US 20240184134A1

(19) United States
(12) Patent Application Publication
Anderson et al.

(10) Pub. No.: US 2024/0184134 A1
(43) Pub. Date: Jun. 6, 2024

(54) DUAL-AXIS HINGE MECHANISM

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Jonathan M. Anderson**, Mountain View, CA (US); **John Raff**, Menlo Park, CA (US); **Teodor Dabov**, San Francisco, CA (US)

(21) Appl. No.: **18/441,933**

(22) Filed: **Feb. 14, 2024**

Related U.S. Application Data

(63) Continuation of application No. PCT/US2022/075298, filed on Aug. 22, 2022.

(60) Provisional application No. 63/260,587, filed on Aug. 26, 2021.

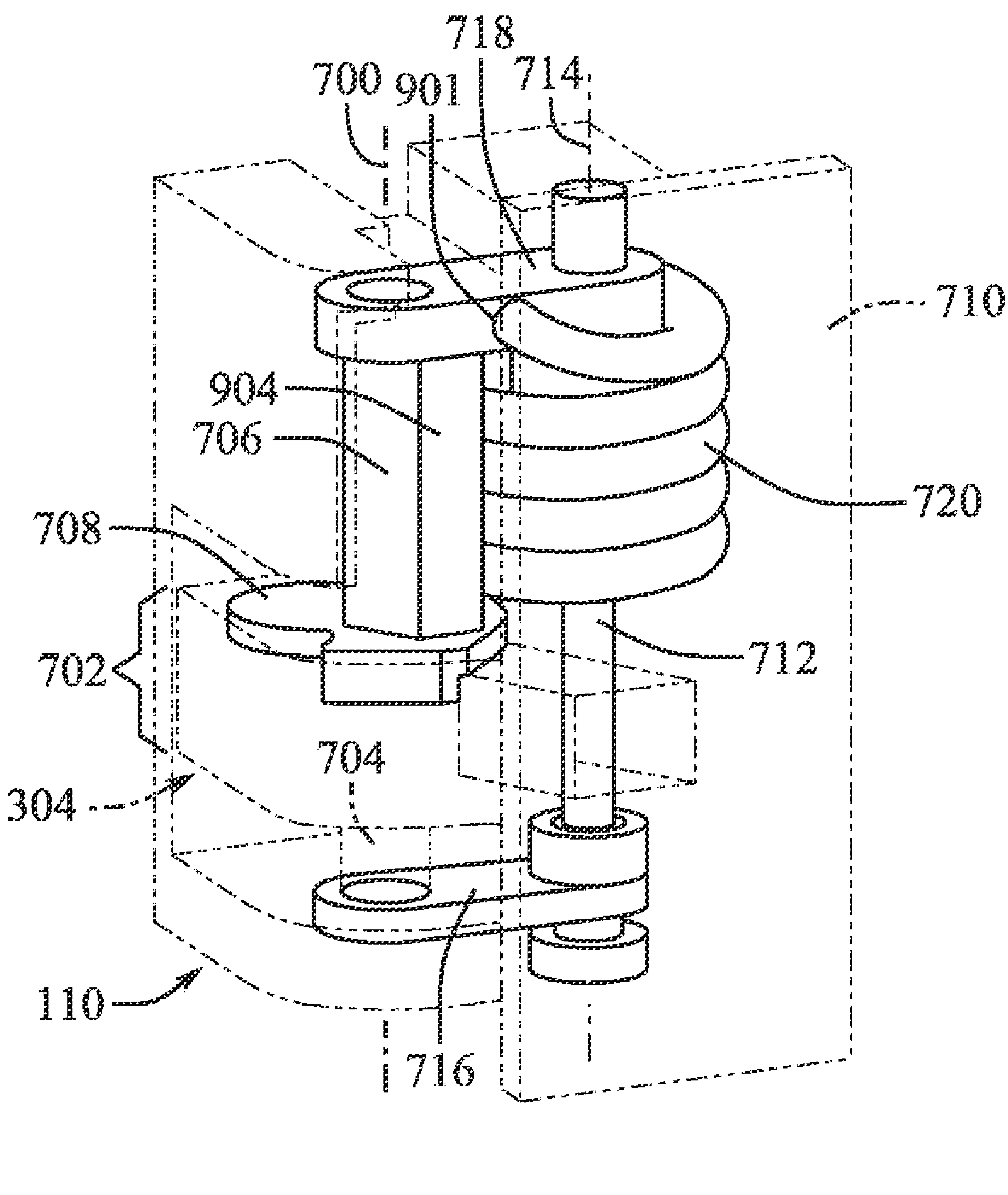
Publication Classification

(51) **Int. Cl.**
G02C 5/22 (2006.01)

(52) **U.S. Cl.**
CPC *G02C 5/2209* (2013.01)

(57) **ABSTRACT**

Eyewear includes a frame connected to an arm using a hinge mechanism that enables movement of the arm to a folded position, a nominal position, and a hyperextended position. In the nominal position, gaps and exposure of any electronic components of the eyewear are minimized or eliminated. A hinge with multiple axes of rotation of different parts allows the arm to automatically snap between multiple stable positions relative to the frame while also being able to flex and apply a clamping force to a wide array of heads. A cable or other electrical connector can extend through a portion of the hinge to protect and guide the cable between electronic parts in the arm and frame.



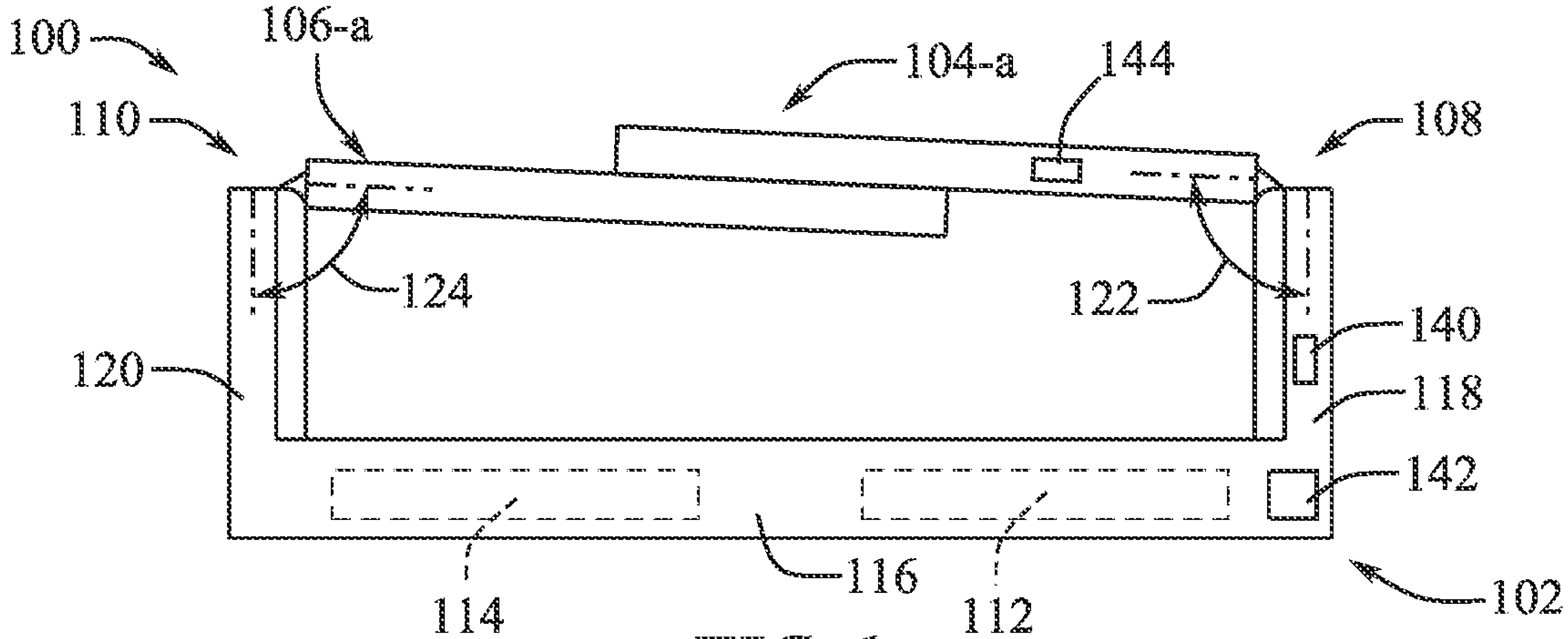

100
106-a
104-a
144
110
108
124
122
140
120
118
142
116
114
112
102

FIG. 1

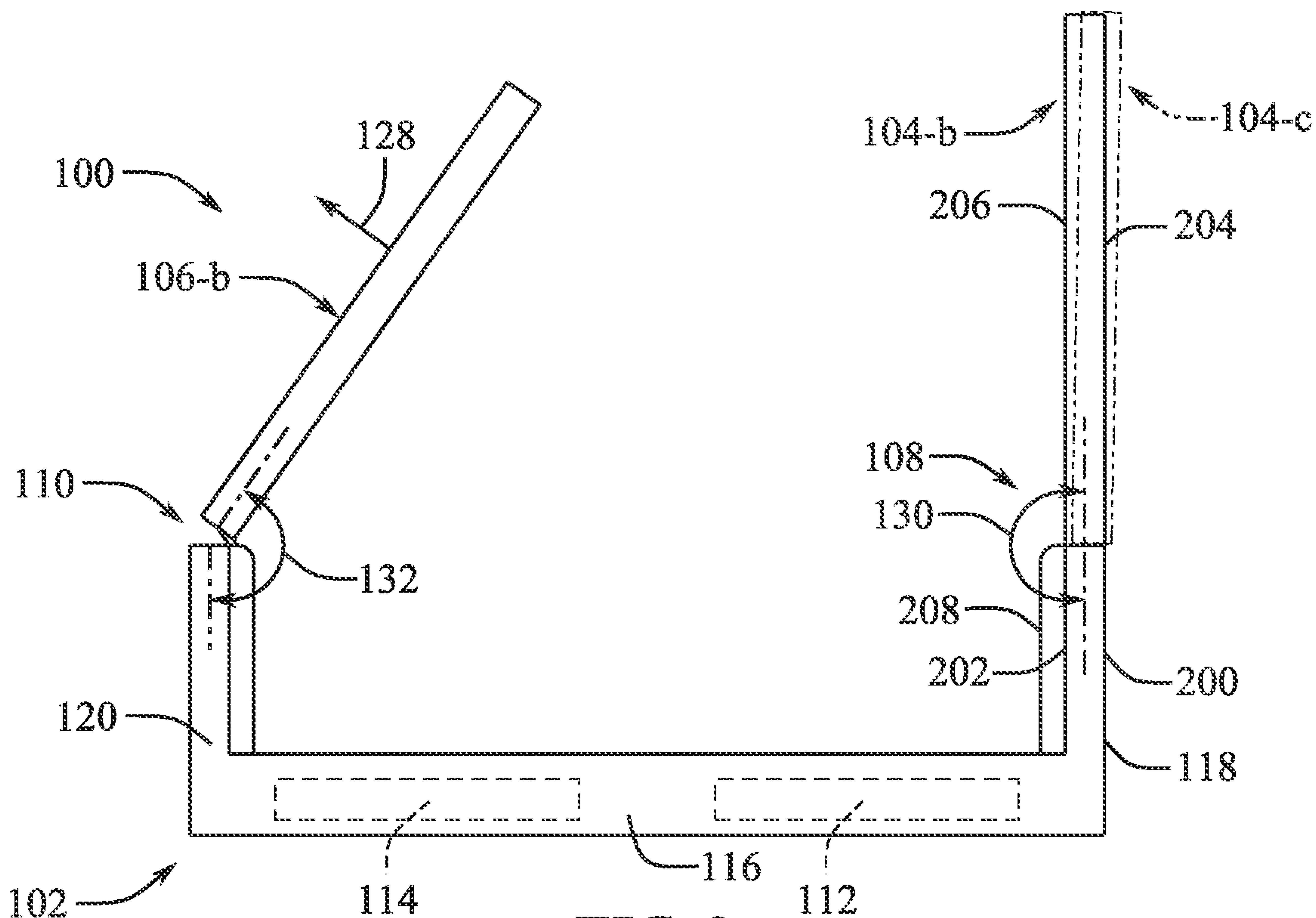

128
104-b
104-c
100
206
204
106-b
108
110
130
132
208
202
200
120
118
116
102
114
112

