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(54) Title: APPARATUS AND METHOD FOR GENERATING ACOUSTIC ENERGY IN A RECEIVER ASSEMBLY

(57) Abstract: A receiver assembly includes a first diaphragm assembly having a diaphragm, and a second diaphragm assembly having a diaphragm. A linkage assembly is coupled to an armature of the receiver. The linkage assembly is also coupled to the first diaphragm assembly and to the second diaphragm assembly.



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APPARATUS AND METHOD FOR GENERATING ACOUSTIC ENERGY IN A RECEIVER ASSEMBLY

CROSS-REFERENCE TO RELATED PATENT APPLICATION

[0001] This application claims the benefit of U.S. Provisional

5 Application No. 60/469,154, filed May 9, 2003, the disclosure of which is hereby incorporated herein by reference in its entirety for all purposes.

[0002] This application is related to U.S. Application No. _____
(Atty. Docket No. 30521/3079A), entitled " APPARATUS AND METHOD FOR
GENERATING ACOUSTIC ENERGY IN A RECEIVER ASSEMBLY," filed on
10 the same day as the present application, which is hereby incorporated by reference herein in its entirety for all purposes.

TECHNICAL FIELD

[0003] This patent generally relates to receivers used in listening
devices, such as hearing aids or the like, and more particularly, to a
15 diaphragm assembly for use in a vibration-balanced receiver assembly capable of maintaining performance within a predetermined frequency range and a method of manufacturing the same.

BACKGROUND

[0004] Hearing aid technology has progressed rapidly in recent years.

20 Technological advancements in this field continue to improve the reception, wearing-comfort, life-span, and power efficiency of hearing aids. With these continual advances in the performance of ear-worn acoustic devices, ever-increasing demands are placed upon improving the inherent performance of the miniature acoustic transducers that are utilized. There are several
25 different hearing aid styles including: Behind-The-Ear (BTE), In-The-Ear or All In-The-Ear (ITE), In-The-Canal (ITC), and Completely-In-The-Canal (CTC).

[0005] Generally, a listening device, such as a hearing aid, includes a microphone assembly, an amplifier and a receiver (speaker) assembly. The microphone assembly receives vibration energy, i.e. acoustic sound waves in audible frequencies, and generates an electronic signal representative of these sound waves. The amplifier accepts the electronic signal, modifies the electronic signal, and communicates the modified electronic signal (e.g., processed signal) to the receiver assembly. The receiver assembly, in turn, converts the increased electronic signal into vibration energy for transmission to a user.

[0006] Conventionally, the receiver assembly utilizes moving parts (e.g., armature, diaphragm, etc.) to generate acoustic energy in the ear canal of the hearing aid wearer. If the receiver assembly is in contact with another hearing aid component, the momentum of these moving parts will be transferred from the receiver assembly to the component and from the component back to the microphone assembly. This transferred momentum or energy may then cause unintended electrical output from the microphone, i.e., feedback. This mechanism of unwanted feedback limits the amount of amplification that can be applied to the electric signal representing the received sound waves. In many situations, this limitation is detrimental to the performance of the hearing aid. Consequently, it is desirable to reduce the vibration and/or magnetic feedback that occurs in the receiver assembly of the hearing aid or other similar devices.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For a more complete understanding of the disclosure, reference should be made to the following detailed description and accompanying drawings wherein:

5 [0008] FIG 1 is a cross-sectional view of an exemplary embodiment of a receiver assembly;

[0009] FIG. 2 is a perspective view of an exemplary motor assembly shown FIG. 1;

10 [0010] FIG. 3 is a cross-sectional view of another embodiment of a receiver assembly;

[0011] FIG. 4 is a perspective view of another embodiment of a motor assembly;

[0012] FIG. 5 is a cross-sectional view of an alternate embodiment of a receiver assembly;

15 [0013] FIG. 6 is a cross-sectional view of another alternate embodiment of a receiver assembly;

[0014] FIG. 7 is a perspective view of a motor assembly of shown FIGS. 5 and 6;

20 [0015] FIG. 8 is a front view of a described embodiment of a receiver assembly;

[0016] FIG. 9 is a front view of another described embodiment of a receiver assembly;

[0017] FIG. 10 is a front view of another described embodiment of a receiver assembly;

[0018] FIG. 11 is a front view of another described embodiment of a receiver assembly; and

[0019] FIG. 12 is a front view of another described embodiment of a receiver assembly.

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DETAILED DESCRIPTION

[0020] While the present disclosure is susceptible to various modifications and alternative forms, certain embodiments are shown by way of example in the drawings and these embodiments will be described in detail herein. It will be understood, however, that this disclosure is not intended to limit the invention to the particular forms described, but to the contrary, the invention is intended to cover all modifications, alternatives, and equivalents falling within the spirit and scope of the invention defined by the appended claims.

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[0021] It should also be understood that, unless a term is expressly defined in this patent using the sentence "As used herein, the term '____' is hereby defined to mean..." or a similar sentence, there is no intent to limit the meaning of that term, either expressly or by implication, beyond its plain or ordinary meaning, and such term should not be interpreted to be limited in scope based on any statement made in any section of this patent (other than the language of the claims). To the extent that any term recited in the claims at the end of this patent is referred to in this patent in a manner consistent with a single meaning, that is done for sake of clarity only so as to not confuse the reader, and it is not intended that such claim term be limited, by implication or otherwise, to that single meaning. Unless a claim element is defined by reciting the word "means" and a function without the recital of any

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structure, it is not intended that the scope of any claim element be interpreted based on the application of 35 U.S.C. §112, sixth paragraph.

[0022] The following patent applications describe techniques that may be employed in certain embodiments of receiver assemblies: U.S. Patent

5 Application Serial No. 10/719,809, entitled "Apparatus For Creating Acoustic Energy In A Balanced Receiver Assembly And Manufacturing Method Thereof," filed on November 21, 2003; U.S. Patent Application Serial No.

10/719,765, entitled "Apparatus For Energy Transfer In A Balanced Receiver Assembly And Manufacturing Method Thereof," filed on November 21, 2003;

10 both applications claim the benefit of U.S. Provisional Patent Application No. 60/428,604, filed on November 22, 2002; U.S. Patent Application Serial No.

09/755,664, entitled "Vibration Balanced Receiver," filed on January 5, 2001,

is a continuation-in-part of the now-abandoned U.S. Patent Application Serial No. 09/479,134, entitled "Vibration Balanced Receiver," filed January 7, 2000,

15 U.S. Patent Application Serial No. 09/809,130, entitled "Vibration-Dampening Receiver Assembly", filed on March 15, 2003. These patent applications are hereby incorporated by reference herein in their entireties for all purposes. It is to be understood, however, that the techniques described in these patent applications are not required.

20 **[0023]** FIGS. 1 and 2 illustrate an exemplary embodiment of a receiver assembly 100. The receiver assembly 100 includes a housing 102 that may be, for example, rectangular in cross-section with a planar top 104, a bottom 106, and side walls 108, 110. In alternate embodiments, the housing 102 can be manufactured in a variety of configurations, such as, a cylindrical shape, a
25 D-shape, a trapezoid shape, a roughly square shape, or any other desired

geometry. In addition, the scale and size of the housing 102 may vary based on the intended application, operating conditions, required components, etc. Moreover, the housing 102 can be manufactured from a variety of materials, such as, for example, stainless steel, alternating layers of conductive materials, or alternating layers of non-conductive materials (e.g., metal particle-coated plastics). The bottom 106 of the housing 102 may include a plurality of supporting members 112 adapted to support both a magnet assembly 130 and a motor assembly 140. It will be understood that a variety of supporting structures such as, for example, a u-shape plate, a pair of deformed corners, or a glue fillet, may be utilized to support the magnet assembly and motor assemblies 130,140.

[0024] A first and second bellows-like member 114, 116 are provided in the surface of the housing 102 and allow motion in response to the flexing of a linkage assembly 120. The first and second bellows-like member 114, 116 may have an accordion like structure including a plurality of ridges and valleys, may be a pliant sheet of material, and may be any other type of flexible membrane capable of expanding and contracting in response to the flexure of the linkage assembly 120. For example, as is shown in the embodiment depicted in FIG. 1, the first bellows-like member 114 may be disposed in the top 104 of the housing 102, and the second bellows-like member 116 may be disposed in the bottom 106 of the housing 102.

Separate housing sections incorporating the bellows-like members 114 and 116 may be provided, or the bellows-like members 114 and 116 may otherwise be provided within the housing 102. In other words, the bellows-like members 114, 116 may be incorporated separately into the top 104 and the

bottom 106, respectively, or can be a single flexible membrane disposed and joining a fixed portion of the housing 102 to a moveable portion of the housing 102. In operation, the first and second bellows-like member 114, 116 allow movement of a radiating face or piston diaphragm 122 in response to the movement of the linkage assembly 120 to thereby pump or force air.

[0025] The radiating face or piston diaphragm 122 attaches to the inner surface of the side wall 110 by bonding or any other suitable method of attachment. The radiating face 122 translates relative to the housing 102 in accordance with the movement of the linkage assembly 120 driving the first and second bellows-like members 114, 116. The radiating face 122 may be manufactured from mylar or other suitable material of suitable stiffness and rigidity to provide an output acoustical signal of the receiver assembly 100 that corresponds to the input audio signal received at an electrical terminal 124 positioned on an external surface 108a of the side wall 108.

[0026] The receiver assembly 100 further includes a drive coil 126 having a central channel defining a first air gap 128 therethrough. The illustrated drive coil 126 is sized to conform to the shape of the housing 102, but may produced in a variety of shapes and sizes that may or may not correspond to the housing shape. For example, in one embodiment the drive coil 126 may be manufactured having an overall rectangular shape to correspond to the rectangular shape of the housing 102. The drive coil 126 is made of electrically conductive materials having a thickness and a plurality of turns such as the drive coil disclosed in U.S. Patent Application 09/928,673, entitled "Low Capacitance Receiver Coil," filed on August 21, 2001, the disclosure of which is hereby incorporated herein by reference in its entirety

for all purposes. In alternate embodiments, the drive coil 112 may be made of alternating layers of insulating materials (e.g., copper-polymer based film).

[0027] The receiver assembly 100 further includes a magnet assembly 130 including a pair of drive magnets 134 fixedly attached to a magnetic yoke 132. The magnet assembly 130 may generally be shaped to correspond to the shape and configuration of the housing 102, but may be in various shapes and sizes. The magnetic yoke 132 forms a rectangular frame having a central tunnel or channel defining an enclosure into which the drive magnets 134 mount and form a second air gap 136.

[0028] The magnetic yoke 132 may be manufactured of soft magnetic materials having a high permeability and a high saturation induction such as, for example, nickel-iron alloy, iron-silicon alloy, or cobalt-iron vanadium alloy, having a thickness to carry the electromagnetic flux of the drive magnets 134 and the drive coil 126. The drive magnets 134 may be manufactured from a variety of materials, such as, for example, a permanent magnet material (e.g., aluminum-nickel-cobalt, ferrite), a rare earth magnet material such as, for example samarium-cobalt (SmCo), neodymium-iron-boron (NdFeB), having a thickness to provide sufficient electromagnetic flux density within the second air gap 136.

[0029] The receiver assembly 100 further includes a motor assembly 140 including an armature 142, a link or drive rod 144, and at least one member of the linkage assembly 120. The linkage assembly 120 is shown generally semi-lateral, having a plurality of linear link members 120a, 120b, 120c, 120d, 120e and vertices 120f, 120g. The linkage assembly 120 may be formed into a variety of shapes and configurations based on the intended

application, operating conditions, required components, etc. The linkage assembly 120 may be fabricated from a flat stock material such as a thin strip of metal or foil having a surface that defines a plane, and a width that is perpendicular to the plane. Alternately, the linkage assembly 120 may be formed of plastic or some other pliant material. Each of the link members 120a, 120b, 120c, 120d, 120e is illustrated as a substantially flat or linear component connected together at the vertices 120f, 120g. The transitions from one link member (e.g. 120e to 120d, and 120a to 120b) to another link member may be abrupt and sharply angled such as shown at the exemplary vertices 120f, 120g, or may be curved, or even expanded to include at least one short span, such as a link vertex 120c.

