of straight portions **570** and a plurality of curved portions **572**. The straight portions **570** and the curved portions **572** of the elastic mechanism provide open areas to allow for easy spine visualization through the system **550**. The elastic mechanism of the intermediate portion **556** may be curvilinear in shape and allow for elastic deformation in any direction when loaded. The deformation of the elastic mechanism or spring-like element is primarily in the axial direction allowing for flexion and extension. The system **550** is designed to be flexible in the superior/inferior direction and more rigid in lateral bending and torsion. Further, the system **550** may be shaped to match the curvature of the spine in the sagittal and transverse planes. As best seen in FIG. **3**, the system **550** is curved in the transverse plane to correspond to the shape of the vertebrae. A cross-sectional view of system **550** taken along line **4-4** is shown in FIG. **4** and a side view of the system **550** from FIG. **4** is shown in FIG. **5**. The system **550** may also be curved in the sagittal plane to correspond to the shape of the spine. The intermediate portion **556** may be made of a non-uniform geometric shape and have a uniform or non-uniform cross-sectional geometry.

Referring now to FIG. **6**, another embodiment dynamic spinal fixation system or plate **100** is shown. The system **100** includes a first attachment portion **102**, a second attachment portion **104**, and an intermediate portion **106** connecting the first attachment portion **102** and the second attachment portion **104**. The first attachment portion or platform **102** is at a superior end **108** of the system **100** and the second attachment portion or platform **104** is at an inferior end **110**. The first attachment portion **102** and second attachment portion **104** may be rigid sections for affixing the system **100** to the vertebrae. The intermediate portion **106** may be comprised of an elastic mechanism that has a less rigid elastic member with spring-like section for fostering controlled deformation.

The first attachment portion **102** includes a first opening **112** and the second attachment portion **104** includes a second opening **114**. The openings **112** and **114** may be used to secure the system **100** to at least two adjacent vertebrae using bone fasteners. The uniform openings **112** and **114** allow for bone fastener placement anywhere along the openings **112** and **114**. Alternatively, the first and second attachment portions **102** and **104** may include solid sections with at least one aperture through the attachment portions **102** and **104** to allow for placement of bone fasteners through the attachment portions **102** and **104** at pre-designated locations.

The intermediate portion **106** may be comprised of an elastic mechanism that includes a plurality of straight portions **116** and a plurality of curved portions **118**. The straight portions **116** and the curved portions **118** of the elastic mechanism provide open areas to allow for easy spine visualization through the system **100**. The elastic mechanism of the intermediate portion **106** may be curvilinear in shape and allow for elastic deformation in any direction when loaded. The deformation of the elastic mechanism or spring-like element is primarily in the axial direction allowing for flexion and extension. The system **100** is designed to be flexible in the superior/inferior direction and more rigid in lateral bending and torsion. Further, the system **100** may be shaped to match the curvature of the spine in the sagittal and transverse planes.

As seen in FIGS. **7** and **8**, the dynamic spinal fixation system or plate **120** includes a first attachment portion **102**, a second attachment portion **104**, an intermediate portion **106**, and at least one support strut **122**. The first attachment portion **102** and second attachment portion **104** are of the type described above with reference to FIG. **6**. The support struts **122** may be lateral to the midline to enhance the rigidity of the elastic mechanism, in particular in bending and torsion, while still allowing the system **120** to deform elastically. In alternative embodiments the support struts **122** may be along the midline of the system **120**. The support struts **122** provide at least one additional support between the straight portions **116** of the intermediate portion **106** and may be generally parallel to the curved portions **118**. In alternative embodiments, the struts **122** may have a radius of curvature smaller than the radius of curvature of the curved portions **118**. The support struts **122** also create an opening **124** between the curved portions **118** and the support struts **122**. In the depicted embodiment there are four support struts **122**. Additional support struts may also be added generally in parallel with the support struts **122** to provide additional rigidity to the intermediate portion **106**.

Another dynamic spinal fixation system **140** or plate is shown in FIG. **9**. The system **140** includes first attachment portion **102**, second attachment portion **104**, and intermediate portion **142**. The first attachment portion **102** and second attachment portion **104** are of the type described above with reference to FIGS. **6-8**. The intermediate portion **142** may include two or more separate portions. In the depicted embodiment of system **140** the intermediate portion **142** includes a first intermediate side **144** parallel to a second intermediate side **146**. The first intermediate side **144** is a mirror image of the second intermediate side **146**. The intermediate portion **142** connects the first attachment portion **102** and the second attachment portion **104**. The first intermediate side **144** mates with the inferior side of the first attachment portion **102** on a first lateral end **148** and with the superior side of the second attachment portion **104** on a first lateral end **152**. The second intermediate side **146** mates with the inferior side of the first attachment portion **102** on a second lateral end **150** and with the superior side of the second attachment portion **104** on a second lateral end **154**. The intermediate portion **142** is less rigid than the first and second attachment portions **102**, **104** to allow for controlled elastic deformation. The spring-like elastic first intermediate side **144** and second intermediate side **146** enhance the rigidity of the two or more sides **144**, **164**, in particular in bending and torsion, while still allowing the system to deform elastically.

Referring now to FIG. **10**, a dynamic spinal fixation system **160** is shown. The dynamic spinal fixation system **160** includes first attachment portion **102**, second attachment portion **104**, and intermediate portion **162**. The first attachment portion **102** and second attachment portion **104** are of the type described above with reference to FIG. **8**. The intermediate portion **162** may include two or more separate sides. In the depicted embodiment of system **160**, the intermediate portion **162** includes a first intermediate side **164** parallel to a second intermediate side **166**. The first intermediate side **164** is a mirror image of the second intermediate side **166**. The intermediate portion **162** connects the first attachment side **102** and the second attachment side **104**. The first intermediate side **164** mates with an inferior side of the first attachment side **102** at a first medial position **168** and with the superior side of the second attachment portion **104** at a first medial position **172**. The second intermediate side **166** mates with the inferior side of the first attachment portion **102** at a second medial position **170** and with the superior side of the second attachment portion **104** at a second medial position **174**. The intermediate portion **162** is less rigid than the first and second attachment portions **102**, **104** to allow for controlled elastic deformation. The system **160** allows for elastic motion primarily in the axial (flexion/extension) direction while the amount of motion in lateral bending and torsion is dictated by the configuration of the spring-like elements.