FIG. 2

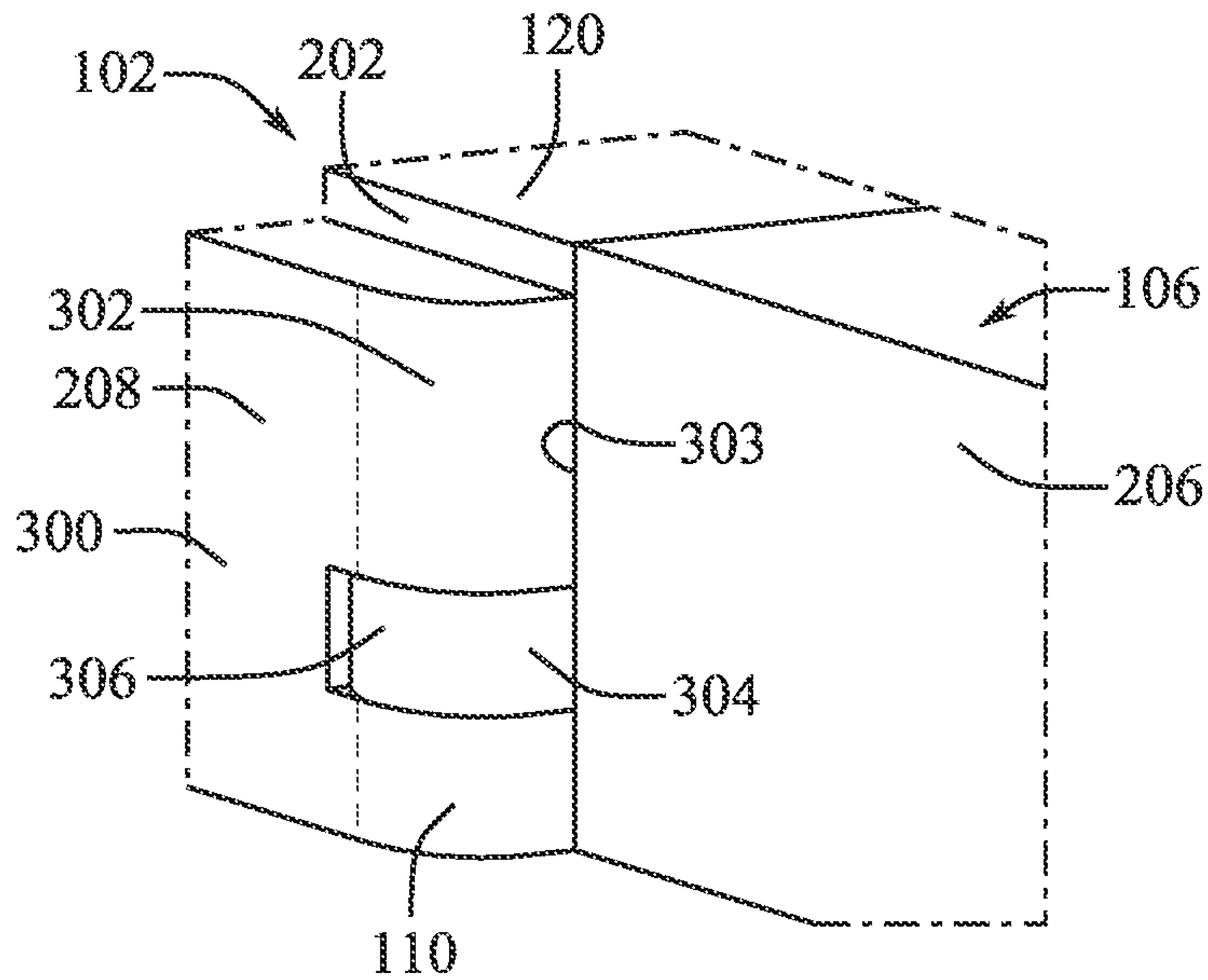

102
202
120
106
302
208
303
206
300
306
304
110

FIG. 3

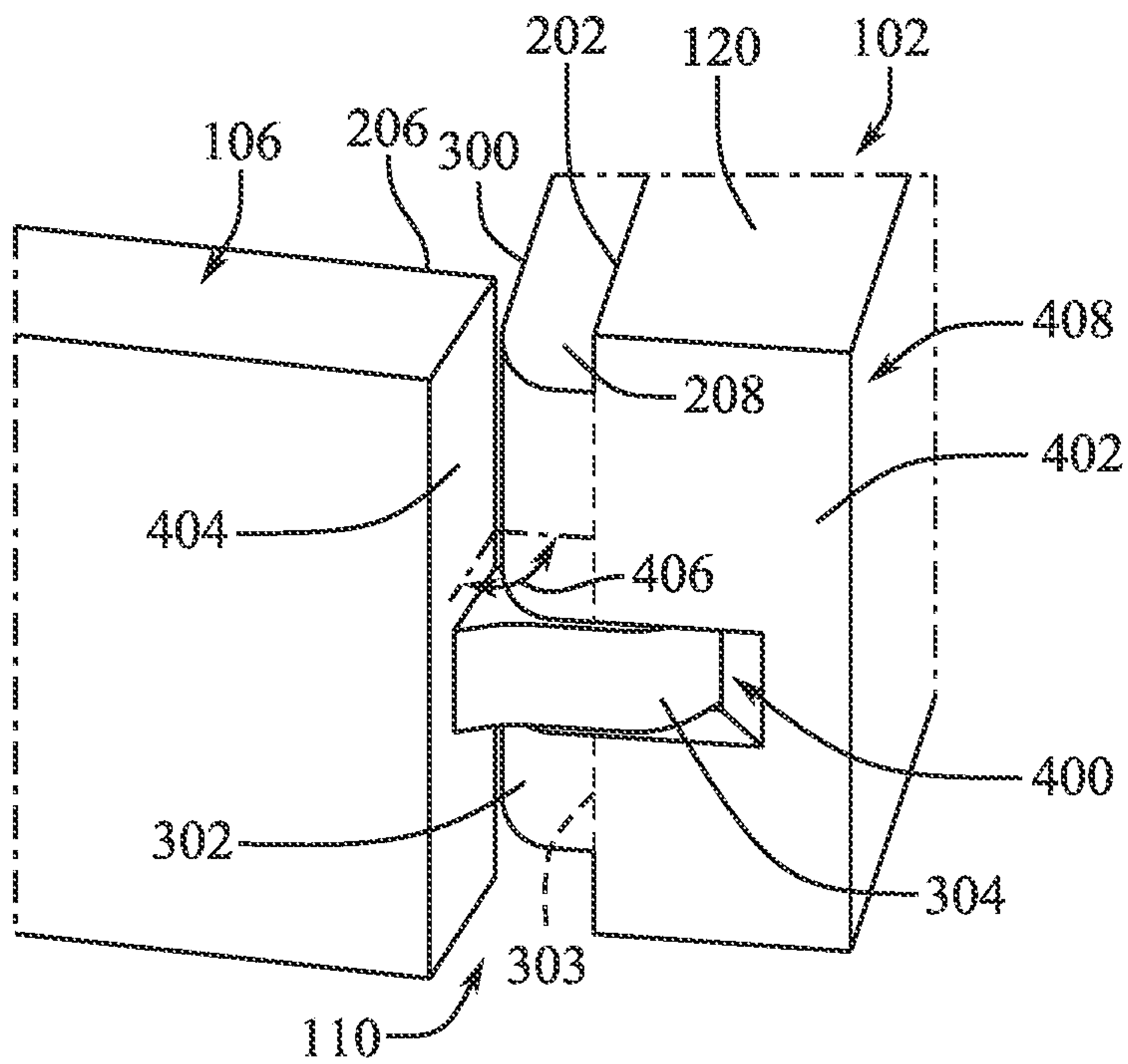

202
120
102
106
206
300
408
208
402
404
406
400
302
304
303
110

FIG. 4

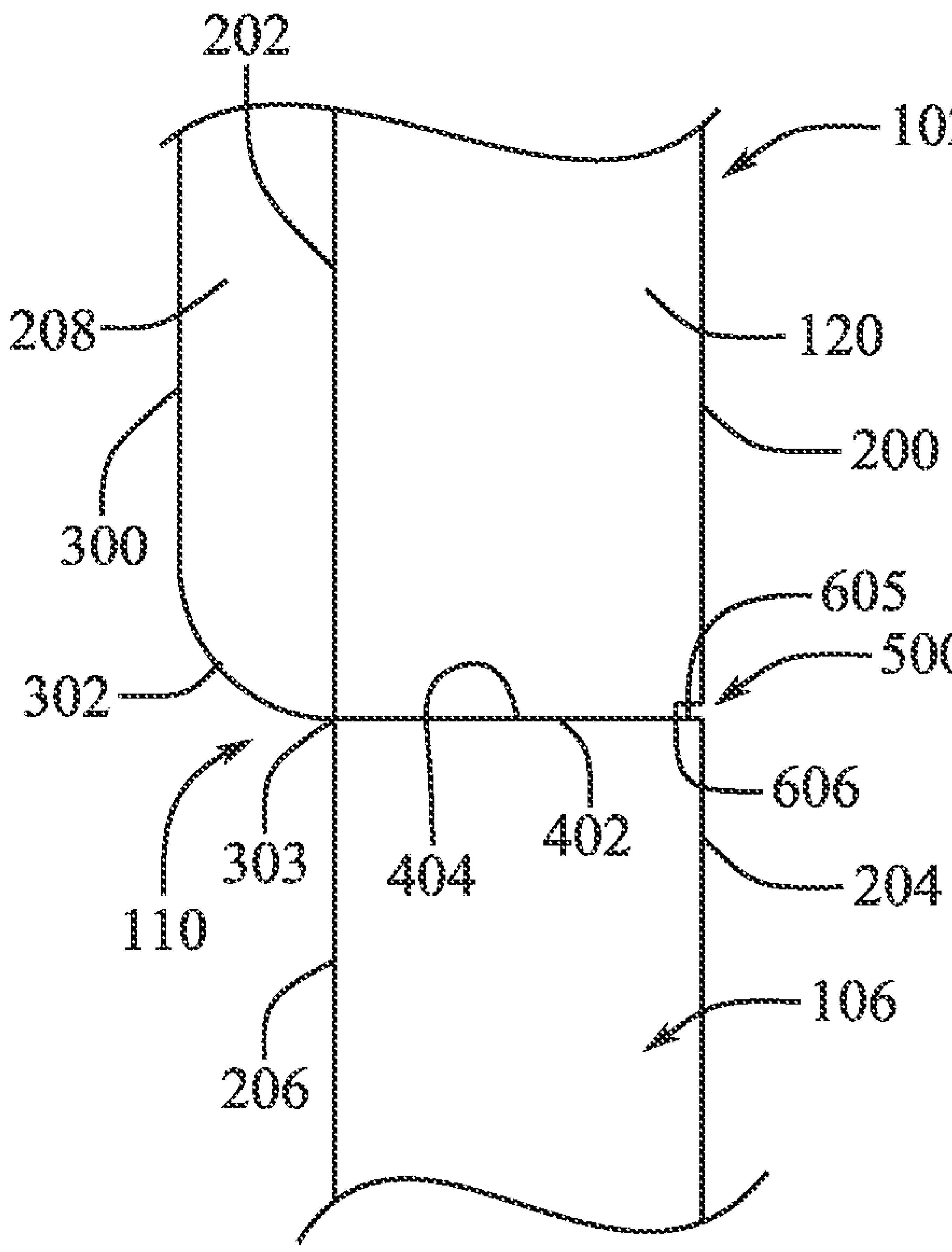


FIG. 5

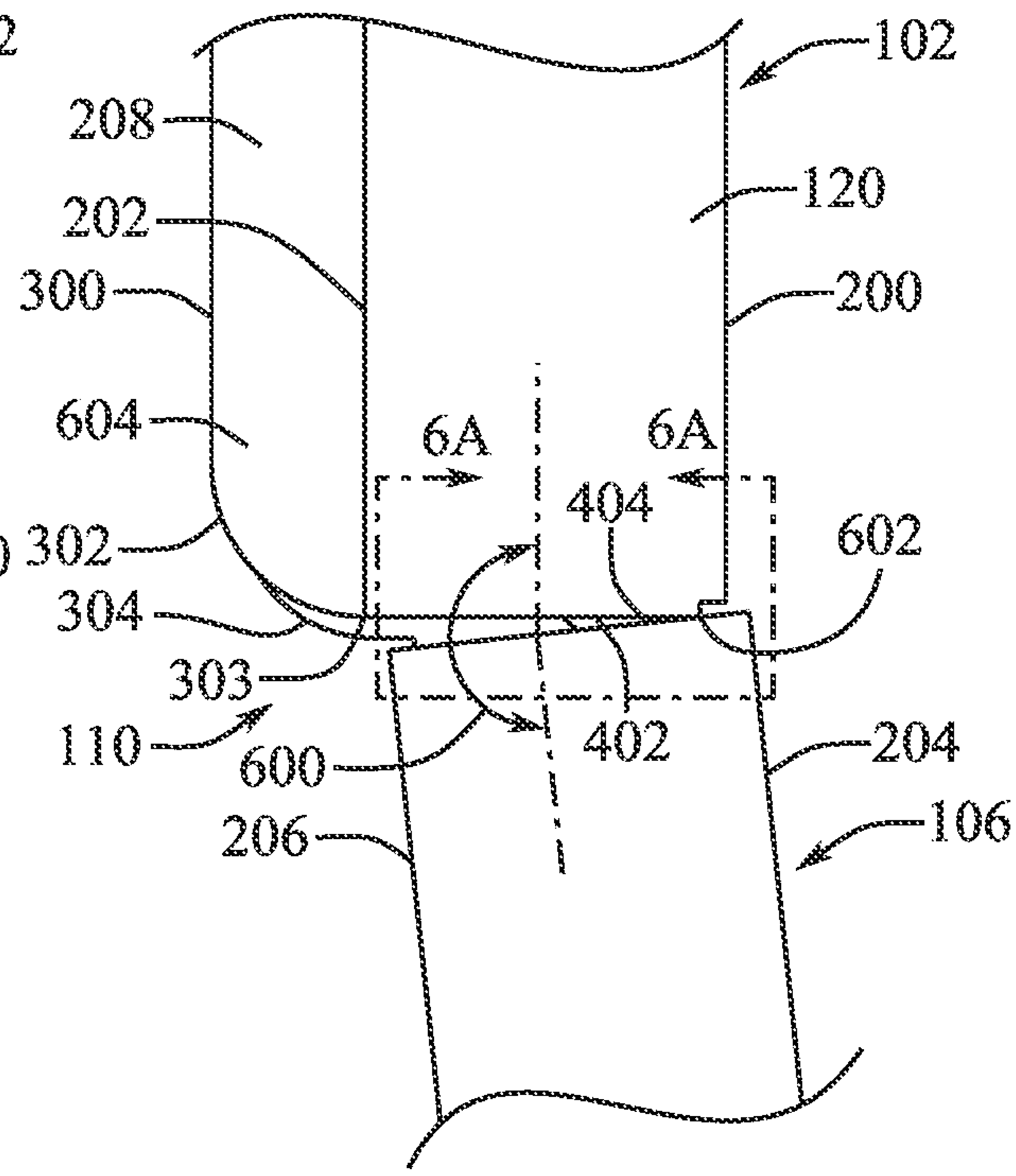


FIG. 6

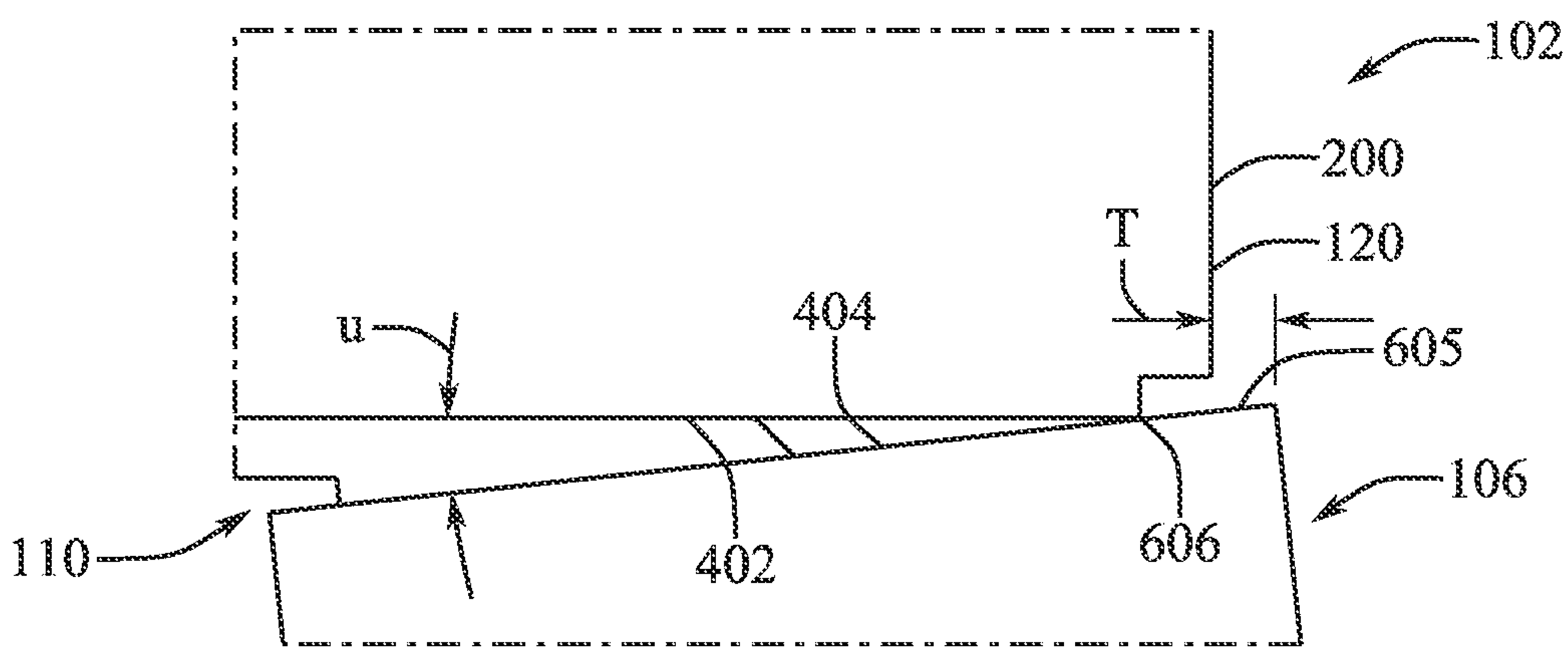


FIG. 6A

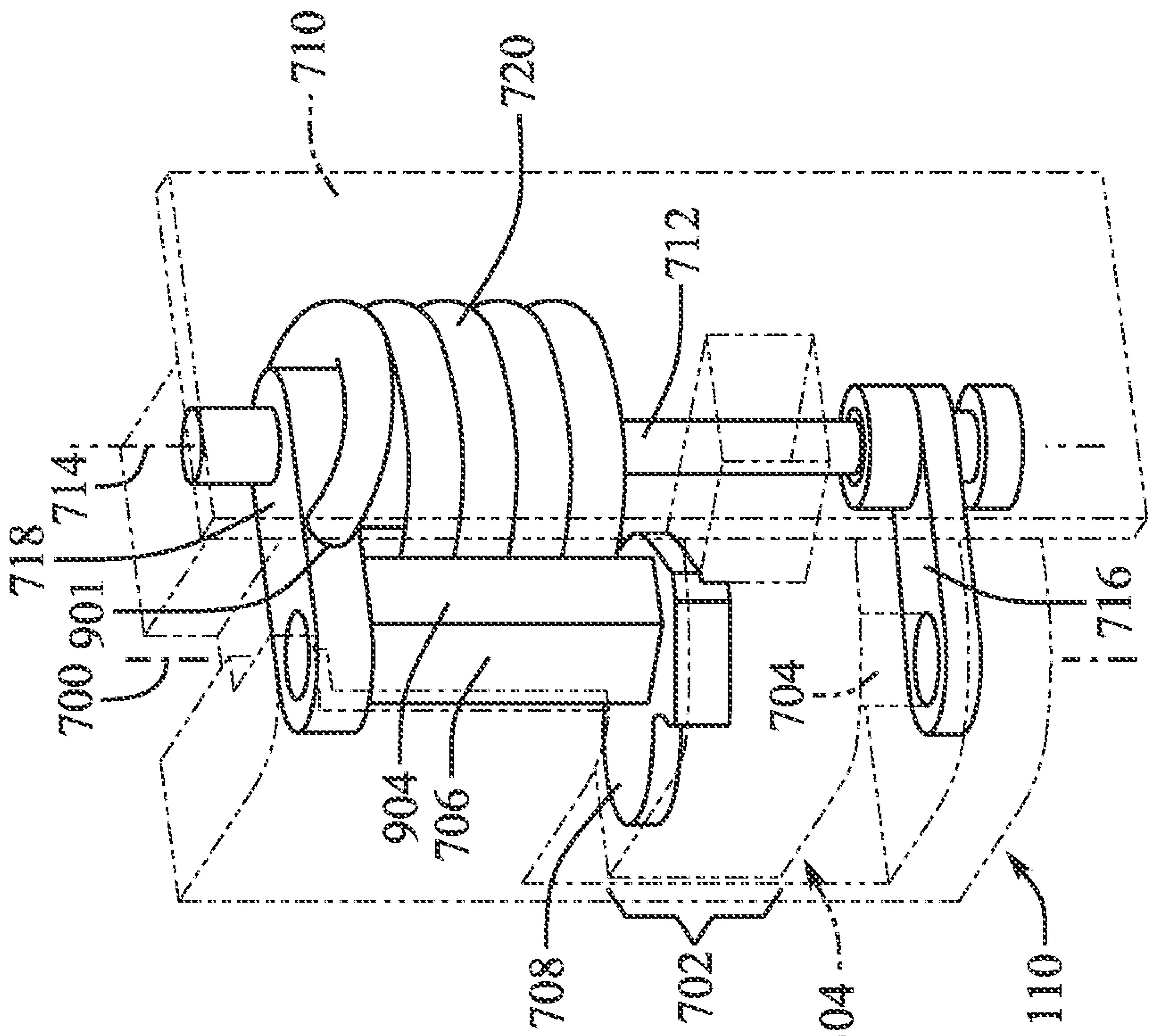

710
720
712
714
718
901
700
904
706
708
702
304
110
704
716

FIG. 8