[0030] The armature 142 may be configured as a generally U-shaped strap having first and second opposing legs 142a, 142b, respectively. One skilled in the art will appreciate the principles and advantages of the embodiments described herein may be useful with all types of receivers, such as, for example, receivers employing an E-shaped armature. The armature 142 extends through the first air gap 128 of the drive coil 126 and the second air gap 136 of the magnet assembly 130. The drive rod 144, attached to the armature 142 adjacent to the free end of the first leg 142a, is positioned within the housing 102. The drive rod 144, in turn, couples to the inner surface of the link member 120a, for example by adhesive bonding, and hence to the remainder of the drive linkage assembly 120. In alternate embodiments, the link member 120a may include an aperture to allow the drive rod 144 to extend therethrough and slideably couples the link member 120a to the linkage assembly 120. The magnet assembly 130 surrounds the first leg

142a of the armature 142 and provides a permanent magnetic field within the second air gap 136.

[0031] At least one mounting member or spacer, two are illustrated as mounting members 150, 152 are introduced to support and secure the linkage assembly 120. The mounting members 150, 152 may be adhesive bumps, may be formed portions of the housing 102, and may be sized to space the linkage assembly 120 away from the magnet assembly 130 and the housing 102. The thickness and material of the mounting members 150, 152 may vary depending on the requirements of the application. It will be understood that a variety of mounting members such as, for example, a glue fillet, may be utilized to support the linkage assembly. In alternate embodiment, a spacer (not depicted) having a hollow section may be placed between the linkage assembly 120 and the magnet assembly 130 to support the linkage assembly 120.

[0032] The outer surface of the mounting member 150 secures to the inner surface of the member 126a by bonding or any other suitable method of attachment, and the inner surface of the mounting member 150 secures to the outer surface of the magnet assembly 130 by bonding or any other suitable method of attachment. Similarly, the inner surface of the mounting member 152 secures to the outer surface of the second leg 142b of the armature 142 by bonding or any other suitable method of attachment, and the outer surface of the mounting member 152 secures to the inner surface of the member 120e by bonding or any other suitable method of attachment.

[0033] In operation, excitation of the drive coil 144 (as shown in FIG. 1) magnetizes the armature 142. Interaction of the first leg 142a with the

magnetic field causes the first leg 142a of the armature 142 to vibrate, which leads to the movement of the drive rod 144. When the drive rod 144 moves in a first direction (e.g., up and down, as shown by the arrow A), the link members 120a, 120b, 120c, 120d, 120e, 120f, and 120g of the linkage assembly 120 move in response to the drive rod 144. The motion of the drive rod 144 is converted into at vertex 120c of the linkage assembly 120, resulting in motion in a second direction (e.g., movement in the direction shown by the arrow B) of the radiating face 122 of the housing 102. As an example, upward movement by the first leg 142a generates a movement of the drive rod 144 substantially aligned with the first direction, which in turn, generates a movement of vertex 120c substantially aligned with the second direction, resulting in movement of the radiating face 122 of the housing 102.

[0034] The bellow-like members 114, 116 of the housing 102 as shown in FIG. 1 enclosed the drive coil 126, the magnet assembly 130, and the motor assembly 140 from the outside, but allow the radiating face 122 to move freely in the second direction (as shown by the arrow B). Formed in this manner, the receiver assembly 100 has the advantage of radiating an increased amount of output acoustical signal without a conventional diaphragm and a sound port. In addition, the sound port may be eliminated, thus allowing the receiver assembly 100 to be less susceptible to the accumulation of cerumen and moisture. A device built in accordance with the embodiment illustrated in FIGS. 1 and 2, has the advantage of reduced overall size while providing improved performance characteristics such as sensitivity, noise, stability, compactness, robustness, maintaining high degree

of reproducibility and other external and environmental conditions (including shock and debris).

[0035] Referring now to FIG. 3, a receiver assembly 200 in accordance with another embodiment of the invention is illustrated. The assembly 200 is similar in construction and function as the assembly 100 illustrated in FIG. 1, and like elements are referred to using like reference numerals wherein, for example 200 and 226 correspond to 100 and 126, respectively. A first and second formation 262, 264 are positioned on opposing sides of the inner surface of the magnet assembly 230 to prevent the first leg 242a of the armature 242 from striking or directly contacting the drive magnet 234, which in turn, stabilizes the radiating face 222 the housing 202. The formations 262, 264 may be constructed of adhesive or other settable material to provide shock resistance for the receiver assembly 200 by inhibiting large deflections of the first armature leg 242a. The formations or bumpers 262, 264 may protect the first armature leg 242a as disclosed in U.S. Application Serial No. 10/089,861, entitled "Electro-Acoustic Transducer With Resistance to Shock-Waves" filed on August 8, 2000, the disclosure of which is hereby incorporated herein by reference in its entirety for all purposes.

[0036] However, the formations 262, 264 may take the form of various shapes, and have a number of different sizes in different embodiments. Moreover, the formations 262, 264 can be manufactured from a variety of materials, such as, for example, damping fluid, an elastomer, an epoxy, or a plastic. The damping fluid may be a shock resistant fluid contained within the gap 236 such as disclosed in U.S. Patent No. 6,041,131, entitled "Shock Resistant Electroacoustic Transducer," issued on March 21, 2000, the

disclosure of which is hereby incorporated herein by reference in its entirety for all purposes. In operation, the formations 262, 264 improve resistance of the receiver assembly 200 during insertion, removal, and cleaning of the ceruman accumulation on the outside of the housing 202. In alternate
5 embodiments, the formations may be manufactured on the inner surface of the drive coil 226, on the first armature 242a within the first air gap 228, on the first armature 242a within the second air gap 236, or on both.

[0037] Referring now to FIG. 4, a receiver assembly 300 in accordance with a yet another embodiment of the invention is illustrated. The assembly
10 300 is similar in construction and function as the assembly 100 illustrated in FIG. 1, and like elements are referred to using like reference numerals wherein, for example 300 and 326 correspond to 100 and 126, respectively.

A second linkage assembly 370 is introduced to restrain inward motion of the radiating face 354, i.e. motion associated with the second direction (see arrow

15 B of FIG. 1). The second linkage assembly 370 is shown generally semi-lateral, having a plurality of link members 370a, 370b, 370c, 370d, 370e and vertices 370f, 370g. The second linkage assembly 370 may take the form of various shapes and configurations based on the intended application, operating conditions, required components, etc. The linkage assembly 370
20 may be fabricated from a flat stock material such as a thin strip of metal or foil having a surface that defines a plane, and a width that is perpendicular to the plane. Alternately, the linkage assembly 370 may be formed of plastic or some other material. The link members 370a, 370b, 370c, 370d, 370e are shown substantially straight and connected together at the vertices 370f,
25 370g. The transitions from one member to its neighbor may be abrupt and

sharply angled such as illustrated by the vertices 370f, 370g, may be rounded, or may be rounded expanded and include at least one short span, such as the vertex 370c.

[0038] The outer surface of the vertex 370c fixedly or removeably
5 attaches to the inner surface of the vertex 320c for example by adhesive bonding or other suitable attachment means. The inner surface of the vertex 370c is symmetrically located on the opposing side of the magnet assembly 330. In operation, excitation of the drive coil (not depicted) magnetizes the first armature leg 342a. Interaction of the first armature leg 342a with the
10 magnetic field causes the first armature leg 342a to vibrate in the first direction (see arrow A of FIG. 1), which leads to movement of the drive rod 344. When the drive rod 344 moves in the first direction, the members of the first linkage assembly 320 move in response to the drive 344. The motion of the drive rod 344 is converted into the second direction at the vertex 320c of
15 the first linkage assembly 320. The members of the second linkage assembly 370 prevent the link members 320a, 320b, 320c, 320d, and 320e of the first linkage assembly 320 from swinging back and forth in an uncontrolled manner. The motion at vertex 320c of the first linkage assembly 320 is transferred to the second linkage assembly 370 at the vertex 370c thereby
20 resulting in motion of the radiating face (e.g., the radiating face 122 shown in FIG. 1) of the receiver assembly 300. Formed in this manner, the second linkage assembly 370 provides additional support and rigidity to the first linkage assembly 320 of the receiver assembly.

[0039] Referring now to FIGS. 5-7, a receiver assembly 400 in
25 accordance with a described embodiment of the invention is illustrated. The

assembly 400 is similar in construction and function as the assembly 100 illustrated in FIG. 1, and like elements are referred to using like reference numerals wherein, for example 400 and 426 correspond to 200 and 226, respectively. A first and second bellows-like member 414, 416 are provided in the surface of the housing 402 to allow or restrain motion in response to the motion of a linkage assembly 420. The first bellows-like member 414 may be formed integral to the planar top 404 of the housing 402, and the second bellows-like member 416 may be formed integral to the bottom 406 of the housing 402 and outside the linkage assembly 420. In operation, the first and second bellows-like member 414, 416 allow movement of a radiating face or piston diaphragm 422 in response to the movement of the linkage assembly 420 to thereby pump or force air.

[0040] The radiating face or piston diaphragm 422 attaches to the inner surface of the side wall 410 by bonding or any other suitable method of attachment. The radiating face 422 may be manufactured of mylar or other material of suitable stiffness and rigidity to provide output acoustical signals that corresponds to the input audio signal received at the electrical terminal 424 positioned on an external surface 408a of the side wall 408.

[0041] The receiver assembly 400 further includes a drive coil 426 having a central tunnel or channel defining a first air gap 428 therethrough. The drive coil 426 is sized to conform to the shape of the housing 402, but may be produced in a variety shapes and sizes that may or may not correspond to the housing shape. For example, in one embodiment the drive coil 426 may be manufactured having an overall rectangular shape corresponding to the rectangular shape of the housing 402. The drive coil

426 is made of electrically conductive materials having a thickness and a plurality of space turns such as the drive coil disclosed in U.S. Patent Application 09/928,673, entitled "Low Capacitance Receiver Coil," filed on August 21, 2001, the disclosure of which is hereby incorporated herein by reference in its entirety for all purposes. In alternate embodiments, the drive coil 426 may be made of alternating layers of insulating materials (e.g., copper-polymer based film).

[0042] The receiver assembly 400 further includes a magnet assembly 430 including a drive magnet 434 fixedly attached to a magnetic yoke 432.

The magnet assembly 430 may generally be shaped to correspond to the shape and configuration of the housing 402, but may be formed to compliment the various shapes and sizes of the different embodiments. The magnetic yoke 432 in the form of a rectangular frame having a relatively large central tunnel or channel forming an enclosure in which the drive magnet 434 are mounted in space relation to form a second air gap 434.

[0043] The magnetic yoke 432 is typically manufactured of magnetically conductive materials having a high permeability and a high saturation induction such as, for example, nickel-iron alloy, iron-silicon alloy, or cobalt-iron vanadium alloy, having a thickness to carry the electromagnetic flux of the drive magnet 434 and the drive coil 426. The drive magnet 434 is typically manufactured of a rare earth magnet material such as, for example samarium-cobalt (SmCo), neodymium-iron-boron (NdFeB), having a thickness to provide sufficient electromagnetic flux density within the second air gap 436.

[0044] The receiver assembly 400 further includes a motor assembly 440. The motor assembly 440 includes an armature 442, a link or drive rod 444, and at least one linkage assembly 420. The linkage assembly 420 is shown generally L-shape, having a plurality of link members 420a, 420b and vertex 420c. The linkage assembly 420 may take the form of various shapes and configurations based on the intended application, operating conditions, required components, etc. The linkage assembly 420 may be fabricated from a flat stock material such as a thin strip of metal or foil having a surface that defines a plane, and a width that is perpendicular to the plane. Alternately, the linkage assembly 420 may be formed of plastic or some other material. Each of the link members 420a, 420b are shown substantially straight and connected together at the vertex 420c. The transitions from one member to its neighbor may be abrupt and sharply angled such as the vertex 420c, or may be expanded and include at least one short span, such as a link vertex 420b.