Referring now to FIG. **11**, an alternative embodiment of a dynamic spinal fixation system or plate **50** is shown. The system **50** includes a member **52** with a superior end **60** and an inferior end **62**. A first attachment portion **54** is at the superior end **60** of the member **52** and a second attachment portion **56** is at the inferior end **62** of the member **52**. An intermediate portion **58** connects the first attachment portion **54** and the second attachment portion **56**. The first attachment portion **54** and second attachment portion **56** or platform sections may have a generally closed geometry such as a circle, ellipse, square, rectangle, or other closed geometry to facilitate placement of bone fasteners, such as bone screws, nails, staples, wires, pins, and the like. The first attachment portion **54** includes a first opening **64** and the second attachment portion **56** includes a second opening **66**. The openings **64** and **66** may be used to secure the system **50** to at least two adjacent vertebrae using bone fasteners. The openings **64** and **66** allow for bone fastener placement anywhere along the openings **64** and **66** because there are no pre-designated locations for the bone fasteners. Alternatively, the first and second attachment portions **54** and **56** may include solid sections with at least one aperture through the attachment portions **54** and **56** to allow for placement of bone fasteners through the attachment portions **54** and **56** at pre-designated locations. The intermediate portion **58** includes at least one closed member **68**. The closed member **68** may be elastic. In the depicted embodiment there are four closed members **68**. In the preferred embodiments the closed members **68** may range from one to ten. The closed elastic members **68** may have an elliptical, circular, rectangular, square, or any other closed shape. The closed elastic members **68** may also be made of a non-uniform geometric shape and have a uniform or non-uniform cross-sectional geometry. The member **52** may be curved in the transverse plane to correspond to the shape of the vertebrae. The member **52** may also be curved in the sagittal plane to correspond to the shape of the spine.

Another dynamic spinal fixation system **180** is depicted in FIGS. **12** and **13**. The dynamic spinal fixation system **180** includes first attachment portion **102**, second attachment portion **104**, and an intermediate portion **182**. The intermediate portion **182** includes a first intermediate side **184** and a second intermediate side **186**. The first attachment portion **102**, second attachment portion **104**, and the first intermediate side **184** are of the type described above with reference to FIG. **6**. The second intermediate side **186** is a mirror image of the first intermediate side **184**. The first intermediate side **184** includes a first plurality of curved portions **188** and a first plurality of straight portions **190**. The second intermediate side **186** includes a second plurality of curved portions **192** and a second plurality of straight portions **194**. The first intermediate side **184** is connected to the first attachment portion **102** and the second attachment portion **104** on the anterior aspect and the second intermediate side **186** is connected to the first attachment portion **102** and the second attachment portion **104** on the posterior aspect. The first intermediate side **184** overlaps with the second intermediate side **186**. The first plurality of straight portions **190** and the second plurality of straight portions **194** are aligned while the first plurality of curved portions **188** and the second plurality of curved portions **192** are opposite each other. In alternative embodiments, the plurality of curved portions could be aligned and the plurality of straight portions could be offset. The intermediate portion **182** enhances rigidity by adding a second intermediate side **186** to the first intermediate side **184**. However, even with the enhanced rigidity of the intermediate portion **182**, the system **180** is able to deform elastically. Additional intermediate portions could also be added to further enhance rigidity of the system **180** while still allowing the system **180** to deform elastically. The first intermediate side **184** and the second intermediate side **186** may have uniform or non-uniform cross-sectional geometry.

Referring now to FIG. **14**, another embodiment dynamic spinal fixation system **200** is shown. The system **200** is of the type described above with reference to FIG. **6** including a first attachment portion **102**, a second attachment portion **104**, and an intermediate portion **106**. The system **200** further includes at least one hard stop **202** attached to the intermediate portion **106**. In the depicted embodiment there are four hard stops **202** and the hard stops **202** comprise arced members positioned between two adjacent straight portions **116**. The hard stops **202** may also be placed between two adjacent curved portions **118**. The hard stops **202** limit the amount of deformation of the intermediate portion **106** when the system **200** is in compression. When the system **200** experiences compressive loading or bending, the intermediate member **106** deforms until the hard stops **202** are engaged on the adjacent straight portions **116**. When the hard stops **202** contact the straight portions **116** deformation is limited.

Depicted in FIG. **15**, is another dynamic spinal fixation system **220** including first attachment portion **102**, second attachment portion **104**, and intermediate portion **106** as described above with reference to FIG. **6**, and further comprising at least one alternative hard stop **222**. The hard stop **222** is attached to the intermediate portion **106** and has a generally domed shape. In the depicted embodiment, there are four hard stops **222** located between two adjacent straight portions **116**. Although not shown, it is also contemplated that the hard stops **222** may be placed between two curved portions **118**. The hard stops **222** also limit the amount of deformation in the intermediate portion **106** during compression of the system **220**. During compression of the system **220**, the intermediate portion **106** is squeezed together until at least one straight portion **116** makes contact with an adjacent a hard stop **222**.

FIG. **16** illustrates another embodiment dynamic spinal fixation system **240** including first attachment portion **102**, second attachment portion **104**, and intermediate portion **106** as described above with reference to FIG. **6**, and further comprising at least one alternative hard stop **242**. The hard stops **242** are redundant hard stops. In the depicted embodiment, there are four hard stops **242**. The hard stop **242** includes a first member **244** and a second member **246**. The first member **244** is arced from a first end **248** to a second end **250**. The second member **246** is also arced from a first end **252** to a second end **254**. The first end **248** of the first member **244** and the first end **252** of the second member **246** are attached to adjacent straight portions **116**. While the second end **250** of the first member **244** and the second end **254** of the second member **246** are arced towards each other in order for second end **250** to overlap with second end **254**.

Under compressive loading, tensile loading, or bending the intermediate portion **106** deforms until the hard stops **242** are engaged on the mating features, which include the first member **244**, the second member **246**, and the second ends **250**, **254** of the first member **244** and second member **246**, respectively. The amount of deformation of the intermediate portion **106** is limited in compression when the first members **244** and second members **246** of the hard stops **242** contact an adjacent straight portion **116**. In addition the amount of deformation of the intermediate portion **106** is also limited in tension when the second end **250** of the first member **244** and the second end **254** of the second member **246** engage each other.

The intermediate members **58**, **106**,**142**, **162**, **182**, and **556**, of FIGS. **2-16** may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes.

Referring now to FIG. **17**, yet another embodiment dynamic spinal fixation system **260** is shown. The system **260** including first attachment portion **102** and second attachment portion **104** as described above with reference to FIG. **6**, and further includes an intermediate portion **262**. The intermediate portion **262** connects the first attachment portion **102** and the second attachment portion **104** and includes at least one curve **264**. In the depicted embodiment the at least one curve **264** arcs in a generally medial direction relative to the system **260**.

Another embodiment dynamic spinal fixation system **280** is illustrated in FIG. **18**. The system **280** including first attachment portion **102** and second attachment portion **104** as described above with reference to FIG. **6**, and further includes an intermediate portion **282**. The intermediate portion **282** connects the first attachment portion **102** and the second attachment portion **104**. The intermediate portion **282** is a more complex portion and includes multiple curved sections **284** and multiple straight sections **286**. In the depicted embodiment the intermediate portion **282** is narrower in width than the first and second attachment portions **102**, **104** and is located in a generally medial position.

