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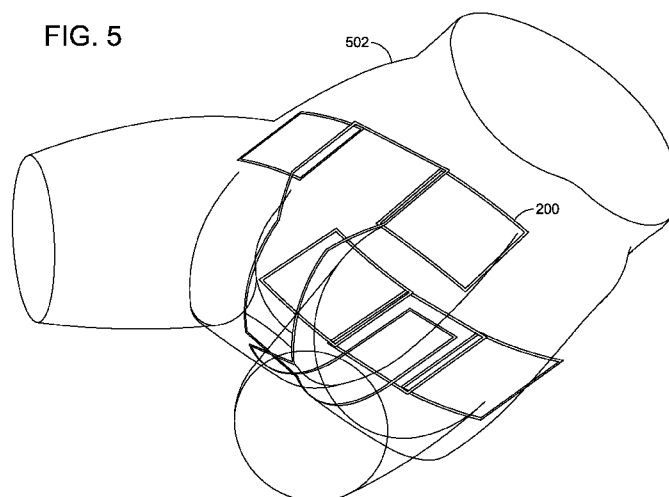
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(54) Title: EXTERNAL PELVIC COIL STRUCTURES AND METHODS

FIG. 5



(57) **Abstract:** Provided are systems and methods for obtaining MRI image data having high SNR. According to some embodiments, the systems and method provide for front to back positioning of pelvic coil assemblies. According to one embodiment, the pelvic coil assemblies are configured to accommodate the male anatomy of the patient being imaged. By accommodating the male anatomy, the pelvic coil assemblies are configured for optimal placement proximate to the patient's prostate. Further, closer positioning enables imaging of a smaller volume of the patient's tissue. Proximity and limitation in volume provide for significant improvement in SNR. The improved SNR can be leverage according to various embodiments of the systems and method into shorter scan times and/or more detailed imaging of a region of interest. Additional embodiments provide adjustable pelvic coil assembly facilitating their use across varying patient populations.

EXTERNAL PELVIC COIL STRUCTURES AND METHODS

RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. § 119 of U.S. Provisional Application
5 No. 61/788,163 filed March 15, 2013, and U.S. Provisional Application No. 61/787,009 filed
March 15, 2013, the contents of which are hereby incorporate by reference in their entirety.

BACKGROUND

The human anatomy presents a variety of challenges in the context of medical screening
10 and diagnosis. The pelvic region of a patient, such as the prostate, which is a walnut-sized gland
located in front of the rectum and just below the bladder, can be problematic to get a good MRI
image. The prostate is in the middle of the pelvis and from a magnetic resonance (“MR”)
standpoint in a difficult position for imaging. In another example, uterine fibroids are also found
in the pelvic region and present unique challenges to imaging approaches. Generally, imaging
15 structures in the pelvic region can be problematic for any patient male or female.

Imaging typically takes place using antennae termed “coils” to detect nuclear magnetic
resonance signals (“NMR”) given off by protons in the presence of a strong magnetic field. The
term “coil” is commonly used to refer to the antenna(e) and its housing or support structure.
Typically, the closer the coil is placed to the imaged area, the stronger the signal and the better a
20 resulting signal-to-noise ratio (“SNR”) will be. The prostate’s proximity to the male anatomy
further complicates attempts to image and place coils proximate to the region of interest.

Regardless of the difficulties, the possibility of life threatening disease drives significant
interest in imaging the prostate in both screening and diagnostic settings. Screening can be
employed to spot potential issues, for example, that may warrant further follow up or more
25 detailed/invasive diagnostic analysis. Conventionally screening approaches are less invasive
and/or take less time, as the goal for screening is to identify potential issues rather than provide
an actual diagnosis. In contrast, the purpose of diagnostic analysis is to provide an actual and
accurate diagnosis of a problem. Oftentimes diagnostics analysis requires additional time and/or
more invasive procedures to provide the level of confidence required to render the diagnosis.

30 Some local coil arrangements have been used to attempt to improve imaging and/or
reduce invasiveness of the imaging procedure. For example, some conventional approaches

employ known endorectal coils, diaper coils, and retainer styled coils to image the prostate. Endorectal coils provide good imaging capability but require highly invasive procedures to employ. Diaper coils are configured to surround the prostate for imaging by completely circling the abdomen (e.g., U.S. Patent No. 7,450,984 which Patent is incorporated by reference herein in its entirety, describes a diaper styled coil arrangement). Retainer style coils use structures that approach the prostate from a side to side (leg to leg) implementation (e.g., U.S. Patent No. 6,836,117, which Patent is incorporated by reference herein in its entirety, describes a retainer coil arrangement).

There are several challenges with the present state of the art for external prostate imaging using MRI. The state of the art for MR prostate screening typically employs multi-channel torso coils alone or in combination with other coils such as a spine coil to image a patient's prostate. Although these coils provide penetration into the body, there are disadvantages to such conventional approaches. For example, the torso and spine coils are large and cover a volume greater than the target organ. The prostate is a small gland and does not require that the whole torso be imaged. Ultimately, by imaging a greater volume than required more noise is collected from the body than is necessary reducing the SNR obtained.

One conventional approach to resolving the image area issue is to employ multiple small coils to limit the area of coverage to a specific region of interest. Multiple small coils can achieve a similar penetration if placed strategically, and further isolate the noise from the rest of the body. Another approach involves algorithmically overcoming the loss in SNR by filtering out noise, but such algorithmic approaches usually require averaging of the signal, resulting in longer scanning times. Another problem is that motion artifacts may arise from breathing or bowel movement, and such artifacts are exacerbated by longer scanning times.

SUMMARY

It is realized that conventional approaches do not satisfactorily resolve the problems of obtaining high SNR with short scan times. It is also realized that if the scan can be completed quickly, i.e., between breaths or during a breath-hold, then artifact problems of conventional approaches can be minimized or eliminated. Closer positioning of coils provides a high SNR which can be leveraged into options for faster scanning (e.g., on the order of a breath hold or

between breaths). Accordingly, various embodiments of a pelvic coil assembly are provided, that enable closer positioning of the imaging coils by accommodating the patient anatomy.

According to one aspect, it is realized that further improvements are required in the structures and coil arrangements to enable higher signal to noise ratio ("SNR") capture of MRI
5 images of the prostate. Additionally, there is a need to provide for easy access and quick setup during imaging of this intimate location proximate to the male anatomy. Reducing complexity in positioning and improving setup speed and duration of image capture will reduce patient discomfort and potentially lead to increased adoption. Further, speed and efficiency can be especially beneficial in the screening setting where short imaging times are expected, if not
10 required. For example, providing coils that enable simple front to back positioning over the prostate can improve setup speeds and configuration.

According to another aspect, it is realized that improvements in coil positioning, and reductions in configuration and setup can be achieved by providing a local coil device that accommodates the male anatomy. Accordingly, there are described embodiments and methods
15 for employing a pelvic coil assembly configured to accommodate the male anatomy by providing an opening in a pelvic coil assembly structure. The opening is configured to pass around the male anatomy and position portions of coils, optionally snugly, against the patient's perineum. In some embodiments, portions of individual coils surround the opening. Thus, the portions of the individual coils pass snugly against the patient's skin adjacent to the base of the male
20 anatomy. By passing the male anatomy through the opening, coil assemblies can be optimally positioned proximate to the prostate. Embodiments of the pelvic coil assembly that accommodate the male anatomy can be position from the front of the pelvis over the male anatomy to the back of the pelvis to provide the optimal positioning to image the prostate. Further, by enabling optimal positioning higher SNR can be readily obtained. As is known in the
25 art, the closer a coil can be positioned to a target area the better the signal will be. The high SNR obtained can be leveraged into faster screening times (e.g., commonly in a screening setting) or more detailed imaging (e.g., commonly in a diagnostic setting).

According to another aspect, constructing a pelvic coil assembly comprising a structure for housing individual coils, where the housing structure includes an opening to accommodate
30 the male anatomy, facilitates easy access and setup. Accommodating the male anatomy rather than avoiding it or compressing it, as in some conventional approaches, provides better

positioning thus yielding high SNR. In some embodiments, the pelvic coil assembly can be positioned front to back over the male anatomy. This straightforward approach can reduce setup and configuration requirements. In some examples, this approach can limit the need for medical personnel assistance in positioning and/or configuration.

5 Additionally, the pelvic coil assembly housing structure can be configured to adjust to patient dimensions. In some embodiments, the pelvic coil assembly can include an adjustment component configured to expand the girth and volume of the housing structure. According to one embodiment, the individual coils within the housing structure can be positioned so that their relative positioning remains substantially the same during adjustments (e.g., to prevent
10 interactions or loop-to-loop coupling). The adjustment mechanism can be further configured to position the opening, and the front and back coil structures, to accommodate patients of varying waist dimension.

 According to one aspect, a pelvic coil assembly is provided. The assembly comprises a plurality of receive coils, including at least one butterfly coil, a housing structure containing the
15 plurality of receive coils, wherein the housing structure includes a curved portion configured to follow a contour of a pelvic region, an aperture defined in the curved portion, the aperture configured to receive genitalia, and wherein the at least one butterfly coil is disposed within the curved portion of the housing structure and at least a portion of the at least one butterfly coil is adjacent to the aperture.

20 The foregoing aspect can include any one or more of the following embodiments, wherein: the housing structure further comprises a first waist-line structure extending from the curved portion; the first waist-line structure is configured to extend laterally around a portion of a circumference of a patient; the plurality of receive coils include at least one surface coil housed in the first waist-line structure; the at least one butterfly coils includes a crossing portion, and the
25 housing structure is configured to position the crossing portion of the at least one butterfly coil at a perineum of a patient; the at least one butterfly coil includes a first loop structure, and wherein the first loop structure is disposed around the aperture; the crossing portion is positioned within the housing structure at a base of the aperture; the housing structure further comprises a second waist-line portion; the second waist-line structure is configured to extend laterally around a
30 portion of a circumference of a patient; the plurality of receive coils include at least one surface coil housed in the second waist-line structure; the housing structure further comprises an

adjustment component; the adjustment component is configured to alter a curvature of the curved portion of the housing structure; the assembly further comprises an adjustment component; the adjustment component is configured to vary a distance between the first and second waist-line structures to allow for adjustment of different size patient circumferences; the adjustment
5 component is configured to maintain a relative positioning of the plurality of coils with respect to each other; wherein the plurality of coils comprise receive only coils; and wherein the plurality of coils include at least one transmit coil.

According to one aspect, a method for obtaining an MRI image of a patient's prostate, the method comprising: fitting a pelvic coil assembly to the patient, including positioning patient
10 genitalia through an aperture in the pelvic coil assembly so that the aperture in the pelvic coil assembly is disposed at a base area of the patient's genitalia, and providing at least one butterfly coil in the pelvic coil assembly such that the act of positioning the aperture includes positioning a crossing portion of the at least one butterfly coil adjacent to the patient's perineum. According to one embodiment, the method further comprises an act of obtaining a screening image of the
15 patient's prostate with the pelvic coil assembly.

According to one aspect, a pelvic coil assembly is provided. The assembly comprises a housing structure containing at least one butterfly coil, wherein the housing structure includes a curved portion configured to follow a contour of a pelvic region, an aperture defined in the curved portion, the aperture configured to receive genitalia, and wherein the at least one butterfly
20 coil is disposed within the curved portion of the housing structure and at least a portion of the at least one butterfly coil is adjacent to the aperture. Further embodiments include: wherein the at least one butterfly coil is constructed of two loop portions and a crossing portion, wherein the crossing portion is positioned at a base of the aperture such that the crossing portion is proximate to the patient's perineum; and wherein at least one loop of the butterfly coil surrounds the
25 aperture.

According to one aspect, a pelvic imaging assembly is provided. The assembly comprises a pelvic coil structure including at least one butterfly coil, the pelvic coil structure comprising a curved portion configured to follow a contour of a pelvic region, an aperture defined in the curved portion, the aperture configured to receive genitalia, wherein at least a part
30 of the at least one butterfly coil is disposed within the curved portion of the coil structure and at

least a portion of the at least one butterfly coil is adjacent to the aperture; and a patient positioning structure.