[0045] The armature 442 is configured as a generally U-shaped strap having first and second opposed legs 442a, 442b, respectively. One skilled in the art will appreciate the principles and advantages of the embodiments described herein may be useful with all types of receives, such as those using an E-shaped armature. The armature 442 extends through the first air gap 428 of the drive coil 426 and the second air gap 436 of the magnet assembly 430. A drive rod 444, attached to the armature 442 adjacent to the free end of the first leg 442a, is positioned within the housing 402. The drive rod 444, in turn, couples to the inner surface of the link member 420a, for example by adhesive bonding, and hence to the remainder of the drive the linkage

assembly 420. The drive rod 444 may be made of a strip of material, such as metal or plastic, capable of vibrating in response to the acoustical signal. In alternate embodiment, the linkage assembly 420 and the drive rod 444 can be formed from the same stock and molded or press-fit to the linkage assembly
5 420 as a single unit. The magnet assembly 430 surrounds the first leg 442a of the armature 442 and provides a permanent magnetic field within the second air gap 436.

[0046] At least one mounting member or spacer, two are illustrated as mounting members 450, 452 are introduced to support and secure the linkage
10 assembly 420. The mounting members 450, 452 may be adhesive bumps, may be formed portions of the housing 102, and may be positioned between the linkage assembly 420 and the inner wall of the housing 402. The thickness and materials of the mounting members 450, 452 may vary depending on the requirements of the application. It will be understood that a
15 variety of mounting members such as, for example, a glue fillet, may be utilized to support the linkage assembly 420.

[0047] The outer surface of the mounting member 450 secures to the inner surface of the member 420a by bonding or any other suitable method of attachment, and the inner surface of the mounting member 450 is held in
20 contact with the outer surface of the radiating face 422 by bonding or any other suitable method of attachment. The inner surface of the mounting member 452 is held in contact with the inner surface of the bottom housing 406 by bonding or any other suitable method of attachment. The outer
25 surface of the mounting member 452 is held in contact with the inner surface of the member 420c by bonding or any other suitable method of attachment.

[0048] In operation, excitation of the drive coil 444 magnetizes the armature 442. Interaction of the first armature leg 442a with the magnetic field causes the first armature leg 442a to vibrate, which lead to the movement of the drive rod 444. When the drive rod 444 moves in response to the motion of the first armature leg 442a in the first direction, the link members 420a, 420b, and 420c of the linkage assembly 420 move in the second direction in response to the drive rod 444. The motion of the first armature leg 442a is converted at the drive rod 444 and the member 420a of the linkage assembly 420, resulting in motion of the radiating face 422 of the housing 402 in the second direction. As an example, the movement by the first armature leg 442a generates a movement of the drive rod 444 substantially aligned with the first direction, which in turn, generates a movement of member 420a of the linkage assembly 420 substantially aligned with the second direction, resulting in movement of the radiating face 422 of the housing 402. In other words, the movement of the first armature leg 442a can cause the drive rod 444 to move in the direction indicated by the theta symbol.

[0049] The first and the second bellows-like members 414, 416 of the housing 402 as shown in FIGS. 5 and 6 enclosed the drive coil 426, the magnet assembly 430, and the motor assembly 440 from the outside, but allow the radiating face 422 to move freely in horizontal motions (depicted as arrow B). Formed in this manner, the receiver assembly 400 has an increased amount of output acoustical signals without a conventional diaphragm and a sound port. In addition, the use of sound port is eliminated, thus allowing the receiver assembly 400 to be less susceptible to the accumulation of cerumen and moisture.

[0050] To further restrain large vibration in response to the vibration of the armature 442, the second bellows-like member 416 as shown in FIG. 6, is positioned inside the linkage assembly 420 to further restrain the motion of the mounting member 450 to a horizontal motion.

5 [0051] FIG. 8 illustrates another embodiment of a receiver assembly. The receiver assembly 500 includes a housing 502 having at least one sound outlet tube 503. The housing 502 may be generally rectangular with a top portion 504, a bottom portion 506, and side wall portions 508, 510. In alternate embodiments, the housing 502 can be manufactured in a variety of configurations, such as, a cylindrical shape, a D-shape, a trapezoid shape, a roughly square shape or any other desired geometry. In addition, the scale and size of the housing 502 may vary based on the intended application, operating conditions, required components, etc. Moreover, the housing 502 can be manufactured from a variety of materials, such as, for example
10 stainless steel, alternating layers of conductive materials, alternating layers of non-conductive materials (e.g., metal particle-coated plastics), etc.

[0052] One or more apertures or acoustic ports 504a, 504b are introduced integral to the top portion 504 to broadcast an output acoustical signal that corresponds to an audio signal received at an electrical terminal
20 (not shown) positioned on an external surface of the housing 502. In alternate embodiment, the acoustic ports 504a, 504b can be formed in the side walls 508, 510. The acoustic ports 504a, 504b may be formed in any suitable manner such as drilling, punching or molding. A sound outlet tube 503 is coupled to the top portion 504 by bonding with adhesive or any other suitable
25 method. In an alternate embodiment, the sound outlet tube 503 can be

formed integral to the side walls 508, 510. The sound outlet tube 503 can be manufactured from a variety of materials such as, for example, stainless steel, alternating layers of conductive materials, alternating layers of non-conductive materials (e.g. metal particle-coated plastics), etc. The sound outlet tube 503
5 can be formed in various shapes and may have a number of different sizes.

The sound outlet tube 503 comprises a sound passage 512 to guide the output acoustical signal via acoustic ports 504a, 504b towards the user's eardrum. The sound passage 512 may be formed in any suitable manner such as drilling, punching or molding. An optional damping element or filter
10 514 may be positioned within the sound passage 512. The damping element or filter 514 may provide an acoustical resistance to the receiver assembly 500, may improve the frequency response, may create delay, and may prevent debris from entering the receiver assembly 500. The receiver
assembly 500 may further include a drive coil (not depicted) which may be
15 located in side-by-side abutting alignment with a magnet assembly 530 within the housing 502 and an electrical terminal (not depicted) positioned on the external surface of the housing 502 for receiving an input audio frequency electrical signal.

[0053] The receiver assembly 500 further includes a magnet assembly
20 530 including a pair of drive magnets 534 fixedly attached to a magnetic yoke 532. The magnet assembly 530 may generally be shaped to correspond to the shape and configuration of the housing 502 but may be formed to compliment the various shapes and sizes of other embodiments. The magnetic yoke 532 forms of a generally rectangular frame having a central
25 tunnel or channel defining an enclosure into which the drive magnets 534 may

mount and form an air gap. The magnetic yoke 532 is typically manufactured of a soft magnetic material having a high permeability and a high saturation induction such as, for example, nickel-iron alloy, iron-silicon alloy, cobalt-iron vanadium alloy, etc., having a thickness to carry the electromagnetic flux of the drive magnets 534 and the drive coil (not depicted). The drive magnets 534 are typically manufactured of a magnetic material such as a permanent magnetic material (e.g., Alnico, Ferrite) or a rare earth magnet material such as, for example Samarium-Cobalt (SmCo), Neodymium-Iron-Boron (NdFeB), having a thickness to provide sufficient electromagnetic flux density within the air gap.

[0054] The receiver assembly 500 may further include a motor assembly 540 including an armature 542, a link or drive rod 544, and at least one linkage assembly 520. The linkage assembly 520 includes a plurality of link members 520a, 520b, 520c, 520d, 520e and vertices 520f, 520g. The linkage assembly 520 may be formed into a variety of shapes and configurations based on the intended application, operating conditions, required components, etc. The linkage assembly 520 is typically fabricated from a flat stock material such as a thin strip of metal or foil. Alternately, the linkage assembly 520 may be formed of plastic or some other material. Each of the link members 520a, 520b, 520c, 520d, 520e is illustrated as a substantially flat component connected together at the vertices 520f, 520g. The transitions from one link member to another link member may be abrupt and sharply angled such as shown at the exemplary vertices 520f, 520g, or may be curved or expanded and include at least one short span, such as the link member 520c. The armature 542 is configured as a generally U-shaped

strap having first and second opposed legs 542a, 542b, respectively. In other embodiments, different types of armatures may be used such as E-shaped armatures. At least the leg 542a of the armature 542 extends through an air gap of the drive coil (not shown) and an air gap of the magnet assembly 530.

5 One end of the drive rod 544 may be coupled to a free end of the first armature leg 542a. The other end of the drive rod 544 couples to an inner surface of the link member 520c by means of adhesive or any other suitable method. In an alternate embodiment, the member 520c may include an aperture to allow the drive rod 544 to extend therethrough and coupled to the member 520c by bonding or any other suitable method. Also, the linkage
10 assembly 520 and the drive rod 544 can be formed from the same stock and molded or press-fit to the linkage assembly 520 to form one unit. The magnet assembly 530 provides a permanent magnetic field within the air gap of the of the drive magnet 534 through which the leg 542a if the armature 542 extends.

15 [0055] A first and second diaphragm assembly 550, 560 are introduced to increase the radiating area, each of whose reciprocating motion displaces air to produce acoustic output. The diaphragm assemblies 550, 560 include thin films 552, 562 and diaphragms 554, 564 attached to the thin films 552, 562. The diaphragm assemblies 550, 560 may have a generally rectangular
20 shape that generally corresponds to that of the side portions 508, 510 but may take the form of various shapes and have a number of different of sizes in different embodiments. The diaphragm assemblies 550, 560 are secured to the outer surface of the magnet assembly 530 by bonding with adhesive or any other suitable attachment. In alternate embodiment, the diaphragm
25 assemblies 550, 560 can be secured to the inner surface of the housing 502

by bonding with adhesive or any other suitable attachment. The diaphragms 554, 564 are shown to have at least one layer. However, the diaphragms 554, 564 may utilize multiple layers and coupled together by bonding with adhesive, compression, mechanical attachment at the edges, etc. The

5 diaphragms 554, 564 can be manufactured from a variety of materials such as aluminum, stainless steel, beryllium copper, titanium, tungsten, platinum, copper, brass, or alloys thereof, non-metals such as modified ethylene vinyl acetate thermoplastic adhesive, thermo set adhesive, epoxy, polyimide (Kapton), plastic, plastic matrix, fiber reinforced plastic, etc., or multiples of
10 these could be used. Formed in this manner, the diaphragm assemblies 550, 560 increase the radiating area to provide an output acoustical signal correspond to the input audio signal received at the electrical signal (not depicted) such that the acoustic pressures developed by the diaphragm assemblies 550, 560 are essentially in-phase with each other.

15 **[0056]** The diaphragm assemblies 550, 560 and the armature 542 are coupled to the linkage assembly 520. The first diaphragm assembly 550 is coupled to the linkage assembly 520 at or near the link member 520a by bonding or any other suitable method. The second diaphragm assembly 560 is coupled to the linkage assembly 520 at or near the link member 520e by
20 bonding or any other suitable method.

[0057] In operation, excitation of the drive coil (not shown) in response to electronic signals at the electrical terminals (not shown) magnetizes the armature 542. Interaction of the first armature leg 542a with the magnetic field causes the first armature leg 542a to vibrate vertically, which leads to the
25 movement of the drive rod 544. When the drive rod 544 moves in response to

the vertical motion of the first armature leg 542a, the members of the linkage assembly 520 move in response to the drive rod 544. The vertical motion of the first armature leg 542a is converted into lateral motion at the members 520a, 520e of the linkage assembly 520, resulting in lateral motion of the diaphragms 554, 564 substantially perpendicular to the vertical motion of the first armature leg 542a. As an example, upward vertical movement by the first armature leg 542a in the direction F generates upward vertical movement of the drive rod 544 in the direction F, which in turn, generates upward vertical movement at member 520c of the linkage assembly 520 in the direction F.