Depicted in FIG. **19** is still another embodiment dynamic spinal fixation system **300**. The system **300** including first attachment portion **102** and second attachment portion **104** as described above with reference to FIG. **6**, and further includes an intermediate portion **302**. The intermediate portion **302** connects the first attachment portion **102** and the second attachment portion **104**. The intermediate portion **302** includes at least one wide curve **304** per level. In the depicted embodiment the intermediate portion **302** includes two wide curves **304**.

Referring now to FIG. **20** another dynamic spinal fixation system **320** is shown. The system **320** includes first attachment portion **102** and second attachment portion **104** as described above with reference to FIG. **6**, and further includes an intermediate portion **322**. The intermediate portion **322** connects the first attachment portion **102** and the second attachment portion **104**. The intermediate portion **322** includes a solid or closed elastic member or element **324**. The solid member **324** may be of any shape that deforms elastically when loaded.

The intermediate portions **262**, **282**, **302**, and **322** of FIGS. **17-20** may be made of a metal, polymer, ceramic, or composite material. Further the intermediate portions **262**, **282**, **302**, and **322** of FIGS. **17-20**, may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes.

The dynamic spinal fixation systems of FIGS. **2-20** each illustrate a one level system. Each of the systems of FIGS. **2-20** can be modified to include additional attachment portions and either additional or elongated intermediate portions for engaging more than two adjacent vertebrae. For example and as seen in FIGS. **21-24**, the dynamic spinal fixation system **340** is a two level system for the spine. The system **340** includes a first attachment portion **102** and a second attachment portion **104** as described above with reference to FIG. **8**, and further includes an intermediate portion **342**. The intermediate portion **342** includes a first intermediate member **344**, a third attachment portion **346**, and a second intermediate member **348**. The first intermediate member **344** and second intermediate member **348** may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes. The third attachment portion **346** may be rigid for affixing the system **340** to a vertebra. The third attachment portion **346** includes a third opening **350** which may be used to secure the system **340** to a vertebra using at least one bone fastener. The third opening **350** is uniform and therefore allows for placement of bone fasteners at any point along the third opening **350**. The first, second, and third openings **112**, **114**, and **350**, respectively, may include a ridge or lip for the bone fasteners to mate with when inserted into the patient's vertebrae to maintain a low profile of the first, second, and third attachment portions **102**, **104**, and **346**, respectively. The low profile will prevent the bone fasteners from protruding above the first, second, and third attachment portions **102**, **104**, and **346**, respectively, and agitating the patient's tissue. Alternatively, the attachment portions **102**, **104**, and **346** may include solid sections with at least one aperture through the platform to allow for placement of bone fasteners through the attachment portions **102**, **104**, and **346** at pre-designated locations.

Referring now to FIG. **21**, the first intermediate member **344** and the second intermediate member **348** are of the type illustrated in FIG. **6** and described with reference to intermediate portion **106**. The first intermediate member **344** and the second intermediate member **348** may each be comprised of a single elastic component including a plurality of straight portions **352** and a plurality of curved portions **354**. The straight portions **352** and the curved portions **354** provide open areas that allow for easy visualization through the system **340** to a patient's spine. The first intermediate member **344** and the second intermediate member **348** may be curvilinear in shape and allow for elastic deformation in any direction when loaded. Further, the system **340** may be shaped to match the curvature of the spine in the sagittal and transverse planes.

Referring now to FIG. **22**, the dynamic spinal fixation system **340** includes an alternative first intermediate member **344** and second intermediate member **348** of the types illustrated in FIG. **7** and described above with reference to intermediate portion **106** including at least one support strut **122**. The first intermediate member **344** and the second intermediate member **348** may each be comprised of a single elastic component including a plurality of straight portions **352** and a plurality of curved portions **354**. The support struts **122** may be lateral to the midline of the system **340** enhance the rigidity of the first intermediate member **344** and the second intermediate member **348**, in particular in bending and torsion, while still allowing elastic deformation. The support struts **122** provide at least one additional rod between the straight portions **352** of the first intermediate member **344** and the second intermediate member **348** and are generally parallel to the curved portions **354**. Alternatively, the struts **122** may have a radius of curvature smaller than the radius of curvature of the curved portions **118**. The support struts **122** also create an opening **124** between the curved portions **354** and the support struts **122**. In the depicted embodiment there are four support struts **122** for each of the first intermediate member **344** and the second intermediate member **348**.

Referring now to FIG. **23**, the dynamic spinal fixation system **340** includes yet another alternative first intermediate member **344** and the second intermediate member **348**. The first intermediate member **344** and second intermediate member **348** are of the type illustrated in FIG. **9** and described with reference to intermediate portion **142**. The first intermediate member **344** and second intermediate member **348** each include a first portion **144** parallel to a second portion **146**. The first portion **144** is a mirror image of the second portion **146**. The first intermediate member **344** connects the first attachment portion **102** and the third attachment portion **346**. The first portion **144** mates with the inferior side of the first attachment portion **102** on a first lateral end **148** and with the superior side of the third attachment portion **346** on a first lateral end **360**. The second portion **146** mates with the inferior side of the first attachment portion **102** on a second lateral end **150** and with the superior side of the third attachment portion **346** on a second lateral end **362**. The second intermediate member **348** connects the third attachment portion **346** and the second attachment portion **104**. The first portion **144** mates with the inferior side of the third attachment portion **346** on a first lateral end **364** and with the superior side of the second attachment portion **104** on a first lateral end **152**. The second portion **146** mates with the inferior side of the third attachment portion **346** on a second lateral end **366** and with the superior side of the second attachment portion **104** on a second lateral end **154**.

The intermediate portions **344** and **348** are less rigid than the first, second, and third attachment portions **102**, **104**, **346**, respectively, to allow for controlled elastic deformation. The spring-like elastic first portions **144** and second portions **146** enhance the rigidity of the two or more intermediate portions **344** and **348**, in particular in bending and torsion, while still allowing the intermediate portion to deform elastically.

Referring now to FIG. **24**, the dynamic spinal fixation system **340** includes a first intermediate member **344** that is different than the second intermediate member **348**. In the depicted embodiment the first intermediate member **344** is of the type illustrated in FIG. **6** and described with reference to intermediate portion **106** and the second intermediate member **348** is of the type illustrated in FIG. **7** and described with reference to intermediate portion **106** and including at least one support strut **122**. The hybrid two level construct of intermediate portion **342** includes a first intermediate member **344** that is a more elastic member and a second intermediate member **348** that is a more rigid member. Alternative multi-level dynamic spinal fixation systems may include various combinations of the intermediate portions of FIGS. **2-20**. Each of the intermediate portions of FIGS. **2-20** may have different medial and lateral stiffness. For example, the medial stiffness may be higher than the lateral stiffness alternatively the medial stiffness may be lower than the lateral stiffness. These hybrid multi-level systems may be used to augment the stiffness of spinal levels adjacent to a single (central) level anterior cervical discectomy and fusion ("ACDF").