The foregoing aspect can include any one or more of the following embodiments, wherein: the patient positioning structure is configured to optimize patient placement with
5 respect to the at least one butterfly coil; the patient positioning structure includes at least one incline portion configured elevate a leg of the patient; wherein the coil structure includes paired inclined portions constructed and arranged to elevate and separate the patient's legs; wherein the patient positioning structure includes at least one outer barrier; the at least one outer barrier is constructed and arranged to fit within a bore of an MRI scanner; the at least one outer barrier is
10 configured to limit the position of the patient's leg such that, the patient's leg will not touch the bore of the MRI scanner; the patient positioning structure includes at least a second outer barrier, and the at least the first and second outer are configured to limit the positions of the patient's legs such that, the patient's legs will not touch the bore of the MRI scanner; at least one of the coil and support structures are configured to include at least a first wing section; the at least the first
15 wing section is configured to accept a patient's weight during repositioning of the patient; the at least one of the coil and support structures are configured to include at least a second wing section; the at least the first and second wing sections are configured to receive and distribute the force of the patient pulling on the first and second wing sections during positioning of the patient; the assembly further comprises an adjustment component; the adjustment component is
20 configured to vary a patient width accepted by the patient support structure; the patient support structure includes the pelvic coil assembly.

Still other aspects, features, embodiments, and advantages of these exemplary aspects and embodiments, are discussed in detail below. Any embodiment, feature disclosed herein may be combined with any other embodiment to comprise any aspect in any manner consistent with
25 aspects disclosed herein, and references to "an aspect," "an embodiment," "some embodiments," "an alternate embodiment," "various embodiments," "one embodiment" or the like are not necessarily mutually exclusive and are intended to indicate that a particular feature, embodiment, structure, advantage or characteristic described in connection with any embodiment may be included in at least any aspect or embodiment. Thus, any embodiment disclosed herein may be
30 combined with any other embodiment or aspect in any manner that is consistent with the aspects and embodiments disclosed herein.

The appearances of such terms herein are not necessarily all referring to the same embodiment. The accompanying drawings are included to provide illustration and a further understanding of the various aspects and embodiments, and are incorporated in and constitute a part of this specification. The drawings, together with the remainder of the specification, serve to explain principles and operations of the described and claimed aspects and embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Various aspects of at least one embodiment are discussed below with reference to the accompanying figures, which are not intended to be drawn to scale. Where technical features in the figures, detailed description or any claim are followed by reference signs, the reference signs have been included for the sole purpose of increasing the intelligibility of the figures, detailed description, and claims. Accordingly, neither the reference signs nor their absence are intended to have any limiting effect on the scope of any claim elements. In the figures, each identical or nearly identical component that is illustrated in various figures is represented by a like numeral. For purposes of clarity, not every component may be labeled in every figure. The figures are provided for the purposes of illustration and explanation and are not intended as a definition of the limits of the invention. In the figures:

FIG. 1 is a diagram of a pelvic coil assembly, according to one embodiment;

FIG. 2 is a schematic diagram of an example arrangement of individual coils within a pelvic coil assembly, according to one embodiment;

FIG. 3 is a diagram of a butterfly coil;

FIG. 4 is a diagram of an alternate view of the coil arrangement for one embodiment of pelvic coil assembly

FIG. 5 is a diagram illustrating positioning of the coil arrangement of FIG. 1 on a model for one embodiment of the pelvic coil assembly;

FIG. 6 is a schematic diagram of an example arrangement of individual coils within a pelvic coil assembly, according to one embodiment;

FIG. 7 is a diagram of an alternate view of a coil arrangement for one embodiment of a pelvic coil assembly;

FIG. 8 is a diagram illustrating positioning of the coil arrangement of FIG. 7 on a model, according to one embodiment;

FIG. 9 is a schematic diagram of an adjustable pelvic coil assembly, according to one embodiment;

FIG. 10 illustrates an example process flow for capturing image data with a pelvic coil assembly, according to one embodiment;

5 FIG. 11A-F illustrate views of an example saddle structure for positioning a patient, according to one embodiment; and

FIG. 12 is a diagram showing an embodiment of a pelvic coil assembly, according to an embodiment.

10

DETAILED DESCRIPTION

Fig. 1 illustrates an example embodiment of a pelvic coil assembly 100. Coil 100 is fabricated with a housing structure 101 configured to cover the patient's pelvic area and house individual imaging coils. In one example, the housing structure can be fabricated out of pliable material, such that the coil 100 and/or the housing structure 101 can be conformed to the curvature of a patient's pelvis. For example, the housing structure can be fabricated out of pliable material, such that the coil 100 and/or the housing structure 101 can be conformed to the curvature of a patient's pelvis. In one embodiment, the housing structure can be flexible, including for example a latex/spandex material configured to conform to the body.

According to one embodiment, the individual coils within the housing structure 101 are a mixture of receive only coils. The housing structure 101 includes a curved portion 102 following the curvature of the patient's pelvis from front to back (from the patient's perspective). In some embodiments, the housing structure is configured to conform to the curvature of a patient's pelvis, or flexible enough to adapt to contour of patient body. In some embodiments, the housing structure and/or curved portion 102 can include mechanical supports to provide rigidity to some parts of the coil assembly. The curved portion 102 includes an opening 104 configured to accommodate the genitalia, for example to allow the male genitalia to pass through the opening. By positioning the external portions of the genitals within and through the opening 104, the curved portion 102 of the coil 100 is configured for optimal placement against the patient's pelvis, e.g., the patient's pelvic floor. Once positioned at the patient's pelvic floor at least a portion of the individual coils (i.e., those surrounding opening 104) are configured to go around, and not over, the genitalia. According to another embodiment, it is appreciated that the

coils can be transmit/receive coils, and that although transmit coils typically need to have a better homogeneity than receive coils for more uniform stimulation, where the coils of any of the embodiments disclosed herein are focused on imaging the prostate, the coil arrangements and coil assemblies disclosed herein should also be sufficient for use in a transmit mode also. For example, it is appreciated that the butterfly portion of the coil arrangement can be used in the transmit/receive mode.

According to one embodiment, a receive-only butterfly coil 106 is housed within the curved portion 102. As is known in the art, the butterfly coil 106 can be configured to provide for NMR sensitivity when oriented orthogonally to the main magnetic field provided by an MRI system. Conventionally, MRI systems provide a main magnetic field in the Z direction (e.g., 220 of Fig. 2). Shown in Fig. 2 is another embodiment of a pelvic coil assembly 200. Fig. 2 illustrates an example arrangement of the antennae within a housing making up the individual coils of the pelvic coil assembly 200. Typically, the plane of the individual coils are oriented parallel to the Z plane 220 to provide sensitivity to the main magnetic field (e.g., coils 202, 206, 208, 210, and 212 are oriented substantially parallel to the Z plane 220). These individual coils (e.g., 202, 206, 208, 210, and 212) are sensitive to an NMR signal that rotates in the X (222) -Y (223) plane. Similar to the butterfly coil 106 of Fig. 1, butterfly coil 204 provides NMR sensitivity when oriented orthogonally to the Z plane 220.

In some embodiments, a coil assembly (e.g., 100) can include a butterfly coil alone, positioned around the opening. Returning to Fig. 1, extending upward and laterally from the front of the curved portion 102 is a waist-line portion 108 of the pelvic coil assembly 100. Within the waist-line portion, a plurality of standard surface coils can be housed (e.g., as shown in Fig. 2). As discussed above, the surface coils are sensitive to an NMR signal that rotates in the X-Y plane and the butterfly coil 106 provides sensitivity when oriented orthogonally to the main magnetic field.

Shown in Fig. 1 is an embodiment of the pelvic coil assembly having one butterfly coil. Other embodiments can include multiple butterfly coils and provide for different positioning configured to provide sensitivity when oriented orthogonally to the main magnetic field. Butterfly coil 106 includes a first loop 110 and a second loop 112. The first loop 110 is positioned around the opening 104. According to various embodiments, the butterfly coil 106 (and first and second loops 110-112) are positioned within the housing structure 101 such that

the crossing portion 114 of the two loops is positioned as close to the prostate as possible. Manipulation of the coil assembly 100 during a procedure (e.g., by medical personnel) may assist the positioning of the coil and crossing portion 114 optimally. Shown for purposes of clarity, in Fig. 3 is a standard configuration of a known butterfly coil 300.

5 Some embodiments of the pelvic coil assembly 100 can also include a second waist-line portion extending from the back of the curved portion 102 (not shown). Additional surface coils can be housed within a rear waist-line portion. The additional coils can increase the SNR obtained during imaging. For example, coils 208, 210, and 212 (Fig. 2) can be housed within a rear waist-line portion of a pelvic coil assembly (including, e.g., coil 100). According to various
10 embodiments, the waist-line (e.g., 108) portions extend laterally in a direction around a patient's waistline. The waist-line portions are configured to extend partially around the waist, limiting the imaging area to a smaller region of interest than other conventional coil configurations. For example, the waist-line portions are configured to extend laterally but exclude portions of the hips so as not to circumnavigate all the way around the torso/waist-line of a patient. By
15 excluding portions of the hips from imaging, the pelvic coil assembly reduces noise that would otherwise be captured. The reduction in noise during image capture improves SNR. In some embodiments, exclusion of imaging fatty areas located in the hips, bone matter from the hips and/or adjacent tissue, by limiting the lateral extension of the belt line-portions improves SNR over conventional approaches that surround and image the entire waistline of a patient.

20 According to some embodiments, any number of surface coils can be combined with a number of butterfly coils to provide the individual coils within a pelvic coil assembly. However, part of the challenge associated with using multiple coils for imaging is the fact that the fields of individual coils may interact, resulting in loop-to-loop coupling, where these interactions reduce the quality of the coil. Shown in Fig. 2 are overlapping portions between adjacent coils (e.g.,
25 228, 230, 232, and 234). The overlap between adjacent coils can be used in various embodiments to limit the effects of coupling. In some embodiments, overlap between adjacent coils can be used to cancel out any additional field contributions. Other known approaches for limiting coupling effects can also be incorporated in various embodiments of the pelvic coil assembly (including, for example, addition of capacitors, inductors, or additional circuits
30 between coils which cancel coupling effects, etc.).

Fig. 4 illustrates another view of coil 200. The view in Fig. 4 is provided to highlight some of the features of coil 200. For example, butterfly coil 204 can be configured to include opposed sloped portions 402 and 404. These sloped portions can follow the contours of a respective housing for the coil assembly. For example, the housing and antennae (e.g., 402 and 404) can be constructed and arranged to follow the curvature of the patient's body at the crease where the legs meet the body.

Fig. 5 illustrates a coil arrangement and the positioning of an embodiment the pelvic coil assembly 200 according to a patient model 502. Not shown in Fig. 5 are the housing structures for the individual coils of coil 200, the patient's genitals, nor the opening in the housing structures. According to some embodiments, the housing structure for a pelvic coil assembly (e.g., 200) is dimensioned such that a waist-line portion (e.g., 108, Fig. 1) fits snugly against the waist and pelvic region of a patient. Further, the waist-line portions are configured to fit under any excess abdominal fat. Various patient populations having widely varying characteristics are envisioned as being subjects of prostate imaging. Typically, the lower waist and pelvic region is less susceptible to large changes even where a patient may be considered obese. Oftentimes, an overweight patient develops a paunch or a region of larger diameter at the abdomen, where the waist-line remains more consistent with a patient who is not overweight. Positioning a waist-line portion of the pelvic coil assembly under any such paunch or excess diameter region of the abdomen enables closer positioning of the coil to the prostate, again resulting in higher SNR during imaging.