The upward vertical movement at member 520c of the linkage assembly 520 causes members 520a, 520e of the linkage assembly 520 to move inwardly toward each other generally perpendicular to the direction F, which in turn, causes the diaphragm 554 and the diaphragm 564 to move inwardly toward each other generally perpendicular to the direction F.

[0058] FIG. 9 illustrates yet another embodiment of a receiver assembly. The assembly 600 is similar in construction and function as the assembly 500 illustrated in FIG. 8, and similar elements are referred to using like reference numerals wherein, for example 600 and 650 correspond to 500 and 550, respectively. In this embodiment, a second linkage assembly 680 is introduced. The second linkage assembly 680 includes a plurality of link members 680a, 680b, 680c, 680d, 680e and vertices 680f, 680g. The second linkage assembly 680 may take the form of various shapes and configurations based on the intended application, operating conditions, required components, etc. The linkage assembly 680 is typically fabricated from a flat stock material such as a thin strip of metal or foil. Alternately, the linkage

assembly 680 may be formed of plastic or some other material. Each of the link members 680a, 680b, 680c, 680d, 680e is illustrated as a substantially flat component connected together at the vertices 680f, 680g. The transitions from one link member to another link member may be abrupt and sharply angled such as 680f, 680g, or may be curved or even expanded and include at least one short span, such as vertex 680c. An outer surface of the vertex 680a may be coupled to an inner surface of the vertex 620a by bonding or any other suitable method. An outer surface of the vertex 680e may be coupled to an inner surface of the vertex 620e by bonding or any other suitable method. Alternatively, the first linkage assembly 620 and the second linkage assembly 680 can be formed from the same stock and molded or press-fit to the linkage assembly 620 to form one unit.

[0059] In operation, excitation of the drive coil (not shown) in response to the modified electronic signals at the electrical terminals (not shown) magnetizes the armature 642. Interaction of the first armature leg 642a with the magnetic field causes the first armature leg 642a to vibrate, which lead to the movement of the drive rod 644. When the drive rod 644 moves in response to a vertical motion F of the first armature leg 642a, the members of the linkage assemblies 620, 680 move in response to the drive rod 644. The vertical motion of the first armature leg 642a is converted into lateral motion at the members 620a, 620e of the first linkage assembly 620 and members 680a, 680e of the second linkage assembly 680, resulting in lateral motion of the diaphragm assemblies 650, 660 substantially perpendicular to the vertical motion of the first armature leg 642a. As an example, vertical movement by the first armature leg 642a in the direction F generates upward vertical

movement of the drive rod 644 in the direction F, which in turn, generates upward vertical movement at members 620c, 680c of the first and second linkage assemblies 620, 680 in the direction F. The upward vertical movement at members 620c, 680c causes members 620a, 680a to move inwardly towards members 620e, 680e, and causes members 620e, 680e to move inwardly towards members 620a, 680a. This in turn causes diaphragms 654, 664 to move inwardly toward each other. In another embodiment, an additional mass can be attached, for example, to the member 680c of the second linkage assembly 680 to help decrease vibration of the receiver assembly 600.

[0060] FIG. 10 illustrates still another embodiment of a receiver assembly. The assembly 700 is similar in construction and function as the assembly 500 illustrated in FIG. 8, and similar elements are referred to using like reference numerals wherein, for example 700 and 750 correspond to 500 and 550, respectively. In this embodiment, a drive rod such as the drive rod 544 as shown in FIG. 8 is not required, but rather a linkage assembly 720 is coupled to an armature 742. The linkage assembly 720 may include link members 720a, 720b, and 720c, and a bottom surface of the link member 720c may be coupled to a top surface of the armature leg 742a. Vertical movement of the armature leg 742a in the direction F generates upward vertical movement of the member 720c in the direction F, resulting in movement of the diaphragms 754, 764 generally perpendicular to the direction F and generally outwardly away from each other. In another embodiment, a bottom surface of the armature leg 742a may be coupled to a top surface of the link member 720c. Also, the linkage assembly 720 could be

positioned such that movement of the armature leg 742a in the direction F would cause movement of the diaphragms 754, 764 generally inwardly toward each other.

[0061] FIG. 11 illustrates another embodiment of a receiver assembly.

5 The assembly 800 is similar in construction and function as the assembly 500 illustrated in FIG. 8, and similar elements are referred to using like reference numerals wherein, for example 800 and 850 correspond to 500 and 550, respectively. In this embodiment, acoustic ports 810a, 810b are introduced on a side wall 810 to broadcast an output acoustical signal that corresponds
10 to an audio signal that is transmitted into the receiver assembly 800 via electrical terminal (not depicted). A sound outlet tube 803 corresponding to the acoustic ports 810a, 810b may be coupled to the side wall 810 of the housing 802. In an alternate embodiment, the acoustic ports 810a, 810b can be formed on the side wall 808, and the sound outlet tube 803 could be
15 coupled to the side wall 808.

[0062] As shown in FIG. 11, a linkage assembly 820 is shown generally quadrilateral, having a plurality of link members 820a, 820b, 820c, 820d, 820e, 820f, 820g, 820h, 820i, 820j, 820o and vertices 820k, 820l, 820m, 820n. The linkage assembly 820 may take the form of various shapes (e.g.,
20 elliptical-like shape such as elongate circle, oval, ellipse, hexagon, octagon,, circle, etc.). The link members 820a, 820b, 820c, 820d, 820e, 820f, 820g, 820h, 820i, 820j, 820o are coupled together at vertices 820k, 820l, 820m, 820n. The transitions from one member to its neighbor may be abrupt and sharply angled such as vertices 820k, 820l, 820m, 820n, or may be curved or
25 expanded and include at least one short span, such as members 820a, 820c,

820e, 820f. A drive rod 844 may be coupled to the linkage assembly 820.

Also, the linkage assembly 820 and the drive rod 844 can be formed from the same stock and molded or press-fit to the linkage 820 to form one unit. The diaphragm assemblies 850, 860 may be secured to an inner surface of a top

5 portion 804 and an inner surface of a bottom portion 806 by bonding or any other suitable method. In an alternate embodiment, the diaphragm

assemblies 850, 860 can be secured to the outer surface of a magnet

assembly 830 by bonding or any other suitable method of attachment. The

diaphragm assemblies 850, 860 and the armature 842 are coupled to the

10 linkage assembly 820. An inner surface of the first diaphragm assembly 850 is coupled to the linkage assembly 820 at or near the link member 820c by

bonding or any other suitable method of attachment. An inner surface of the

second diaphragm assembly 860 is coupled to one end of the drive rod 844.

Another end of the drive rod 844, in turn, is coupled to linkage assembly 820

15 at or near the link member 820f by bonding or any other suitable method. A

free end of an armature leg 842a is coupled to the linkage assembly 820 at or

near the link member 820f. The motion of the vertices 820a, 820e of the

linkage assembly 820 is partially constrained by link members 820i, 820j,

820o of the linkage assembly 820, thus restricting movement of the vertices

20 820a, 820e in directions parallel to the directions F and G. As an example,

upward vertical movement by the first armature leg 842a in the direction F

generates a downward vertical movement of link member 820c, resulting in

downward vertical movement of the diaphragm 854 in the direction G.

Upward vertical movement by the first armature leg 842a in the direction F

25 generates upward vertical movement of the drive rod 844, resulting in upward

vertical movement of the second diaphragm assembly 860 in the direction F.

The opposing motions of the armature 842, and the diaphragms 854, 864

enable the vibration balancing of the receiver 800 over a wide frequency

range. In an alternate embodiment, the moving mass of at least one of the

5 diaphragm assemblies 850, 860, such as the first diaphragm assembly 850
can be increased to be substantially equal to the moving mass of the second
diaphragm assembly 860, the moving mass of the drive rod 844, and the
moving mass of armature leg 842a to further reduce vibration of the receiver
assembly 800. Also, an additional mass could be attached, for example, to

10 the link 820c.

[0063] Referring now to FIG. 12, a receiver assembly 900 in
accordance with a described embodiment of the invention. The assembly 900
is similar in construction and function as the assembly 800 illustrated in FIG.
11, and similar elements are referred to using like reference numerals

15 wherein, for example 900 and 950 correspond to 800 and 850, respectively.
In this embodiment, a linkage assembly 920 is shown generally quadrilateral,
having a plurality of link members 920a, 920b, 920c, 920d, 920e, 920f, 920g,
920h, 920i, 920j and vertices 920k, 920l, 920m, 920n. The linkage assembly
920 may take the form of various shapes (e.g., elliptical-like shape such as
20 elongate circle, oval, ellipse, hexagon, octagon, circle, etc.). The members
920a, 920b, 920c, 920d, 920e, 920f, 920g, 920h, 920i, 920j and connected
together at the vertices 920k, 920l, 920m, 920n. The transitions from one
member to its neighbor may be abrupt and sharply angled such as vertices
920k, 920l, 920m, 920n compared to FIG. 8, or may be expanded and include
25 at least one short span, such as members 920a, 920c, 920e, 920f. A drive

rod 944 may be coupled to the linkage assembly 920. Also, the linkage assembly 920 and the drive rod 944 can be formed from the same stock and molded or press-fit to the linkage 920 to form one unit. The diaphragm assemblies 950, 960 may be coupled to an inner surface of a side portion 908 and an inner surface of a side portion 910 by bonding with adhesive. In alternate embodiment, the diaphragm assemblies 950, 960 can be secured to an outer surface of a magnet assembly 930 by bonding with adhesive. The diaphragm assemblies 950, 960 and the armature 942 are coupled to the linkage assembly 920. The inner surface of the first diaphragm assembly 950 is coupled to the linkage assembly 920 at or near the link member 920c by bonding or any other suitable method. One end of the drive rod 944 couples to a free end of an armature leg 942a. The other end of the drive rod 944 is coupled to an inner surface of the link member 920c by bonding or any other suitable method. An inner surface of the second diaphragm assembly 960 is coupled to the linkage assembly 920 at or near the link member 920g. The motion of the vertices 920a, 920e of the linkage assembly 920 is partially constrained by legs 920i, 920j of the linkage assembly 920, thus restricting movement of the vertices 920a, 920e in the direction generally parallel to F and in a direction opposite to F. As an example, upward vertical movement by the armature leg 942a in the direction F generates upward vertical movement of the drive rod 944, resulting in upward vertical movement of the diaphragm 954 via the upward vertical movement of the link member 920c in the direction F. Upward vertical movement by the first armature leg 942a generates downward vertical movement of link member 920f, resulting in downward vertical movement of the diaphragm 964. The opposing motions of

the armature 942, and the diaphragms 954, 964 enables the vibration balancing of the receiver 900 over a wide frequency range. In an alternate embodiment, the moving mass of at least one of the diaphragm assemblies 950, 960, such as the second diaphragm assembly 960 can be increased to
5 be substantially equal to the moving mass of the first diaphragm assembly 950, the moving mass of the drive rod 944, and the moving mass of armature leg 842a to further reduce vibration of the receiver assembly 900. Also, an additional mass could be attached, for example, to the link 920f.

[0064] In the embodiments described above with respect to Figs. 8-12,
10 two in-phase diaphragms are used. Thus, in these embodiments, it may be possible to increase the radiating area as compared to a receiver utilizing only one diaphragm. Also, it may be possible to generate a greater acoustical output as compared to a receiver utilizing only one diaphragm. Further, it may be possible to generate a similar acoustical output using less power as
15 compared to a receiver utilizing only one diaphragm. In some implementations, a receiver assembly utilizing two in-phase diaphragms may not provide any of these advantages, but rather may provide different advantages.

[0065] Although various linkage assemblies have been described
20 above and shown in the figures having link members of particular relative lengths, as well as ratios between lengths of link members, one of ordinary skill in the art will recognize that the relative lengths and ratios of lengths of link members may be varied in different implementations.