Although only single and double level dynamic spinal fixation systems have been shown and described, additional levels may be added to the systems as needed to stabilize a patient spine, creating systems with three levels or more. In addition, the multi-level systems may include more than three alternating attachment portions and intermediate portions for longer ACDFs.

Illustrated in FIG. **25** is another embodiment dynamic spinal fixation system **380** of the type described above with reference to FIG. **6** and further including an interbody fusion cage device **382**. The system **380** includes a first attachment portion **102**, a second attachment portion **104**, and an intermediate portion **106** of the type described above with reference to FIG. **6**. The device **382** includes a hollow member **384** with a cavity **386**. A bone graft may be inserted into the cavity **386** to allow for fusion to occur between two adjacent vertebrae. The interbody fusion cage device **382** is integrated into the dynamic spinal fixation system **380**. The device **382** and system **380** may be pre-assembled prior to surgery or may be assembled during surgery. During surgery, the device **382** is placed into the disc space of the spine. Then the system **380** is aligned with a first vertebra **388** and a second vertebra **390** and may be affixed to the vertebrae using bone fasteners as described above with reference to FIG. **6**. The dynamic spinal fixation systems of FIGS. **2-25** may be comprised of a metallic material, or alternatively of an elastic, hyperelastic, or deformable polymer, ceramic, or composite material.

An alternative dynamic spinal fixation system **400** is depicted in FIG. **26**. The system **400** includes a first attachment portion **402**, a second attachment portion **404**, a third attachment portion **406**, a first intermediate portion **408**, and a second intermediate portion **410**. The first intermediate portion **408** connects the first attachment portion **402** and the second attachment portion **404**. The second intermediate portion **410** connects the second attachment portion **404** and the third attachment portion **406**. The first attachment portion **402**, second attachment portion **404**, and third attachment portion **406** each include two bone fastener openings **412** for using to secure the system **400** to a patient's vertebrae. The first intermediate portion **408** includes a first elastic element **414**, which may be a continuous curved torsional spring-like element, and four arms **416** connecting the first elastic element **414** and the fastener openings **412** of the first and second attachment portions **402** and **404**, respectively. The second intermediate portion **410** includes a second elastic element **418**, which may also be a continuous curved torsional spring-like element, and four arms **420** connecting the second elastic element **418** and the fastener openings **412** of the second and third attachment portions **404** and **406**, respectively. The first intermediate portion **408** and second intermediate portion **410** may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes.

The system **400** may be attached to a patient's spine by securing fastener openings **412** of the first attachment portion **402** to a first vertebra **422**, fastener openings **412** of the second attachment portion **404** to a second vertebra **424**, and fastener openings **412** of the third attachment portion **406** to a third vertebra **426**. When loaded the system **400** deforms elastically by rotation around the torsion spring elements or the first intermediate portion **408** and second intermediate portion **410**. The system **400** can be pre-compressed or pre-extended prior to attachment to a patient's first, second, and third vertebrae **422**, **424**, and **426**, respectively, to facilitate distraction or compression, respectively.

Referring now to FIGS. **27-31**, another embodiment dynamic spinal fixation system **450** is illustrated. The system **450** includes a first attachment portion **452**, a second attachment portion **454**, a third attachment portion **456**, a first intermediate portion **458**, and a second intermediate portion **460**. The first attachment portion **452**, second attachment portion **454**, and third attachment portion **456** are more rigid for affixing the system **450** to a patient's vertebrae. The first attachment portion **452**, second attachment portion **454**, and third attachment portion **456** include a first opening **462**, a second opening **464**, and a third opening **466**, respectively. The first opening **462** may be used to secure the system **100** to a first vertebra **468** using bone fasteners. The second opening **464** may be used to secure the system **100** to a first vertebra **470** using bone fasteners. The third opening **466** may be used to secure the system **100** to a first vertebra **472** using bone fasteners.

The first intermediate portion **458** and a second intermediate portion **460**, or spring-like elastic sections, are less rigid than the attachment portions **452**, **454**, **456** for fostering controlled elastic deformation. The first intermediate portion **458** connects the first attachment portion **452** and second attachment portion **454**. The second intermediate portion **460** connects the second attachment portion **454** and third attachment portion **456**. As best seen in FIG. **27**, the first intermediate portion **458** and second intermediate portion **460** may each include a single elastic element **474** with a plurality of coils. Alternatively and as depicted in FIG. **28**, the first intermediate portion **458** and second intermediate portion **460** may each include a first elastic element **476** with a plurality of coils and a second elastic element **478** with a plurality of coils. The first elastic element **476** is parallel with the second elastic element **478** and both are comprised of elastic, metallic, spring-like components with uniform or non-uniform cross-sectional geometry. Additional parallel elastic elements could also be added to the intermediate portions **458**, **460**. The system **450** illustrated in FIG. **28** may also be monolithic and comprised of only a single component.

FIG. **29** depicts another embodiment of first intermediate portion **458** and second intermediate portion **460**, wherein the first and second intermediate portions **458** and **460** respectively, each include a first elastic element **480** with a single coil and a second elastic element **482** with a single coil. The first elastic element **480** is parallel to the second elastic element **482**. The first element **480** and second element **482** may be elastic torsional spring-like elements. Additional parallel elastic elements may be added in parallel to first and second elastic elements **480**, **482**.

Illustrated in FIG. **30** is another embodiment of first intermediate portion **458** and second intermediate portion **460**. The first intermediate portion **458** includes a first elastic element **484** parallel to a second elastic element **486**. The first element **484** and second element **486** are elastic leaf spring-like elements.

Referring now to FIG. **31**, yet another embodiment of first intermediate portion **458** and second intermediate portion **460** is shown. The first intermediate portion **458** and second intermediate portion **460** include at least one piston element **490** in series with an elastic element **492**. The elastic element **492** being in series with the piston element **490** offers resistance to deformation. When the system **450** deforms under a load it is guided by the piston element **490** which is rigid in all directions other than vertical. The system **450** may also be compressed or extended prior to being secured to a patient's spine to allow for pre-distraction or pre-loading of the patient's spine.

The system **450** in FIGS. **27-31** can be pre-compressed or pre-extended prior to attachment to a patient's first, second, and third vertebrae **468**, **470**, and **472**, respectively, to facilitate distraction or compression, respectively. In addition, each configuration of the intermediate portions of system **450** allows for elastic motion primarily in the axial (flexion/extension) direction while the amount of motion in lateral bending and torsion is dictated by the configuration of the intermediate portions of the systems **450**. Further, additional elastic elements may be added in parallel to the intermediate portions of the systems **450** in FIGS. **28-30** to enhance the rigidity of the system **450**, in particular in bending and torsion, while still allowing the system **450** to deform elastically. The intermediate portions **458**, **460** of FIGS. **27-31** can have different geometries including but not limited to simple and slightly curved or complex and multiply curved, with narrow curves or wide curves, with one, two or more curves per level. The intermediate portions **458**, **460** can also be solid or closed geometries that are elastically deformable such as metals, polymers, or composites. The first intermediate portion **458** and second intermediate portion **460** of FIGS. **27-31** may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes.