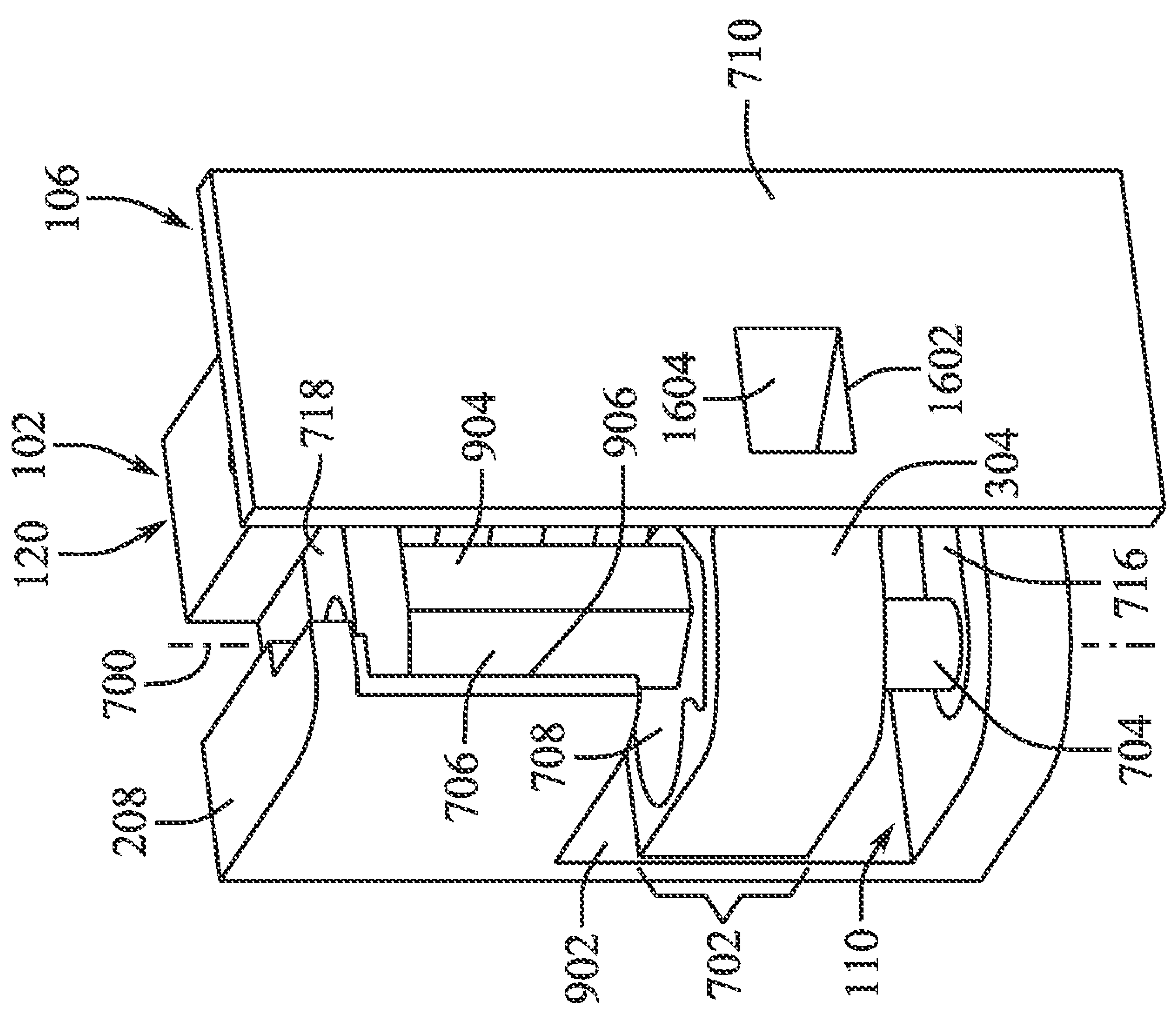

106
710
102
120
718
904
906
1604
1602
304
700
208
706
708
716
704
902
702
110

FIG. 7

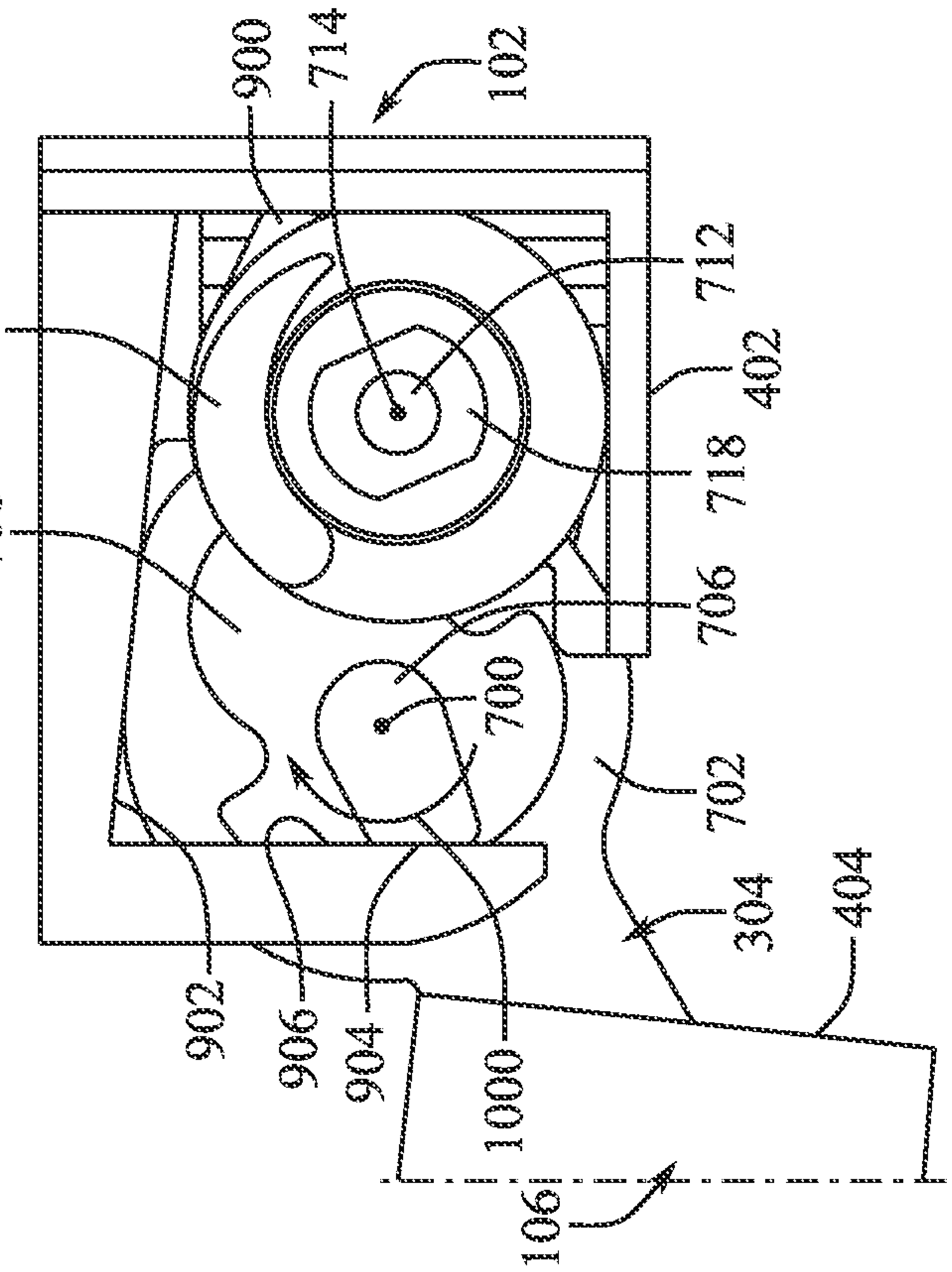

102
714
900
712
720
402
718
708
706
700
702
304
404
902
906
904
1000
106

FIG. 10

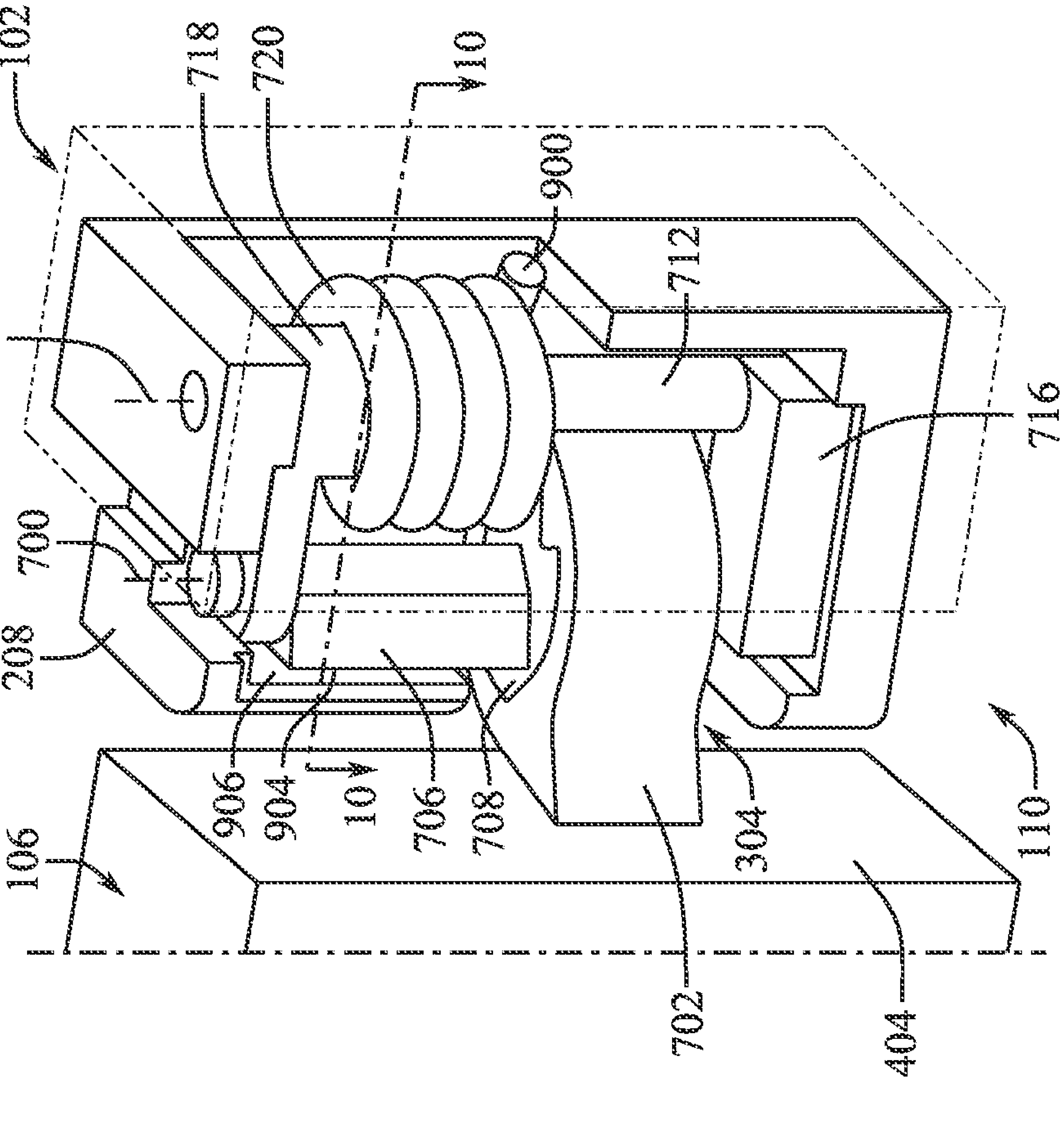

102
714
718
720
10
900
712
700
208
716
906
904
10
706
708
304
110
106
702
404

FIG. 9

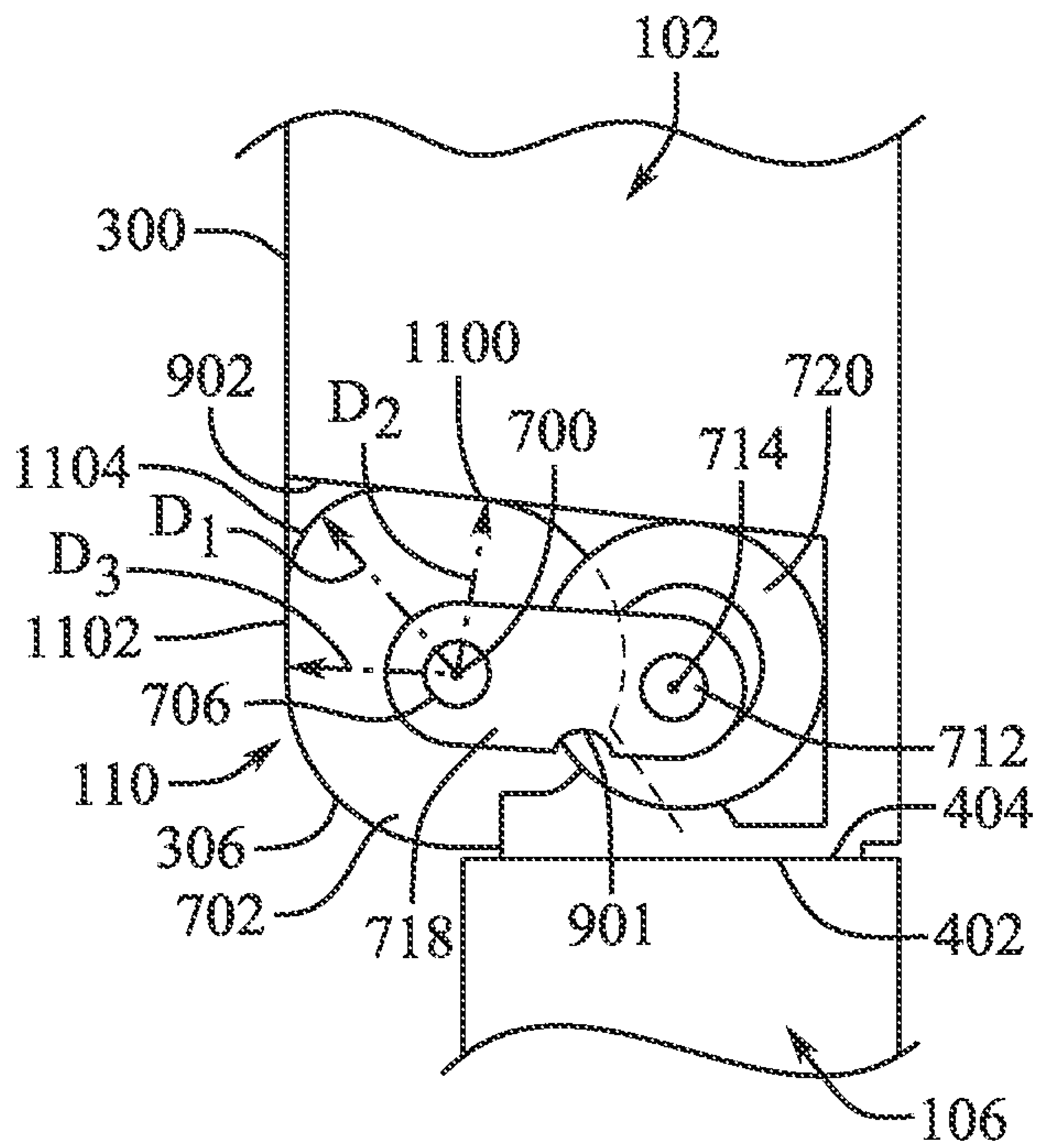


FIG. 11

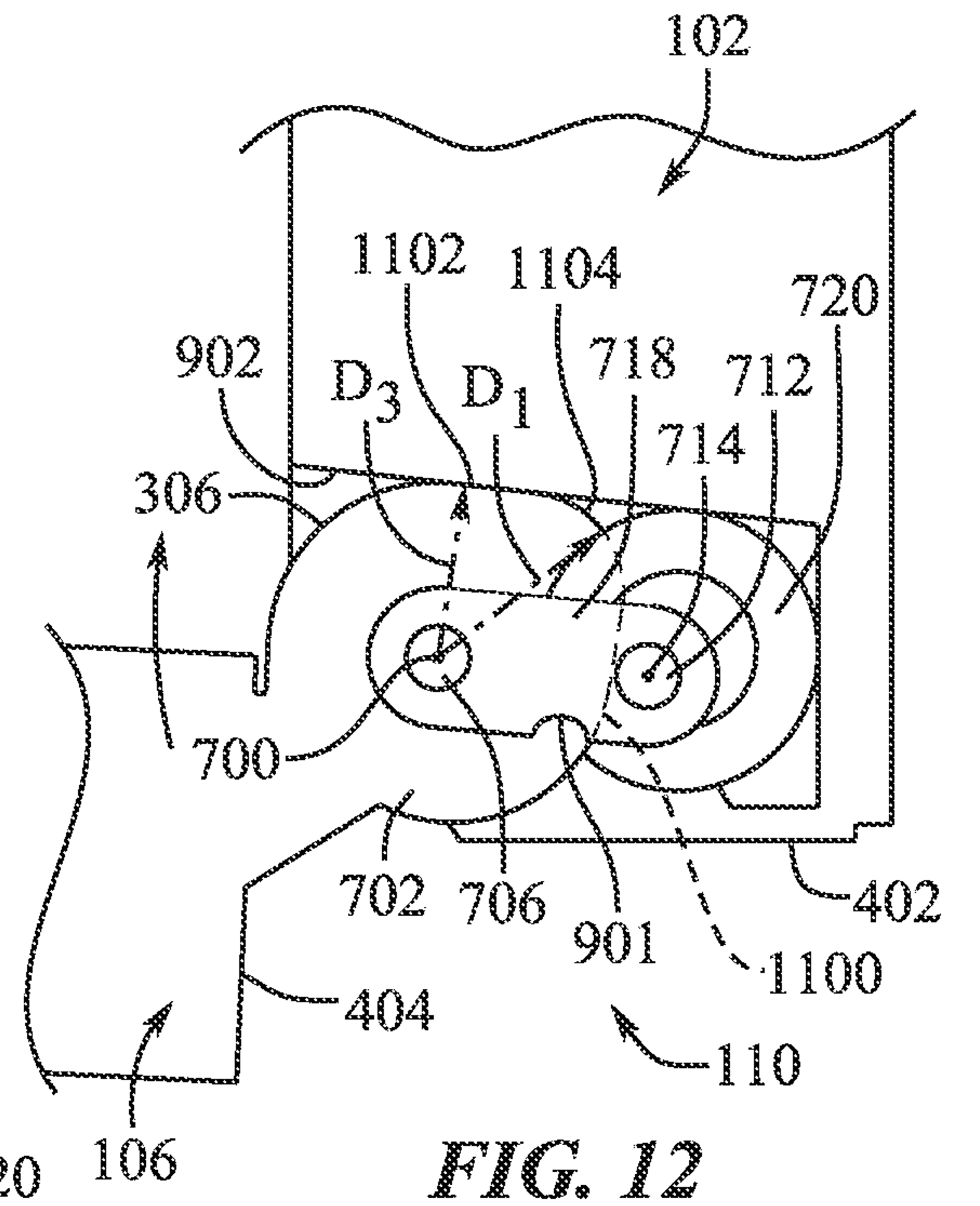


FIG. 12