CLAIMS

What is claimed is

1. A receiver assembly, comprising:
a first diaphragm assembly having a diaphragm;
5 a second diaphragm assembly having a diaphragm;
a linkage assembly coupled to an armature of the receiver, coupled to
the first diaphragm assembly, and coupled to the second
diaphragm assembly.
- 10 2. A receiver assembly according to claim 1, wherein the linkage
assembly comprises:
a first central link member;
a first link member flexibly coupled to a first end of the first central link
member;
15 a second link member flexibly coupled to a second end of the first
central link member.
- 20 3. A receiver assembly according to claim 2, wherein the first
central member is coupled to the armature.
4. A receiver assembly according to claim 3, further comprising a
drive rod to couple the first central member to the armature.
- 25 5. A receiver assembly according to claim 3, further comprising:
a third link member flexibly coupled to an end of the first link member
and attached to the diaphragm of the first diaphragm assembly;

a fourth link member flexibly coupled to an end of the second link member and attached to the diaphragm of the second diaphragm assembly.

- 5 6. A receiver assembly according to claim 2, wherein the link assembly further includes:
- a second central link member;
- a third link member flexibly coupled to a first end of the second central link member and flexibly coupled to the first link member;
- 10 a fourth link member flexibly coupled to a second end of the second central link member and flexibly coupled to the second link member.

7. A receiver assembly according to claim 6, wherein the first central link member is coupled to the armature and coupled to the first diaphragm assembly; and
- 15 wherein the second central link member is coupled to the second diaphragm assembly.

- 20 8. A receiver assembly according to claim 7, further comprising a drive rod to couple the first central member to the armature.

9. A receiver assembly according to claim 7, further comprising a drive rod to couple the first central member to the first
- 25 diaphragm assembly.

10. A receiver assembly according to claim 7, further comprising:
a fifth link member flexibly coupled to an end of the first link member
and flexibly coupled to an end of the third link member; and
5 a sixth link member flexibly coupled to an end of the second link
member and flexibly coupled to an end of the fourth link
member.

11. A receiver assembly according to claim 10, further comprising:
10 a seventh link member coupled to the fifth link member and coupled to
a magnetic housing of the motor;
an eighth link member coupled to the sixth link member and coupled to
the magnetic housing of the motor.

12. A receiver assembly according to claim 10, further comprising:
15 a seventh link member coupled to the fifth link member and coupled to
a housing of the receiver assembly;
an eighth link member coupled to the sixth link member and coupled to
the housing of the receiver assembly.

20 13. A receiver assembly according to claim 6, further comprising:
a fifth link member attached to the diaphragm of the first diaphragm
assembly, the fifth link member flexibly coupled to an end of the
first link member and flexibly coupled to an end of the third link
25 member;

a sixth link member attached to the diaphragm of the second diaphragm assembly, the sixth link member flexibly coupled to an end of the second link member and flexibly coupled to an end of the fourth link member.

5

14. A receiver assembly, comprising:

a first diaphragm assembly having a diaphragm;

a second diaphragm assembly having a diaphragm;

a linkage assembly coupled to an armature of the receiver, coupled to

10

the first diaphragm assembly, and coupled to the second

diaphragm assembly, the linkage assembly including:

a first central link member;

a first link member flexibly connected to a first end of the first central link member;

15

a second link member flexibly connected to a second end of the first central link member.

wherein the movement of the armature causes movement of the

linkage assembly, thereby causing in-phase movement of the

diaphragm of the first diaphragm assembly and the diaphragm

20

of the second diaphragm assembly.

15. A receiver assembly according to claim 14, wherein the first central member is coupled to the armature.

16. A receiver assembly according to claim 15, further comprising a drive rod to couple the first central member to the armature.

17. A receiver assembly according to claim 15, further comprising:
a third link member flexibly connected to an end of the first link member
and attached to the diaphragm of the first diaphragm assembly;
a fourth link member flexibly connected to an end of the second link
member and attached to the diaphragm of the second
diaphragm assembly.

18. A receiver assembly according to claim 14, wherein the link
assembly further includes:
a second central link member;
a third link member flexibly connected to a first end of the second
central link member and flexibly coupled to the first link member;
a fourth link member flexibly coupled to a second end of the second
central link member and flexibly coupled to the second link
member.

19. A receiver assembly according to claim 18, wherein the first
central link member is coupled to the armature and coupled to
the first diaphragm assembly; and
wherein the second central link member is coupled to the second
diaphragm assembly.

20. A receiver assembly according to claim 18, further comprising:
a fifth link member attached to the diaphragm of the first diaphragm
assembly, the fifth link member flexibly coupled to an end of the
first link member and flexibly coupled to an end of the third link
member;
a sixth link member attached to the diaphragm of the second
diaphragm assembly, the sixth link member flexibly coupled to
an end of the second link member and flexibly coupled to an end
of the fourth link member.

21. A receiver assembly, comprising:
a first diaphragm;
a second diaphragm;
a linkage assembly coupled to an armature of the receiver, coupled to
the first diaphragm, and coupled to the second diaphragm;
wherein the movement of the armature causes movement of the
linkage assembly, thereby causing movement of the first
diaphragm and the second diaphragm.