In addition, as each of the dynamic spinal fixation systems of FIGS. **26-31** have been described with reference to three sections for engaging three adjacent vertebrae and two intermediate deformable portions or compliant sections for a two-level anterior cervical discectomy and fusion ("ACDF"), it should be understood that each of the systems in FIGS. **26-31** can be modified for a single-level ACDF. A single-level ACDF would only include two sections for engaging two adjacent vertebrae and one intermediate portion or elastic section. Similarly, it should also be understood that each of the systems in FIGS. **26-31** can be modified to include more than three alternating attachment sections and intermediate sections for longer ACDF's, which may be more than two-levels.

FIGS. **32-36** show spinal fixation systems that allow the bone fasteners, for example, screws, to be secured to the vertebrae before the systems are placed onto the spine. The systems generally contain at least two attachment portions or rigid platform-like sections which are used to secure the systems to a patient's vertebrae. The attachment portions are generally more rigid than the rest of the system to facilitate bone fastener fixation to the bony vertebral bodies by allowing bone fasteners, such as screws, nails, staples, wires, pins, and the like, to pass through the systems at the attachment portion or portions.

FIGS. **32** and **33** illustrate a monolithic implant **500** and a multi-component implant **510**, respectively. The implant **500** is a static spinal fixation implant and the implant **510** is a dynamic implant. The implants **500**, **510** each include a first attachment portion **520** including an opening **522** with a relief **524**, a second attachment portion **526** including an opening **528** with a relief **530**, and an intermediate portion **518**. The first and second attachment portions **520**, **526** allow for a surgeon to insert the bone fasteners into the vertebrae first, thereby, providing a complete view of the patient's spine. Then the surgeon may insert the implants **500**, **510** by placing them over the bone fasteners at the reliefs **524**, **530** and sliding the bone fasteners into position within the openings **522**, **528**. Once the bone fasteners are in place along the openings **522**, **528**, additional bone fasteners may be inserted to secure the implants **500**, **510** to the vertebrae. The intermediate portions **518** may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes. Referring now to FIG. **33**, the multi-component implant **510** allows for some adjustment in length of the intermediate portion **518** along the long axis of the implant **510**.

Referring now to FIGS. **34** and **35**, another dynamic spinal fixation system or plate **550** embodiment is shown. The system **550** includes a first attachment portion **552**, a second attachment portion **554**, and an intermediate portion **556** that connects the first attachment portion **552** and second attachment portion **554**. The intermediate portion **556** may be of the type described above with reference to FIG. **2** and include an elastic mechanism composed of a plurality of straight portions **570** and a plurality of curved portions **572**. The first attachment portion **552** is at a superior end **558** of the system **550** and the second attachment portion **554** is at an inferior end **560**. The first attachment portion **552** includes a first opening or slot **562** which is oriented in a transverse direction and further includes a relief **564** or a larger aperture creating a "key hole" slot. Likewise, second attachment portion **554** includes a second opening or slot **566** which is oriented in a transverse direction and further includes a relief **568** or larger aperture creating a "key hole" slot. The reliefs **564**, **568** are centered in the first and second openings **562**, **566**, respectively. In alternative embodiments, the openings **562**, **566** could also include additional reliefs allowing for additional bone fasteners to be inserted into the vertebrae before placement of the system **550** onto a patient's spine. In other alternative embodiments, the openings **562**, **566** could also be oriented vertically or in any other direction. Multiple openings or tracks **562**, **566** in each attachment portion **552**, **554** may also be included in alternative embodiments.

The reliefs **564**, **568** allow the first attachment portion **552** and second attachment portion **554** to be placed over the bone fastener heads, such as screw heads, that are already fixed to a vertebral body. The bone fasteners could also be pins, wires, nails, or any other method for fixing system **550** to a bone. The first and second openings **562**, **566** are smaller than the geometry of the head of the bone fastener and the reliefs **564**, **568**. Thus, the geometry of the first and second openings **562**, **566**, respectively, allows the first and second attachment portions **552**, **554** to be captured between the bone fastener heads and the underlying vertebra when the system **550** is slid into position between the head of the bone fasteners and the vertebra. Once the system **550** is in a desired position the surgeon may insert additional bone fasteners to secure the system **550** to the patient's spine.

An alternative embodiment dynamic spinal fixation system **600** is depicted in FIGS. **36** and **37**. The system **600** includes a first attachment portion **602**, a second attachment portion **604**, and an intermediate portion **606** that connects the first attachment portion **602** and second attachment portion **604**. The intermediate portion **606** may be of the type described above with reference to FIG. **2** and include a single elastic mechanism that includes a plurality of straight portions **620** and a plurality of curved portions **622**. The first attachment portion **602** is at a superior end **608** of the system **600** and the second attachment portion **604** is at an inferior end **610**. The first attachment portion **602** includes a first opening or slot **612** which is curved and further includes a relief or a single larger aperture **614**. Likewise, second attachment portion **604** includes a second opening or slot **616** which is curved and further includes a relief or single larger aperture **618**. The openings **612**, **616** could also include additional reliefs allowing for additional bone fasteners to be inserted into the vertebrae before placement of the system **600** onto a patient's spine. The openings **612**, **616** of system **600** are concave slots that may be used to compress the intermediate portion **606** as the system **600** is slid transversely under the already-placed one or more screws or fasteners. Alternatively, the concave slots of openings **612**, **616** may be used to distract the intermediate portion **606** or to maintain the same distance between the vertebrae based on the position the fasteners are inserted into the vertebrae. The slots **624** could also be convex allowing the motion segment to be distracted. The system **600** may be inserted onto the spine as described above with reference to FIGS. **34** and **35**, however rather than sliding the system into position, the surgeon would rotate the system **600** into position between the head of the bone fasteners and the vertebra.

The dynamic spinal fixation systems of FIGS. **38-39** depict embodiments similar to those described above with reference to FIGS. **34-35**, but wherein the systems include alternative relief positions. The reliefs may be located superiorly or inferiorly to the openings of the attachment portions to facilitate compression or distraction of the dynamic spinal fixation systems.

Referring now to FIG. **38**, the dynamic spinal fixation system **650** includes first attachment portion **652**, second attachment portion **654**, and intermediate portion **556** which connects first attachment portion **652** and second attachment portion **654**. The first attachment portion **652** is at a superior end **656** of the system **650** and the second attachment portion **654** is at an inferior end **658**. The first attachment portion **652** includes a first opening **660** which is oriented in a transverse direction and further includes a relief **662** positioned superior to a midline of the first opening **660**. The second attachment portion **654** includes a second opening **664** which is oriented in a transverse direction and further includes a relief **666** positioned inferior to a midline of the second opening **664**. The relief **660** is connected to the first opening **660** and the relief **666** is connected to the second opening **664**.