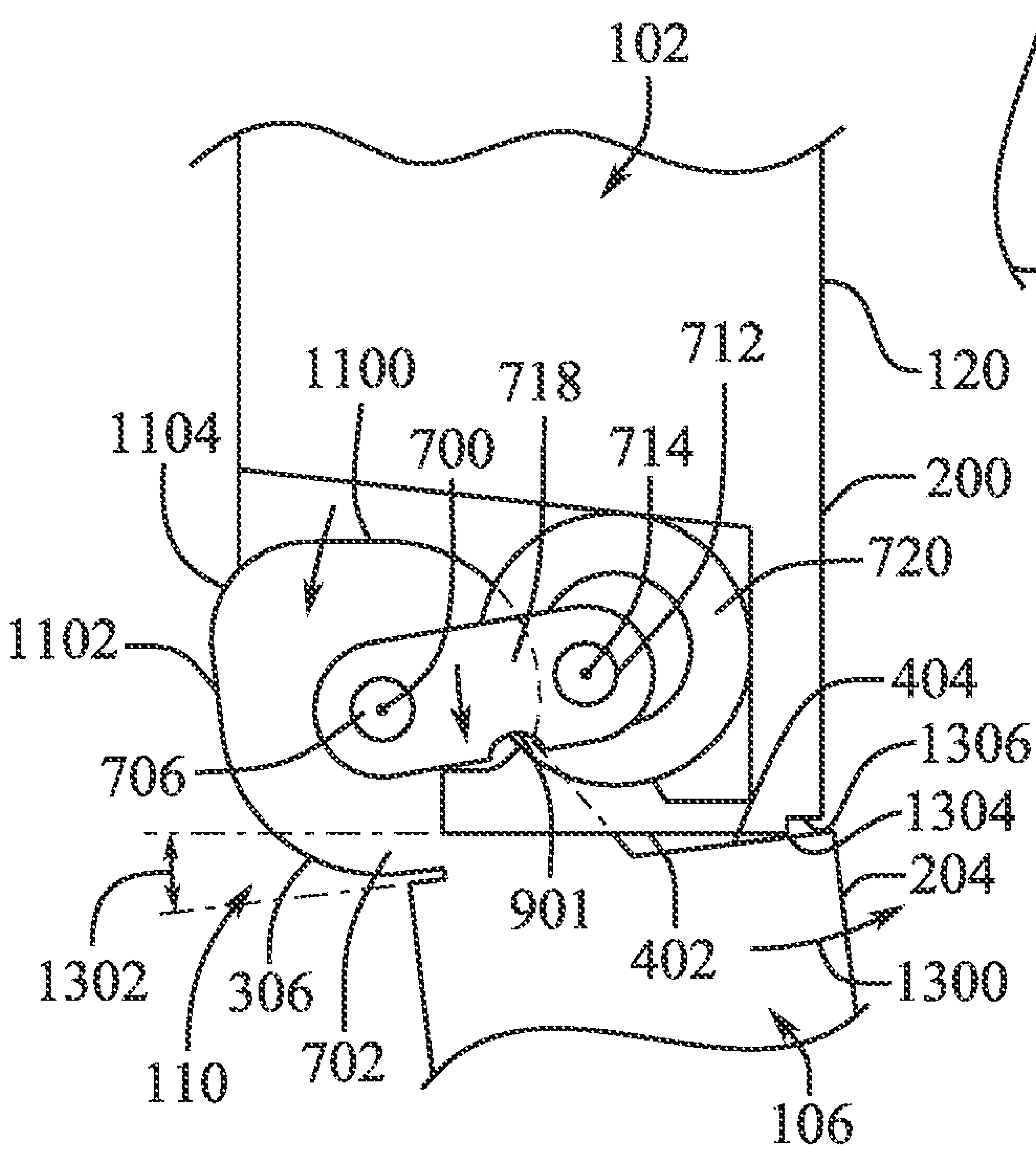


FIG. 13

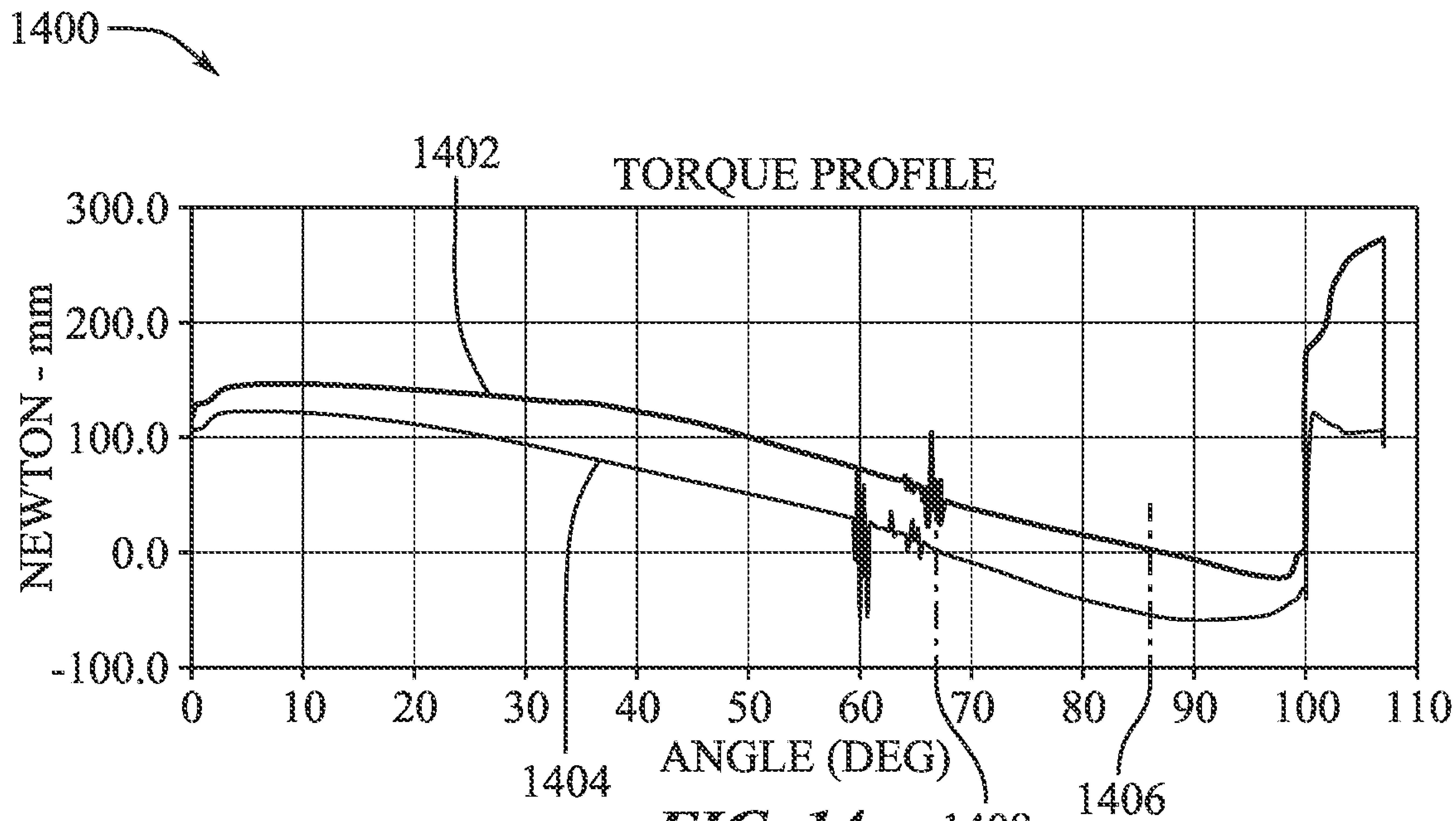

1400
1402
TORQUE PROFILE
300.0
200.0
100.0
0.0
-100.0
NEWTON - mm
0
10
20
30
40
50
60
70
80
90
100
110
ANGLE (DEG)
1404
1408
1406

FIG. 14

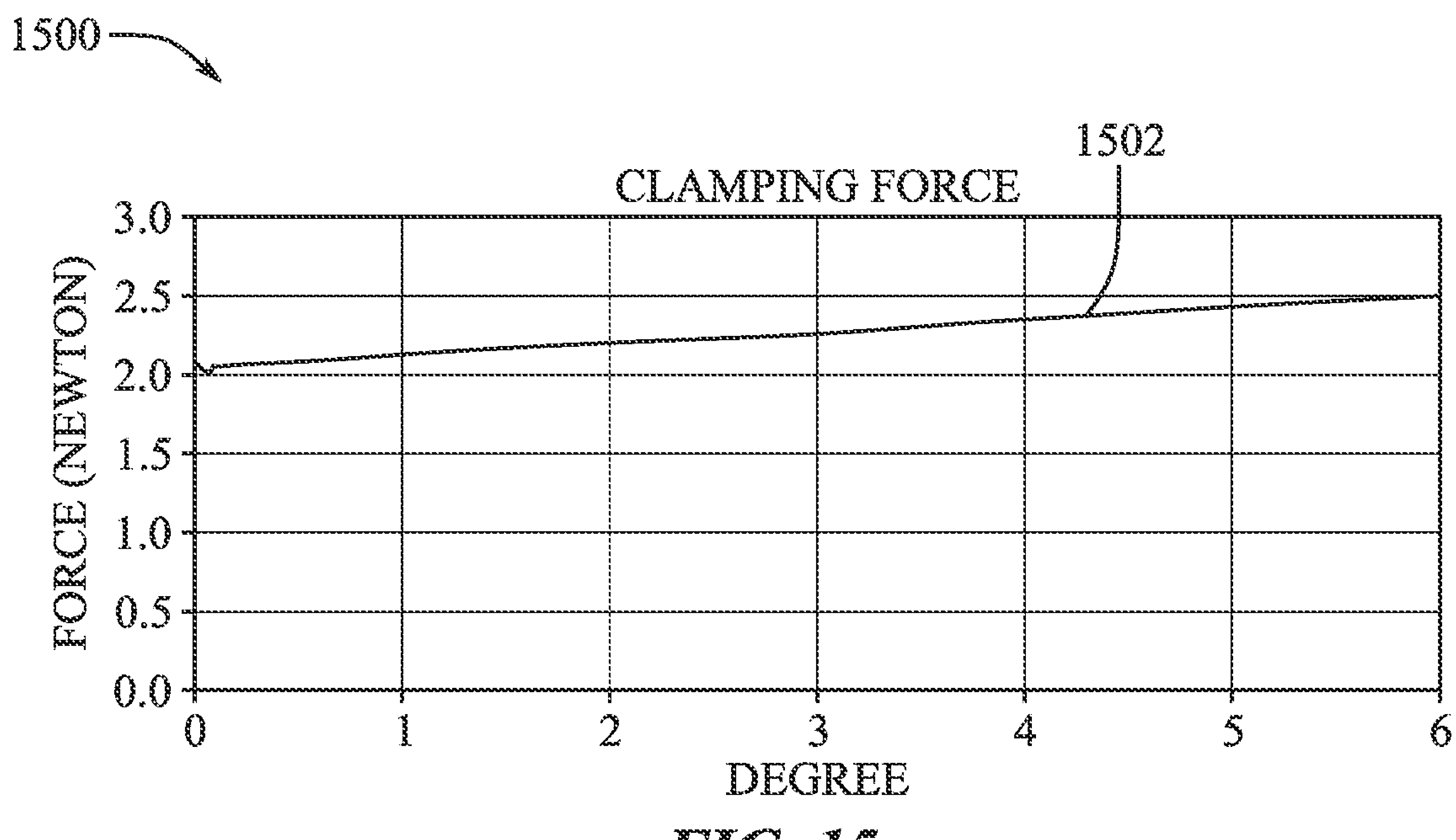

1500
1502
CLAMPING FORCE
3.0
2.5
2.0
1.5
1.0
0.5
0.0
FORCE (NEWTON)
0
1
2
3
4
5
6
DEGREE

FIG. 15

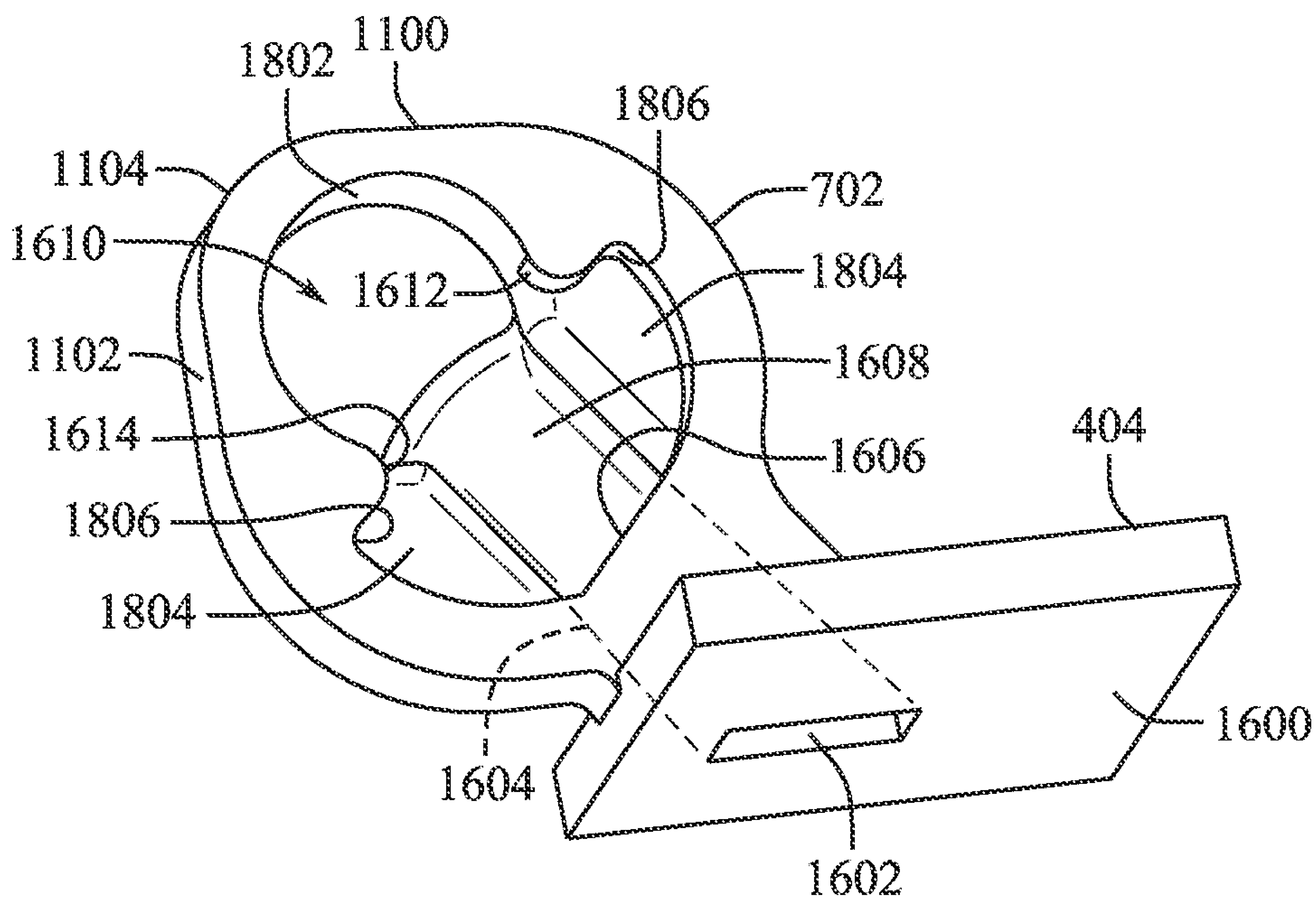

1100
1802
1806
1104
702
1610
1612
1804
1102
1608
1614
1606
404
1806
1804
1600
1604
1602