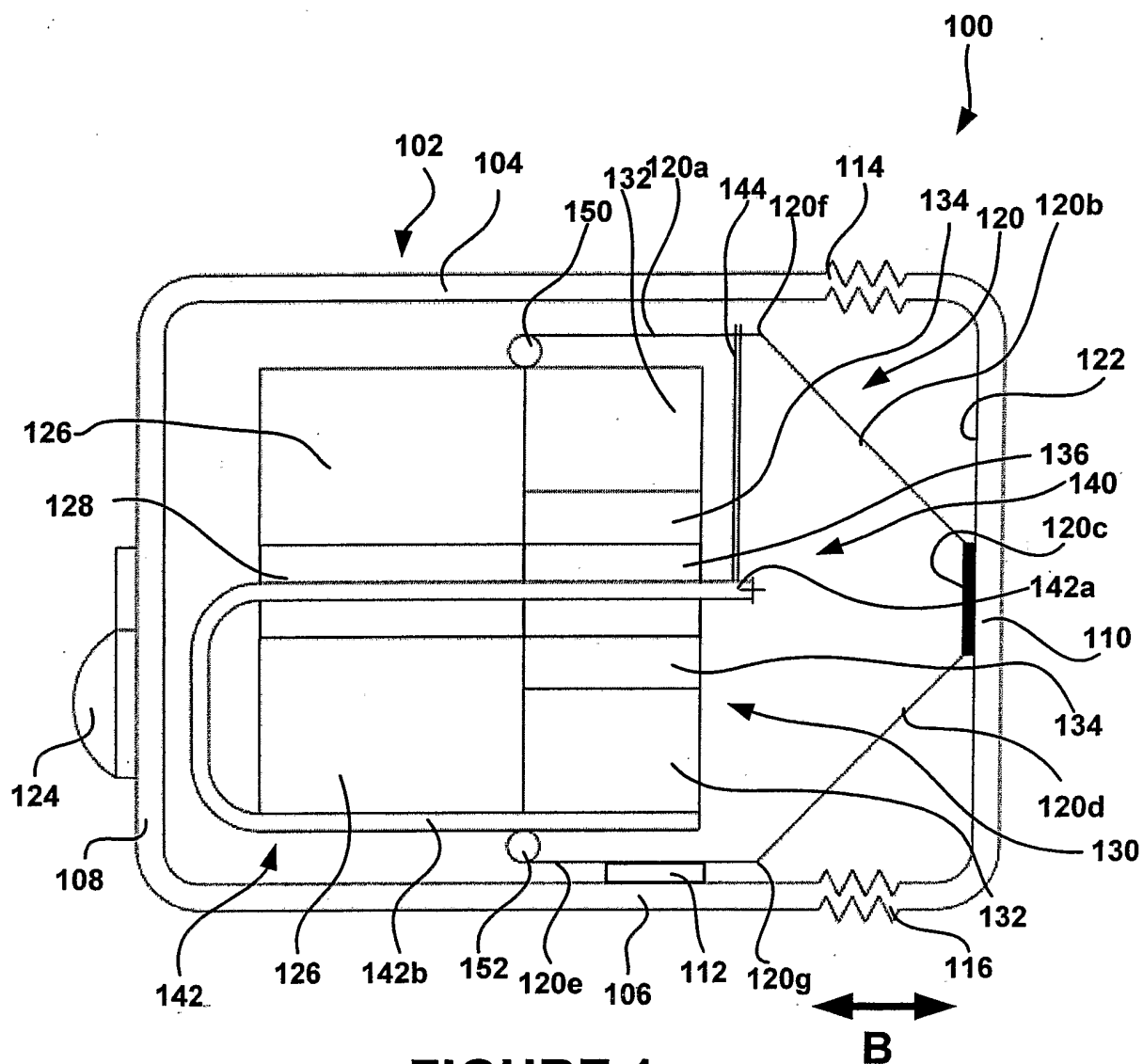


FIGURE 1

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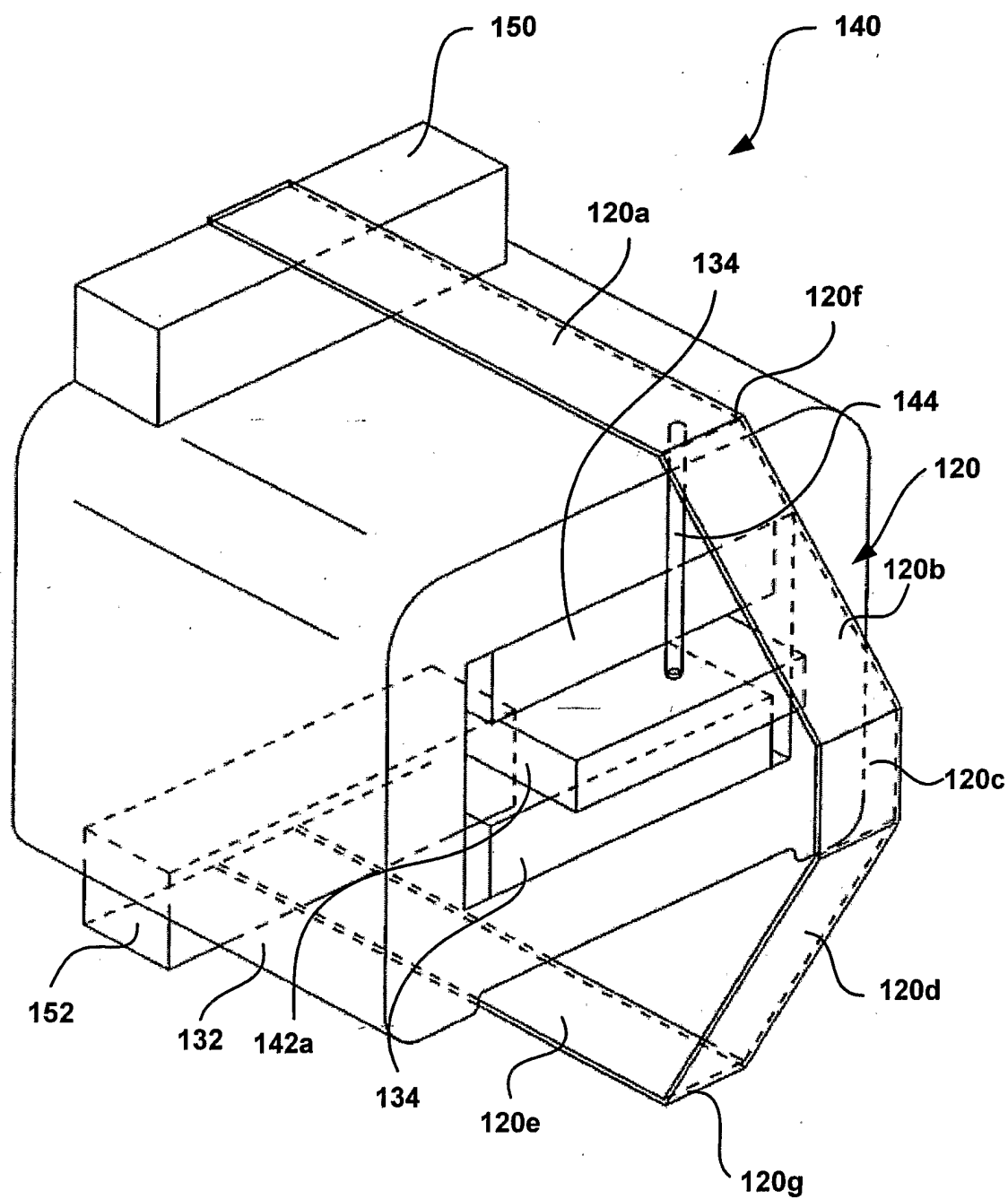
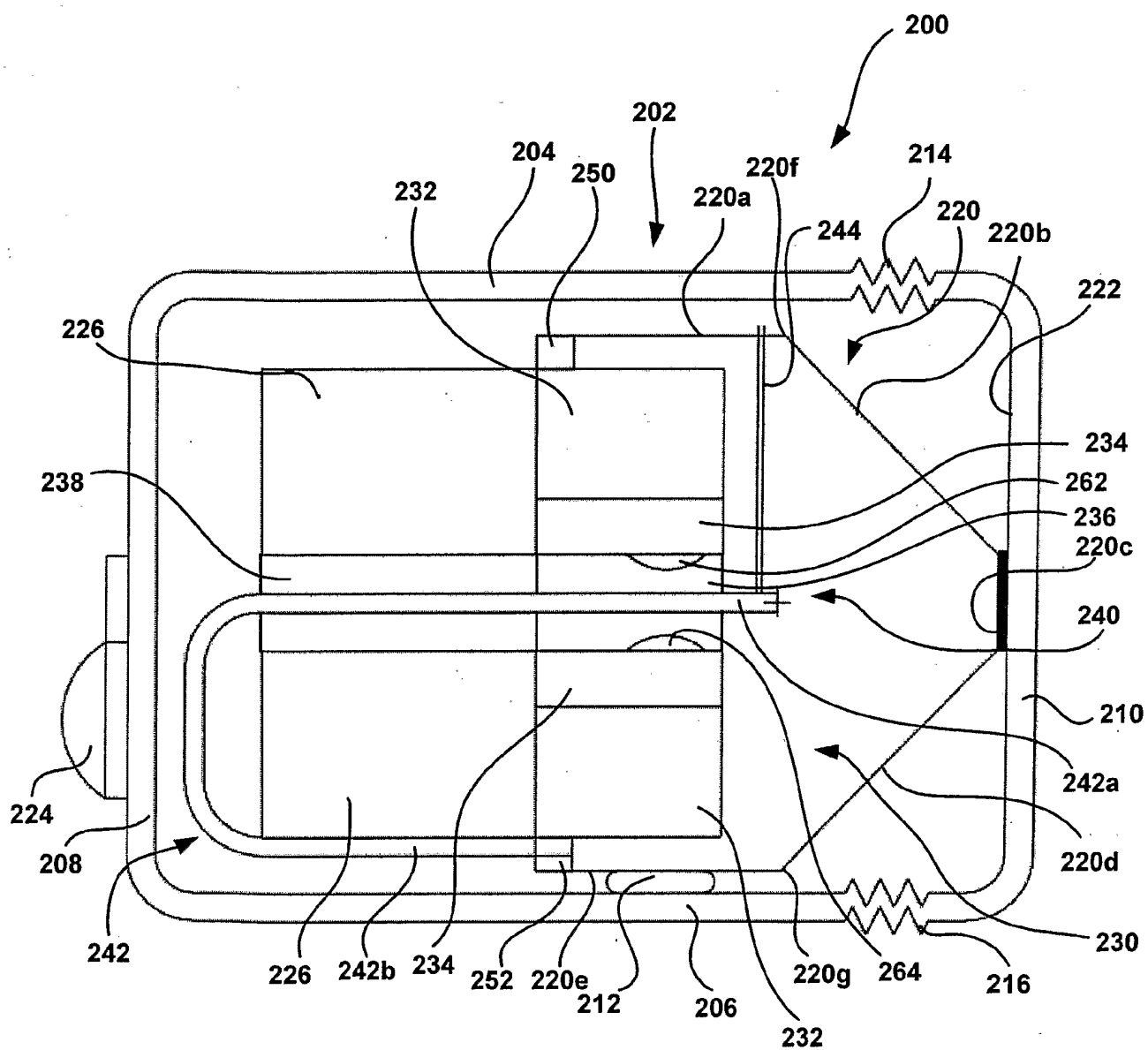
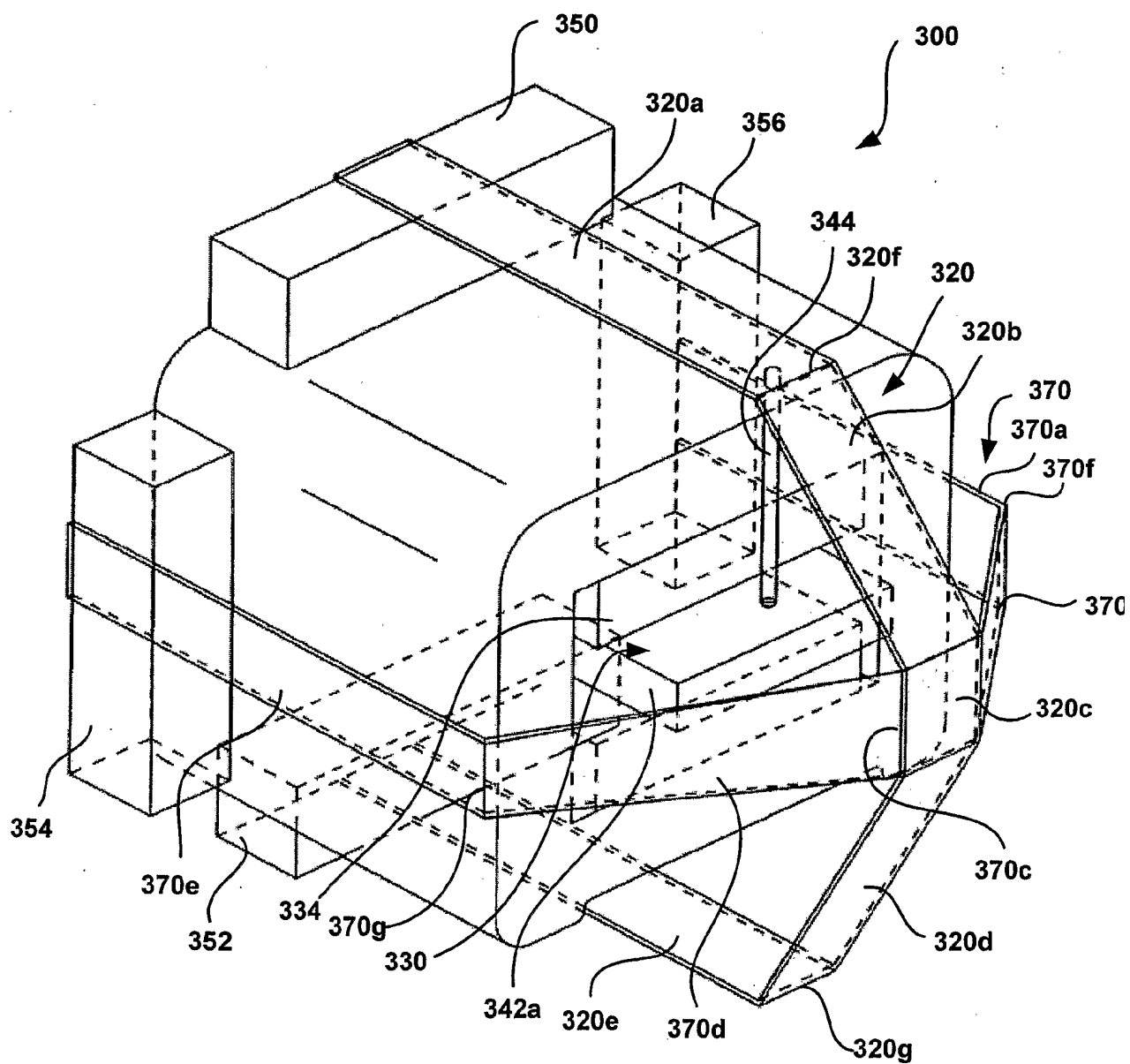