Referring now to FIG. **39**, the dynamic spinal fixation system **670** includes first attachment portion **672**, second attachment portion **674**, and intermediate portion **676** which connects first attachment portion **672** and second attachment portion **674**. The first attachment portion **672** is at a superior end **678** of the system **670** and the second attachment portion **674** is at an inferior end **680**. The first attachment portion **672** includes a first opening **682** which is oriented in a transverse direction and further includes a relief **684** positioned inferior to a midline of the first opening **682**. The second attachment portion **674** includes a second opening **686** which is oriented in a transverse direction and further includes a relief **688** positioned superior to a midline of the second opening **686**. The relief **684** is connected to the first opening **682** and the relief **688** is connected to the second opening **686**.

In the embodiments depicted in FIGS. **34-45**, at least one of the attachment portions contains at least one relief allowing a bone fastener head to pass through the dynamic spinal fixation systems. Alternatively, more than one attachment portion may have a relief allowing a bone fastener to pass through the dynamic spinal fixation systems. Further, all the attachment portions could have reliefs allowing bone fasteners to pass through the dynamic spinal fixation systems. The intermediate portions of FIGS. **34-45** may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes. Although the systems illustrated in FIGS. **34-45** only show one level systems, multiple level systems are also contemplated and these multiple level systems include at least one attachment portion with a relief. In addition, the length of each system shown in FIGS. **34-45** may be adjustable to accommodate the spacing between the already-placed bone fasteners. The systems may also be compressed or extended to allow the already-placed bone fasteners to pass through the reliefs in the attachment portions.

Referring now to FIG. **40**, a dynamic spinal fixation system **700** is shown. The system **700** includes a first attachment portion **702**, second attachment portion **704**, and intermediate portion **706** which connects first attachment portion **702** and second attachment portion **704**. The first attachment portion **702** and second attachment portion **704** are of the type described above with reference to first attachment portion **702** and second attachment portion **704** of FIGS. **34-35**. The intermediate portion **706** or spring-like elastic section has a non-uniform cross-sectional geometry which facilitates the desired stiffnesses in different bending directions. For example, the thickened lateral cross-sectional geometry **708** selectively increases torsional stiffness without significantly increasing flexion/extension stiffness.

As best seen in FIGS. **41-43**, another dynamic spinal fixation system **720** is shown. The system **720** includes a first attachment portion **722**, second attachment portion **724**, and intermediate portion **726** which connects first attachment portion **722** and second attachment portion **724**. The first attachment portion **722** includes a first opening **728** that is oriented in a transverse direction and further includes a relief **732**. The second attachment portion **724** includes a second opening **730** that is oriented in a transverse direction and further includes a relief **734**. The reliefs **732**, **734** are centered in the first and second openings **728**, **730**, respectively. The intermediate portion **726** includes at least one elastic mechanism with a plurality of straight portions **736** and a plurality of curved portions **738** and at least one support strut **740**. The support struts **740** may be lateral to the midline and at different distances from the midline based on the desired rigidity of the intermediate portion **726**. The support struts **740** are generally parallel to the curved portions **738** and are located between the straight portions **736**. In the depicted embodiment there are four support struts **740**.

Referring now to FIG. **41**, an opening **742** is created between the curved portions **738** and the support struts **740**. In FIG. **42**, an opening **744** is created between the curved portions **738** and the support struts **740**. The opening **744** is larger than the opening **742** because the support struts **740** are closer to the midline in FIG. **42** than in FIG. **41**. Referring now to FIG. **43**, an opening **746** is created between the curved portions **738** and the support struts **740**. Opening **746** is larger than openings **742** and **744** because the support struts **740** are closer to the midline in FIG. **43** than in either FIG. **41** or **42**. The support struts **740** may provide various levels of rigidity by reinforcing the intermediate portion **726**. The amount of rigidity which intermediate portion **726** has will be based on the distance the support strut **740** is from the midline or the size of the openings **742**, **744**, and **746**. For example, the system **720** of FIG. **43** will be more rigid than the system of FIG. **42** and both will be more rigid than the system of FIG. **41** because strut **740** in FIG. **43** is closest to the midline creating the largest opening **746** and strut **740** in FIG. **41** is farthest from the midline creating the smallest opening **742**. The rigidity may be enhanced as the support struts **740** are moved closer to the midline, in particular in bending and torsion, while still allowing the system **720** to deform elastically.

FIGS. **44** and **45** illustrate another embodiment of a dynamic spinal fixation system **690**. The system **690** includes a first attachment portion **602**, a second attachment portion **604**, and an intermediate portion **106**. The first attachment portion **602** and second attachment portion **604** are of the type described above with reference to FIGS. **36** and **37**. The intermediate portion **106** is of the type described above with reference to FIG. **7** wherein the intermediate portion **106** includes at least one support strut **122**.

Referring now to FIGS. **46-48**, another embodiment of a dynamic spinal fixation system **750** is shown with a method of inserting the system **750** onto two vertebrae. The system **750** includes a first open attachment portion or platform section **752**, a second open attachment portion or platform section **754**, and an intermediate portion **756**. The intermediate portion **756** may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes. The first open attachment portion **752** and second open attachment portion **754** are open on at least one side. The first open attachment portion **752** includes a base **758**, an arm **760**, and a hinge mechanism **762** which connects the arm **760** to the base **758** and allows for the arm **760** to open and close. The second open attachment portion **754** includes a base **764**, an arm **766**, and a hinge mechanism **768** which connects the arm **766** to the base **764** and allows for the arm **760** to open and close. The system **750** may be secured to a first vertebra **770** and a second vertebra **772** by first inserting bone fasteners **774** into the first vertebra **770** and inserting bone fasteners **776** into the second vertebra **772**. The bone fasteners **774**, **776** are screws in the depicted embodiment, but may also be nails, staples, wires, pins, and the like. Next the arms **760** and **766** are placed in an open position and base **758** is aligned with fasteners **774** and base **764** is aligned with fasteners **776**. The system **750** may then be slid laterally between the already inserted bone fasteners **774** and **776** and the first and second vertebrae **770** and **772**, respectively. The arms **760** and **766** may then be lowered to close the first attachment portion **752** and the second attachment portion **754** using the hinge mechanisms **762**, **768** or similar mechanism. When the arms **760** and **766** have been lowered, the bone fasteners **774** and **776** are captured within the first open attachment portion **752** and second open attachment portion **754**, respectively. Bone fasteners **774** and **776** may then be tightened to secure the system **750** to the first and second vertebrae **770** and **772**, respectively.