Fig. 6 is an example schematic diagram of another example arrangement of individual coils within a pelvic coil assembly 600. According to one embodiment, coil 600 includes a butterfly coil 602 that follows a curved portion of the pelvic coil assembly housing structure (not shown). The respective end of the butterfly coil 602 overlap a front waist-line portion 604 and a rear waist-line portion 606 of the pelvic coil assembly 600. The front waist-line portion 604 includes three surface coils 608, 610, and 612. The rear waist-line portion 600 includes three surface coils 614, 616, and 618. The surface coils in the front and rear belt line portions can be architected within the housing of the coil to follow the natural curvature of the human body at the waist-line area. Additionally, the respective individual coils can be positioned within the housing to provide some overlap for reducing loop-to-loop coupling (e.g., at 620, 622, 624, and 626).

Fig. 7 is an alternate view of the antennae arrangement of the individual coils making up pelvic coil assembly 600. The alternate view highlights some features of an example configuration of the butterfly coil 602. According to some embodiments, the first loop 700 of butterfly coil 602 can include sloped portions of the trace 702 and 704. The sloped portions (e.g., 702 and 704) can be configured to follow the contours of a respective housing for the coil assembly. For example, the housing and sloped portions of the antennae (e.g., 702 and 704) can be constructed and arranged to follow the curvature of the patient's body at the crease where the legs meet the body. Similarly, the second loop 701 of the butterfly coil 602 can also include respective sloped portions 706 and 708. Fig. 8 illustrates a coil arrangement and the positioning of an embodiment the pelvic coil assembly 600 according to a patient model 802.

According to another aspect, an adjustable pelvic coil assembly can be provided to facilitate the use of a pelvic coil assembly. According to some implementations, adjustable pelvic coil assemblies can provide a one size fits all/most model. For example, the housing structures of the pelvic coil assembly can include adjustment mechanisms configured to change the relative position of the individual coils and/or portions of the housing structure to accommodate patients having different waist sizes, different body dimensions, larger girth, broader hips, etc. Shown in Fig. 9 is an example embodiment of an adjustable pelvic coil assembly 900. The adjustable pelvic coil 900 can be configured to transition between position 902 and position 904, accommodating patients having larger pelvic dimensions. According to one embodiment, the housing structure for coil 900 can include a first and second layer for the curved portion of the housing structure (e.g., at 906 and 908). The first and second layer can be slideably mated. In response to sliding the first layer 906 with respect to the second layer 908 the spacing between the front and back of the housing structure is modified. Various structures can be used to slideably mate the first and second layers, including, for example, channels and guides, key and lock structures, tongue and grooves, rail assemblies, etc.

In some additional embodiments an adjustable pelvic coil assembly can be formed of a coil layer secured to an adjustable base layer. The coil layer can be semi-rigid and house the individual coils included in the pelvic coil assembly (e.g., surface coils and butterfly coils). The adjustable base layer can be configured with adjustable connections or portions to enable transitions between various U shaped configurations. For example, the adjustable base layer can include a plurality of pivots or be fabricated of a bendable/flexible material configured to

broaden and/or shorten the curvature of the U portion of the pelvic coil assembly. According to one embodiment, the coil layer will deform in accordance with the configuration of the adjustable base layer while maintaining the relative positioning of the individual surface coils. As a result of the change in curvature of the U portion, the butterfly coil can undergo deformation, however, the positioning of the crossed portion of the butterfly coil at the perineum can be maintained, providing an optimal imaging positioning. According to some embodiments, the opening within the housing structure of the pelvic coil assembly (including for example, first and second layers and/or coil layer and adjustable base layer) can be configured to accommodate the male anatomy in a variety of positions. As a result the opening can exceed the proportions required for the average male, to insure proper positioning, for example, when the adjustable pelvic coil assembly is configured with a broader curved portion or a shallower U configuration.

According to other embodiments, other adjustment mechanisms can be included in the pelvic coil assembly (e.g., accordion structures, pivots, joints, ball and socket connectors, etc.). Additional embodiments can also provide fixed pelvic coil assemblies constructed to accommodate different physical characteristics. Both adjustable and fixed position pelvic coil assemblies can be used to obtain improvements in SNR.

Shown in Fig. 10 is an example process 1000 for capturing MRI image data using a pelvic coil assembly. Process 1000 begins at 1002, with positioning the pelvic coil assembly on a patient to be imaged. Positioning the pelvic coil assembly on the patient at 1002 can include positioning patient genitalia through an aperture in the pelvic coil assembly. The patient's genitalia can be positioned so that the aperture in the pelvic coil assembly is disposed at a base area of the patient's genitals. Positioning the assembly at 1002 can also include the positioning of a butterfly coil contained within the pelvic coil assembly such that a crossing portion of the butterfly coil is positioned adjacent to the patient's perineum.

Once the coil is positioned proximate to the prostate, an MRI provides a strong magnetic field (e.g., at 1004). Gradient and RF fields are then applied. The pelvic coil assembly is configured to capture MRI data at 1006 (e.g., as NMR signals) responsive to the application of the magnetic fields. Various post capture processing operations can be performed on the captured data. In some embodiments, process 1000 is executed as part of a screening procedure. Based on the improvement to SNR resulting from the positioning of the pelvic coil assembly and

the focus of the imaging area, the MRI data capture for screening can occur within a short period of time (e.g., within the time for a held breath and/or between breaths).

In some embodiments, additional structures can be used to facilitate positioning of the pelvic coil assembly during imaging. Conventional MRI systems place a patient in the bore of a MRI system so as to apply a magnetic field. Positioning of the patient within the bore can facilitate image capture. According to one embodiment, a saddle can be positioned on an MRI table to facilitate optimum positioning of the patient and correspondingly the pelvic coil assembly.

Shown in Figs. 11A-F are views of an example saddle structure 1102. Referring to Fig. 11A, the saddle structure 1102 is configured to position the patient 1104 optimally within the bore of an MRI, such that a pelvic coil portion 1106 is in an optimal position for detection. Similar to the pelvic coil assembly discussed above, the pelvic coil portion 1106 includes an opening 1108 for accommodating a patient's genitalia. The individual coils are not shown, but as discussed herein the pelvic coil portion can include any one of or combinations of the coils that have been disclosed herein. According to some embodiments, the saddle structure 1102 elevates and bends the patient's knees and abducts the patient's hips to maximize the space against the perineum to place a coil, without allowing the patient's knees to hit the sides of the MRI scanner. In one embodiment, the saddle structure includes incline portions 1110 and 1112 which are configured to elevate and bend the patient's knees in conjunction with a spacing between them at 1114. The saddle structure can include optional retainers at 1116 and 1118 configured to prevent the patient's knees from hitting the sides of the MRI scanner. According to one embodiment, the saddle structure is constructed to allow the maximum room to position the pelvic coil portion 1106 optimally in the bore of the MRI.

Fig. 11B shows an additional view of the saddle structure 1102 without the patient 1104. According to some embodiments, the saddle structure can include a hard base 1119 (i.e. a "saddle" like part) between the legs allowing wings 1120 and 1122 to operate like handles for the patient to pull on to ensure the patient is well seated on the saddle structure 1102. In some implementations, handles can be provided to enable the patient pull on the handles compressing fatty tissue that is to be imaged and getting coils within the saddle structure closer to the region of interest.

Shown in Fig. 11C is another view of the saddle structure 1102. Fig. 11D shows the saddle structure 1102 without a patient. Figs. 11E and 11F show a top down view of the saddle structure 1102 with a patient 1104 and without a patient. In some embodiments, the retainer structures (e.g., 1116 and 1118) are employed to ensure that the patient's knees do not hit or touch the bore of an MRI scanner. This can be a significant issue where the patient is being introduced into the bore feet first. In other embodiments, it is appreciated that the saddle structure can be implemented without retainer structures. For example, a removable support for set up can be employed as well as a strap that goes around the knees to limit movement. However, referring to FIG. 11C, it is realized retaining structures 1116 and 1118 are well suited to maximizing the separation 1130 between the knees of the patient. It is further realized that increasing the separation 1130 between the patient's knees can yield a wider area 1136 at the opening 1108 of the saddle structure. The greater area 1136 can provide for different and larger coil arrangements. The different and larger coil arrangement can provide a better SNR.

It is also appreciated that patient positioning achieved by the saddle structure can be relevant to procedures done in conjunction with imaging. For example, the saddle structure 1102 can also facilitate a prostate biopsy and can also facilitate imaging in conjunction with gynecological procedures. In some embodiments, it is appreciated that in addition to a butterfly coil with a loop surrounding the opening 1108, additional individual, such as any one or more of or combination of the coils disclosed herein, coils can be positioned throughout the saddle structure, for example, such as in wings 1120 and 1122.

Fig. 12 is a diagram of an embodiment of a pelvic coil assembly 1200. When positioned within the bore of an MRI, the magnetic field applied is shown by z, x, and y planes (e.g., at 1204, 1206, and 1208. Portions of a patient model 1210 illustrate the positioning of the coil 1200 with respect to the region of interest to be imaged (e.g., 1202 – the patient's prostate). In other embodiments, different coil assemblies can be included in a pelvic coil. For example, the pelvic coil can include strip-line, butterfly, circular, saddle coils, and can also include coils having custom architectures, and other surface coils.

According to another aspect, it is realized that the pelvic coil assembly can also be used to image a female patient and thus the pelvic coil assembly can include an opening configured to accommodate female genitalia as well as male genitalia. In some implementations, the configuration of coil assembly can facilitate other medical procedures in conjunction with

imaging. For example, the opening can provide access for medical personal to perform biopsy procedures, as well as other procedures. In some embodiments, additional apertures can be included in a pelvic coil assembly. In one example, additional apertures are positioned to enable coupling with an endo coil array to facilitate imaging of the anus or vagina.

5 According to one embodiment, the opening is constructed so that a loop of a coil arrangement circumnavigates around female genitalia and is not placed over the genitalia as is the case in conventional diaper type arrangements. Accommodating the female anatomy can also provide better positioning of the pelvic coil assembly thereby yielding higher SNR even with female patients. Some embodiments for use with female patients can include covers
10 configured to mate with the provided opening to alleviate privacy concerns while still enabling better positioning.

 One should appreciate that the present invention is not limited in its application to the details of construction and the arrangement of components set forth in the foregoing description or illustrated in the drawings. The invention is capable of other embodiments and of being
15 practiced or of being carried out in various ways. Also, the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” or “having,” “containing”, “involving”, and variations thereof herein, is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

20 Having thus described several aspects of at least one embodiment of this invention, it is to be appreciated various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description and drawings are by way of example only, and the scope
25 of the invention should be determined from proper construction of the appended claims, and their equivalents.

 What is claimed is:

CLAIMS

1. A pelvic coil assembly comprising:
a plurality of coils, including at least one butterfly coil;
5 a housing structure containing the plurality of receive coils, wherein the housing structure includes:
a curved portion configured to follow a contour of a pelvic region;
an aperture defined in the curved portion, the aperture configured to receive
genitalia; and
10 wherein the at least one butterfly coil is disposed within the curved portion of the housing structure and at least a portion of the at least one butterfly coil is adjacent to the aperture.
2. The assembly of claim 1, wherein the housing structure is configured to be positioned in close proximity to skin of the patient in the region surrounding a base of male genitalia.
- 15 3. The assembly of claim 1, wherein the housing structure further comprises a first waist-line structure extending from the curved portion.
4. The assembly of claim 1, 2, or 3, wherein the first waist-line structure is configured to
20 extend laterally around a portion of a circumference of a patient.
5. The assembly of claim 3, wherein the plurality of receive coils include at least one surface coil housed in the first waist-line structure.
- 25 6. The assembly of claim 1, 2, or 3, wherein the at least one butterfly coils includes a crossing portion, and the housing structure is configured to position the crossing portion of the at least one butterfly coil at a perineum of a patient.
7. The assembly of claim 6, wherein the at least one butterfly coil includes a first loop
30 structure, and wherein the first loop structure is disposed around the aperture.

8. The assembly of claim 7, wherein the crossing portion is positioned within the housing structure at a base of the aperture.

9. The assembly of claim 1, 2, 3 or 5, wherein the housing structure further comprises a second waist-line portion.

10. The assembly of claim 9, wherein the second waist-line structure is configured to extend laterally around a portion of a circumference of a patient.