FIGURE 2

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**FIGURE 3**

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**FIGURE 4**

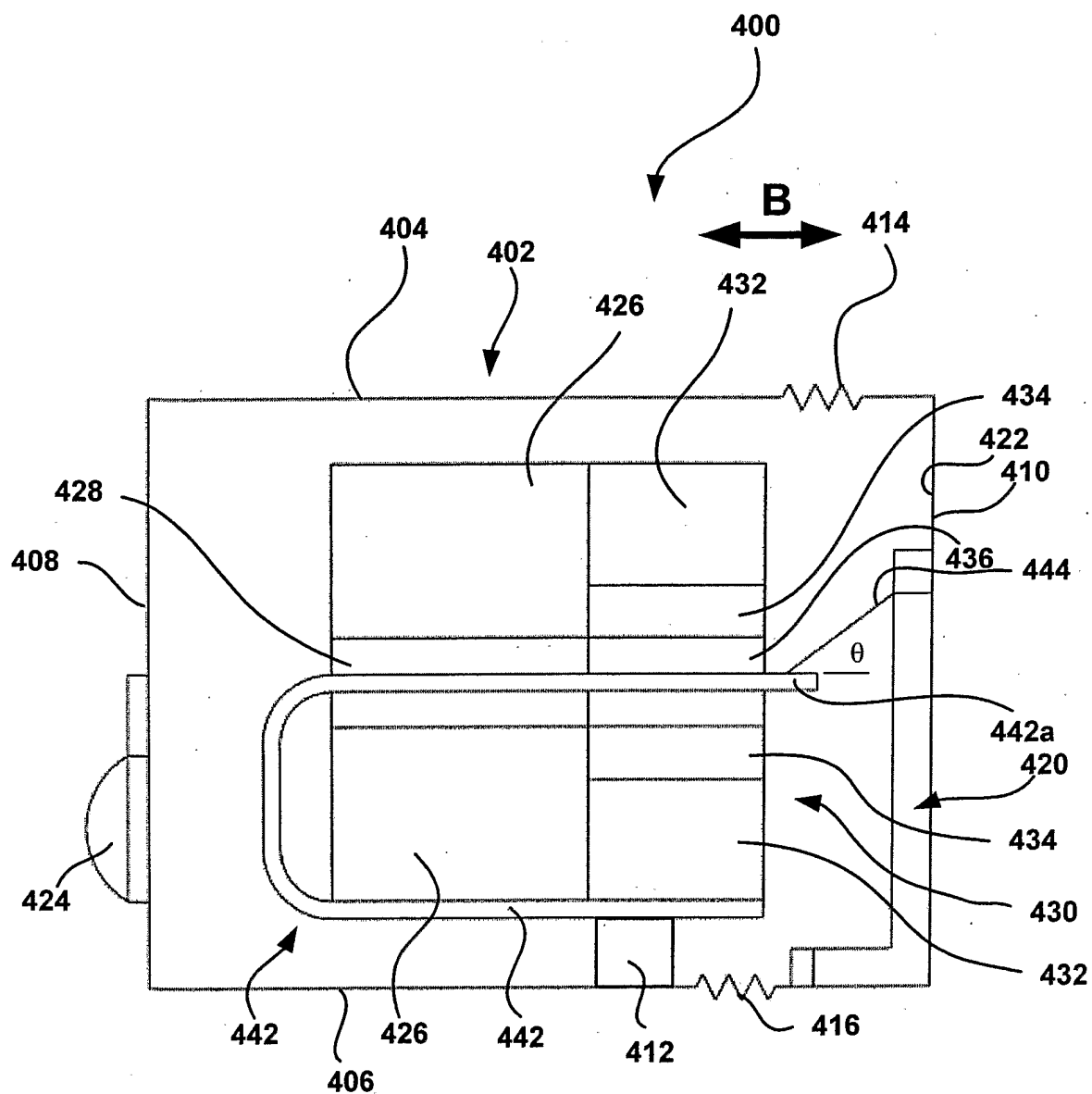


FIGURE 5

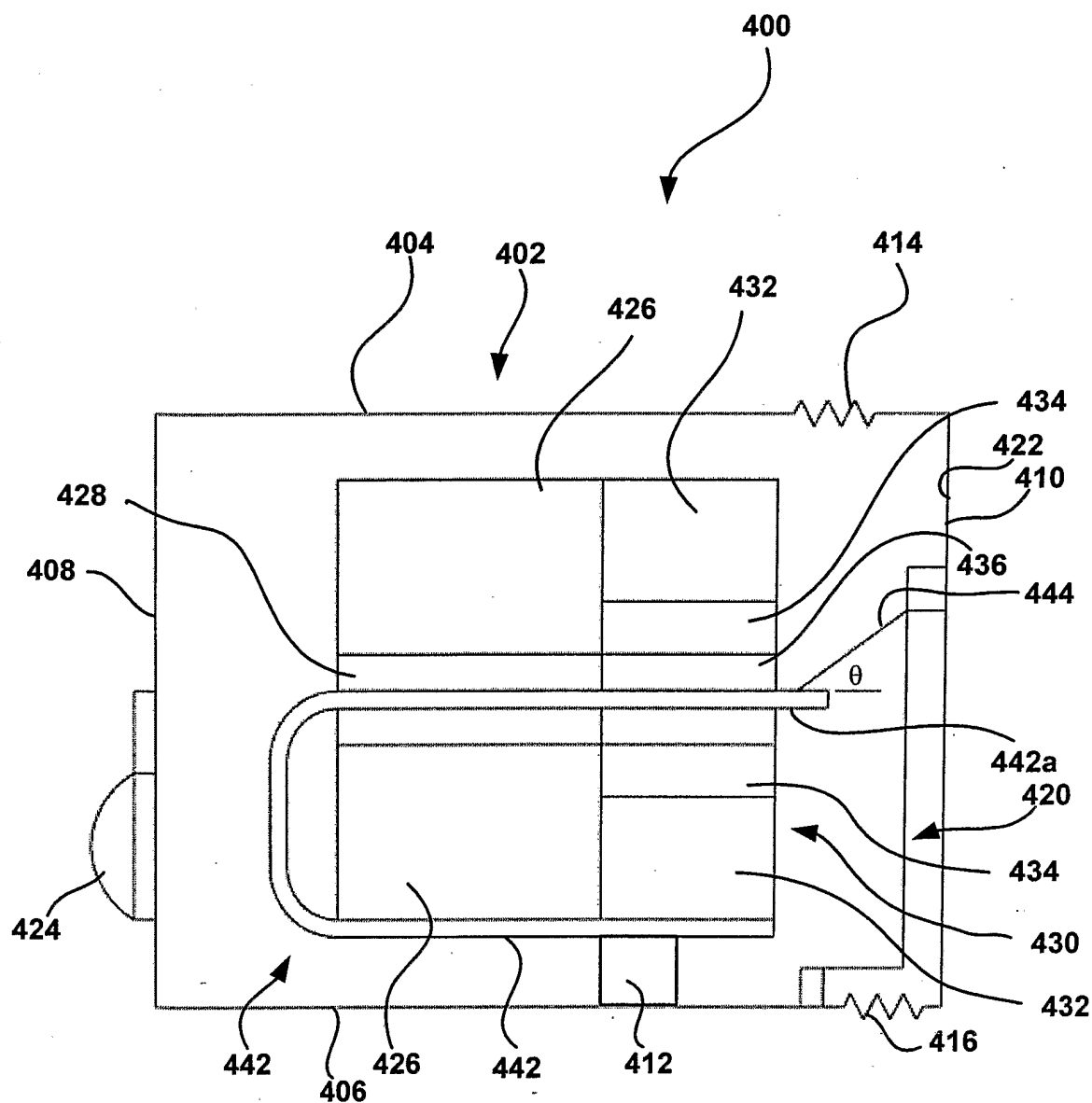
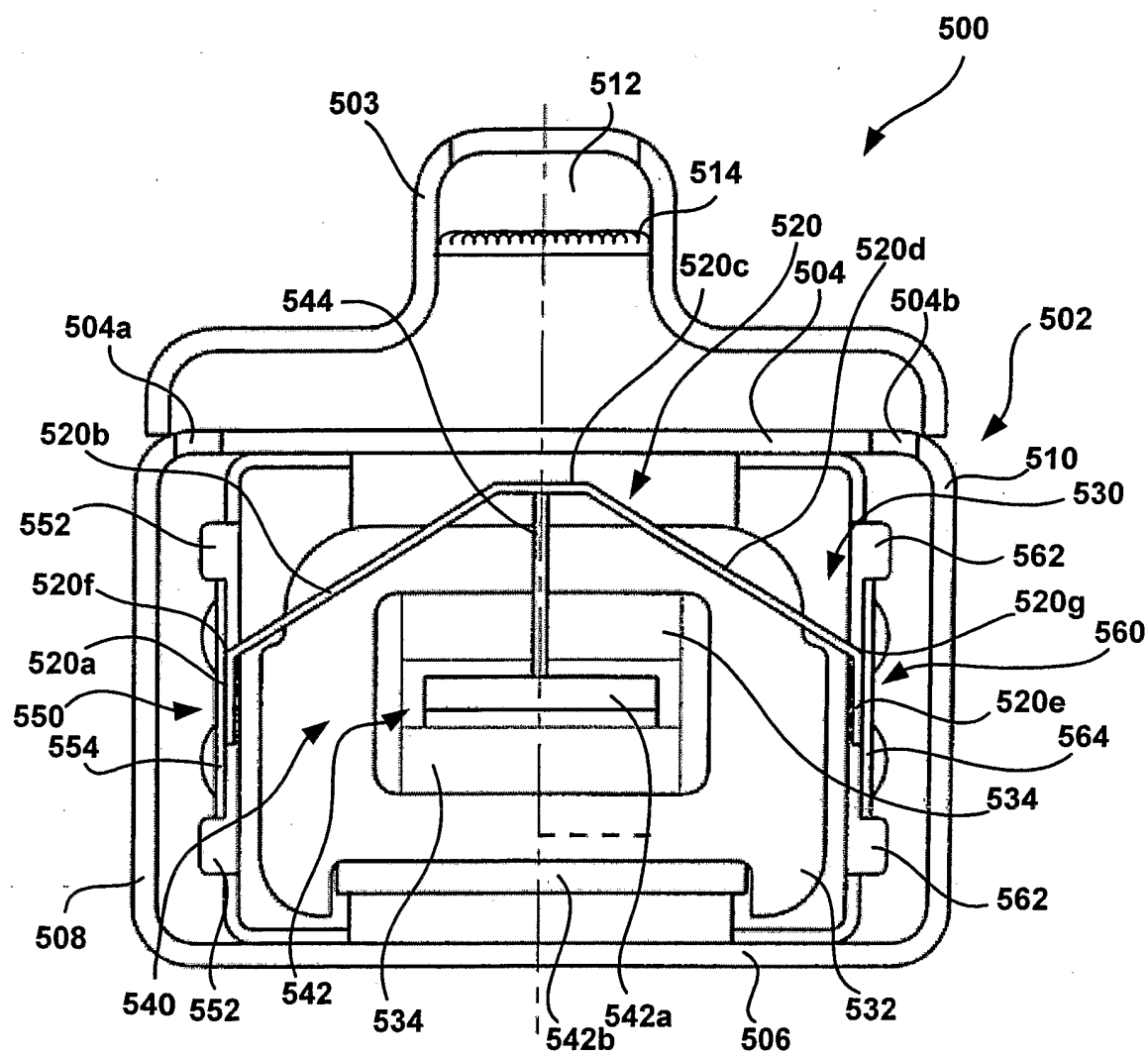
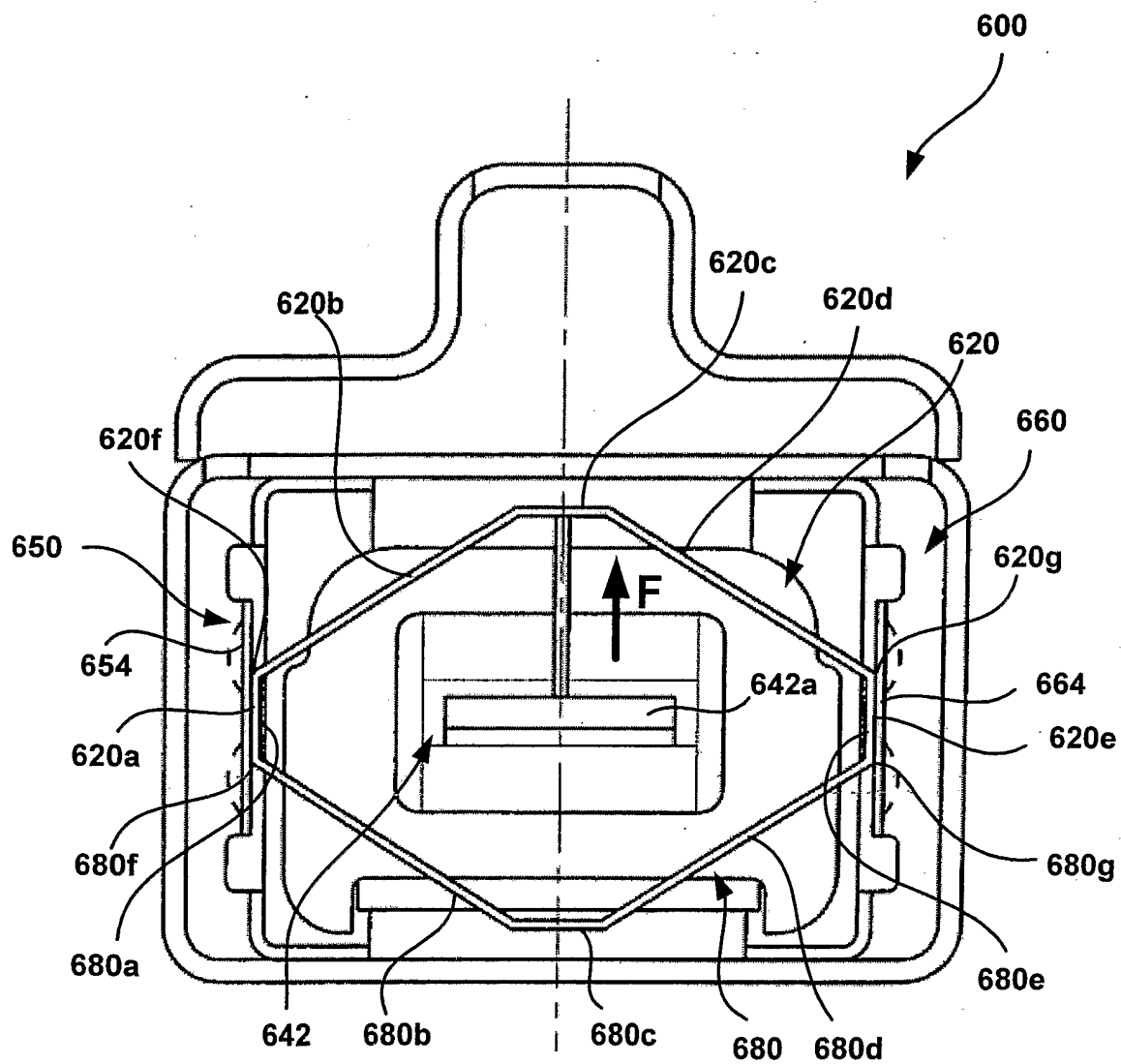