Another dynamic spinal fixation system **800** is shown in FIG. **49**. The system **800** includes two first attachment portions **802**, two second attachment portions **804**, and at least one brace **806**. The first attachment portions **802** include first attachment sections **808** and first strut portions **810**. The second attachment portions **804** include second attachment sections **812** and second strut portions **814**. The first strut portions **810** of the two first attachment portions **802** are connected vertically to the second strut portions **814** of the two second attachment portions **804**. The strut portions **810** and **814** include a mechanism that has an adjustable length. The attachment portions **802** and **804** have a generally u-shaped geometry that are open on the outside allowing the attachment portions **802** and **804** to be slid between bone fastener heads and the vertebrae. The attachment portions **802** are slid in a superior direction between vertebra **816** and fastener heads **820** to capture the system **800**. The attachment portions **804** are slid in an inferior direction between vertebra **818** and fastener heads **822** to capture the system **800**. Once attachment portions **802** and **804** are slid into place, although not shown, a hinged enclosure, like the arms **760** and **766** of FIGS. **46-48**, may capture the bone fastener heads **820** and **822**.

Illustrated in FIG. **50** is another dynamic spinal fixation system **830**. The system **830** includes a first attachment portion **832**, a second attachment portion **834**, and two bone fasteners **836**. The first attachment portion **832** includes a first attachment section **834** and a first strut portion **836**. The second attachment portion **838** includes a second attachment section **840** and a second strut portion **842**. The attachment portions **832** and **834** have a generally U-shaped geometry that is open on the outside allowing the attachment portions **832** and **834** to be slid between bone fastener heads **844** and the vertebrae. The attachment portion **832** is slid in a superior direction and the attachment portion **834** is slid in an inferior direction between the vertebrae and bone fastener heads **844** to capture system **830**. The strut portions **840** and **842** include a mechanism that has an adjustable length and the first strut portion **836** includes a plurality of teeth **846** to facilitate engagement of an adjustable mechanism. The systems **750**, **800**, and **830** of FIGS. **46-50** may be reinforced with an absorbable biomaterial that is resorbed over time and as the biomaterial is absorbed, the stiffness of the dynamic spinal fixation systems changes.

Referring now to FIGS. **51-55**, a surgical method for implanting a dynamic spinal fixation system is depicted and will now be described. The method utilizes some of the devices, features, aspects, components and the like described above, and therefore reference will be made to the above described embodiments, such as the illustrated embodiments presented in the figures and discussed above. However, such references are made for exemplary purposes only and are not intended to limit the surgical method beyond the specifically recited steps. Further, the surgical method may be discussed under the umbrella of particular vertebrae, but such an application is not intended to be limiting and the method described herein may be used or conducted with vertebrae not specifically discussed herein without departing from the spirit and scope of the surgical method.

Assuming the patient has a spinal injury, disease, or trauma, an anterior spinal surgery, such as an anterior cervical discectomy and fusion ("ACDF"), may be performed to correct the damaged spine using the systems **550** or **600**. The methods disclosed each include placing the bone fasteners first and the systems **550** or **600** second. The fasteners may also be used to distract or compress the spine prior to placement of the systems **550** or **600** over the fasteners.

As depicted in FIG. **56**, the method **900** consists of the following steps. First, in order to correct a damaged spine an anterior or lateral portion of the spine is exposed by a surgeon, the vertebral level is determined, and the midline position is identified **902**. The bone fasteners, screws in the depicted embodiments, are then applied at the superior vertebra and the inferior most vertebrae leaving a gap between the screws and the vertebrae **904**. A discectomy or corpectomy is then performed by inserting a distractor into the screws for distraction and once decompression is complete a graft, implant, or interbody spacer is placed into the disc space and then the distraction apparatus is removed **906**. Next a system of a desired length is chosen to correspond to the distance between the screws and if compression or distraction is desired, a smaller or larger system is selected. Alternatively, the length of the system may be adjusted by compressing or distracting the system prior to placing the reliefs over the screw heads and translating the system to capture the attachment portions between the screw heads and vertebrae **908**. The screws are then tightened to secure the attachment portions between the screw heads and vertebrae with additional screws being inserted through the openings **910** if necessary. Finally, the patient's incision is closed **912**.

When a dynamic spinal fixation system is chosen for step **908** the inter-screw distance must first be determined. Then a surgeon must decide whether it is desirable to apply compression or extension to the graft. If the surgeon wishes to apply compression to the graft then a shorter system **550** or **600** is utilized or the system **550** or **600** may be stretched or expanded prior to placing it over the screws. Alternatively, if the surgeon wants to apply distraction to the graft then a longer system **550** or **600** is utilized or the system **550** or **600** may be compressed prior to placing it over the screws.

As illustrated in FIGS. **51-52**, in step **904**, a first fastener **920** may be applied to the superior vertebra **924** approximately 2 to 3 millimeters ("mm") off the midline to the right or left side. A second fastener **922** is then applied to the inferior most vertebrae **926** just off the midline, approximately 2 to 3 mm, and on the same side as the first fastener **920**. The first vertebra may be adjacent the second vertebra. Alternatively, the first vertebra may be separated from the second vertebra, for example, the first vertebra may be the C4 and the second vertebra may be the C6 in a two level procedure. In the depicted embodiment, the first and second fasteners **920**, **922** are applied to the left side of the midline of the vertebrae **924**, **926**. The reliefs **564**, **568** of dynamic spinal fixation system **550** are aligned with the already placed fasteners **920**, **922**. The system **550** is then slid in line with the midline of the spine and the fasteners **920**, **922** move into the left lateral sides of the openings **562**, **566**, respectively. After the system **550** is positioned, additional fasteners may be applied on the right lateral sides of the openings **562**, **566**. The fasteners may then be locked to the system **550** by a locking mechanism, such as an expansion screw or an interference type plate or screw. The first and second fasteners **920**, **922** may also be applied to the right side of the midline of the vertebrae **924**, **926** and then the fasteners **920**, **922** would be slid to the right lateral sides of the openings **562**, **566**, respectively.

As illustrated in FIGS. **53-55**, in step **904**, a first fastener **920** may be applied to the superior vertebra **924** approximately 2 to 3 mm off the midline to the right or left side. A second fastener **922** is then applied to the inferior most vertebrae **926** just off the midline, approximately 2 to 3 mm, and on the side opposite the first fastener **920**. The first vertebra may be adjacent the second vertebra. Alternatively, the first vertebra may be separated from the second vertebra, for example, the first vertebra may be the C4 and the second vertebra may be the C6 in a two level procedure. In the depicted embodiment the first fastener **920** is applied to the left side of the midline of the vertebra **924** and the second fastener **922** is applied to the right side of the midline of the vertebra **926**. Alternatively, the first fastener **920** may be applied to the right side of the midline of the vertebra **924** and the second fastener **922** may be applied to the left side of the midline of the vertebra **926**. In still another alternative embodiment, the first and second fasteners **920** and **922** may be aligned parallel in the vertebrae **924** and **926**, respectively.

