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(54) **CONSTRUCTION SYSTEM WITH LINKABLE ELEMENTS AND METHOD THEREFOR**

(71) Applicant: **STUDIOWEAPON MUSIC & DESIGN LTD.**, Calgary, Alberta (CA)

(72) Inventor: **Stuart MACQUARRIE**, Calgary, Alberta (CA)

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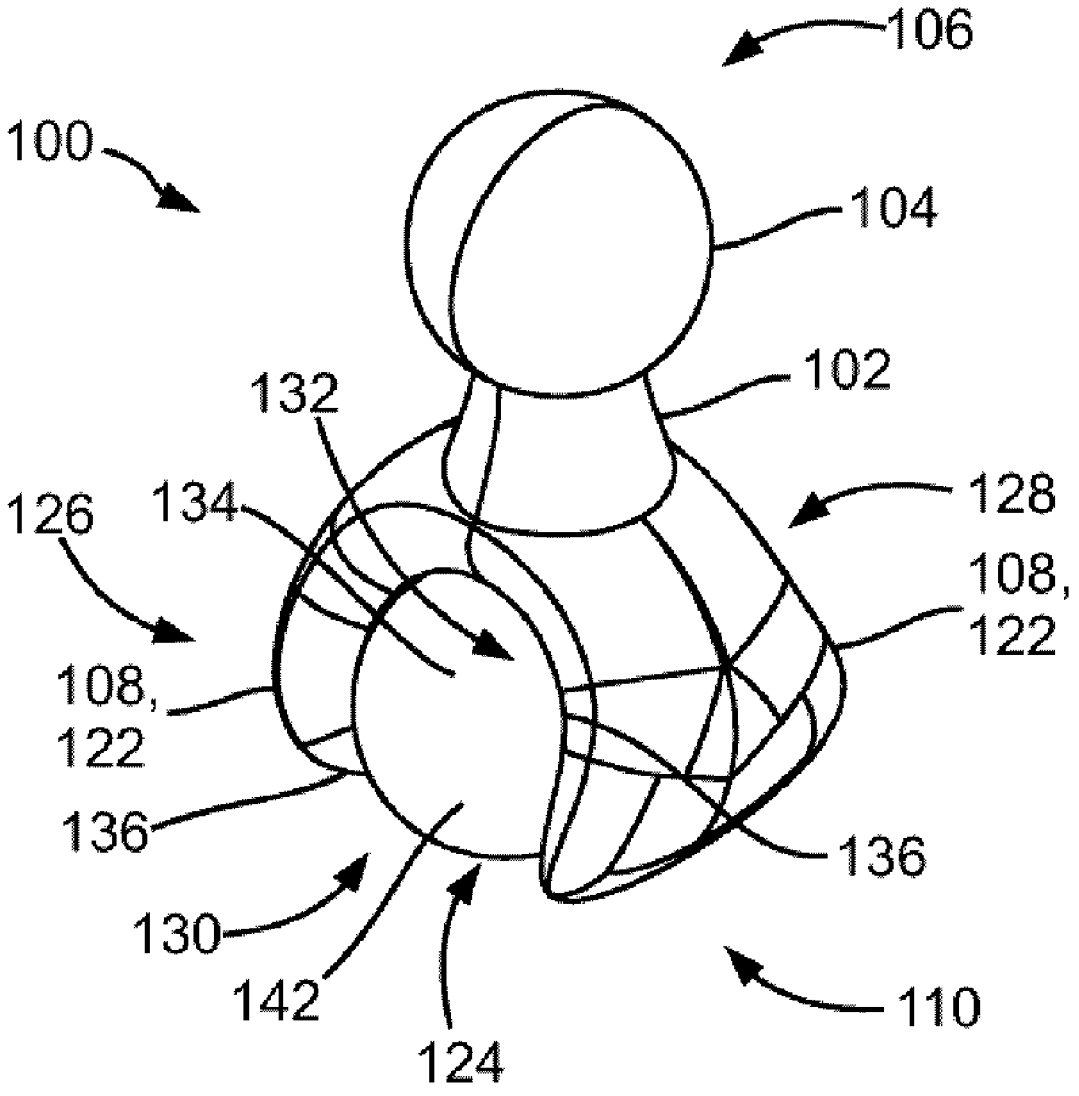
A63H 33/04 (2006.01)

(52) **U.S. Cl.**
CPC ***A63H 33/101*** (2013.01); ***A63H 33/046*** (2013.01); ***A63H 33/042*** (2013.01)

(57) **ABSTRACT**

An interconnectable construction element has a body section, a first socket coupled to a first end of the body section, and a magnetic ball. The first socket has a recess in communication with an opening. The opening extends from a first lateral side of the first socket at least to a distal end thereof. The magnetic ball is individually rotatably receivable into the recess of the first socket for forming a magnetic connection with another interconnectable construction element having another magnetic ball.