11. The assembly of claim 10, wherein the plurality of receive coils include at least one surface coil housed in the second waist-line structure.

12. The assembly of claim 1, 2, 3, or 5, wherein the housing structure further comprise an adjustment component.

13. The assembly of claim 12, wherein the adjustment component is configured to alter a curvature of the curved portion of the housing structure.

14. The assembly of claim 1, further comprising an adjustment component.

15. The assembly of claim 14, wherein the adjustment component is configured to vary a distance between the first and second waist-line structures to allow for adjustment of different size patient circumferences.

16. The assembly of claim 15, wherein the adjustment component is configured to maintain a relative positioning of the plurality of coils with respect to each other.

17. The assembly of claim 1 - 3, 5, 14, 15, or 16, wherein the plurality of coils comprise receive-only coils.

18. The assembly of claim 17, wherein the plurality of coils include at least one transmit/receive coil.

19. A method for obtaining an MRI image of a patient's prostate, the method comprising:

5 fitting a pelvic coil assembly to the patient, including positioning patient genitalia through an aperture in the pelvic coil assembly so that the aperture in the pelvic coil assembly is disposed at a base area of the patient's genitalia; and

providing at least one butterfly coil in the pelvic coil assembly such that the act of positioning the aperture includes positioning a crossing portion of the at least one butterfly coil
10 adjacent to the patient's perineum.

20. The method of claim 19, further comprising an act of obtaining a screening image of the patient's prostate with the pelvic coil assembly.

15 21. A pelvic coil assembly comprising:

a housing structure containing at least one butterfly coil, wherein the housing structure includes:

a curved portion configured to follow a contour of a pelvic region;

20 an aperture defined in the curved portion, the aperture configured to receive genitalia; and

wherein the at least one butterfly coil is disposed within the curved portion of the housing structure and at least a portion of the at least one butterfly coil is adjacent to the aperture.

22. The assembly of claim 21, wherein the at least one butterfly coil is constructed of two
25 loop portions and a crossing portion, wherein the crossing portion is positioned at a base of the aperture such that the crossing portion is proximate to the patient's perineum.

23. The assembly of claim 22, where a least one loop of the butterfly coil surrounds the aperture.

30 24. A pelvic imaging assembly comprising:

a pelvic coil structure including at least one butterfly coil, the pelvic coil structure comprising:

a curved portion configured to follow a contour of a pelvic region;

an aperture defined in the curved portion, the aperture configured to receive

5 genitalia;

wherein at least a part of the at least one butterfly coil is disposed within the curved portion of the coil structure and at least a portion of the at least one butterfly coil is adjacent to the aperture; and

a patient positioning structure.

10

25. The assembly of claim 24, wherein the patient positioning structure is configured to optimize patient placement with respect to the at least one butterfly coil.

26. The assembly of claim 24 or 25, wherein the patient positioning structure includes at least one incline portion configured elevate a leg of the patient.

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27. The assembly of claim 26, wherein the coil structure includes paired inclined portions constructed and arranged to elevate and separate the patient's legs.

28. The assembly of claim 24 or 25, wherein the patient positioning structure includes at least one outer barrier.

20

29. The assembly of claim 28, wherein the at least one outer barrier is constructed and arranged to fit within a bore of an MRI scanner.

25

30. The assembly of claim 28, wherein the at least one outer barrier is configured to limit the position of the patient's leg such that, the patient's leg will not touch the bore of the MRI scanner.

31. The assembly of claim 28, wherein the patient positioning structure includes at least a second outer barrier, and the at least the first and second outer are configured to limit the

30

positions of the patient's legs such that, the patient's legs will not touch the bore of the MRI scanner.

32. The assembly of claim 24 or 25, wherein at least one of the coil and support structures are
5 configured to include at least a first wing section.

33. The assembly of claim 32, wherein the at least the first wing section is configured to accept a patient's weight during repositioning of the patient.

10 34. The assembly of claim 33, wherein the at least one of the coil and support structures are configured to include at least a second wing section.

35. The assembly of claim 34, wherein the at least the first and second wing sections are configured to receive and distribute the force of the patient pulling on the first and second wing
15 sections during positioning of the patient.

36. The assembly of claim 34, further comprising an adjustment component.

37. The assembly of claim 36, wherein the adjustment component is configured to vary a
20 patient width accepted by the patient support structure.

38. The assembly of claim 24 or 25, wherein the patient support structure includes the pelvic coil assembly.

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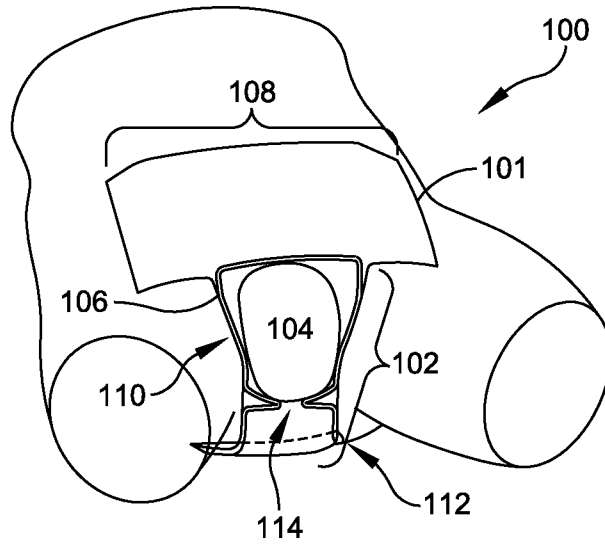