Once the fasteners **920**, **922** are inserted into the vertebrae **924**, **926**, a dynamic spinal fixation system **600** is aligned at an angle with the first fastener **920** and the second fastener **922** so that the previously placed fasteners **920** and **922** are accommodated at the reliefs **614** and **618** in the first attachment portion **602** and the second attachment portion **604**, respectively. The openings **612** and **616** are curved and concave with respect to the center of the system **600**. The curved and concave openings **612** and **616** allow the system **600** to be rotated once the system **600** is placed over at least one of the already placed fasteners **920** and/or **922**. The system **600** is then rotated in line with the midline of the spine and the fasteners **920** and **922** move into the openings **612** and **616**, as best illustrated in FIG. **52**. As the system **600** is rotated the radius of curvature of the openings **612** and **616** allows for compression or distraction of the intermediate portion **606** when the system **600** is rotated under the fasteners **920** and **922**.

In an alternative embodiment, the first and second fasteners **920**, **922** may be applied to the vertebrae **924**, **926** parallel to each other. The system **600** is aligned parallel with the fasteners **920**, **922** and the reliefs **614** and **618** are aligned with the fasteners **920**, **922**. Then system **600** is slid into position moving the fasteners **920**, **922** into the openings **612**, **616**.

Once the system **600** is rotated to the desired position along the spine, the first attachment portion **602** and second attachment portion **604** are captured between the heads of the fasteners **920** and **922** and the superior vertebra **924** and inferior vertebrae **926**. A third fastener **928** may optionally be inserted into the opening **612** and a fourth fastener **930** may also optionally be inserted into the opening **616** to further secure the system **600** to the first and second vertebrae **924** and **926**, respectively. In alternative embodiments, the openings **612** and **616** may also be convex with respect to the center of the system **600** and thereby allow for compression of the intermediate portion **606** when the system **600** is slid laterally under at least one fastener. Although the method has been described with inserting the fasteners in a given sequence, it is understood by one skilled in the art that the fasteners may be inserted into the spine in any sequence and that the dynamic spinal fixation systems may be slide or rotated in either direction.

While the above detailed description of the invention is in the context of the cervical spine, it is understood by one skilled in the art that the same design is scalable for use in the lumbar spine for anterior lumbar interbody fusion ("ALIF") or dynamic stabilization of the cervical and lumbar spine. Further while the preferred and alternative embodiments are comprised of a metallic material, it is understood that the same design is achievable through use of an elastic, hyperelastic, or deformable polymer, ceramic, or composite.

The invention has been described with reference to the preferred embodiments. It will be understood that the architectural and operational embodiments described herein are exemplary of a plurality of possible arrangements to provide the same general features, characteristics, and general system operation. Modifications and alterations will occur to others upon a reading and understanding of the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations.

What is claimed is:

1. A surgical method for fusing a spine, comprising:

obtaining a dynamic spinal fixation system, comprising:

a member with a superior end and an inferior end;

a first attachment portion at the superior end of the member, wherein the first attachment portion includes a first opening with a first relief;

a second attachment portion at the inferior end of the member, wherein the second attachment portion includes a second opening with a second relief; and

an intermediate portion connecting the first attachment portion and the second attachment portion;

inserting a first bone fastener into a first vertebra of a patient and a second bone fastener into a second vertebra of the patient, wherein the first vertebra is superior the second vertebra;

aligning the first relief with the first fastener and the second relief with the second fastener;

moving the member into alignment with the first vertebra and the second vertebra for fixation by sliding the member along the first fastener into the first opening and along the second fastener into the second opening; and

tightening the first fastener to the first vertebra and the second fastener to the second vertebra to secure the dynamic spinal fixation system to at least the first vertebra and the second vertebra of a patient's spine.

2. The method of claim **1**,

wherein the intermediate portion of the dynamic spinal fixation system comprises:

a third attachment portion with a third opening;

a first elastic mechanism connecting the first attachment portion and the third attachment portion; and

a second elastic mechanism connecting the third attachment portion and the second attachment portion.

3. The method of claim **2**, wherein at least one of the first elastic mechanism and the second elastic mechanism includes a plurality of curved sections and straight sections, wherein the curved sections are connected to the straight sections.

4. The method of claim **3**, wherein the straight sections are transverse to the sagittal plane.

5. The method of claim **2**, wherein the cross-sectional geometry of at least one of the first elastic mechanism and the second elastic mechanism is polygonal in the coronal plane.

6. The method of claim **2**, wherein the cross-sectional geometry of at least one of the first elastic mechanism and the second elastic mechanism is oblong in the coronal plane.

7. The method of claim **1**, wherein the dynamic spinal fixation system further comprises at least one stop member between two adjacent sections of at least one of the first elastic mechanism and the second elastic mechanism.

8. The method of claim **7**, wherein the at least one stop member is between two adjacent straight sections of at least one of the first elastic mechanism and the second elastic mechanism.

9. The method of claim **8**, wherein the at least one stop member includes a first portion to stop movement of at least one of the first elastic mechanism and the second elastic mechanism along a superior-inferior axis.

10. The method of claim **8**, wherein the at least one stop member includes a first portion attached adjacent to a second portion and wherein the first portion mates with the second portion to inhibit movement of at least one of the first elastic mechanism and the second elastic mechanism along a superior-inferior axis.

11. The method of claim **1**, wherein the position of the first relief is selected from centered in the first opening, superiorly in the first opening, and inferiorly in the first opening, and the position of the second relief is selected from centered in the second opening, superiorly in the second opening, and inferiorly in the first opening.

12. The method of claim **1**, wherein the first relief and second relief are sized to receive a bone fastening mechanism.

13. The method of claim **1**, wherein the first opening and the second opening are curved in the coronal plane along a midline of the member.

14. The method of claim **1**, wherein the member is curved in the sagittal plane to correspond to the shape of a patient's spine and in the transverse plane to correspond to the shape of the patient's vertebrae.

15. The method of claim **1**, wherein the intermediate portion of the dynamic spinal fixation system includes at least one support strut.

16. The method of claim **15**, wherein the at least one support strut is lateral to a midline of the member.

17. The method of claim **15**, wherein the at least one support strut is aligned along the midline of the member.

18. The method of claim **1**, wherein the dynamic spinal fixation system further comprises an interbody fusion cage device coupled to the intermediate portion.

19. The method of claim **1**, wherein the first relief and the second relief of the member are aligned at an angle with the first fastener and the second fastener and the member is rotated to align the member with the first vertebra and the second vertebra, sliding the first fastener and second fasteners along the first opening and the second opening in opposite directions from a midline of the member.

20. The method of claim **1**, wherein the first relief and the second relief of the member are aligned vertically with the first fastener and the second fastener and the member is slid in a perpendicular direction to the vertebrae to align the member with the first vertebra and the second vertebra thereby sliding the first fastener and the second fastener along the first opening and second opening in the same direction.

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