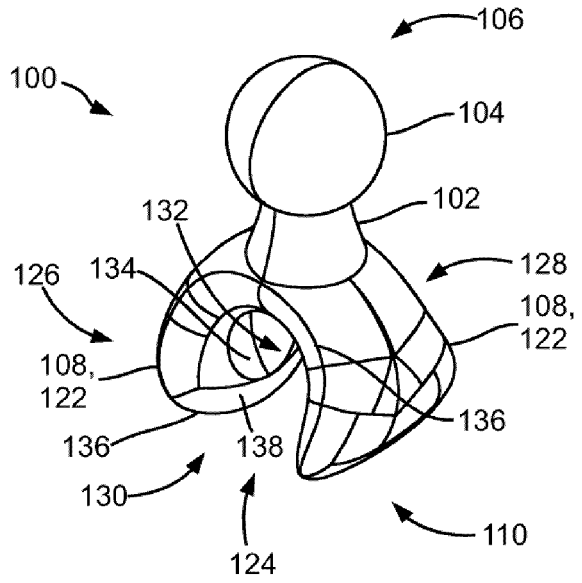


FIG. 1A

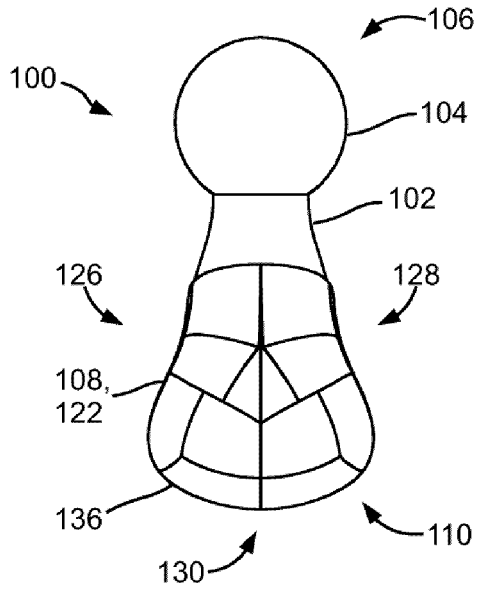


FIG. 1B

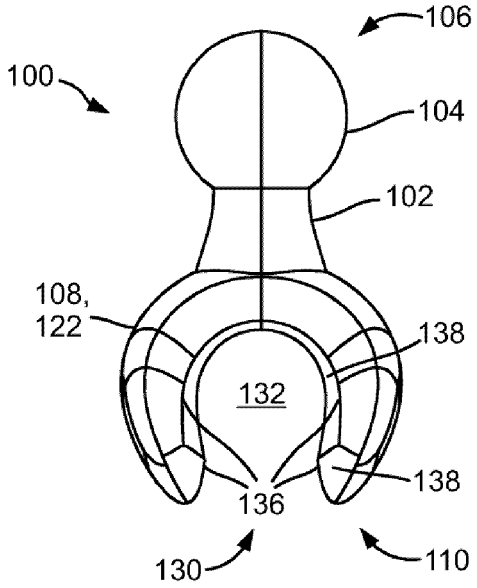


FIG. 1C

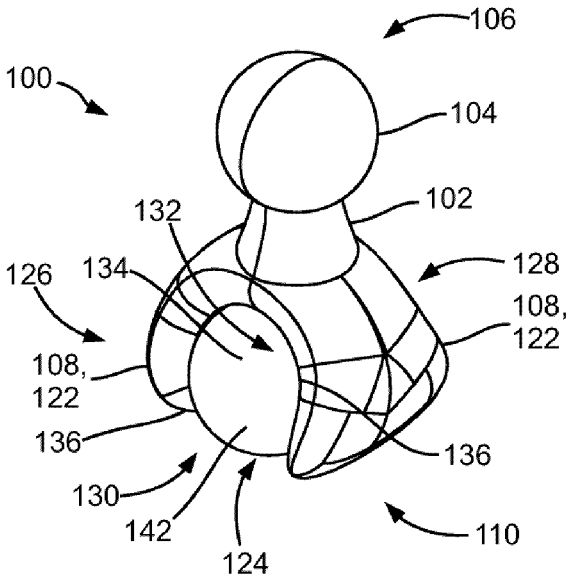


FIG. 2

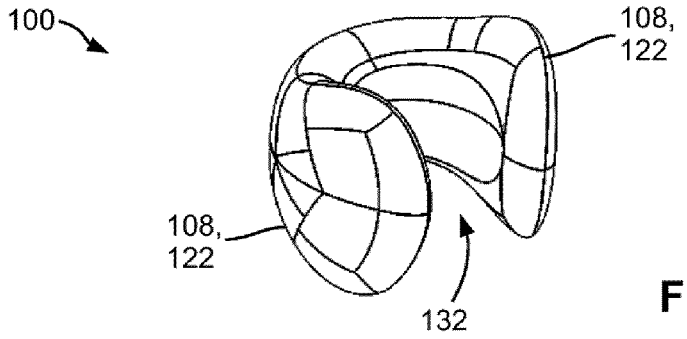


FIG. 3A

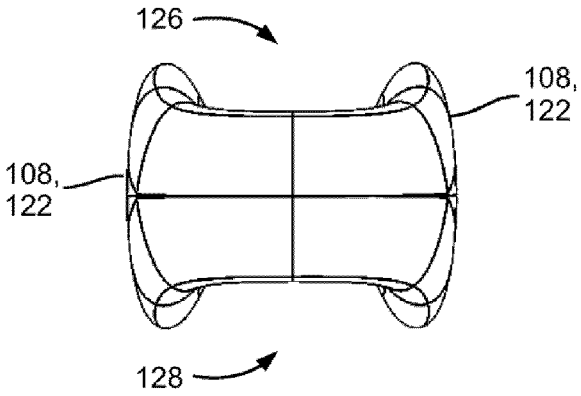


FIG. 3B

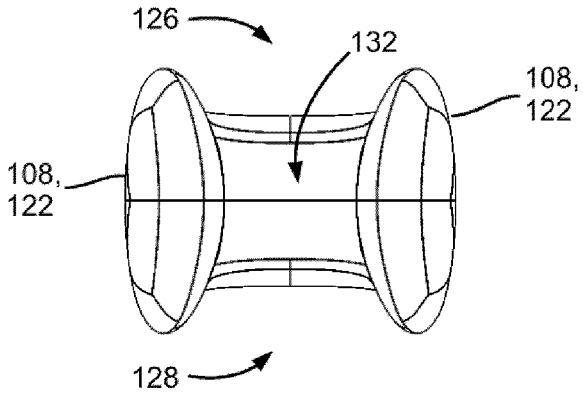


FIG. 3C

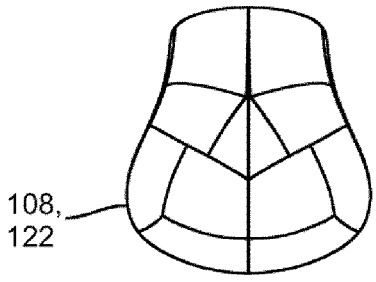


FIG. 3D

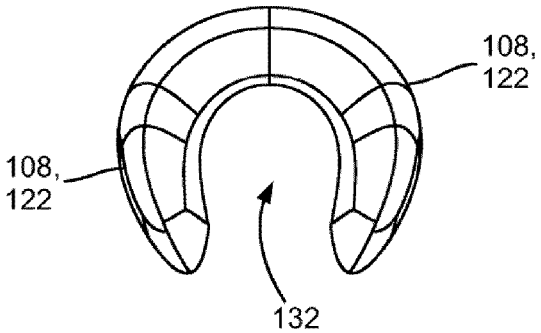


FIG. 3E

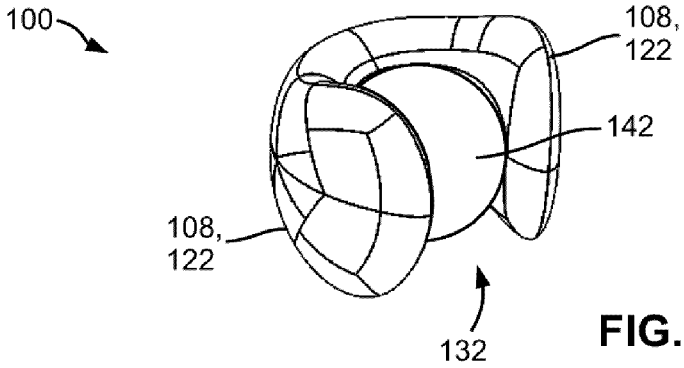


FIG. 4

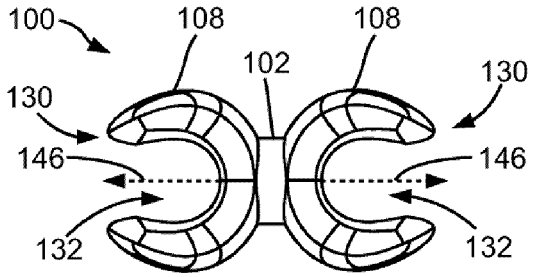