FIG. 1

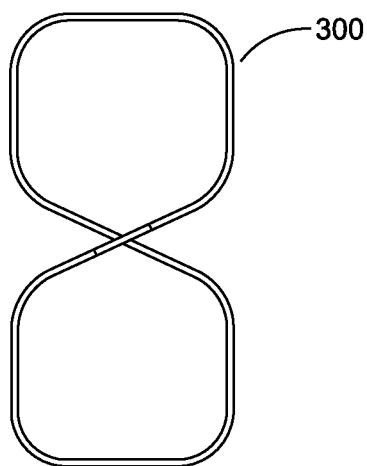


FIG. 3

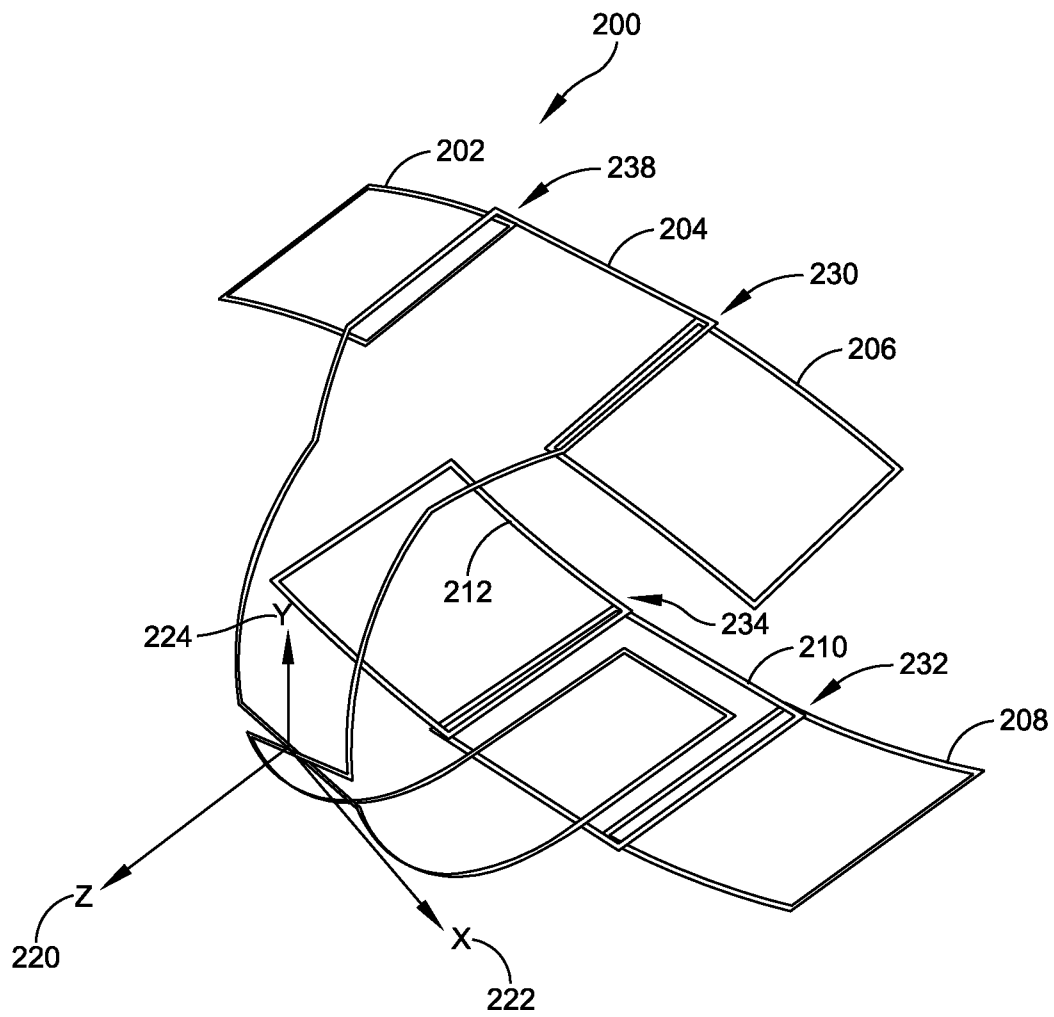


FIG. 2

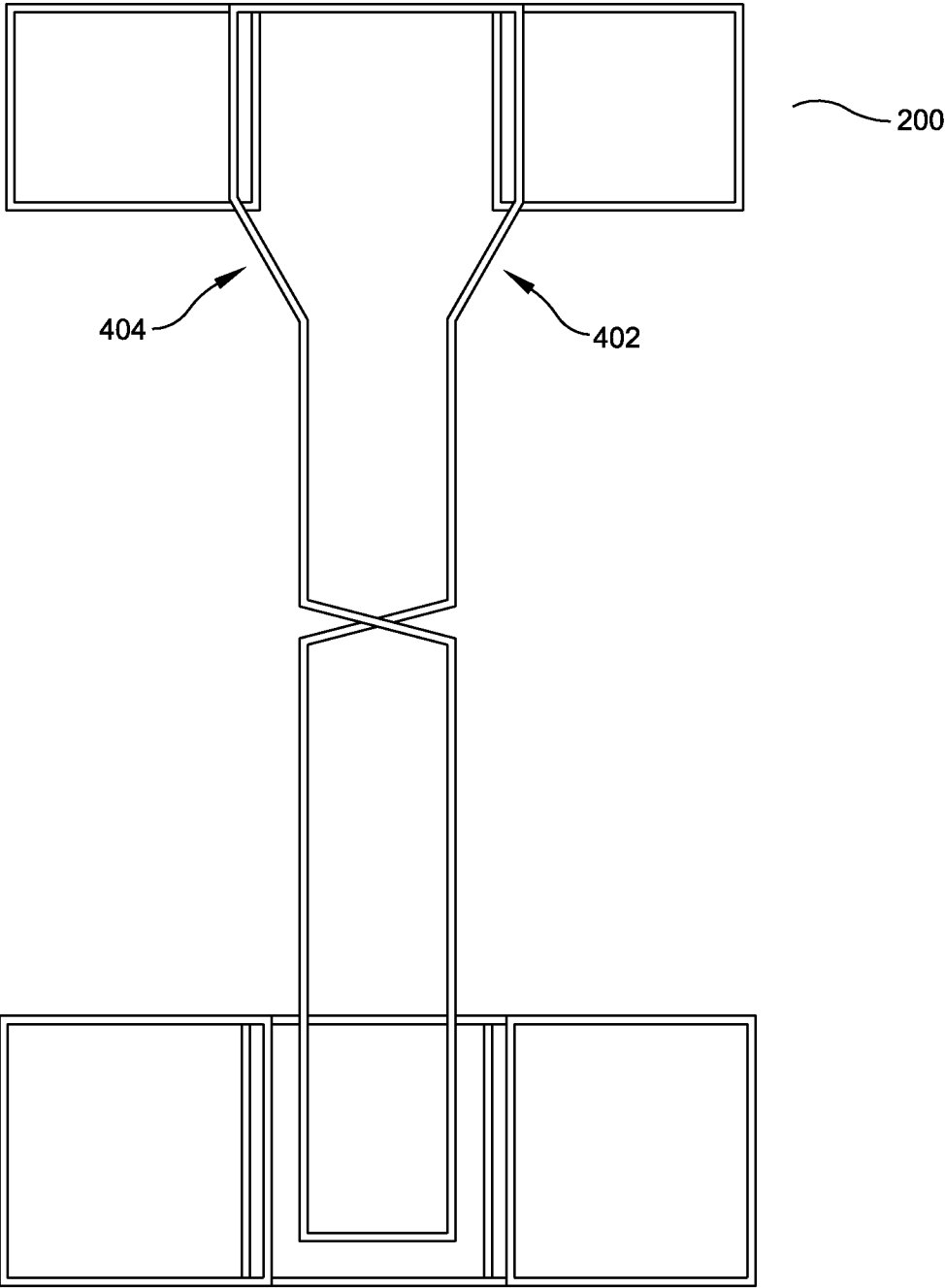


FIG. 4

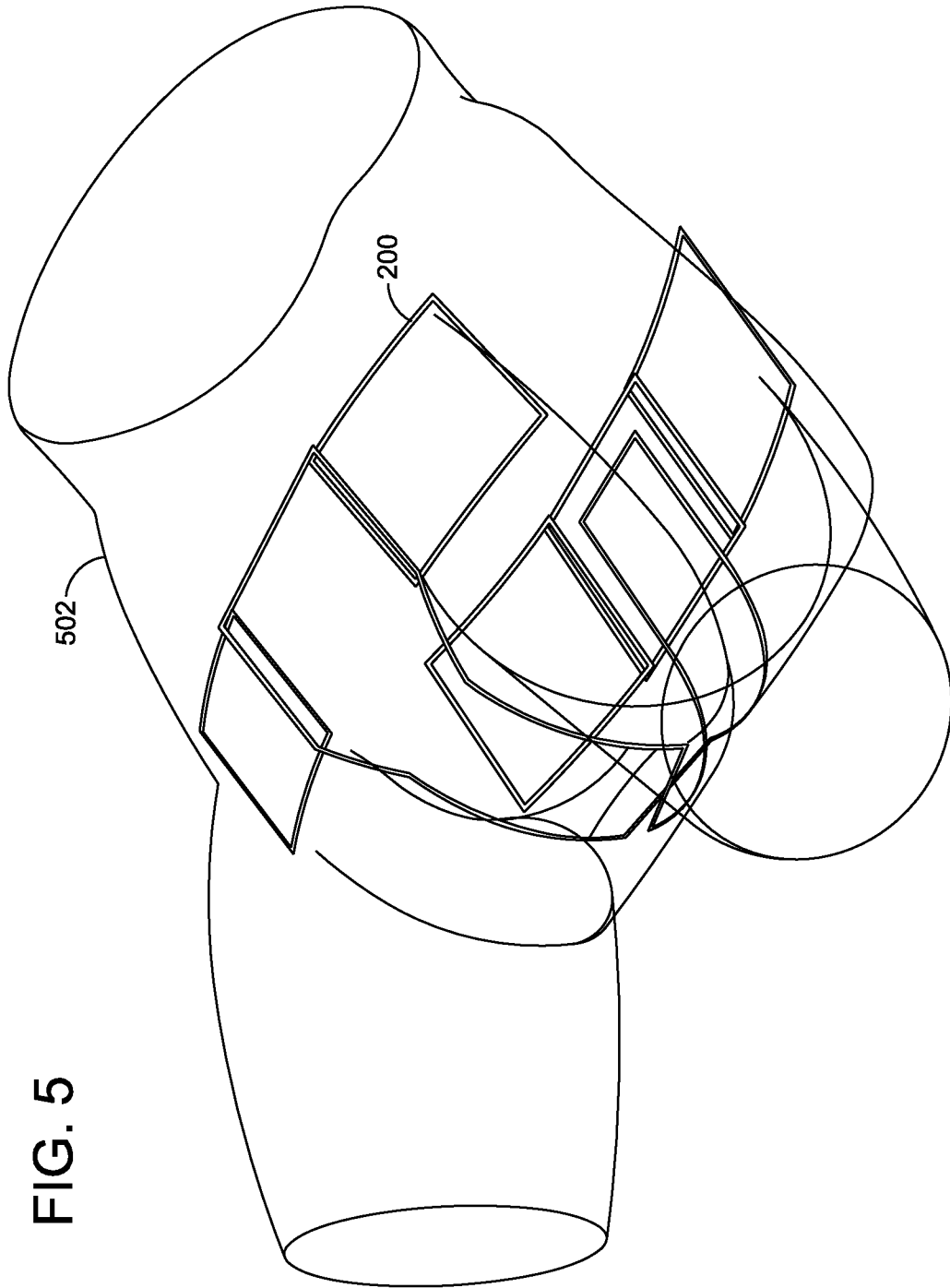


FIG. 5

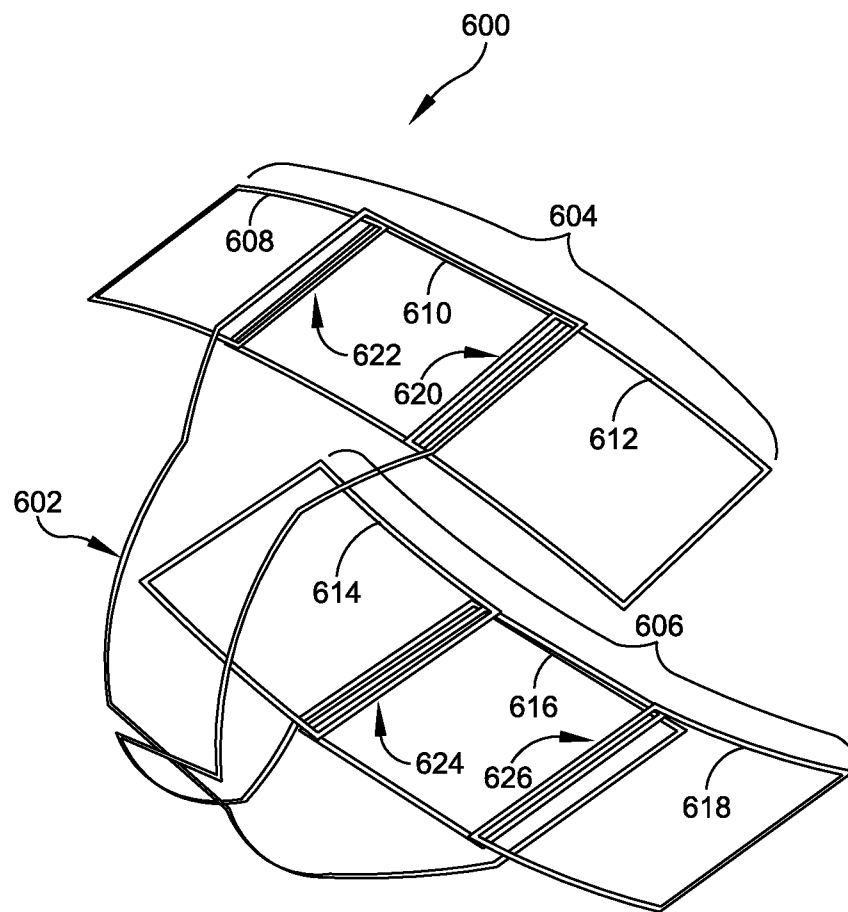


FIG. 6

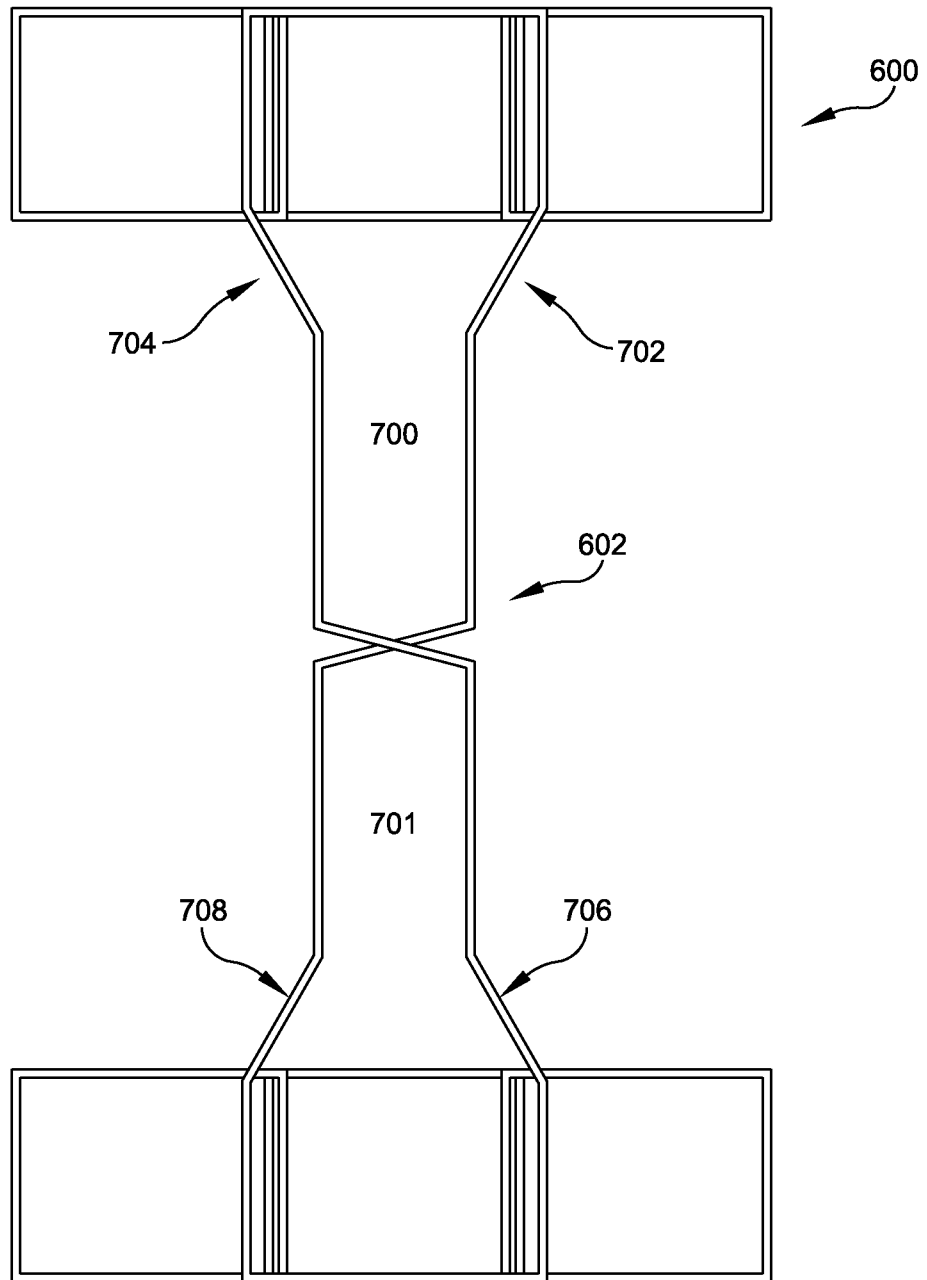