FIG. 16

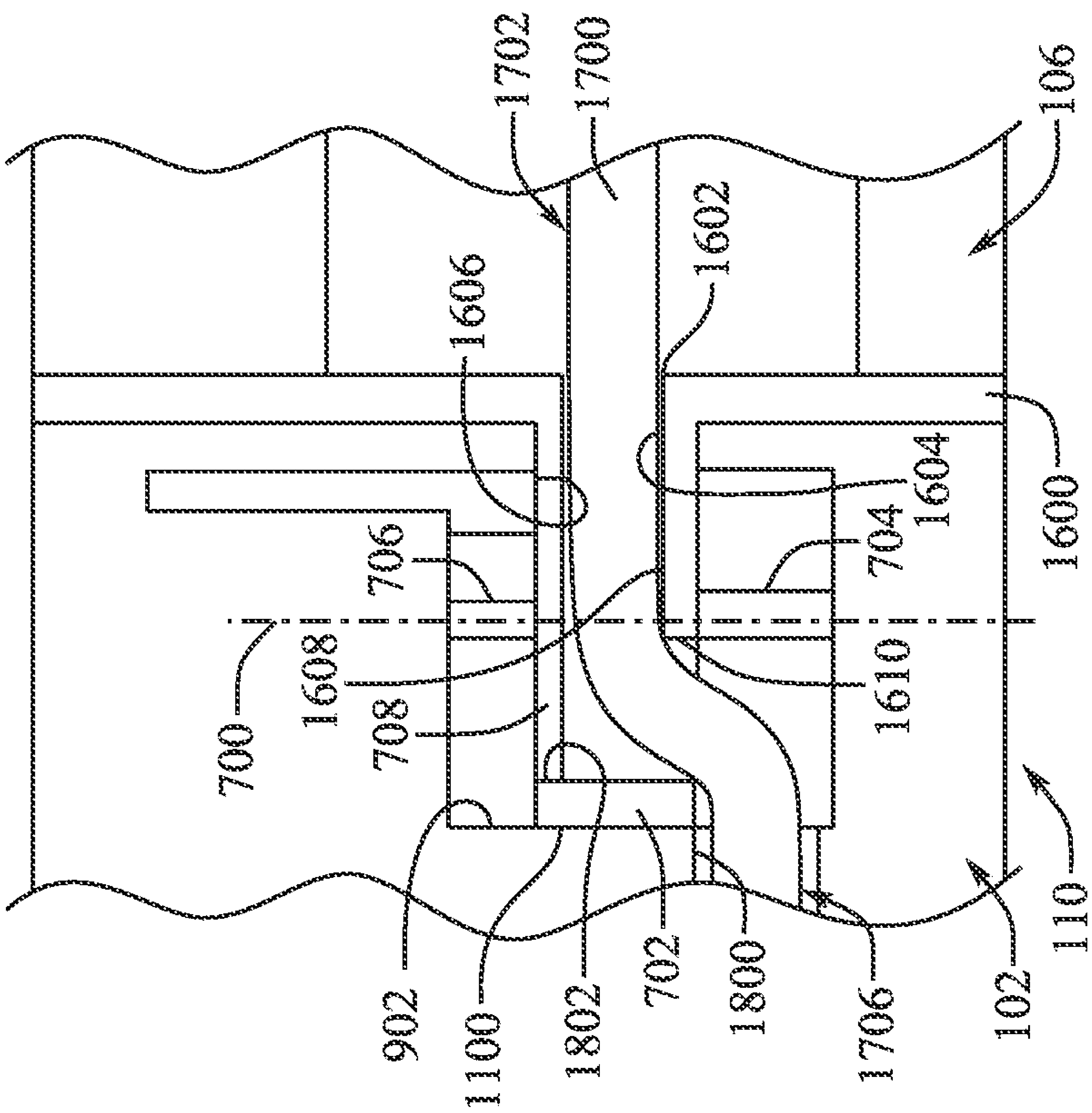

1702
1700
106
1606
1602
1604
1600
706
704
700
1608
708
1610
902
1100
1802
702
1800
1706
102
110

FIG. 18

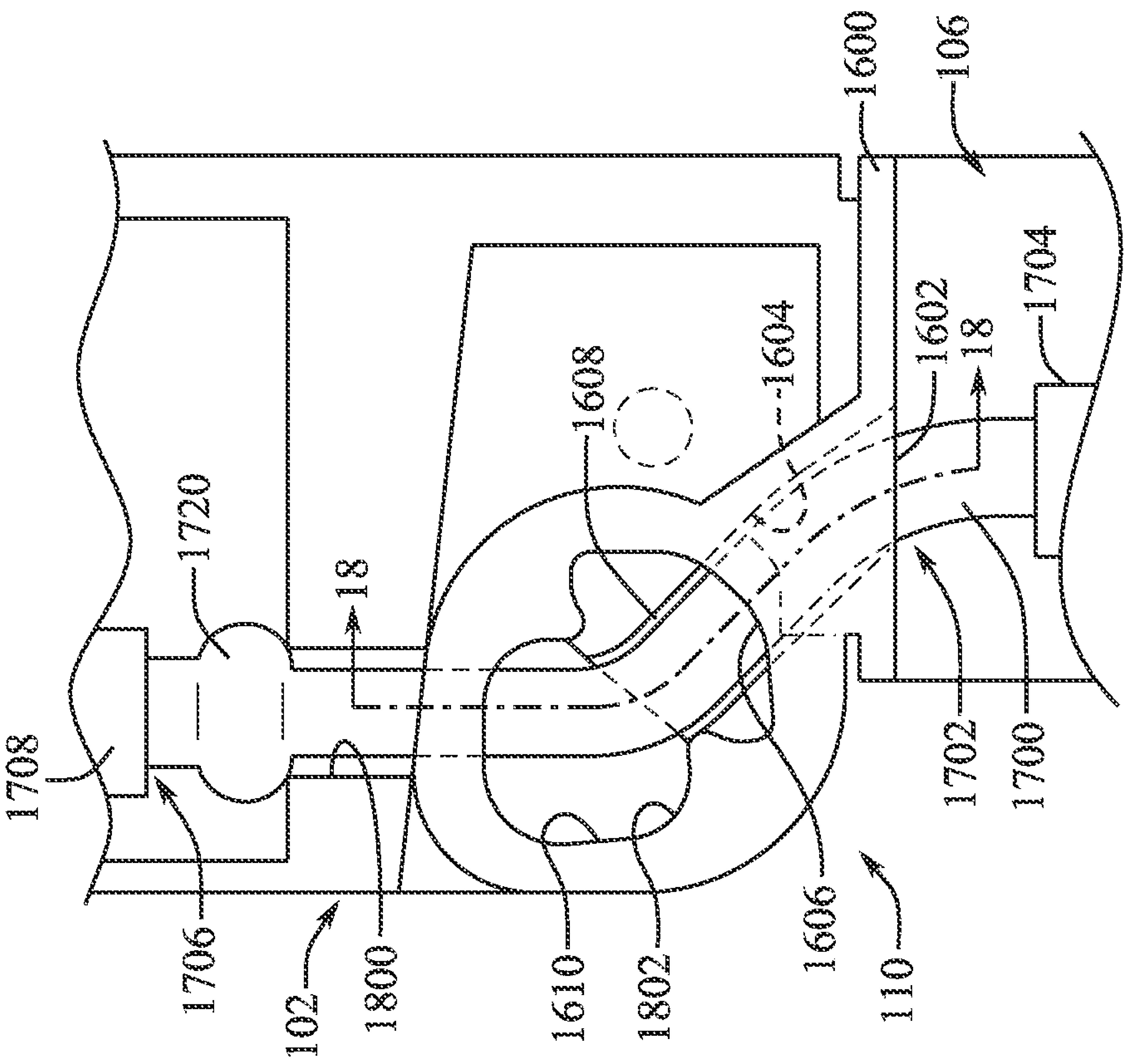

1600
106
1704
1602
18
1604
1608
1720
18
1708
1706
102
1800
1610
1802
1606
110
1702
1700

FIG. 17

DUAL-AXIS HINGE MECHANISM

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This is a continuation of International Patent Application No. PCT/US2022/075298, filed 22 Aug. 2022, and entitled "DUAL-AXIS HINGE MECHANISM," which claims priority to U.S. Provisional Patent Application No. 63/260,587, filed 26 Aug. 2021, and entitled "DUAL-AXIS HINGE MECHANISM," the entire disclosure of which is hereby incorporated by reference.

FIELD

[0002] The described embodiments relate generally to eyewear frames and hinges. More particularly, the present embodiments relate to hinges for electronic eyewear.

BACKGROUND

[0003] Hinges of eyewear are common points of failure and nuisance for manufacturers and wearers. There is a constant need for improvements to eyewear comfort, aesthetics, quality, manufacturing efficiency, and durability, especially with respect to the hinges incorporated in eyewear bearing electronic components.

SUMMARY

[0004] An aspect of the present disclosure relates to electronic eyewear including a frame containing a light emitter and a waveguide to direct light from the light emitter, where the frame has a first surface. An arm can also be included and can have a second surface, and a hinge can pivotally join the frame and the arm. The hinge can include a first axis of rotation and a second axis of rotation.

[0005] In some examples, the electronic eyewear can further include a first central axis normal to the first surface and a second central axis normal to the second surface. According to some examples, with the hinge in a first open position, the first surface is parallel to the second surface and the first central axis is parallel to the second central axis. In other examples, with the hinge in a second open position, the first surface is non-parallel to the second surface and the second central axis is translated relative to the first central axis.

[0006] In some embodiments, the hinge includes a torque profile configured to automatically move to the folded position and to automatically move to the first open position. The hinge can include a cam and a support surface, with the cam having a first flat surface and a second flat surface, wherein the first flat surface engages the support surface with the hinge in the folded position. The second flat surface can engage the support surface with the hinge in the first open position. In some embodiments, the first and second flat surfaces are out of contact with the support surface with the hinge in the second open position. The hinge can include a first portion inserted into a second portion, with the first portion having a first curved exterior surface and with the second portion having a second curved exterior surface. The first and second curved exterior surfaces can be vertically aligned when the hinge is in the first open position.

[0007] The hinge can include a spring member to bias the first surface and the second surface to the first open position from the second open position. The hinge can also include a first rotation axis and a second rotation axis, wherein the hinge rotates about the first rotation axis when moving from the folded position to the first open position, and wherein the hinge rotates about the second rotation axis when moving from the first open position to the second open position.

[0008] In some embodiments, the frame has a frame lateral side surface and the arm has an arm lateral side surface, wherein in the second open position, the arm lateral side surface is positioned laterally external to the frame lateral side surface.

[0009] Another aspect of the disclosure relates to a hinge for glasses including a first hinge portion defining a cam support surface and a rotation assembly, with the rotation assembly including a spring, a shaft, and a linkage; and a second hinge portion defining a cam rotatably coupled with the linkage and having a first flat surface and a second flat surface. The spring is configured to bias the cam to rotate about the shaft toward the cam support surface via the linkage. Additionally, the cam can be rotatable between a first position and a second position such that in the first position the first flat surface engages the cam support surface, and in the second position the second flat surface engages the cam support surface.

[0010] In some embodiments, the cam can include a second shaft coupled to the linkage. The rotation assembly can further include a second linkage rotatably coupled with the cam, wherein the linkage is positioned opposite the first and second flat surfaces relative to the second linkage. In some embodiments, the cam includes a hard stop surface configured to stop rotation of the cam relative to a stop surface of the first hinge portion. The cam can have an internal channel, wherein a cable is routable between the first and second hinge portions through the internal channel. The cam can be rotatable about the shaft to a third position with the first and second flat surfaces spaced away from the cam support surface. The spring can bias the first and second flat surfaces toward the second position from the third position.

[0011] Yet another aspect of the disclosure relates to electronic glasses including an arm structure having a first electronic component, a protrusion, and an aperture defined through the protrusion; a frame structure having a second electronic component and a recess receiving the protrusion, wherein the protrusion is rotatable relative to the recess between a folded position and an unfolded position; and a cable connecting the first and second electronic components, with the cable being contained by the aperture and the recess in the folded position and in the unfolded position.

[0012] In some embodiments, the glasses can further include a flexible seal, wherein the cable includes a longitudinal axis, and wherein the cable is configured to translate along the longitudinal axis to flex the flexible seal. The protrusion can include a curved surface, wherein the frame structure includes a rounded external surface, and wherein the curved surface and the rounded external surface have matching curvature at least in the unfolded position. The cable can bend at least twice within the aperture. Furthermore, the aperture can have a recess portion in which the cable is positioned, wherein a rotation axis of the protrusion extends through the recess portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The disclosure will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

[0014] FIG. **1** shows a top view of eyewear with its arms in a folded condition.

[0015] FIG. **2** shows a side view of the eyewear with its arms in partially unfolded and unfolded/nominal positions.

[0016] FIG. **3** shows an internal rear perspective view of a hinge of the eyewear in a nominal position.

[0017] FIG. **4** shows an external rear perspective view of the hinge of the eyewear in a folded position.

[0018] FIG. **5** shows a top view of a hinge of the eyewear in a nominal position.

[0019] FIG. **6** shows a top view of the hinge in a hyper-extended position.

[0020] FIG. **6**A shows a detail view of FIG. **6**.

[0021] FIG. **7** shows a perspective view of portions of the hinge in a nominal position.

[0022] FIG. **8** shows a perspective view of portions of the hinge in a nominal position with the arm and frame shown in broken lines.

[0023] FIG. **9** shows a perspective view of portions of the hinge in a folded position with the frame partially shown in broken lines.

[0024] FIG. **10** shows a top section view as taken through section lines **10-10** in FIG. **9**.

[0025] FIG. **11** shows a simplified top section view of the hinge in a nominal position.

[0026] FIG. **12** shows a simplified top section view of the hinge in a folded position.

[0027] FIG. **13** shows a simplified top section view of the hinge in a hyperextended position.

[0028] FIG. **14** shows a chart of torque profiles of a hinge of the eyewear while unfolding and folding.

[0029] FIG. **15** shows a chart of a clamping force to angular displacement relationship for the eyewear in hyper-extension.

[0030] FIG. **16** shows a perspective top view of a cam portion of the hinge of the eyewear.

[0031] FIG. **17** shows a simplified top view of a cable routed through the hinge of the eyewear.

[0032] FIG. **18** shows a simplified side section view of the hinge and cable routing as taken through section lines **18-18** in FIG. **17**.

DETAILED DESCRIPTION

[0033] Reference will now be made in detail to exemplary embodiments illustrated in the accompanying drawings. It should be understood that the following descriptions are not intended to limit the embodiments to one preferred embodiment. Rather, it is intended to cover alternatives, modifications, and equivalents as can be included within the spirit and scope of the described embodiments as defined by the appended claims.