FIG. 5

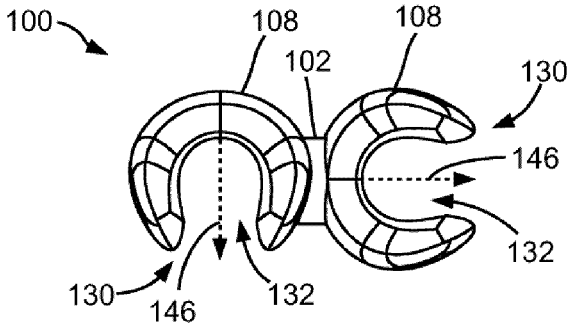


FIG. 6

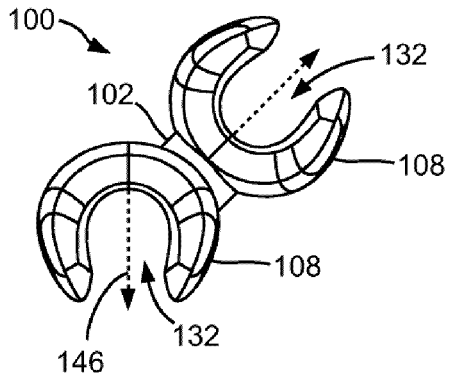


FIG. 7

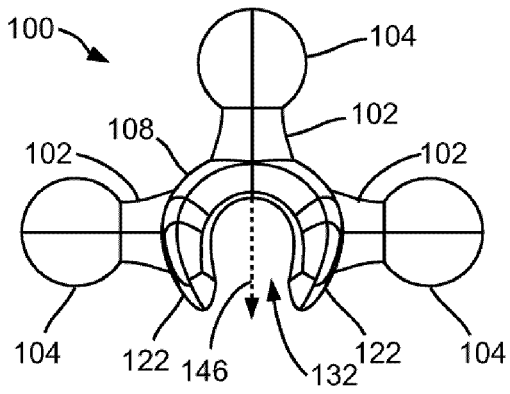


FIG. 8

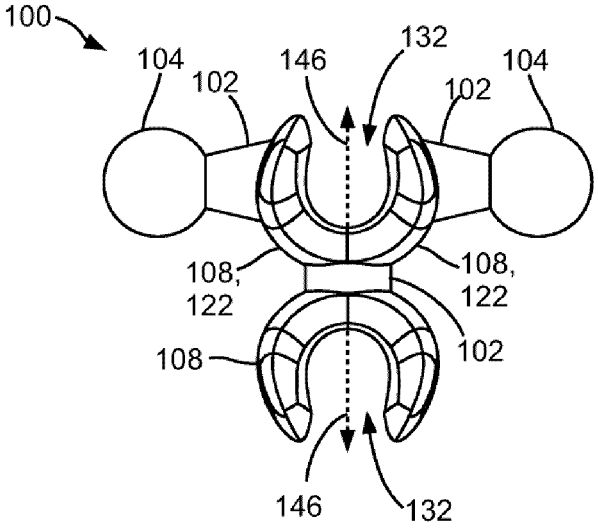


FIG. 9

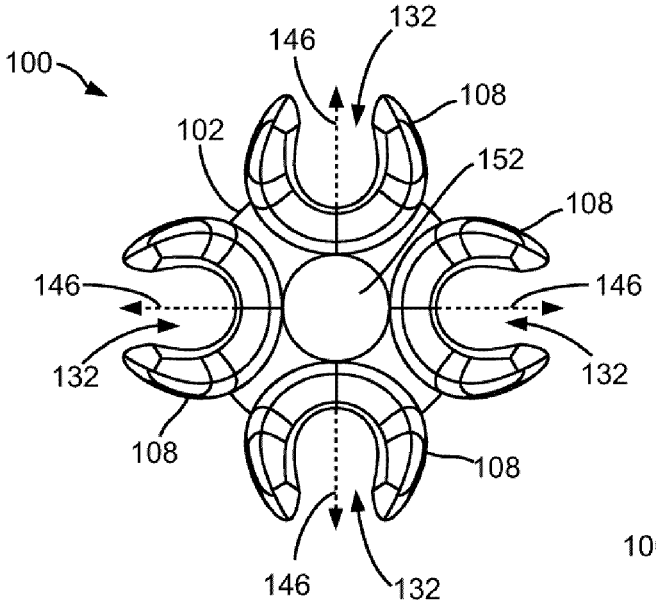


FIG. 10

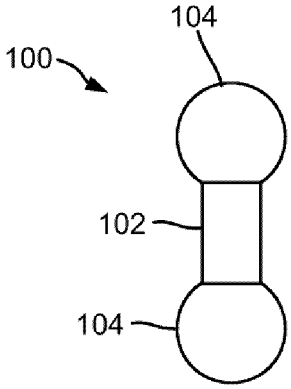


FIG. 11

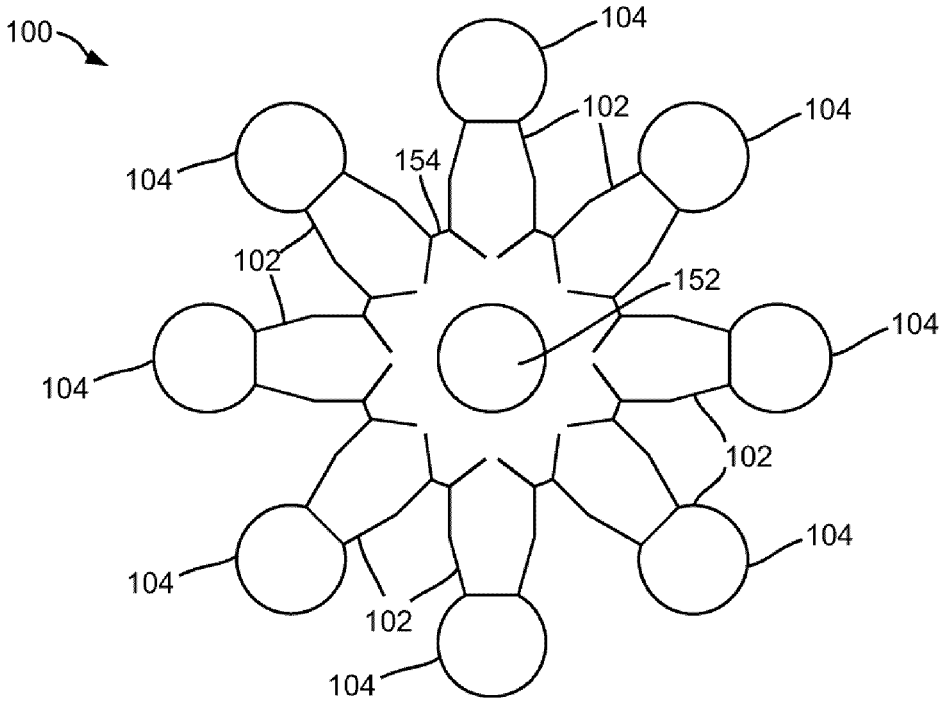

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FIG. 12

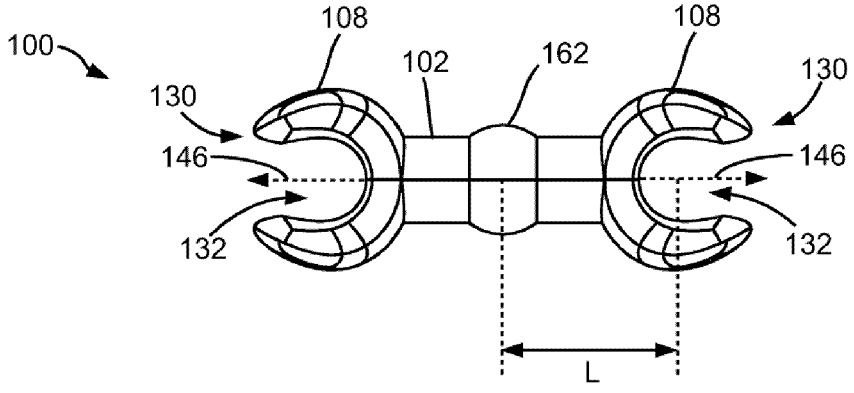
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FIG. 13