FIG. 7

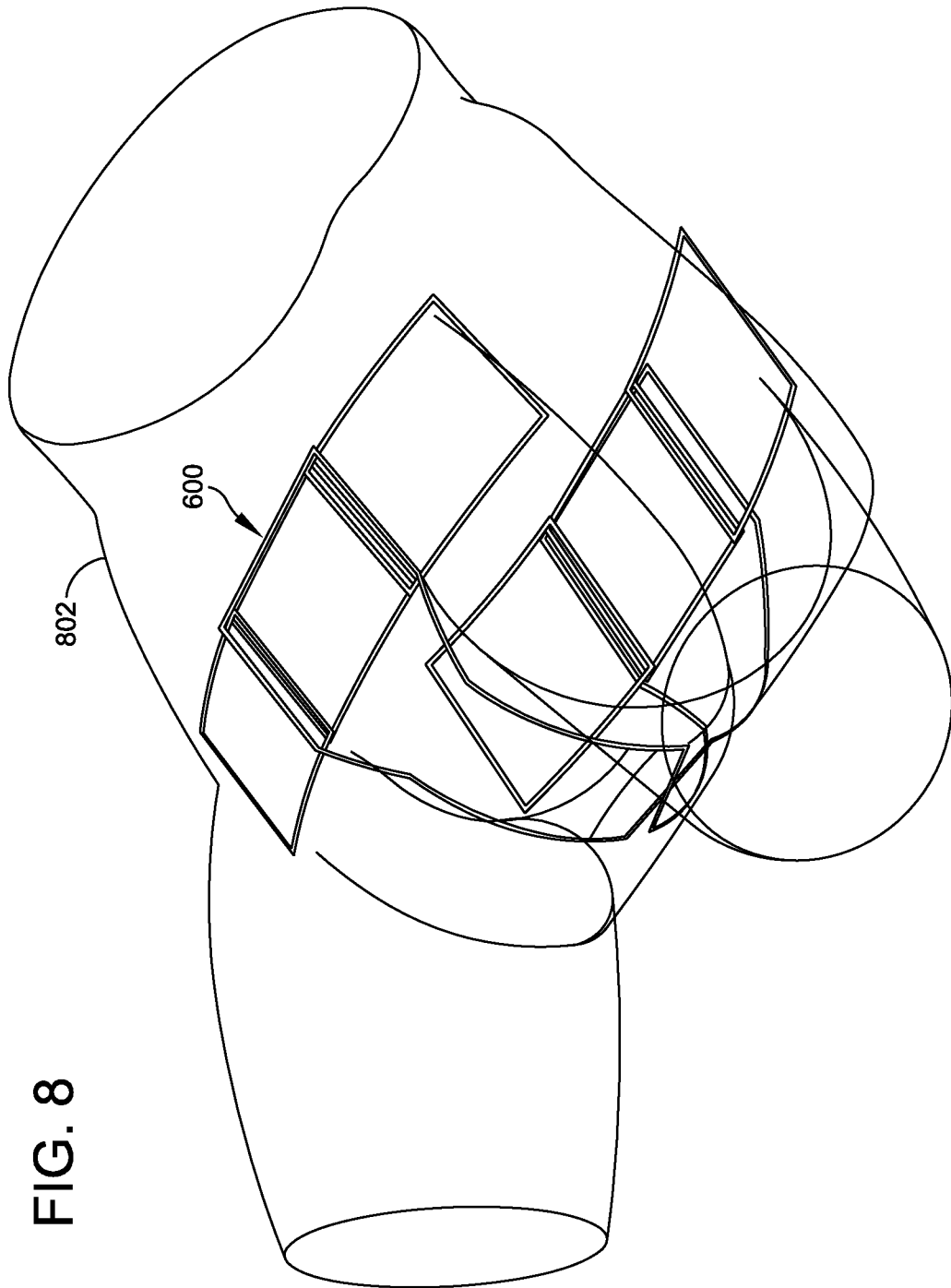
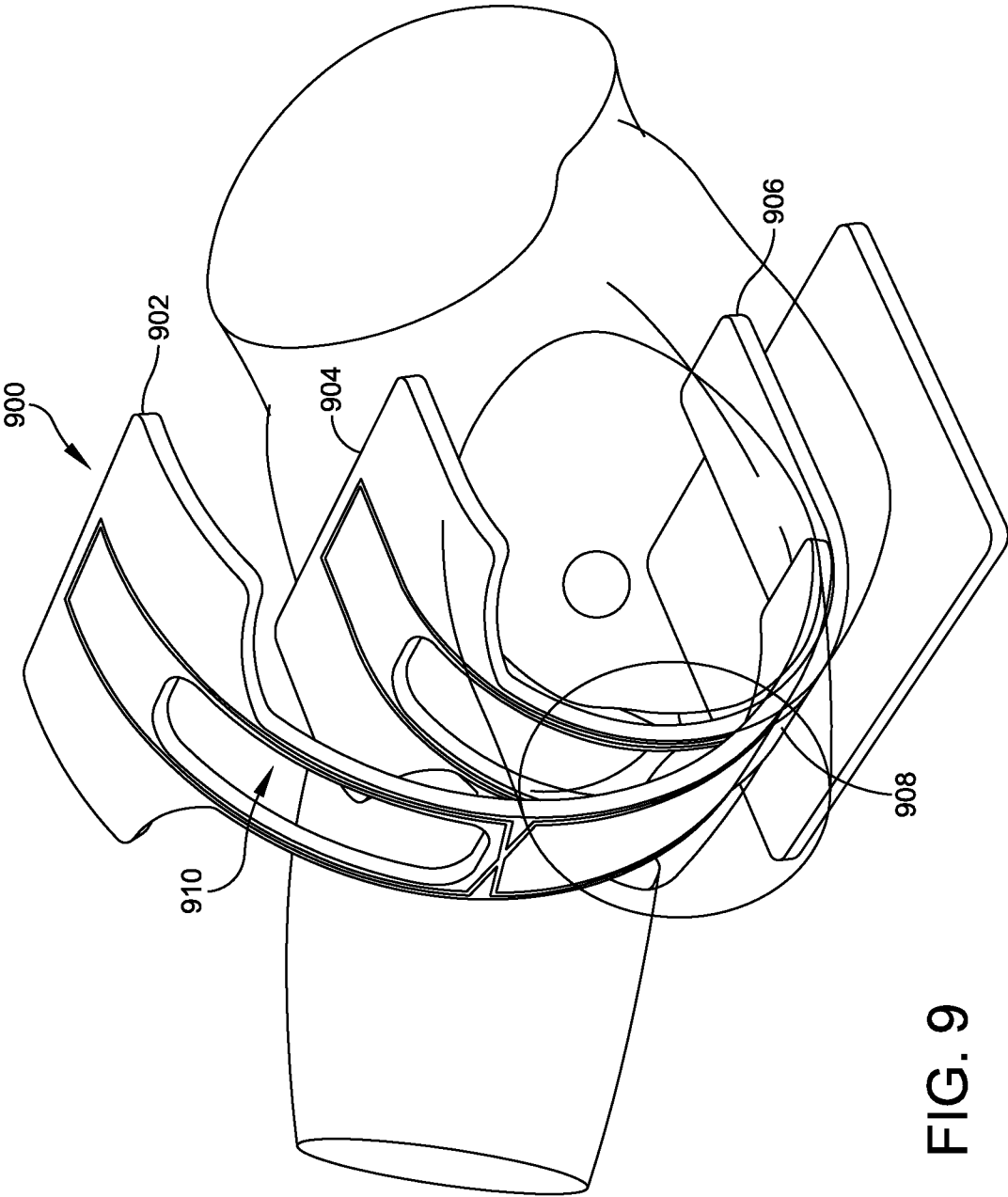


FIG. 8



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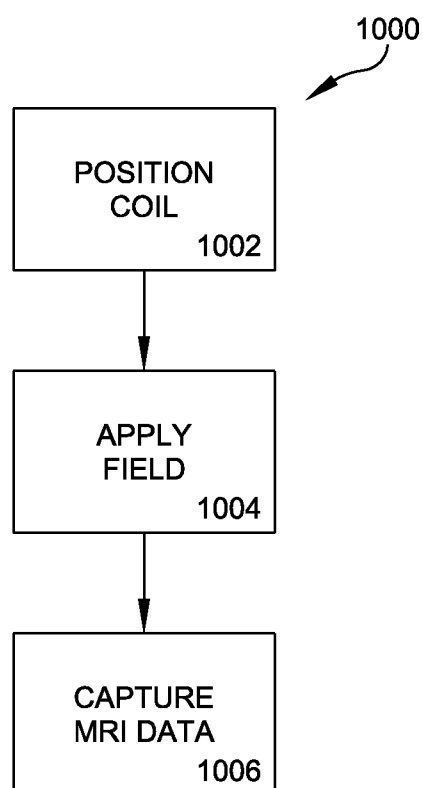


FIG. 10

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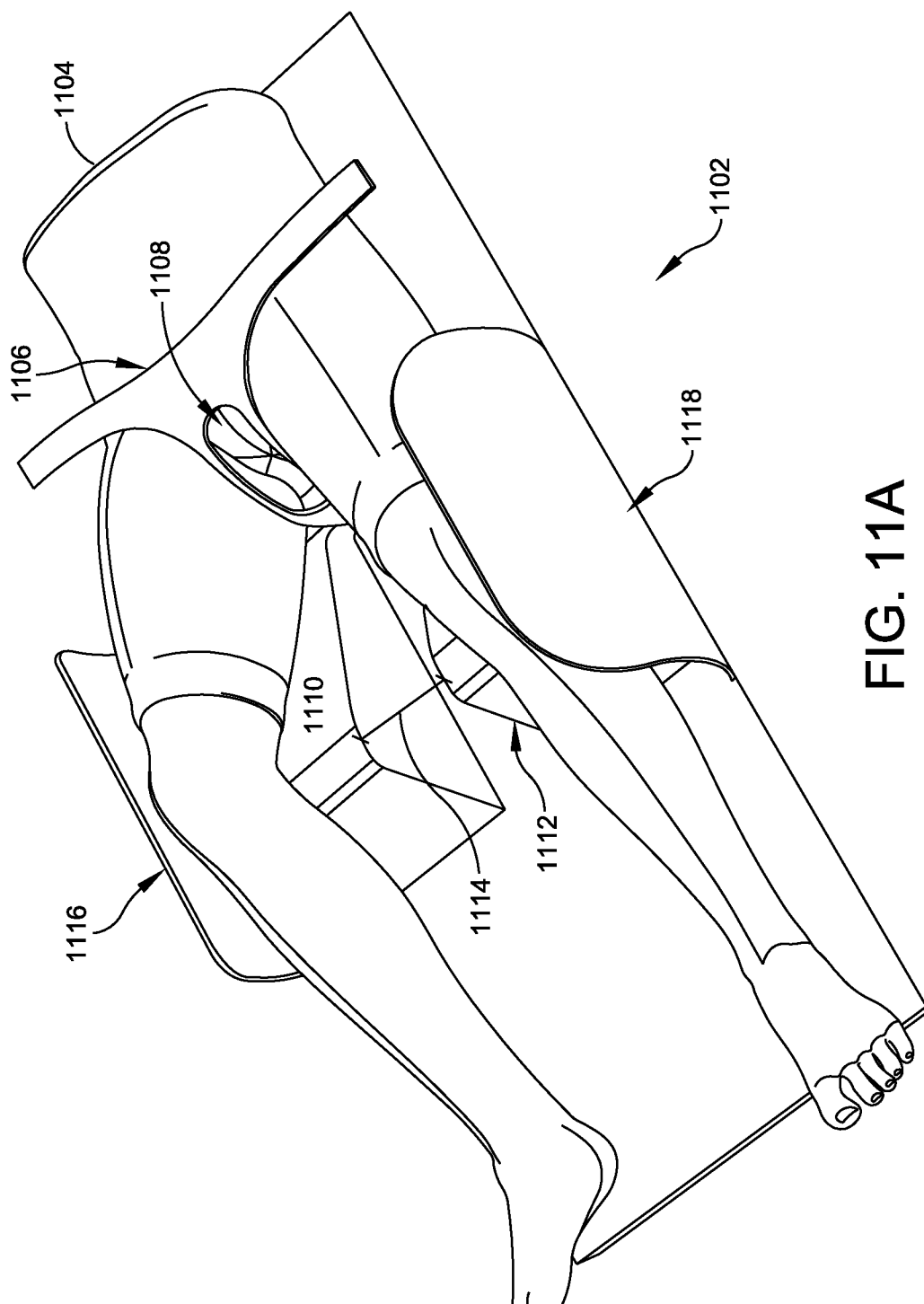