[0034] The following disclosure relates to eyewear worn on a user's head that has a frame configured to be positioned in front of the eye(s) and an arm connected to the frame by a hinge that allows the arm to fold into a storage position relative to the frame. The hinge is configured to automatically move to two different stable positions relative to the frame, such as, for example, the folded position with the arm at an about 90-degree angle relative to a projection portion of the frame to which the hinge is connected, and a nominal, open, or unfolded position wherein the arm extends at an about 180-degree angle relative to the frame projection. Thus, the hinge can be referred to as being bi-stable, wherein it is stable when folded and unfolded, and the hinge is biased to automatically move and transition the angular orientations of the frame and arm (e.g., snap) to those positions due to a moment applied by a biasing member when the angle between the frames in the hinge is not at the about 90-degree angle or the about 180-degree angle relative to the projection portion of the frame.

[0035] When the eyewear is in the nominal open configuration, a rear facing surface of the frames and a front facing surface of the arm can face each other and can be parallel to each other while contacting each other. In this manner, the hinge for the arm can have minimal space between the frame and the arm, thereby reducing the probability that hair or other debris gets trapped or snagged in the hinge while the frames are open and in the nominal position (e.g., while being worn or while resting on a desktop). Additionally, the outer surfaces surrounding the hinge on the frame and arm can have similar dimensions, curvature, and other surface characteristics to help the hinge more seamlessly visually blend into the eyewear. As used herein, a directional indicator such as a "front" of the wearer of the eyewear or a front or front-facing surface of the eyewear should be understood as being directed in a horizontally forward position relative to the wearer's face or from the front of the lenses of the eyewear with the eyewear being worn and the wearer is sitting or standing upright. This direction may be referred to as a positive Y direction or along a positive Y-axis. Similarly, a "rear" direction should be understood as being directed opposite the front direction (e.g., on the negative Y-axis), and a "right" or "left" direction should be understood as being directed to the right or left of the wearer in that position, respectively (e.g., on the positive and negative sides of an X-axis perpendicular to the Y-axis, respectively). A "vertical" direction should be understood as being oriented up or down from the front, rear, left, or right directions (e.g., on a Z axis perpendicular to the Y and X axes). Thus, parts that are "vertically aligned" should be understood as being aligned in the Z-direction, are aligned when viewed along the Z-axis, or overlap each other and are spaced apart along the Z-axis.

[0036] Within the housing of the frame, the hinge can have a cam portion and a cam supporting surface, wherein the cam portion is biased into contact with the cam supporting surface by a biasing member (e.g., a torsion spring). The perimeter of the cam can have some outer surfaces that are flat or flattened relative to other outer transition surfaces of the cam that can contact the cam supporting surface. One flat or flattened surface can engage the cam supporting surface when the arm is in the folded configuration, and another flat or flattened surface can engage the cam supporting surface when the arm is in the open, nominal configuration. Curved or transition surfaces between the flat or flattened surfaces can help the cam slidably rotate against the cam supporting surface to snap, jump, slide, or otherwise transition to the folded or nominal configurations where the flat or flattened surfaces stably engage the cam supporting surface. Thus, the cam and the cam supporting surface of the hinge can provide the bi-stable movement of the eyewear arm. The surfaces of the cam can be designed to respond to a torque applied by the biasing member, wherein with the arm at a transition position between the folded position and the nominal position, application of a moment to the arm toward one of these positions will cause the arm to automatically move (e.g., snap, glide, or otherwise rotate or translate) to that position without need for the initial moment or torque to be constantly applied by a user. Then, once the arm reaches one of the stable positions, it will come to rest in that position and will resist rotation out of that position unless a sufficient moment or torque is applied that overcomes the biasing moment from the biasing member.

[0037] The size, shape, and positioning of the arm relative to the frame can be designed to accommodate and comfortably stay positioned on a wide range of users' heads. Additionally, to accommodate an additional range of larger head sizes, the arms of the eyewear can be configured to hyperextend relative to the frame (e.g., an additional few or several degrees) while still providing a comfortable and secure clamping force to the sides on the user's head. When the arm is hyperextended relative to the frame, the cam of the hinge can be pulled away from the cam supporting surface, and the front facing surface of the arm and rear facing surface of the frame can be at least partially offset and spaced apart from each other. For instance, the movement of the arm can form a gap between the front facing surface and the rear facing surface at an inner end of those surfaces relative to the wearer's head and can contact each other at an outer end of those surfaces relative to the wearer's head. In this manner, the front and rear facing surfaces can be nonparallel to each other and can contact each other at a point or line along the surfaces.

[0038] A single hinge for the eyewear can be referred to as having dual axes of rotation. The arm can rotate relative to the frame about a first axis of rotation extending through the cam while transitioning between the folded configuration and the nominal configuration. The arm can also rotate relative to the frame about a second axis of rotation extending through a shaft or other pivot axis that is offset from the first axis of rotation, extending through a biasing member of the hinge, and/or positioned laterally external to the perimeter of the cam while transitioning between the nominal configuration and the hyperextended position. Implementing two axes of rotation in this manner can enable the front and rear facing surfaces to sit flush, in contact, and parallel to each other in the nominal configuration, while still allowing hyperextension or folding of the arm when needed.

[0039] The eyewear can be configured with electronic components that are positioned in the frame, positioned in the arm, and/or connected through the hinge, such as components in the arm that are electrically connected to components in the frame by an electrical connection extending through the hinge. Some electronic components can include a circuit board or similar substrate or processing and memory device, an energy source (e.g., battery), a light emitter (e.g., a light projector or laser emitter), and a waveguide (e.g., a passive waveguide or active waveguide positioned in, on, or around the lenses of the frames within the field of view of the wearer. In some embodiments, the electrical connection can include a cable or wire that extends through the hinge between the electronic components in the arm and frame. The cable can be hidden within the hinge to protect it from exposure, pinching, bending, or damage that could occur while the arm moves relative to the frame, or due to the cable being accessible to probes or sharp objects external to the arm and frame. Accordingly, the cable can extend through a passage, aperture, or tunnel through the cam, and the cam can act as a partial housing for the cable that limits or completely eliminates this exposure of the cable. A cable passing through the cam aperture can be safely routed from the interior of the arm, through the cam, and into the interior of the frame in a manner that is invisible to an outside viewer, or that only is visible through tiny sub-millimeter-width gaps between these components, and is thereby effectively invisible.

[0040] To accommodate the cable routing, the cable can be configured to bend multiple times within the hinge to change its elevation and lateral position in the hinge. At least a portion of the cam aperture can be designed to receive the cable while allowing a large proportion of the movement of the cam between the folded position and the nominal or hyperextended position to avoid any contact with the circumference of the cable. This can help to ensure long cable life due to minimized contact and stress concentration against the sides of the cam aperture, especially where the cam and cable most frequently move.

[0041] Eyewear of the present disclosure can include various types of eyeglasses (e.g., glasses with prescription lenses, sunglasses, bifocals, reading glasses, fashion frames, lensless frames, etc.), spectacles, goggles, headsets (e.g., virtual reality, alternate reality, or otherwise modified reality headsets), eye patches, masks (e.g., eye masks, sleep masks, costumes, etc.), and other devices worn on the head. "Electronic eyewear" includes head-mounted devices (e.g., virtual reality, alternate reality, or otherwise modified reality headsets or glasses/spectacles incorporating aspects thereof) that include electronic components such as circuits, electrically-connected sensors, processors, electronic memory devices, electrical energy sources (e.g., batteries), and electronic input and output devices (e.g., displays, switches, buttons, etc.). These devices can be configured to be supported by the sides or cars of the head and the front of the face, such as the bridge of the nose, eyebrows, or eye socket support structures in the wearer's skull and skin. In some embodiments, the eyewear can include electronic components such as output devices (e.g., displays, lights, infrared or ultraviolet emitters, lasers, speakers, haptic vibration or pulse generators, related devices, and combinations thereof), input devices (e.g., microphones, buttons, touch sensors, switches, related devices, and combinations thereof), and other sensors (e.g., thermometers, accelerometers, gyroscopes, related devices, and combinations thereof). In some embodiments, the eyewear can include an onboard power source, such as a battery to provide power to the electronic components. A waveguide can be included and contained in the frame to direct and control the provision of light to the wearer via the lenses of the frames or via a separate viewing location (e.g., a prism positioned in front of the wearer's eyes independent of the main eyeglass lenses).

[0042] These and other embodiments are discussed below with reference to the figures. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes only and should not be construed as limiting. Furthermore, as used herein, a system, a method, an article, a component, a feature, or a sub-feature including at least one of a first option, a second option, or a third option should be understood as referring to a system, a method, an article, a component, a feature, or a sub-feature that can include one of each listed option (e.g., only one of the first option, only one of the second option, or only one of the third option), multiple of a single listed option (e.g., two or more of the first option), two options simultaneously (e.g., one of the first option and one of the second option), or combination thereof (e.g., two of the first option and one of the second option).

[0043] FIGS. **1** and **2** illustrate a top view of a piece of eyewear **100** having a frame **102** and arms **104**, **106** rotatably attached to the frame **102** using hinges **108**, **110**. The frame **102** can include a set of lenses **112**, **114** set into a front portion **116** configured to be located in front of a wearer's head. For example, a central part of the front portion **116** can rest on the bridge of the wearer's nose to support the weight of the frame **102**. The frame **102** can also include a pair of temple-area-extending projections **118**, **120** that extend from the front portion **116** to the front ends of the arms **104**, **106** and support, at their rear ends, the hinges **108**, **110**. The frame **102** can house and contain one or more electronic components such as the output devices, input devices, and other sensors described elsewhere herein. The frame **102** can be substantially rigid so that the output devices, input devices, and other sensors remain oriented stationary relative to each other on the frame **102** as the user wears the eyewear **100** or operates the hinges **108**, **110** to move the arms **104**, **106**. The projections **118**, **120** can define a housing for an internal cavity, chamber, or recess configured to hold electronic components and parts of the hinges **108**, **110**. Some electronic, light-emitting, or light-directing components (e.g., **140**) can be positioned in the projection **118**, some such components (e.g., **142**) can be positioned in the front portion **116** (or can simultaneously overlap the front portion **116** and projection **118**), and some such components (e.g., **144**) can be positioned in an arm (e.g., **104**-*a*). These components **140**, **142**, **144** are omitted from FIG. **2** but would still be positioned in their respective locations with the eyewear **100** in the configuration of FIG. **2**. In some embodiments, the electronic, light-emitting, or light-directing components **140**, **142**, **144** can include a light emitter, a projector, a waveguide, an energy source, a circuit board, a processing device, a memory device, a rangefinder, or other components discussed herein and known in the fields of electronic and holographic eyewear, heads-up displays, and similar technologies. In some embodiments, one component **140** includes a light emitter, and another component (e.g., **142** and/or **142** plus 112) includes a waveguide operable to direct light from the light emitter (e.g., toward an eye of the wearer). In embodiments with a waveguide, the eyewear can be used to show information to the wearer on or through at least one of the lenses **112**, **114** by reflecting light from a light emitter in the frame **102** using the waveguide so that the light has a more distant appearance to the viewer, thereby permitting the wearer to more comfortably focus the light presented to the eye via the eyewear **100**. Some components **140**, **142** can be positioned in front of the arms **104**, **106**. Thus, a first or rear-facing surface of the projection **118** supporting the components **140**, **142** can be positioned rearward from the components **140**, **142**, as shown in FIG. **1**. See also FIG. **17** and its related descriptions herein.

[0044] FIG. **1** shows the eyewear **100** with the arms **104**, **106** in a folded configuration (signified as **104**-*a*, **106**-*a*) in which the arms **104**, **106** have longitudinal axes positioned at about 90-degree angles **122**, **124** relative to longitudinal axes of the projections **118**, **120**. In various embodiments, the angles **122**, **124** can be within a range of values, such as, for example, in a range of about 70-degrees to about 105-degrees, in a range of about 75-degrees to about 95-degrees, or about 80-degrees to about 85-degrees. The angles **122**, **124** for each arm **104**, **106** at positions **104**-*a*, **106**-*a* can be dependent upon which of the arms **104**, **106** is folded first, wherein the first arm folds to a smaller angle (e.g., **124**) relative to the second arm's angle (e.g., **126**). The second sequentially folded arm (e.g., **104**) can contact and bias the first sequentially folded arm (e.g., **106**) forward toward the front portion **116** of the frame **102**. The hinges **108**, **110** can include stop surfaces configured to engage each other when the arms **104**, **106** are in at least the first folded configuration (e.g., **106**-*a*) so that the arm does not rotate into contact with the frame **102** or lens (e.g., **112**). See also FIGS. **9** and **10** and their related descriptions herein.

[0045] FIG. **2** shows the eyewear **100** with the arms **104**, **106** in respective fully and partially unfolded positions relative to the frame **102**. Arm **104** is shown in an open, nominal position (indicated by **104**-*b*), and arm **106** is shown in a partially open position (indicated by **106**-*b*). The hinges **108**, **110** can have bi-stable biased movement, wherein the arms **104**, **106** are biased into their stable closed positions **104**-*a*, **106**-*a*, or the stable nominal position **104**-*b* (and the corresponding nominal position for **106**). Thus, positioning an arm between those positions will bias the arm toward whichever stable position is the nearest. For example, in the position of arm **106**-*b*, the hinge **110** can apply a moment to the arm **106**-*b* biasing it towards its nominal configuration, e.g., along direction **128** in FIG. **2**. In the nominal positions, the arms **104**, **106** can have their longitudinal axes coaxial with longitudinal axes of the projections **118**, **120**, wherein an angle between the axes (e.g., **130**) is about 180-degrees. In some embodiments, the angle between the axes (e.g., **130**) can be within a range of about 175-degrees to about 185-degrees. Thus, in an unstable position, the hinges (e.g., **110**) can have an angle between the ranges of the closed positions (e.g., the ranges corresponding to angles **122**, **124** above), as indicated by angle **132** which is about 145-degrees (i.e., closer to about 180 than to about 90).

[0046] Furthermore, with the arm in a nominal position, the hinge **108** can hyperextend such that the arm moves to a hyperextended position relative to the projection of the frame **102**. For instance, as shown in FIG. **2**, arm **104** in nominal position **104**-*b* can rotate at hinge **108** to the position of arm **104**-*c*, wherein the angle **130** grows by a value within a range of about 5-degrees to about 10-degrees. In an example embodiment, the angle **130** grows by about 6-degrees to about 9.5-degrees, and in another example, the angle **130** grows by about 6.1-degrees to about 9.2-degrees.

[0047] Hyperextension of the arms **104**, **106** can allow the eyewear **100** to adapt to the width across the wearer's head (e.g., the width between the otobasion superior on each side of the head or the bieuryonic breadth) so that the arms **104**, **106** apply an inward directed force against the wearer's head that keeps the eyewear **100** securely in place. The otobasion superior is located at the top of the car where the car is attached to the side of the head at the temple, and the bieuryonic breadth is the distance between the otobasion superior on each side of the head. According to research measurements, in some embodiments, a hyperextended angle displacement growth of about 6.0 to about 6.1-degrees (relative to a 180-degree nominal position) can apply a clamping force to the head to retain the eyewear **100** to wearers having a bieuryonic breadth up to the 95th percentile of adult humans, and an angle displacement growth of about 9.2-degrees (relative to the 180-degree nominal position) can apply a substantially equal clamping force to wearers having a bieuryonic breadth up to the 99th percentile of adult humans when using the hinges **108**, **110**. Accordingly, hyperextension of the arms **104**, **106** can allow the eyewear **100** to adapt to and be comfortably and securely worn by nearly all adult humans.

[0048] The frame **102** can include an outer surface **200** and an inner surface **202** positioned opposite each other on a projection (e.g., **118**). A corresponding outer surface **204** and corresponding inner surface **206** of the arm **106** can be aligned with the outer and inner surfaces **200**, **202**, respectively, when an arm is in the nominal position. Furthermore, a front facing surface of the arm and a rear facing surface of the projection **118** can be parallel to and contacting each other in the nominal position, as further described in connection with FIGS. **5** and **6**. The frame **102** can also include a protruding portion **208** extending inward from the inner surface **202**, wherein the inner surface of the protruding portion **208** is laterally offset from the inner surface **206** of the arm **104**. Corresponding surfaces **200**, **202**, **204**, **206**, and protruding portion **208** can be located at the hinge **110** for arm **106** (in mirrored positioning relative to hinge **108** and arm **104**), as described in further detail in connection with FIGS. **3-8**, **11-13**, and **16-18**.

[0049] FIG. **3** illustrates a perspective view of the arm **106**, frame **102**, and hinge **110** that shows the inner surfaces **202**, **206** in the nominal position. Hinge **108** and the nearby structures of the arm and frame can appear as a mirror image. The protruding portion **208** can have a flat inner surface **300** aligned substantially parallel to the inner surfaces **202** and **206**. The protruding portion **208** can also include a transition surface **302** that gradually transitions inner surface **300** to inner surfaces **202** and **206**. For example, the transition surface **302** can form a quarter circle radius when viewed from above. In other embodiments, the transition surface **302** can form a ramp or a flat angle between surfaces **202** and **300**. The transition surface **302** can have an end **303** where the frame **102** meets the arm **106**. Thus, that end **303** can be aligned with the interface between the frame **102** and arm **106** in a way that minimizes the appearance of seams and gaps between the frame **102** and arm **106**.