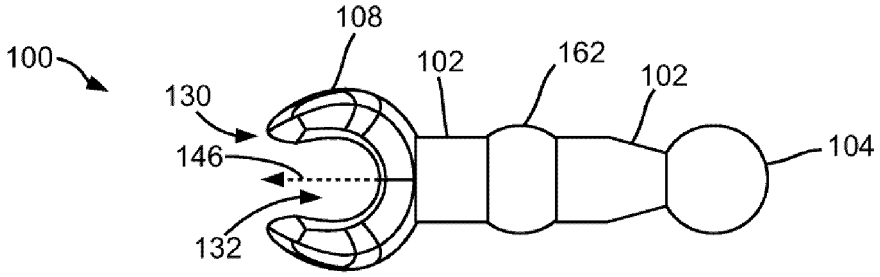


FIG. 14

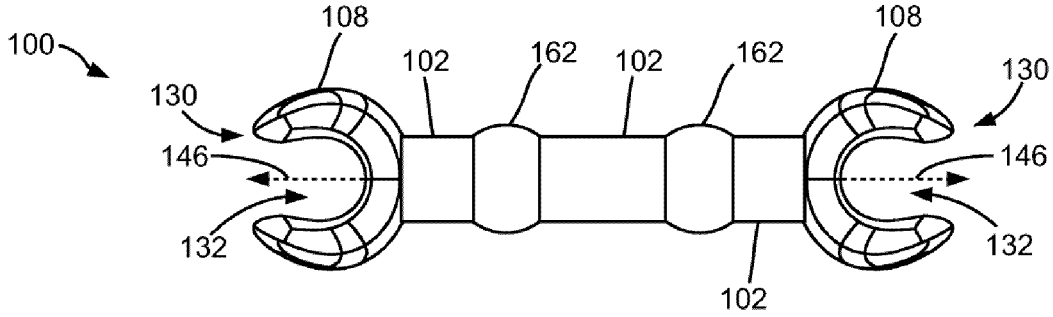


FIG. 15

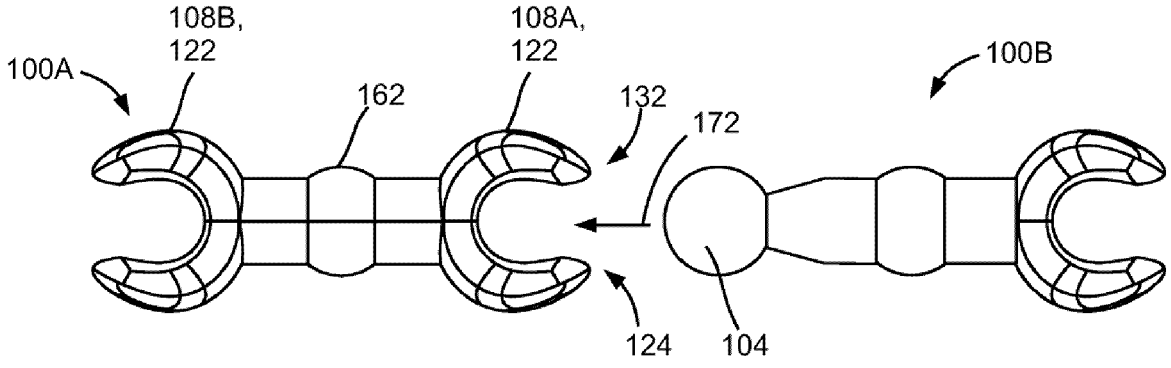


FIG. 16A

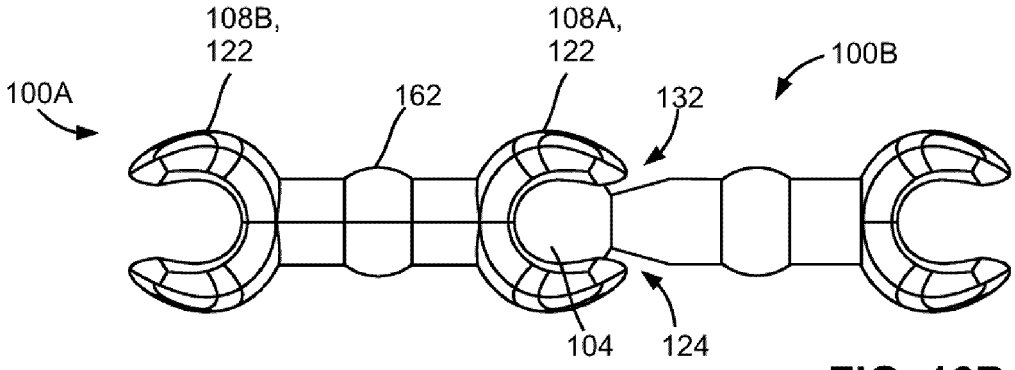


FIG. 16B

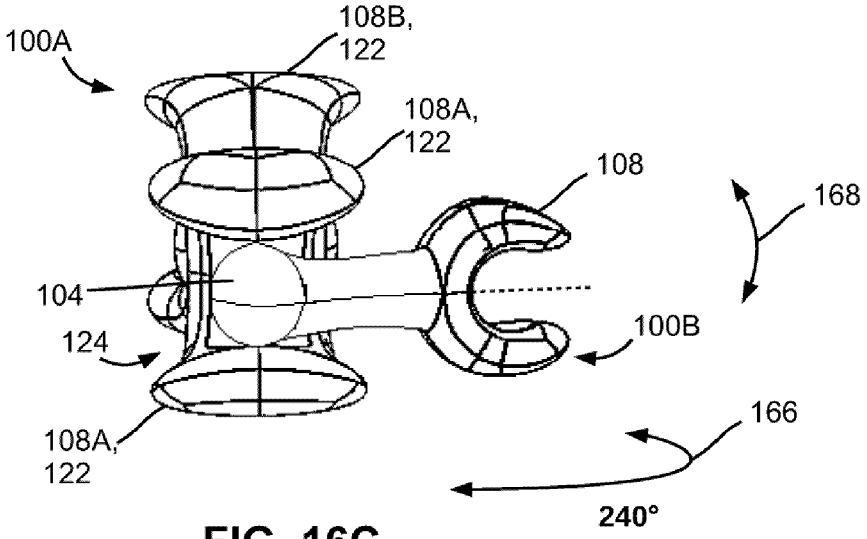


FIG. 16C

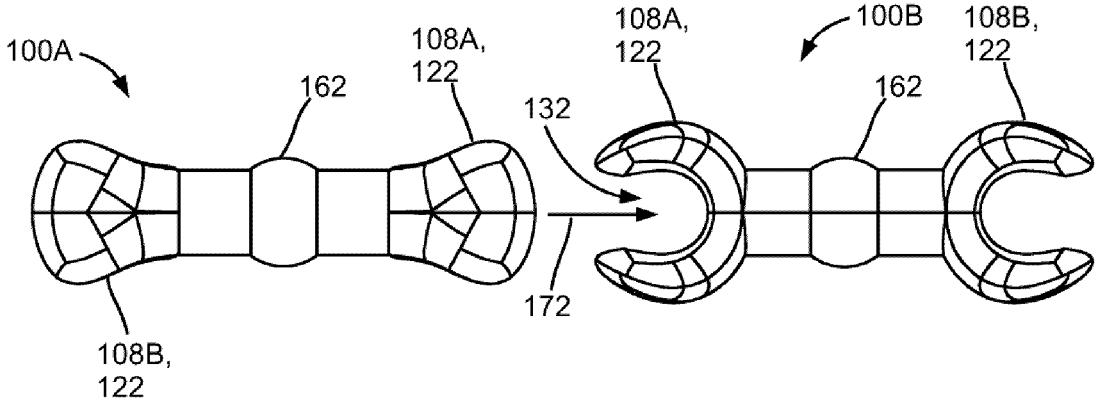