FIG. 11A

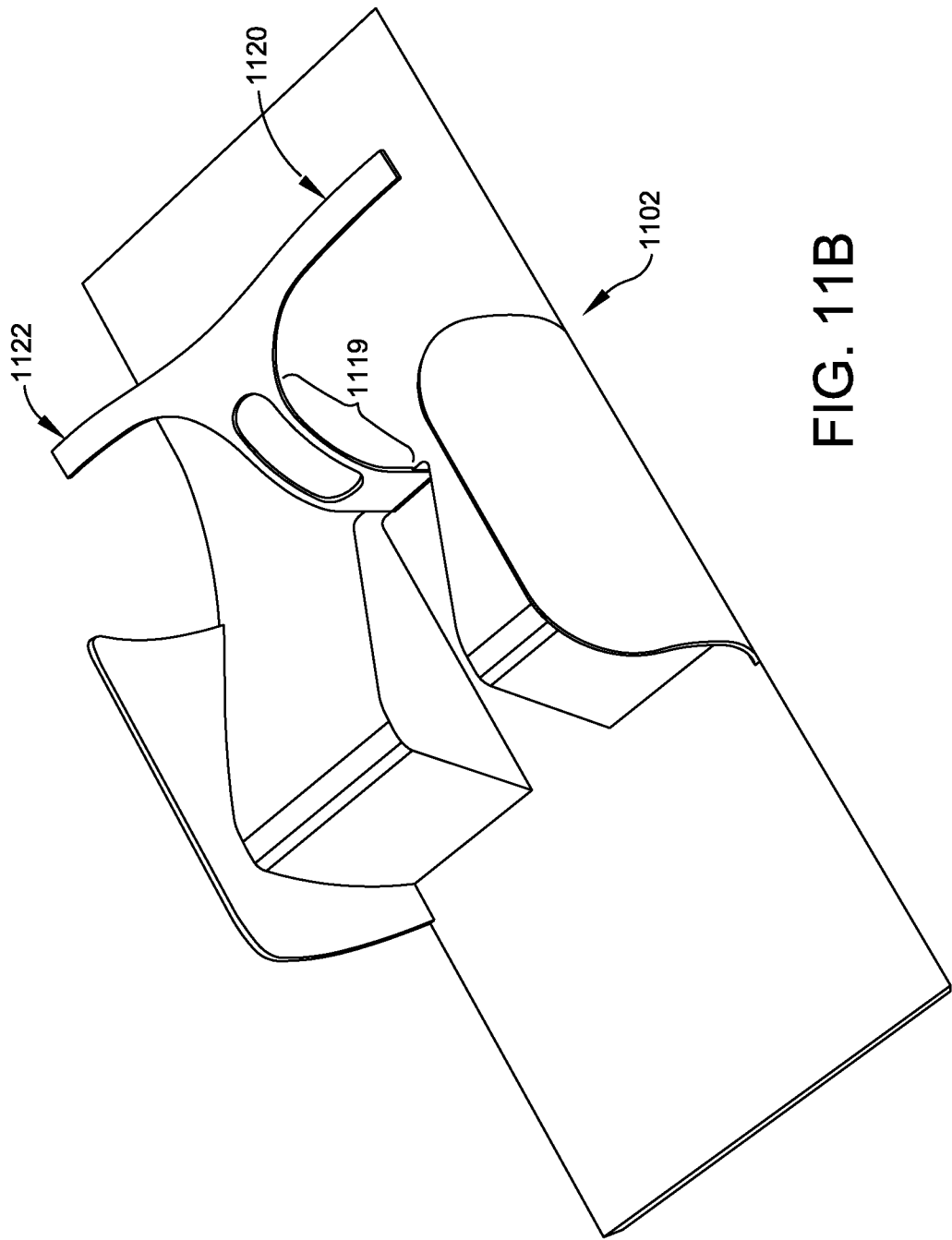
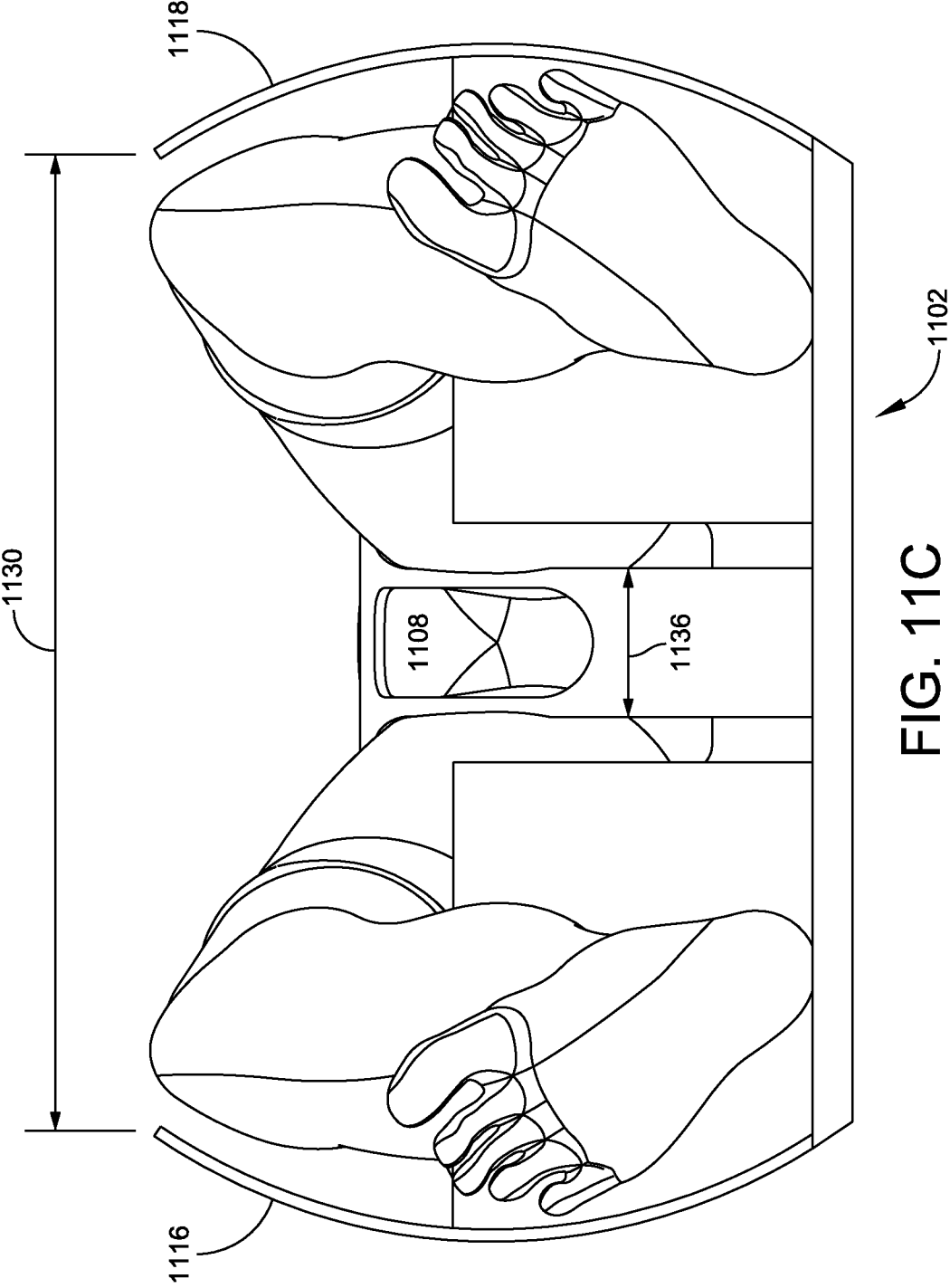