FIGURE 6

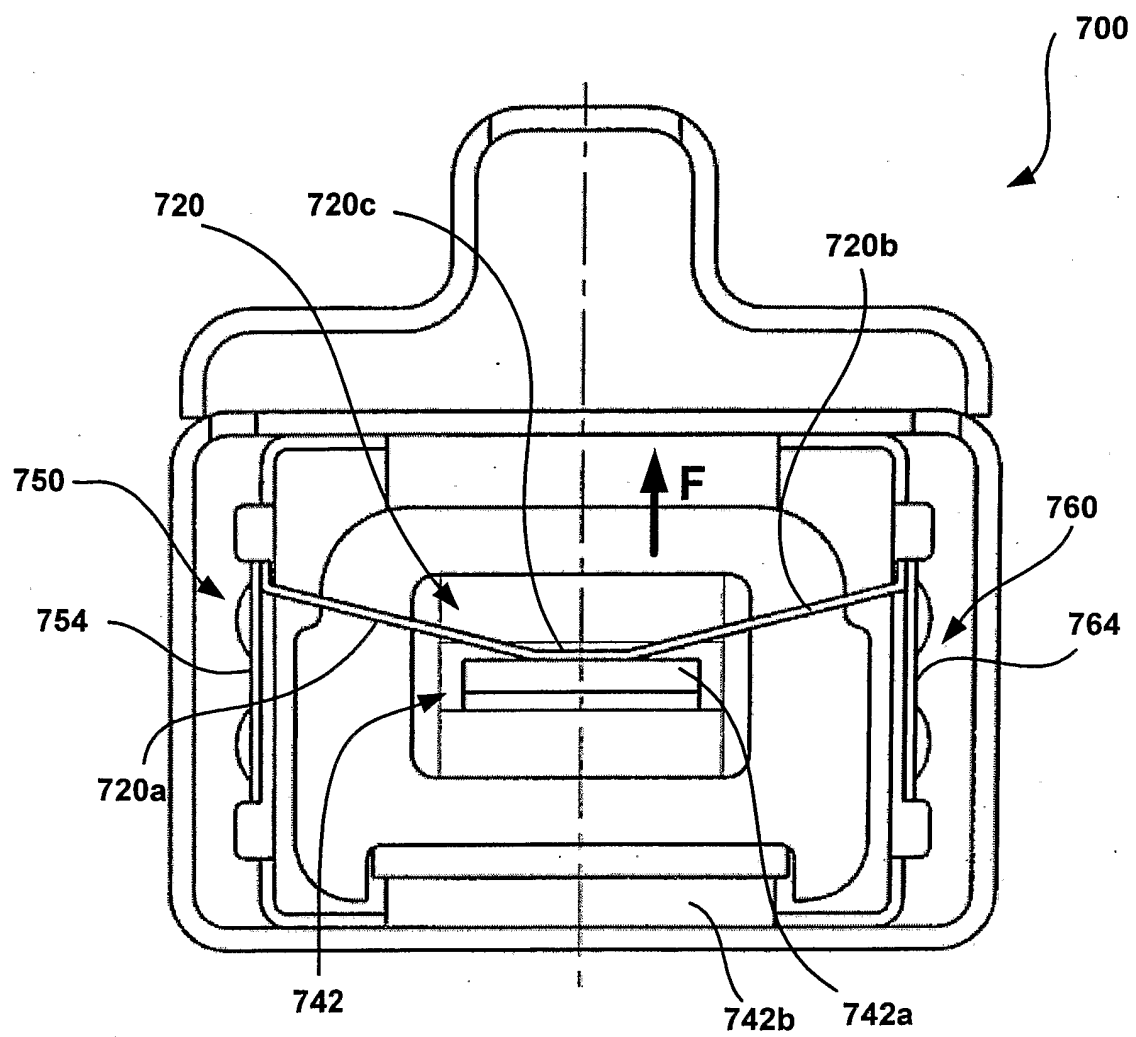
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**FIGURE 8**

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**FIGURE 9**

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**FIGURE 10**

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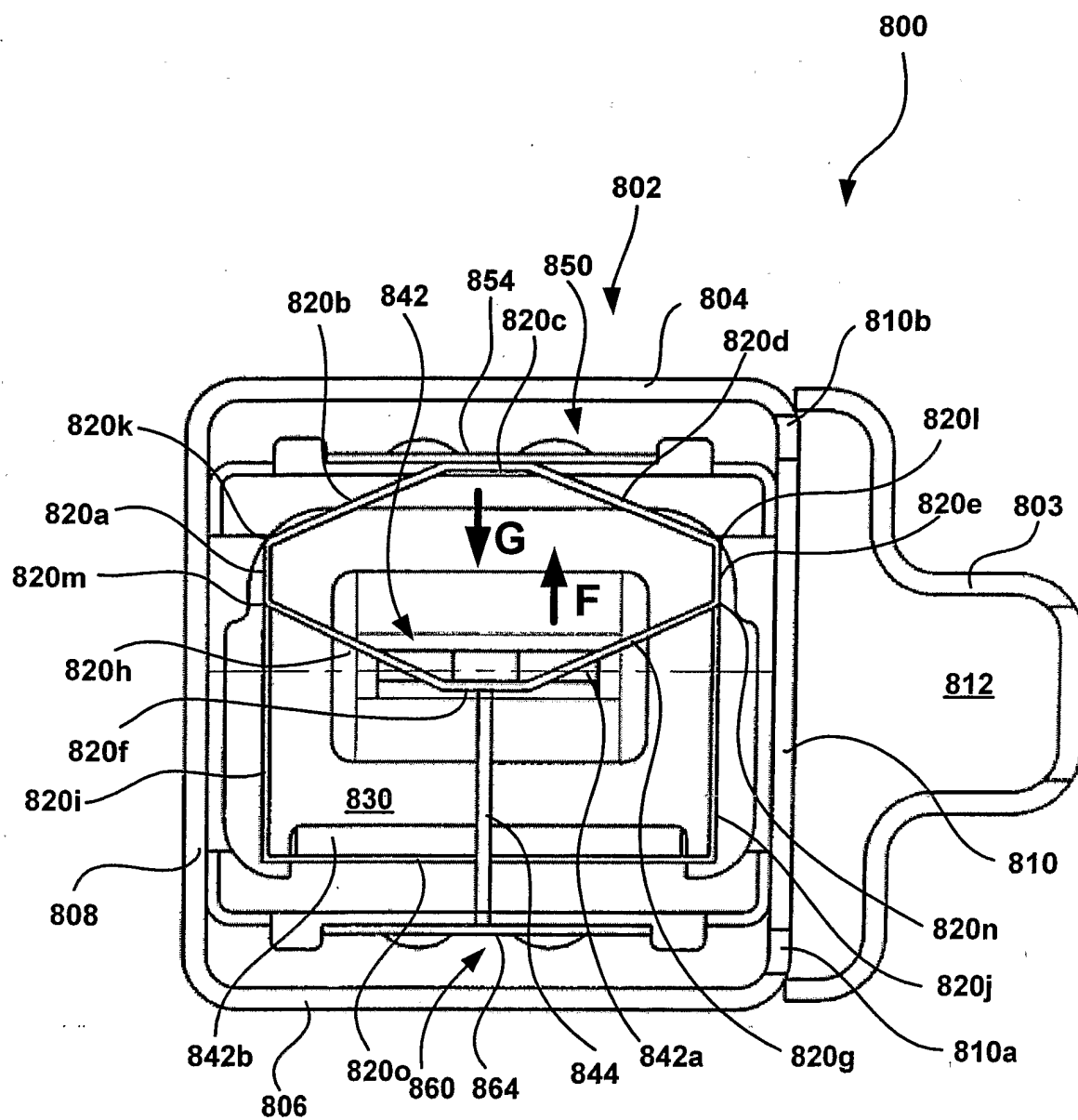


FIGURE 11

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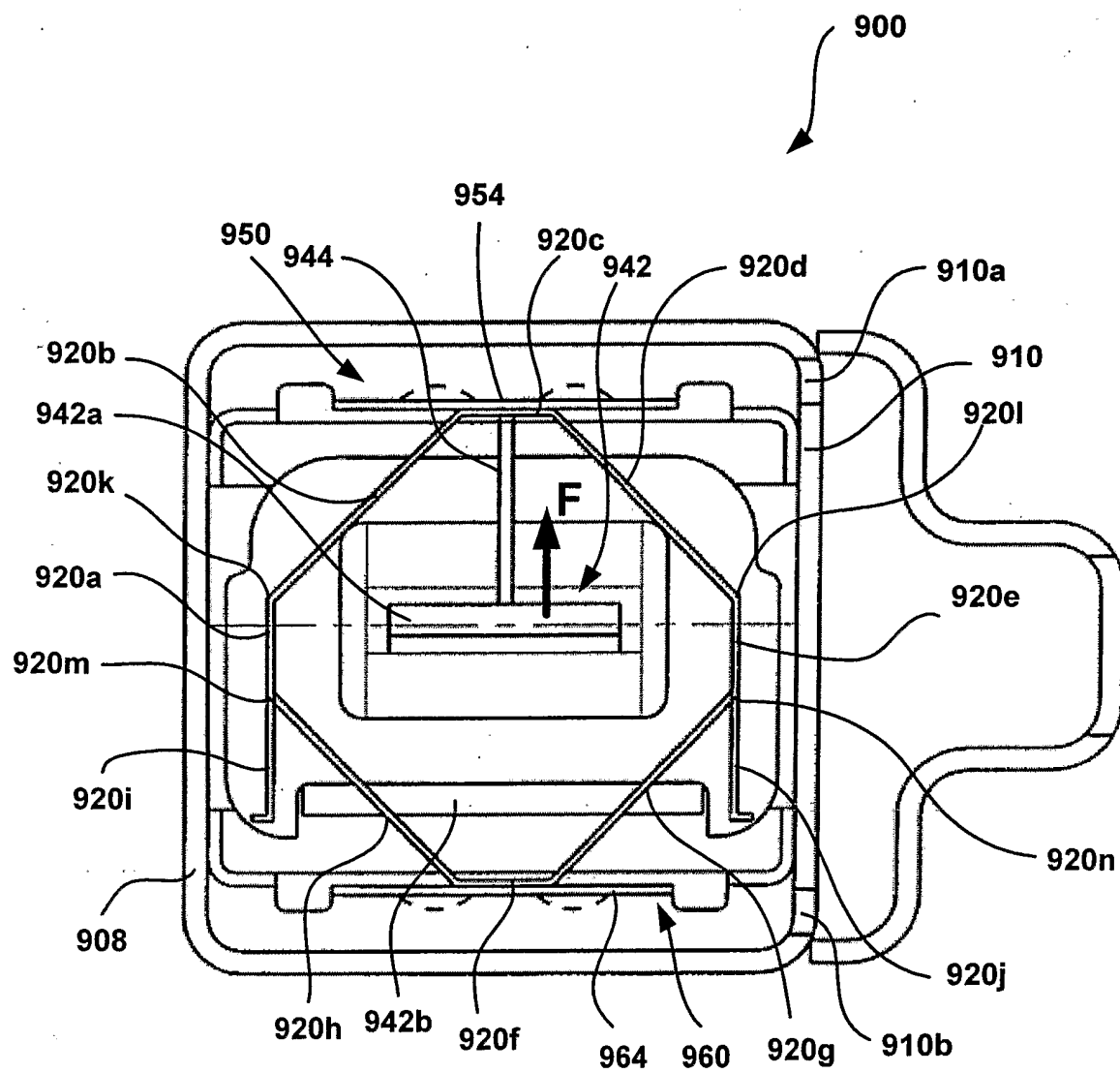


FIGURE 12