FIG. 17A

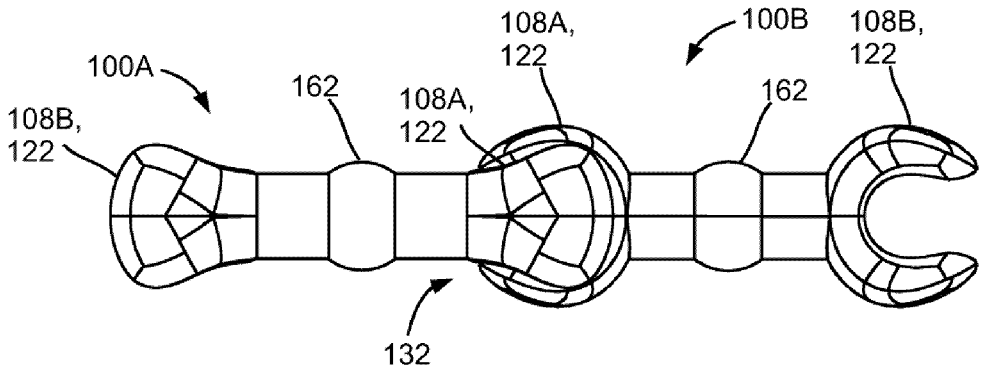


FIG. 17B

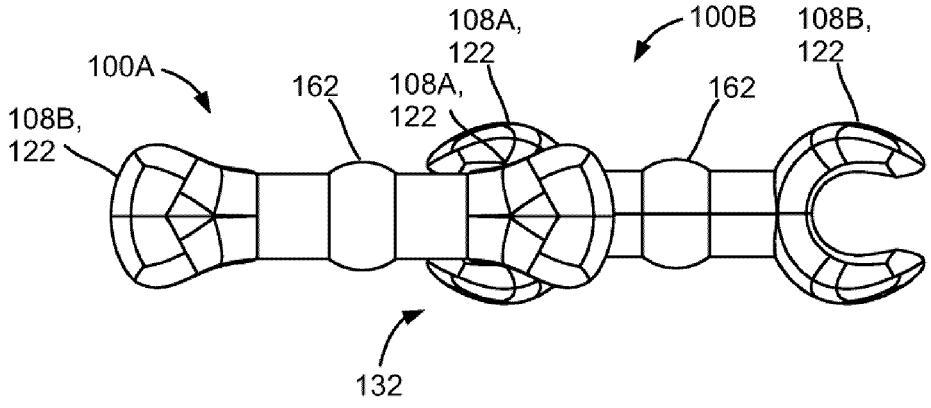


FIG. 17C

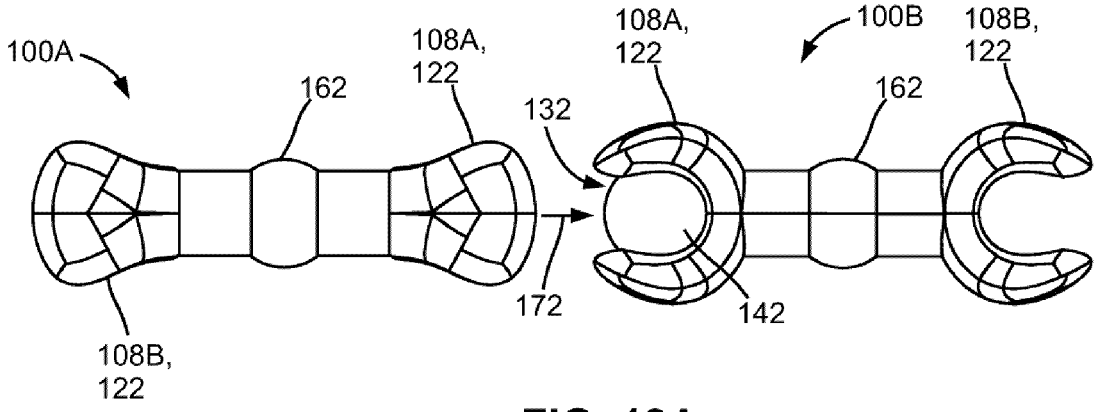


FIG. 18A

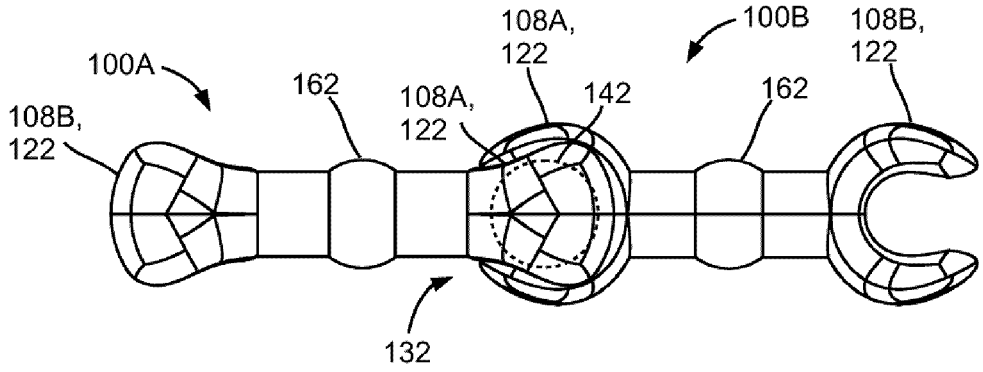


FIG. 18B

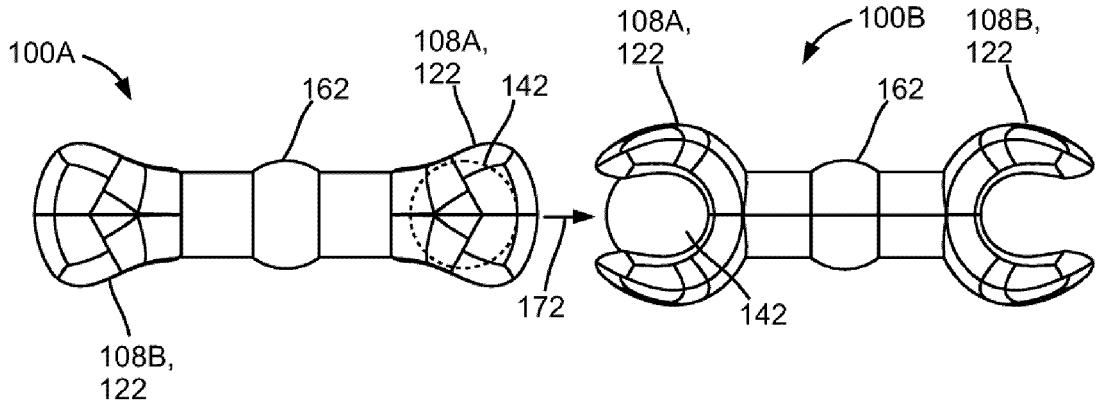


FIG. 19A

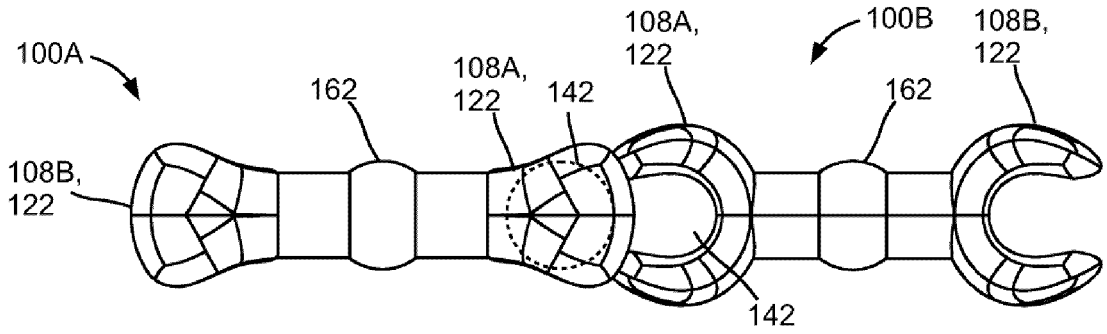