[0050] The hinge **110** can include a hinge component **304** (e.g., a cam or joint member) attached to the arm **106** and movable with the arm. The hinge component **304** can have an inner surface **306** with dimensions in a first horizontal plane that align with (e.g., vertically align with or have matching curvature along the vertical, up-and-down direction) and match dimensions of the transition surface **302** in a second horizontal plane parallel to, and vertically offset from, the first horizontal plane. Thus, for example, the transition surface **302** can have a curvature radius and horizontal position that matches a curvature radius and horizontal (but not vertical) position of inner surface **306** on hinge component **304**. In this manner, the arm **106** and frame **102** can have nearby surfaces **202**, **206** and **302**, **306** flush and aligned with each other for a more seamless aesthetic appearance and in a manner that minimizes the chance that hair or other debris or material will be caught or fall between the frame **102** and arm **106** while they are in the nominal position.

[0051] FIG. **4** shows a perspective view of the arm **106**, the frame **102**, and the hinge **110** with the arm **106** in a folded position **106**-*a*. The hinge component **304** is received into a gap or opening **400** in the transition surface **302** and rear facing surface **402** of the frame **102**. The arm **106** is rotated so that its front facing surface **404** no longer contacts rear facing surface **402**. An angle **406** measured between the front and rear facing surfaces **402**, **404** can be about 90-degrees, or within a range of about 80 degrees to about 100 degrees. The inner surface **206** of the arm **106** can be spaced out of contact with the inner surface **300** of protruding portion **208**, thereby preventing and avoiding scratches on the inner surface **300** or arm **106**.

[0052] FIG. **4** also shows that the hinge **110** conceals and contains any cables, wires, or other electronic conductors extending between the electronic components in the frame **102** and arm **106**. Thus, the housings of the frame **102** and arm **106**, including hinge component **304**, protruding portion **208**, and hinge housing **408**, can protect and conceal conductors and similar electrical lines to keep them safe from damage and to improve overall durability of the eyewear **100**. Gaps between the hinge component **304** and opening **400** can be minimized to reduce the chance that intrusive materials and debris will penetrate into the hinge **110**.

[0053] FIG. **5** shows a top view of the hinge **110** in the nominal position. The front and rear facing surfaces **402**, **404** of the frame **102** and arm **106** are oriented parallel to each other and positioned in close proximity to each other. In some embodiments, the surfaces **402**, **404** contact and abut each other in the nominal position. Furthermore, the outer surfaces **200**, **204** are parallel and aligned with each other, the inner surfaces **202**, **206** are parallel and aligned with each other, and the transition surface **302** is aligned with inner surface **306** on hinge component **304** (thereby rendering the inner surface **306** hidden in this view). Longitudinal axes of the arm **106** and projection **120** can also be coaxial in the nominal position. Accordingly, the longitudinal axes can have an angle between each other of about 180 degrees.

[0054] In some embodiments, a small gap or space **500** is defined around at least the perimeters of the front and rear facing surfaces **402**, **404**, wherein a portion of the frame **102** and arm **106** are spaced out of contact with each other. The space **500** between the frame **102** and arm **106** can be minimized to prevent objects from being trapped at the hinge **110**. For example, the space **500** can have a width of about 0.2 millimeters to prevent hair from fitting into the space **500** while the eyewear **100** is being worn. Similarly, in another example embodiment, the space **500** can have a width within a range of about 0.15 mm and about 0.25 mm. Precision alignment of the frame **102** and arm **106** can remove visual distraction at the hinge **110** and make it appear more seamless and less obvious, especially when viewed from a distance. In some cases, the hinge **110** can have contact surfaces internal to the frame **102** and arm **106** that ensure that in the nominal position, the rear and front facing surfaces **402**, **404** stay spaced apart from each other to prevent contact between each other to preserve durability and surface finish at and around those front facing surfaces **402**, **404**.

[0055] FIG. **6** shows a top view at the hinge **110** similar to FIG. **5** but with the arm **106** hyperextended relative to the projection **120**. Thus, the angle **600** between their longitudinal axes, or central axes normal to the front and rear facing surfaces **402**, **404**, exceeds the angle of the nominal position of FIG. **5**, such as, for example, having a magnitude of about 186 degrees to about 189 degrees. In this position, the front facing surface **404** and rear facing surface **402** can be at least partially separated from each other, such as by being spaced apart at their innermost ends, i.e., near end **303** of transition surface **302**. The rear and front facing surfaces **402**, **404** can contact each other at a contact point **602** located at or immediately inward from the outer surface **200** of the projection **120**. Thus, the hinge **110** can rotate internal to the projection **120** to displace the hinge component **304** in a rearward direction, as shown in FIG. **6**, and the front facing surface **404** can slide against the rear facing surface **402** at point **602**. The inner workings of the hinge **110** are shown in further detail in connection with FIGS. **7-13**.

[0056] FIGS. **5** and **6** also show how the first or rear-facing surface **402** and the second or front-facing surface **404** can abut each other with a portion of the front-facing surface **404** being out of contact with the rear-facing surface at the laterally-positioned space **500**. In other words, the front-facing surface **404** has a lateral portion **605** that is laterally external to the rear-facing surface **402** (e.g., extends laterally from the laterally-outermost edge **606** of the rear-facing surface **402**), as shown in FIG. **5**. As illustrated in FIG. **5**, the longitudinal axes, or central axes normal to the front and rear facing surfaces **402**, **404** are parallel. As the hinge **110** moves to the position of FIG. **6**, the proportion of the front-facing surface **404** that is laterally external to the rear-facing surface **402** increases, as indicated in the detail view of FIG. **6**A. The lateral portion **605**, as measured on the front-facing surface **404** from the laterally-outermost edge **606**, comprises a greater proportion of the front-facing surface **404** with the arm hyperextended as compared to the nominal position. Furthermore, the outer surfaces **200**, **204** (i.e., lateral side surfaces) of the projection **120** and arm **106** move from being substantially aligned, coplanar, and parallel in the nominal position of FIG. **5** to being laterally offset (e.g., by distance T in FIG. **6**A) and non-parallel when the arm **106** is hyperextended, as shown in FIGS. **6** and **6**A. As shown in FIGS. **6** and **6**A, when in the second position, longitudinal axes, or central axes normal to the front and rear facing surfaces **402**, **404** are parallel are translated relative to one another. The angle U between the front-facing surface **404** and rear-facing surface **402** also increases from being substantially zero in the nominal position to being greater than zero/non-zero, as indicated in FIG. **6**A.

[0057] The protruding portion **208** of the frame **102** can include a cover **604** on the exterior of which the surfaces **300**, **302** are defined. FIG. **7** shows a perspective view of the frame **102** and arm **106** with the cover **604** removed to reveal internal components of the hinge **110**. Accordingly, the protrusion **208** is shown without the cover **604**. FIG. **8** is a similar perspective view at the hinge **110** with the frame **102** and arm **106** shown in broken lines to reveal the positioning of other components within the hinge **110**. The arm **106** and hinge component **304** can rotate about an axis of rotation **700** extending through the hinge component **304**. Accordingly, a user rotating the arm **106** relative to the frame **102** can rotate the hinge component **304** about axis of rotation **700**.

[0058] The hinge component **304** can include a cam portion **702** (i.e., a protrusion), a lower shaft portion **704**, and an upper shaft portion **706**. In some embodiments, the cam portion **702** and lower shaft portion **704** can be a single, integral part, and the upper shaft portion **706** can be a separate part that is attached to the cam portion **702**, such as by the upper shaft portion **706** having a lower plate **708** that is welded to the top of the cam portion **702**. In some embodiments, the hinge component **304** can include the cam portion **702**, lower shaft portion **704**, upper shaft portion **706**, and lower plate **708** as a single integral piece. The hinge component **304** can also include an arm plate **710** attached to or formed with the housing of the arm **106** and extending from the cam portion **702**. The arm plate **710** can have a front facing surface used as the front facing surface **404** described above. Accordingly, the hinge component **304** and arm plate **710** (i.e., end block **1600** in FIG. **16**) can all rotate about axis of rotation **700** in response to application of a moment to the arm **106** relative to that axis of rotation **700**.

[0059] The hinge **110** can also have a secondary shaft **712** shown in FIG. **8**. The secondary shaft **712** can define a second axis of rotation **714** about which a lower linkage **716** and an upper linkage **718** are rotatable. The secondary shaft **712** is a fixed to the frame **102** and is not translatable relative to the frame **102**, unlike the first axis of rotation **700**. In some embodiments, the secondary shaft **712** is rotatable relative to the frame **102** using bearings at the ends of the secondary shaft **712**, and in some embodiments, the secondary shaft **712** is not rotatable relative to the frame **102**, such as by the ends of the secondary shaft **712** being adhered or welded to the frame **102**. In that case, the linkages **712**, **718** can be rotatable about the shaft **712** (e.g., using bearings). The secondary shaft **712**, linkages **716**, **718**, and biasing member **720** can be collectively referred to as a rotation assembly. The rotation assembly can, in some embodiments, also include the cam portion **702** and its shafts **704**, **706** and plate **708**.

[0060] A biasing member **720** is positioned around the secondary shaft **712** within the hinge **110**. FIGS. **8** and **9** show the biasing member **720** as a coiled torsion spring having a first end **900** engaged with an inner surface of the frame **102**. FIG. **9** shows the hinge **110** in a folded configuration and with portions of the frame **102** shown in broken lines to reveal the internal components. A second end of the biasing member **720** engages or is attached to the upper linkage **718** (e.g., at upper engagement point **901** in FIG. **8**) and is thereby configured to apply a moment to the upper linkage **718** to bias the upper linkage to rotate about the second axis of rotation **714**. This moment is transferred via the secondary shaft **712** to the lower linkage **716** as well. Thus, the biasing member **720** biases the upper and lower linkages **718**, **716** to rotate the hinge component **304** about the second axis of rotation **714** and into contact with a support surface **902**, as indicated in FIG. **7**. Specifically, the cam portion **702** of the hinge component **304** contacts the support surface **902**, as shown and described in more detail in connection with FIGS. **11-13** below. The moment applied by the biasing member **720** can be overcome by the user of the eyewear **100**, such as when the hinge **110** is hyperextended, and the arm **106** and hinge component **304** can thereby be pulled out of contact with the support surface **902** at least until the moment applied by the wearer is released, and the moment of the biasing member **720** returns the hinge component into contact the support surface **902**.

[0061] As shown in FIG. **9**, the hinge **110** can be operated into a folded position wherein the arm **106** is rotated about the first axis of rotation **700** relative to the nominal position shown in FIGS. **7** and **8**. The movement of the arm **106** relative to the frame **102** can be limited by contact between hard stop surfaces on the upper shaft portion **706** and the frame **102**. The shaft hard stop surface **904** (i.e., a third flat surface of the upper shaft portion **706** of the cam portion **702**) of the upper shaft portion **706** contacts a frame hard stop surface **906**. These hard stop surfaces **904**, **906** can prevent the arm **106** from over-rotating when folded and coming into contact with a lens **112**, **114** or front portion **116** of the eyewear **100**.

[0062] FIG. **10** shows a top section view of the configuration of the hinge **110** shown in FIG. **9** as taken through section lines **10-10**. FIG. **10** indicates where the hard stop surfaces **904**, **906** engage each other in the upper area of the hinge **110**. The hard stop surfaces **904**, **906** are flattened and are configured to contact face-to-face and parallel to each other to limit rotation of the arm **106** about the first axis of rotation **700** in the direction of arrow **1000**. The hard stop surface **904** of the arm **106** faces laterally inward (i.e., toward the center of the frame **102**), and the hard stop surface **906** of the frame **102** faces laterally outward (i.e., away from the center of the frame **102**). The hard stop surfaces **904**, **906** do not prevent the hinge **110** from rotating opposite to the direction of arrow **1000** (i.e., going back toward the nominal position).

[0063] FIGS. **11-13** show a series of section views of the hinge **110** showing how the frame **102**, arm **106**, linkage **718**, shafts **706**, **712**, and biasing member **720** interact. Some features are omitted or simplified to improve clarity. In FIG. **11**, the arm **106** is in the nominal position relative to the frame **102**. In FIG. **12**, the arm **106** is in the folded position relative to the frame **102**. In FIG. **13**, the arm **106** is hyperextended relative to the frame **102**. The cam portion **702** has at least two laterally-facing flat surfaces **1100**, **1102** on its outer perimeter that are separated from each other by a change in surface angle at a curved transition surface **1104**. The inner surface **306** of the cam portion **702** is positioned adjacent to and adjoining flat surface **1102** opposite the transition surface **1104**. In the nominal configuration, the cam portion **702** has one flat surface **1100** engaging and abutting the flat cam support surface **902** of the frame **102**, as shown in FIG. **11**. The other flat surface **1102** is aligned with flat inner surface **300** of the frame **102** at the protruding portion **208**. The rear and front facing surfaces **402**, **404** are abutting each other, as described in greater detail in connection with FIG. **5**.

[0064] The arm **106** is stable relative to the frame **102** in the nominal position of FIG. **11** due to the shape of the cam portion **702** and due to the cam portion **702** being biased into contact with the cam support surface **902** by the linkage **718** and biasing member **720**. The biasing member **720** applies a moment or torque to the linkage **718** which is transferred to the cam portion **702** via the shaft **706**. The width of the flat surface **1100** and its proximity to the first axis of rotation **700** ensures that any rotation of the cam portion **702** would require application of an additional moment or torque to the arm **106** to rotate the arm **106** toward the folded or hyperextended positions, and that additional moment or torque would need to overcome the friction of the cam portion **702** against surface **902** and the biasing force of the biasing member **720** to rotate the first axis of rotation **700** away from support surface **902**. In other words, in order to rotate the cam portion **702** from the position of FIG. **11** to the position of FIG. **12** (with surface **1102** in contact with the cam support surface **902**), the cam portion **702** would need to rotate away from the cam support surface **902** (e.g., with transition surface **1104** contacting the cam support surface **902**, which is at a larger radial distance D_1 from the axis of rotation **700** as compared to the radial distances D_2, D_3 of surfaces **1100**, **1102**). Rotating away from the cam support surface **902** would require at least partially overcoming the biasing moment and friction to make that move. Once reaching a position where transition surface **1104** is contacting the cam support surface **902**, the biasing moment can cause the cam portion **702** (and arm **106**) to "snap" or otherwise automatically move back to the position of FIG. **11** by sliding surface **1104** in contact with the cam support surface **902** (if the contact point between the cam portion **702** and cam support surface **902** on transition surface **1104** is still nearer to flat surface **1100** relative to the larger radial distance D_1 point) or to snap or otherwise automatically move to the position of FIG. **12** by sliding in contact with the cam support surface **902** (if the contact point between the cam portion **702** and cam support surface **902** on transition surface **1104** is nearer to flat surface **1102** relative to the larger radial distance D_1 point).

[0065] Notably, the second axis of rotation **714** and shaft **712** remain stationary as the arm **106** moves, but the first axis of rotation **700** and shaft **706** are capable of revolving about the second axis of rotation **714** as needed. Thus, the first axis of rotation **700** can move away from the cam support surface **902** as the cam portion **702** rotates (e.g., when the cam portion **702** has transition surface **1104** in contact with cam support surface **902**). In this manner, the hinge **110** can be referred to as a dual-axis hinge or a hinge having multiple internal axes of rotation that enable pivoting movement of parts using a linkage between a first axis of rotation (e.g., **700**) and a second axis of rotation (e.g., **714**).

[0066] As shown in FIG. **12**, the arm **106** can be pivoted about the first axis of rotation **700** to a position with flat surface **1102** in contact with cam support surface **902**. Again, the arm **106** is biased into this position by the biasing member **720** via the linkage **718**. The cam portion **702** resists movement away from this position (thereby requiring application of a moment or torque by the user) due to the radial distance D_3 being less than the radial distance D_1 and friction between the cam portion and support surface. The cam portion **702** therefore is biased toward sliding the transition surface **1104** laterally outward (i.e., to the right side in FIG. **12**) to keep the flat surface **1102** as nearly as possible against the cam support surface **902**.

[0067] FIG. **13** shows the hinge **110** in a hyperextended position, wherein a moment or torque (e.g., along direction **128** while the hinge **110** is in the nominal position) has been applied to the arm **106** to rotate it laterally outward. This movement is about axis of rotation **714** and along the direction of arrow **1300**). As shown here, the outward rotation pulls the flat surface **1100** away from the cam support surface **902** as the cam portion **702** rigidly moves with the arm **106**. The front facing surface **404** and rear facing surface **402** are positioned at a non-zero angle **1302** relative to each other, wherein the base of the angle is positioned at a contact point **1304** where the front facing surface **404** contacts a laterally outermost edge of the rear facing surface **402**.