FIG. 11B



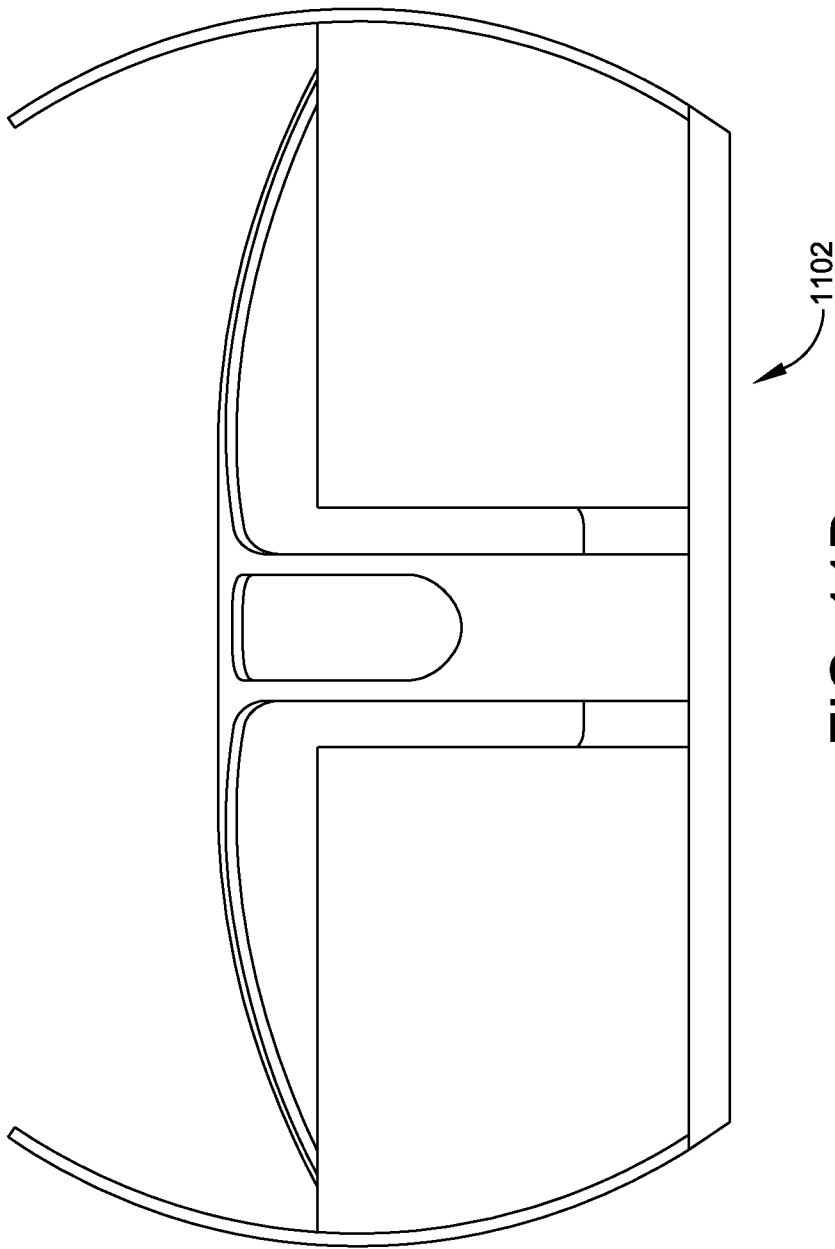


FIG. 11D

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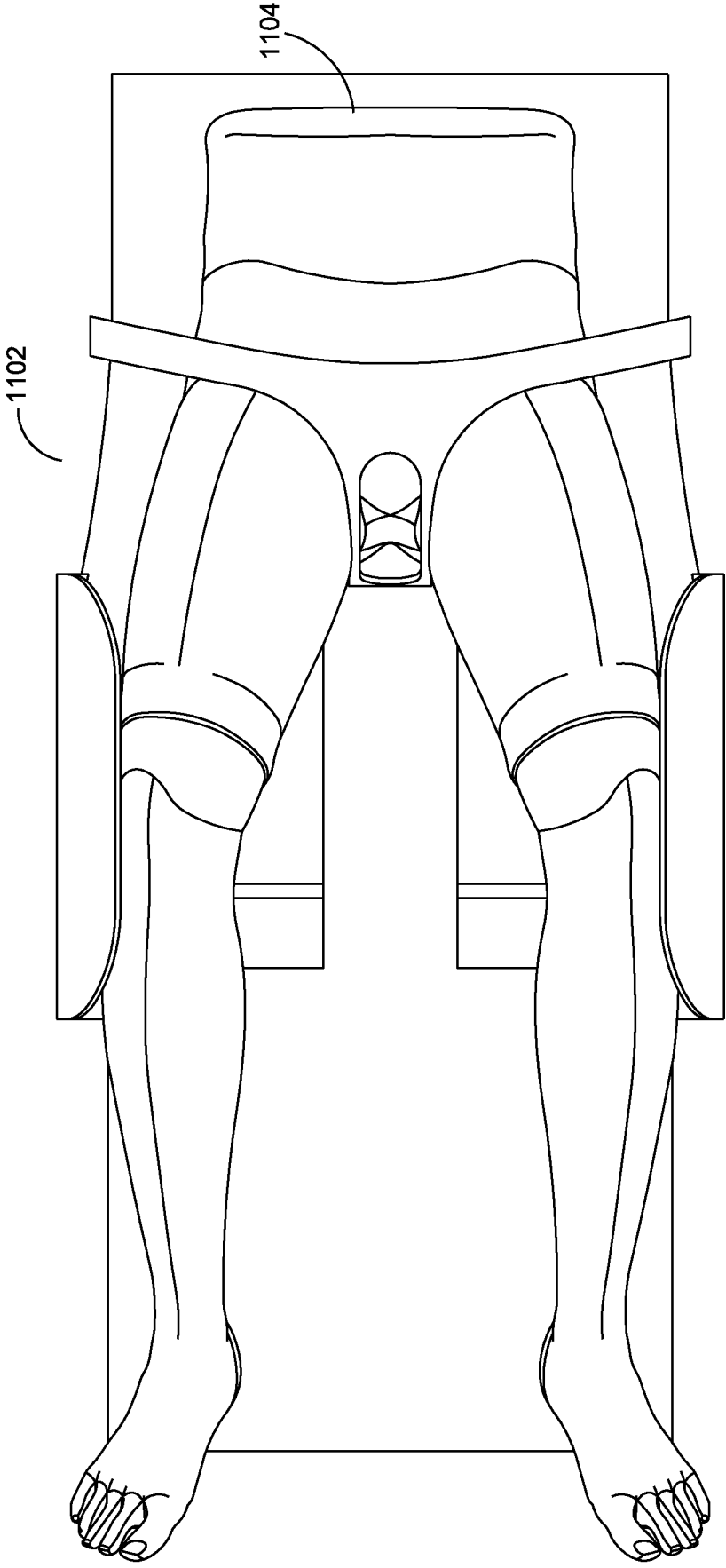


FIG. 11E

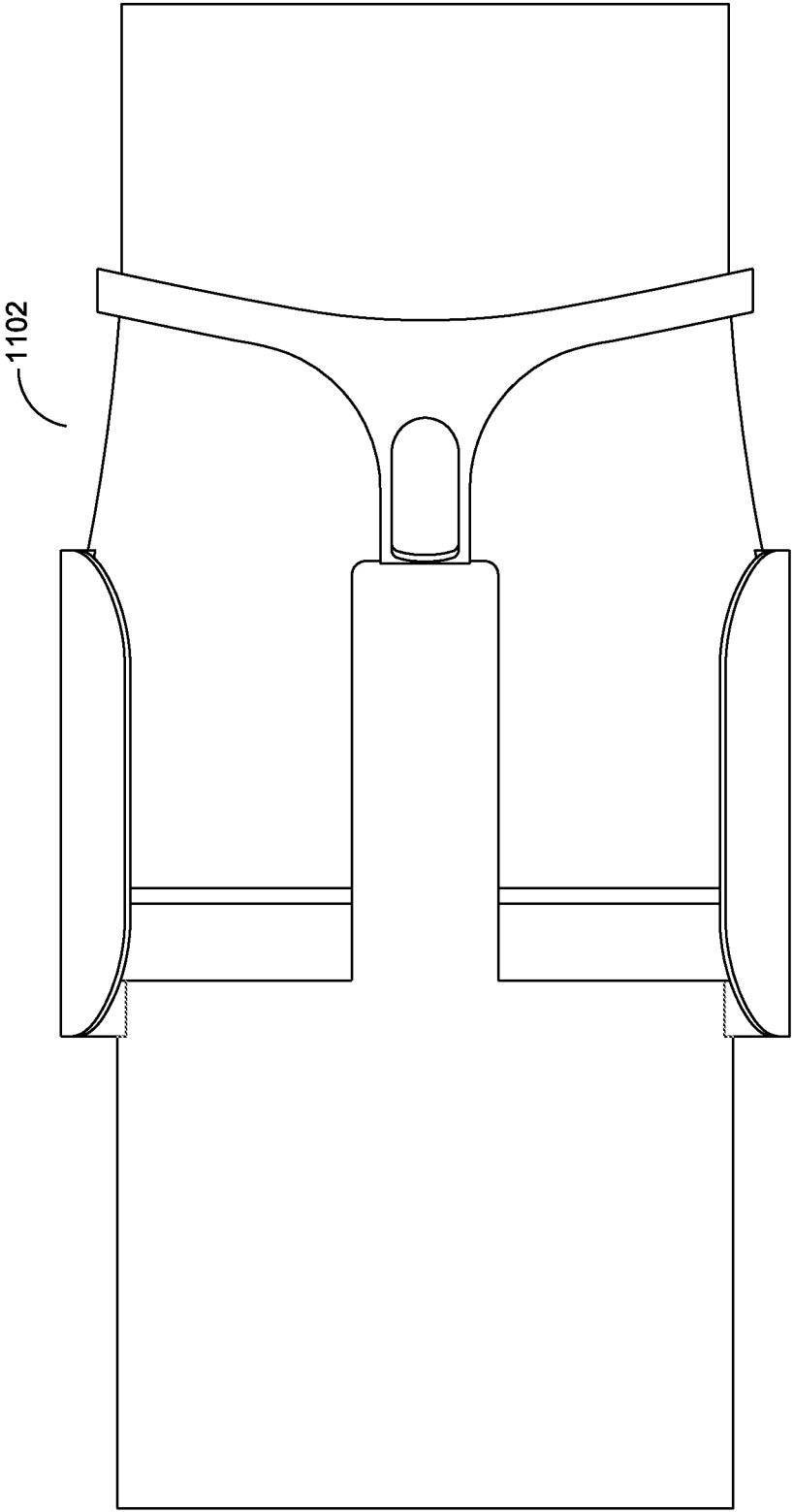


FIG. 11F

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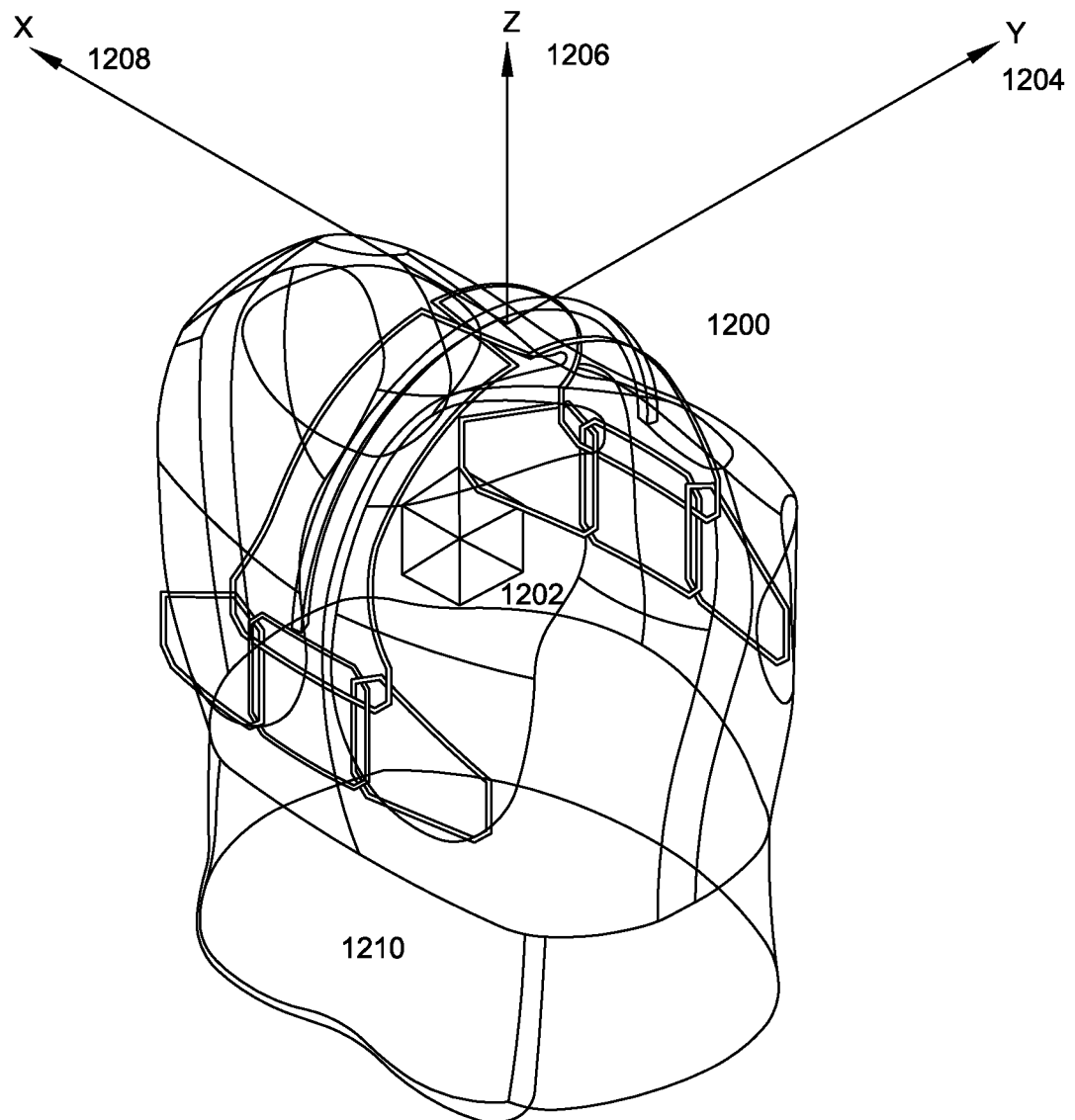


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/022439**A. CLASSIFICATION OF SUBJECT MATTER****A61B 5/055(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B 5/055; A61B 5/05; G01V 3/00; A61F 13/14; G01R 33/44

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: pelvic, coil, MRI, housing, aperture

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012-0293174 A1 (VICTOR TARACILA et al.) 22 November 2012 See abstract, paragraphs [0026]-[0040], claims 1-20 and figures 1-7.	1-12, 17-23
Y		13-16, 24-38
Y	US 5307806 A (RANDALL W. JONES) 03 May 1994 See abstract, column 2, line 61 - column 4, line 42, claims 1-5 and figures 1-4.	13-16, 24-38
A	US 2003-0197508 A1 (MITSURU TAMURA et al.) 23 October 2003 See abstract, paragraphs [0072]-[0076], claims 1-8 and figures 4-7.	1-38
A	US 2004-0002648 A1 (KARL ENGELHARD et al.) 01 January 2004 See abstract, paragraphs [0037]-[0048], claims 1-17 and figures 3-6.	1-38
A	KR 20-0193367 Y1 (CHANG YEUN LEE) 16 August 2000 See abstract, page 2, claims 1-5 and figure 1.	1-38



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

29 July 2014 (29.07.2014)

Date of mailing of the international search report

30 July 2014 (30.07.2014)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/022439

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