FIG. 19B

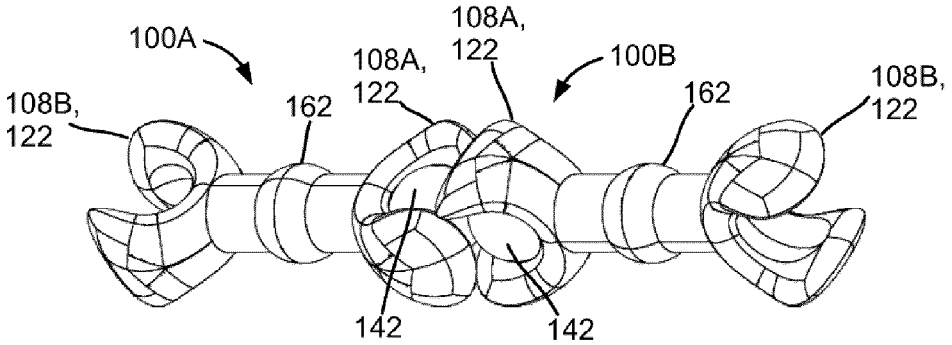
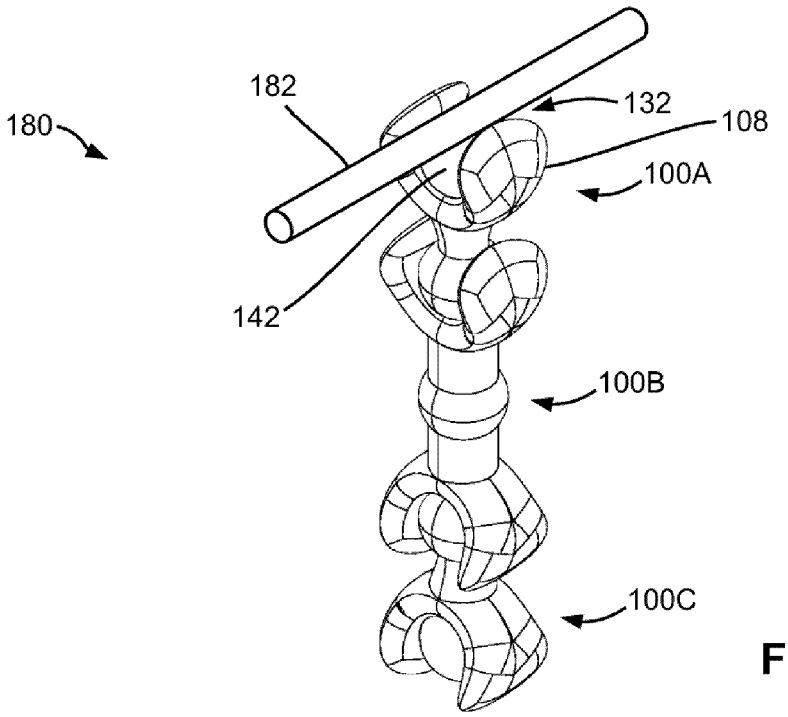


FIG. 19C


180
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142
100B
100C

FIG. 20

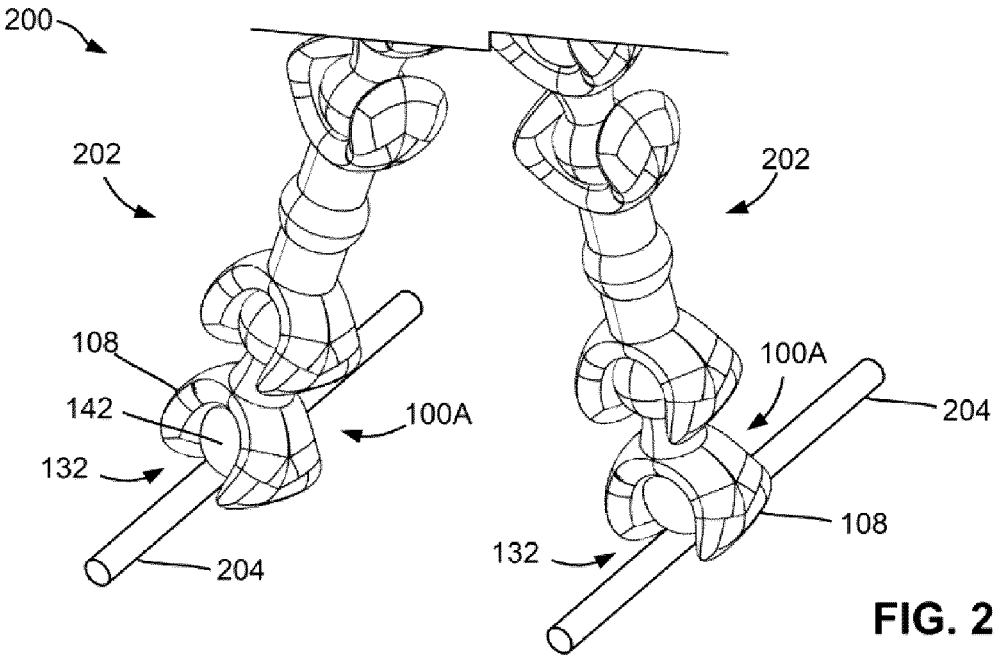
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FIG. 21