[0068] The outer surface **204** of the arm **106** is entirely laterally offset from the outer surface **200** of the side projection **120** of the frame **102** due to the center of rotation of the arm **106** being at axis **714** and not at point **1304**. In some embodiments, the projection **120** includes a rear recess or groove **1306** giving space for the outer edge of the front facing surface **404** to move without scraping against the rear facing surface **402** or outer surface **200** lateral to contact point **1304**. The rotation of the linkage **718** rotates the first axis of rotation **700** and shaft **706** about the second axis of rotation **714**, and the shafts **704**, **706** move the cam portion **702** and arm **106** along with the first axis of rotation **700**.

[0069] The biasing member **720** applies a biasing moment or torque to the linkage **718** which in turn transfers the moment to the shaft **706**, cam portion **702**, and arm **106**. Accordingly, when a wearer of the eyewear places the eyewear **100** on their head and contact between the sides of the head and the arms **104**, **106** pushes the arms laterally outward, the biasing member **720** of each hinge **108**, **110** applies a clamping force to the sides of the head to help keep the eyewear secured to the wearer. Additionally, when the wearer takes off the eyewear, the biasing moment can drive the arms **104**, **106** from the hyperextended configuration to the nominal position, thereby granting the eyewear **100** an orderly, visually aligned appearance and minimal gaps at the hinges **108**, **110** for intrusion of unwanted contaminants or blockages.

[0070] FIG. **14** shows a chart **1400** of torque profiles (i.e., moment profiles) of elements of a hinge of an embodiment of the present disclosure. The hinge can have a displacement angle (as indicated along the horizontal axis) and can apply a biasing moment (as indicated along the vertical axis) at each angle. At an angle of about zero degrees of angular displacement from the folded position, the first torque profile **1402** shows that a biasing member (e.g., **720**) of the hinge (e.g., **108** or **110**) applies about 120 Newton-millimeters of force to the hinge to hold the hinge in the folded position. For example, the moment applied to a cam portion **702** would hold the second flat surface **1102** against surface **902** in FIG. **12**.

[0071] As the angular displacement from the folded position increases (i.e., the hinge is unfolded toward the nominal position), the moment applied by the biasing member gradually changes along profile **1402**, peaking at about 140 N-mm, until declining to a point where it turns from a positive value to a negative value (i.e., at point **1406**, which corresponds to about 86-87 degrees of angular displacement). At that point **1406**, the now-negative moment causes the hinge to automatically move to the nominal position as the transition surface **1104** of the cam is passed at the outer surface where distance D_1 is measured. The moment quickly switches back to a positive value at about 100 degrees of angular displacement when a new flat cam surface (i.e., **1100**) rests against the cam support surface (i.e., **902**), and the hinge is held at rest in the nominal position.

[0072] Second torque profile **1404** shows this process happen in reverse, wherein angular displacement at zero degrees is shown from the nominal position rather than from the folded position. Thus, in the nominal position, i.e., angular displacement of zero for second profile **1404**, the biasing member applies a moment of about 100 N-mm that holds the arm in the nominal position. As the arm is rotated to about 68 degrees of angular displacement toward the folded position, the biasing moment slightly increases then gradually decreases until it switches from a positive moment to a negative moment at point **1408**. This negative moment causes the cam to turn on its own and to automatically move (e.g., snap or otherwise transition its movement without application of additional force by the user) the arm to the folded position (i.e., with flat surface **1102** engaging cam support surface **902**). At about 100 degrees of angular displacement away from the nominal position, the moment returns to a positive value that holds the cam and arm in place in the folded position. From that point, the first profile **1402** would be followed again when the eyewear **100** are re-opened.

[0073] FIG. **15** is a chart **1500** illustrating clamping force applied by the biasing member (e.g., **720**) of the eyewear while the hinge (e.g., **108**, **110**) is being hyperextended. In this case, the profile **1502** shows a force to angular displacement relationship. At zero degrees, i.e., the nominal position of the arm relative to the frame, a clamping force (i.e., a force that would be applied to the side of the wearer's head with the eyewear arms contacting the sides of the head) is about 2 Newtons. As the arm is hyperextended, angular displacement in hyperextension (e.g., growth of angle **600** in FIG. **6**) causes the biasing member to gradually increase clamping force proportionally (or substantially proportionally) to the angular displacement. The magnitude of change in the force value (i.e., an additional about 0.5 N per 6 degrees of displacement) is small enough that it would be difficult to perceive by a wearer having a wider head than another wearer. Accordingly, the eyewear can apply a similar level of clamping force to heads having a wide range of widths at which contact with the arms is made. The rate of change of force to angular displacement of profile **1502** can be kept small by using a biasing member having high stiffness and that acts as an at least substantially linear spring and, potentially, a constant force spring.

[0074] In order to optimize usage of internal space in the frame **102** and arm **106**, electronic components can be spaced apart and positioned the frame **102** and arm **106**. Electrical connectors such as cables can be used to link the electronic components, but cables can be relatively fragile as compared to other components, especially when they are configured to pass through a hinge that subjects them to bending and potentially exposes them when the hinge is operated. FIG. **16** is a top perspective view of the cam portion **702** of the hinge **110** shown in FIGS. **11-13**. The cam portion **702** is integrally formed with or attached to an end block **1600** of the arm **106**. The end block **1600** can include a rear opening **1602** that opens into a cavity in the arm **106** in which an arm electronic component is located. See FIG. **18**. The rear opening **1602** can provide access to a side-enclosed, tunnel-like passage **1604** through the end block **1600** that opens into the cam portion **702** at a front opening **1606**. The front opening **1606** opens to a groove, internal channel, or recess **1608** in the top surface of cam portion **702** which has an aperture **1610** at its front end.

[0075] FIG. **17** shows a top view of the cam portion **702** positioned next to the frame **102**. A cable **1700** can extend through the cam portion **702** by passing from the rear opening **1602** through the passage **1604**, past the front opening **1606**, within the recess **1608**, and downward through the aperture **1610** at the front end. A rear end **1702** of the cable **1700** can be electrically connected to an arm electronic component **1704** in the arm **106**, and a front end **1706** of the cable **1700** can be electrically connected to a frame electronic component **1708** in the frame **102**. Accordingly, the cable **1700** can provide electrical communication across the hinge **110** and between electronic components of the frame **102** and arm **106**. The electronic components **1704**, **1708** can include electronic components disclosed elsewhere wherein, such as the electronic components (e.g., **140**, **142**, **144**) of FIG. **1**.

[0076] The cable **1700** can have a series of bent portions along its length between the rear end **1702** and the front end **1706**. In some embodiments, the cable **1700** can have an S-shaped top profile, as shown (rotated counterclockwise 90 degrees) in FIG. **17**, wherein the cable **1700** has at least two lateral bends at different points along its length as it passes through the hinge **110** (e.g., as it passes through cam portion **702**). Each of the bends can have roughly the same angular magnitude, but can keep the cable **1700** ends **1702**, **1706** substantially parallel to each other due to being supplementary to each other as measured from one lateral side of the cable **1700**. In some embodiments, the cable **1700** bends laterally inward (i.e., horizontally toward the center of the frame **102**) near the rear end **1702** and bends laterally outward (i.e., horizontally away from the center of the frame **102**) near the front end **1706**, or vice versa. By passing through the cam portion **702**, the cable **1700** can be hidden and protected by the shell formed by the outer surfaces of the cam portion **702** in all operational configurations of the hinge **110** (i.e., in the folded, nominal, and hyperextended configurations). See, e.g., FIGS. **3-6**. The cable **1700** can therefore be protected and have a longer service life.

[0077] FIG. **17** also shows that the cable **1700** can have a flexible seal **1720** positioned near the front end **1706** that is configured to engage a mouth of a frame passage **1800** on the frame **102**. The flexible seal **1720** can include an elastically flexible material (e.g., rubber or plastic) that longitudinally lengthens or shortens with movement of the cable **1700** to seal the frame passage **1800** against intrusion of fluids (e.g., water) so that fluids in the hinge **110** do not enter the frame **102**. The flexible seal **1720** can change its length along a longitudinal axis of the cable **1700** and can thereby accommodate the movement of the cable **1700** without causing the cable **1700** to bend or buckle where it is sealed at the frame passage **1800**. The flexible seal **1720** can include a tubular feature wrapped around the cable **1700** or can be formed as part of the sheathing of the cable **1700** and attached firmly to (e.g., pressed against and in sealing contact with) the opening at the front end of the frame passage **1800**.

[0078] FIG. **18** shows a side section view of the hinge **110** as taken through section line **18-18** in FIG. **17**. FIG. **18** therefore shows a side view of the routing of the cable **1700** through the hinge **110** along an outward-facing direction. The cable **1700** has a rear end **1702** that enters the rear opening **1602**, extends forward through passage **1604** out of front opening **1606**, across recess **1608**, and down through aperture **1610** into a frame passage **1800** that leads to the frame electronic component **1708**. As shown here, the cable **1700** makes a downward bend where the recess **1608** meets the aperture **1610** and makes a supplementary upward bend at the bottom of the aperture **1610** before entering the frame passage **1800**. Thus, the rear and front ends of the cable **1700** are substantially parallel despite changing elevation within the hinge **110**.

[0079] FIG. **18** also shows that the cam portion **702** has its upper shaft **706** and lower shaft **704** aligned adjacent to the aperture **1610**, and the axis of rotation **700** of the cam portion **702** extends through the cable **1700**. The axis of rotation **700** also extends through the shafts **704**, **706** and through the recess **1608**. Both shafts **704**, **706** brace the cam portion **702** and prevent it from tilting in the opening **400** as the hinge **110** is operated, thereby reducing or eliminating scraping or binding between the cam portion **702** and the opening **400**. For example, the shafts **704**, **706** help prevent rotation of the arm **106** about its longitudinal axis due to each shaft being positioned on opposite vertical sides of the flat surfaces **1100**, **1102** of the cam.

[0080] Movement of the hinge **110** bends the cable at the recess **1608**. The movement of the cable **1700** and its contact with the sides of the recess **1608** and aperture **1610** can cause stress on the cable **1700**, especially over a large number of folding and unfolding cycles. To mitigate this stress, the aperture **1610** can be sized and configured to avoid contact with the cable **1700** for a majority of the range of motion of the arm **106** relative to the frame **102**. For example, the aperture **1610** can have a width sufficient to avoid contact with the cable **1700** at least until about 70 degrees of rotation of the hinge from the nominal position toward the folded position takes place, wherein 70 degrees is a substantial majority of the overall approximately 85-100 degrees of total angular displacement taken in a complete folding movement. Durability of the cable **1700** can also be supplemented by including curved mandrel surfaces **1612**, **1614** at the interface between the recess **1608** and the aperture **1610**, wherein the cable **1700** can laterally come into contact with a curved mandrel surface and can have its radius of bending limited by the surface radius of the mandrel surface against which it makes contact.

[0081] FIG. **18** also shows in cross-section the cam portion **702** with the lower plate **708** positioned inserted into a top opening **1802** of the cam portion **702** that is positioned over the recess **1608** and aperture **1610**. The cam portion **702** and lower plate **708** can in some embodiments be formed as a single integral piece. In the embodiment shown in FIG. **18**, the lower plate **708** is assembled to the cam portion **702** and affixed (e.g., adhered or welded) into place so that the cam portion **702** and lower plate **708** act as a single rigid structure relative to each other. Using a two-piece assembly in this manner can improve manufacturability of the cam portion **702**, particularly with respect to the creation of the aperture **1610** and recess **1608** by techniques such as milling or laser ablation. The top opening **1802** can have a splined perimeter, wherein the perimeter extends partially around the perimeter of the aperture **1610** and partially around two partial recesses **1804** (see FIG. **16**) which have hook-shaped profile portions **1806**. The lower plate **708** can likewise include a splined perimeter configured to be inserted into the top opening **1802** and resting on the partial recesses **1804** with its own hook-shaped profile sections fitting into the portions **1806**, as shown, for example, in FIGS. **7-10**. The unique, irregular shape of the splined profile enables secure, single-orientation attachment between the cam portion **702** and the lower plate **708** and helps ensure a high amount of torque transfer between the parts without jeopardizing the bond or weld made upon assembly. The splined profile also improves and cases manufacturability of the hinge component **304**.

[0082] Personal information data can be used to implement and improve on the various embodiments described herein provided that it is gathered pursuant to authorized and well established secure privacy policies and practices that are appropriate for the type of data collected. The technology detailed above is not, however, rendered inoperable in the absence of such personal information data.

[0083] It will be understood that the details of the present systems and methods above can be combined in various combinations and with alternative components. The scope of the present systems and methods will be further understood by the following claims.

[0084] The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the described embodiments. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the described embodiments. Thus, the foregoing descriptions of the specific embodiments described herein are presented for purposes of illustration and description. They are not target to be exhaustive or to limit the embodiments to the precise forms disclosed. It will be apparent to one of ordinary skill in the art that many modifications and variations are possible in view of the above teachings.

What is claimed is:

1. Electronic eyewear, comprising:

a frame containing a light emitter and a waveguide to direct light from the light emitter, the frame having a first surface;

an arm having a second surface; and

a hinge pivotally joining the frame and the arm, the hinge comprising a first axis of rotation and a second axis of rotation.

2. The electronic eyewear of claim **1**, further comprising:

a first central axis normal to the first surface; and

a second central axis normal to the second surface;

wherein with the hinge in a first open position, the first surface is parallel to the second surface and the first central axis is parallel to the second central axis; and

wherein with the hinge in a second open position, the first surface is non-parallel to the second surface and the second central axis is translated relative to the first central axis.

3. The electronic eyewear of claim **1**, wherein the hinge comprises a first portion inserted into a second portion, the first portion having a first curved exterior surface, and the second portion having a second curved exterior surface;

wherein the first curved exterior surface is vertically aligned with the second curved exterior surface when the hinge is in the first open position.

4. The electronic eyewear of claim **1**, wherein the hinge further comprises a spring member biasing the rear-facing surface and the front-facing surface to the first open position from the second open position.

5. The electronic eyewear of claim **1**, wherein:

the hinge rotates about the first rotation axis when moving from a folded position to a first open position; and

the hinge rotates about the second rotation axis when moving from the first open position to a second open position.

6. The electronic eyewear of claim **1**, wherein the hinge includes a torque profile configured to automatically move to the folded position and to automatically move to the first open position.

7. The electronic eyewear of claim **5**, wherein the hinge comprises:

a cam having a first flat surface and a second flat surface; and

a support surface;

wherein the first flat surface engages the support surface when the hinge is in the folded position; and

wherein the second flat surface engages the support surface when the hinge is in the first open position.

8. The electronic eyewear of claim **7**, wherein the first flat surface and the second flat surface are out of contact with the support surface when the hinge is in the second open position.

9. A hinge for glasses, comprising:

a first hinge portion defining a cam support surface and a rotation assembly, the rotation assembly comprising a spring, a shaft, and a linkage; and

a second hinge portion defining a cam rotatably coupled with the linkage and having a first flat surface and a second flat surface;

wherein:

the spring is configured to bias the cam to rotate about the shaft toward the cam support surface via the linkage;

the cam is rotatable between a first position and a second position;

the first flat surface engages the cam support surface in the first position; and

the second flat surface engages the cam support surface in the second position.

10. The hinge of claim **9**, wherein the cam comprises a second shaft coupled to the linkage.

11. The hinge of claim **9**, wherein:

the rotation assembly further comprises a second linkage rotatably coupled with the cam; and

the linkage is positioned opposite the first and second flat surfaces relative to the second linkage.

12. The hinge of claim **9**, wherein the cam comprises a hard stop surface configured to stop rotation of the cam relative to a stop surface of the first hinge portion.

13. The hinge of claim **9**, wherein the cam comprises an internal channel, wherein a cable is routable between the first and second hinge portions through the internal channel.

14. The hinge of claim **9**, wherein the cam is rotatable about the shaft to a third position with the first and second flat surfaces spaced away from the cam support surface.

15. The hinge of claim **14**, wherein the spring biases the first and second flat surfaces toward the second position from the third position.

16. Electronic glasses, comprising:

an arm structure including a first electronic component, a protrusion, and an aperture defined through the protrusion;

a frame structure having a second electronic component and defining a recess receiving the protrusion, wherein the protrusion is rotatable relative to the recess between a folded position and an unfolded position; and

a cable connecting the first electronic component and the second electronic component, the cable being contained by the aperture and the recess in the folded position and in the unfolded position.

17. The electronic glasses of claim **16**, further comprising a flexible seal;

wherein the cable comprises a longitudinal axis; and

wherein the cable is configured to translate along the longitudinal axis to flex the flexible seal.

18. The electronic glasses of claim **16**, wherein:

the protrusion includes a curved surface;

the frame structure includes a rounded external surface; and

the curved surface and the rounded external surface have matching curvature in the unfolded position.

19. The electronic glasses of claim **16**, wherein the cable bends at least twice within the aperture.

20. The electronic glasses of claim **16**, wherein:

the aperture comprises a recess portion;

the cable is positioned in the recess portion; and

a rotation axis of the protrusion extends through the recess portion.

* * * * *