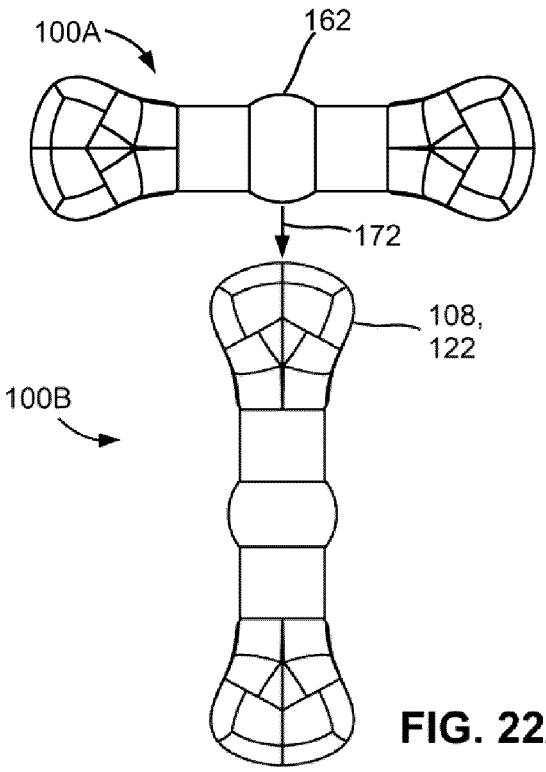

FIG. 22A

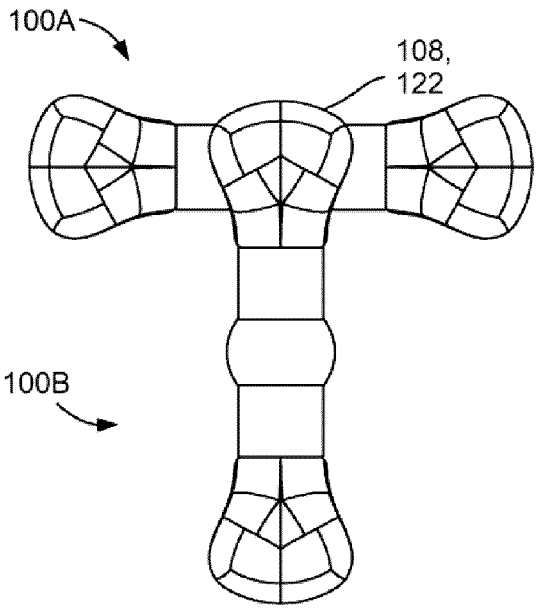

FIG. 22B

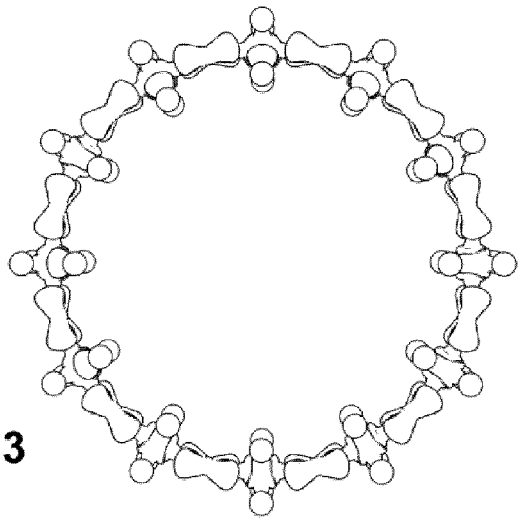

FIG. 23

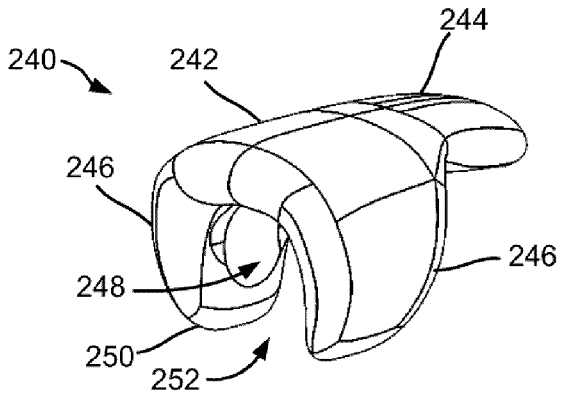

FIG. 24A

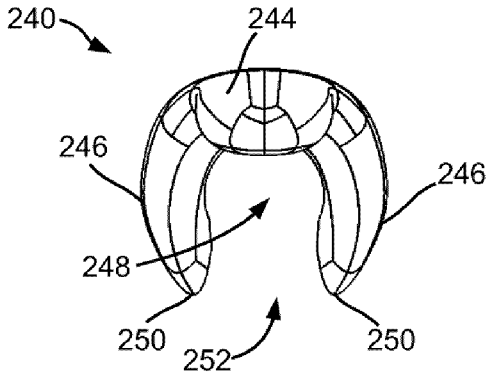

FIG. 24B

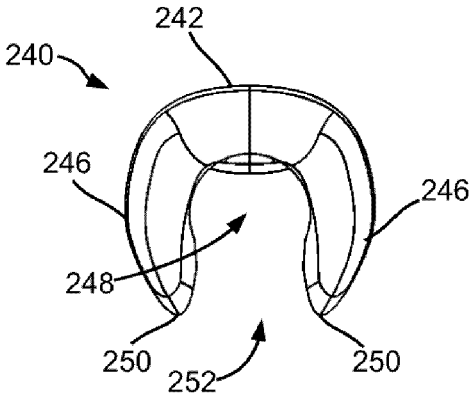

FIG. 24C

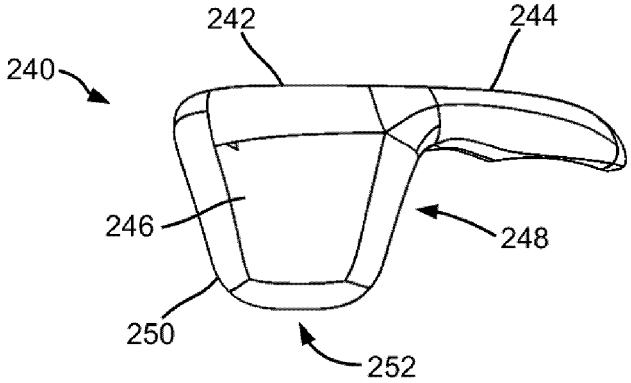

FIG. 24D

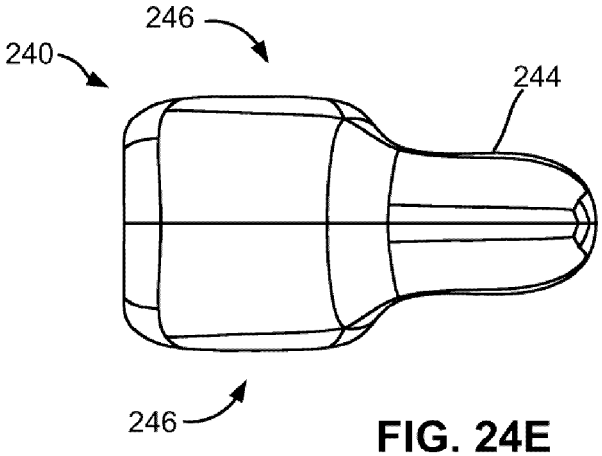

FIG. 24E

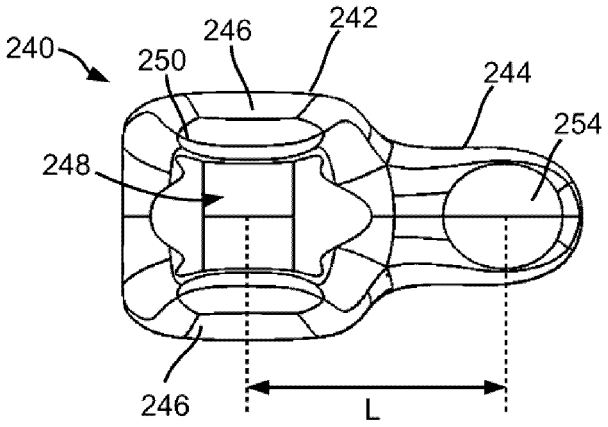

FIG. 24F

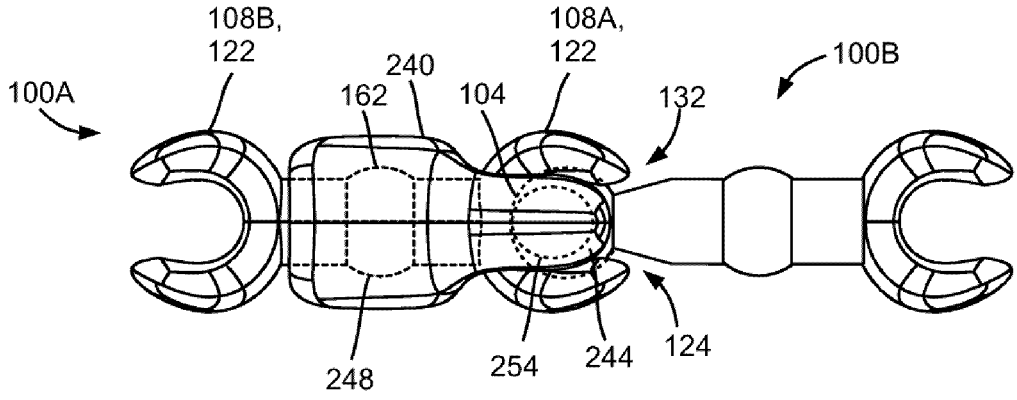

FIG. 25A

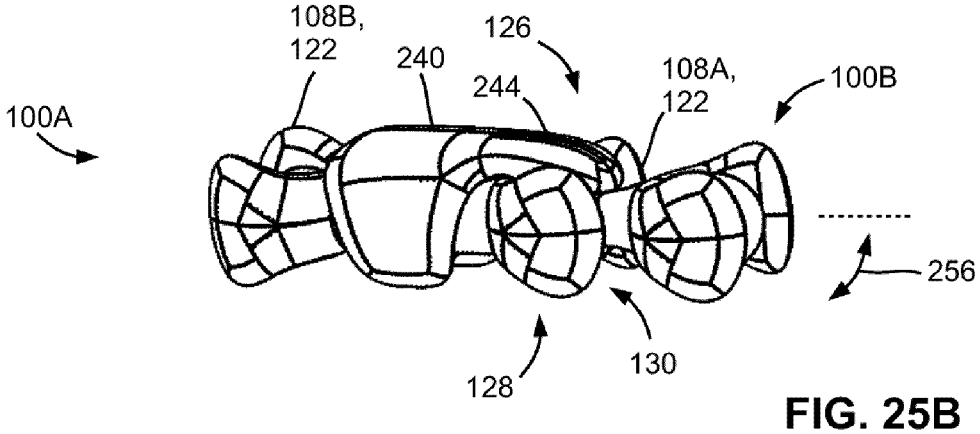

FIG. 25B

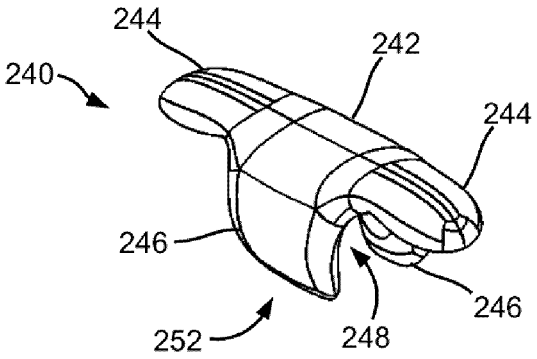

FIG. 26A

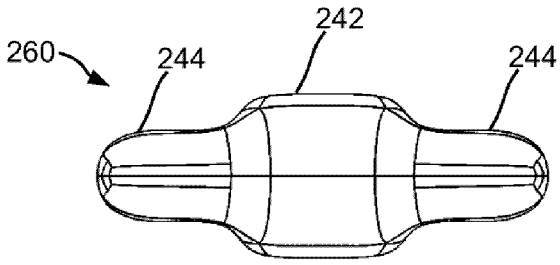

FIG. 26B

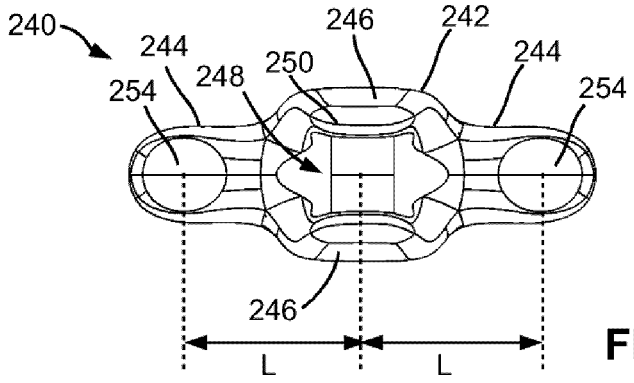

FIG. 26C

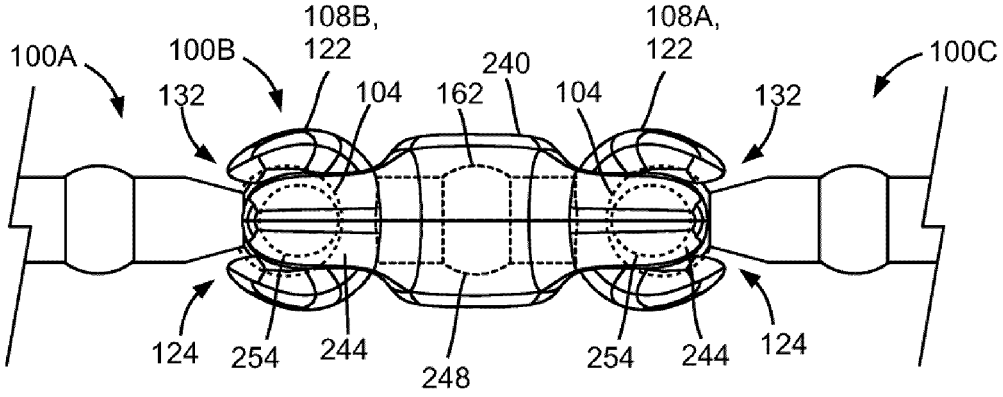

FIG. 27

CONSTRUCTION SYSTEM WITH LINKABLE ELEMENTS AND METHOD THEREFOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and benefit of U.S. Provisional Patent Application Ser. No. 62/979,016 filed on Feb. 20, 2020, the content of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] This present disclosure relates generally to a construction system and method, and particularly to a construction system and method employing a plurality of individual construction elements that may be fitted together by way of magnetic and non-magnetic ball-and-socket joints.

BACKGROUND

[0003] Construction systems using small parts or elements such as construction systems for toys are known. Such construction systems often comprise elements with interconnectable or interlockable male and female connectors (e.g., interconnectable or interlockable connection-head and socket) for connecting the elements together.

[0004] The prior-art construction systems may be used for connecting parts of various shapes using head-to-socket connections and/or socket-to-socket connections. However, such construction systems generally have a number of limitations such as:

[0005] (i) one connector may only be interconnectable with the other connector of the same interconnectable connector pairs,

[0006] (ii) ways for limiting the ranges of rotation of the head-to-socket connections may be lacking.

SUMMARY

[0007] Consequently, a need exists for a construction system that overcomes the limitations of prior systems, is easy to assemble and is inexpensive to manufacture.

[0008] According to some aspects of this disclosure, there is provided a construction element comprising: at least a socket having a recess in communication with an opening, the opening extending from a first lateral side of the socket at least to a distal end thereof; and a magnetic ball rotatably receivable into the recess.

[0009] In some embodiments, the magnetic ball is made of neodymium-iron-boron.

[0010] According to some aspects of this disclosure, there is provided a first construction element for removably coupling to a second construction element for limiting the range of rotation thereof, the second construction element comprising an expansion and a socket spaced from each other, the socket comprising an opening extending from a first lateral side at least to a distal end thereof. The first construction element comprises: an engagement structure having a recess for engaging the expansion of the second construction element; and a tail section extending from the socket, said tail section having a length such that, when the first construction element is coupled to the second construction element with the recess of the first construction element engaging the expansion of the second construction element, the tail section extends to the first lateral side of the opening of the second construction element.

[0011] According to some aspects of this disclosure, there is provided an interconnectable construction element comprising: a body section; a first socket coupled to a first end of the body section, the first socket comprising a recess in communication with an opening, the opening extending from a first lateral side of the first socket at least to a distal end thereof; and a magnetic ball releasably receivable into the recess of the first socket without falling out therefrom for forming a magnetic connection with another interconnectable construction element having another magnetic ball, a magnetic anchor, and/or a ferromagnetic anchor.

[0012] In some embodiments, the magnetic ball is individually rotatably receivable in the first socket.

[0013] In some embodiments, the magnetic ball comprises a material of neodymium-iron-boron.

[0014] In some embodiments, the interconnectable construction element comprises a second socket coupled to a second end of the body section.

[0015] In some embodiments, the body section comprises an expansion spaced from the first socket, the expansion having a maximum diameter greater than that of the body section.

[0016] In some embodiments, the expansion has a spherical shape.

[0017] In some embodiments, the expansion is located at a position intermediate the first and second sockets.

[0018] In some embodiments, the expansion is receivable into the recess of another interconnectable construction element.

[0019] In some embodiments, the magnetic connection is formed by automatic rotation and alignment of the one or more magnetic balls.

[0020] In some embodiments, the interconnectable construction element comprises an injection-molded thermoplastic material, metal, carved wood, composite materials, or a combination thereof.

[0021] According to some aspects of this disclosure, there is provided a rotation-limiting element for removably coupling to a first interconnectable construction element for limiting the range of rotation thereof when the first interconnectable construction element is connected to a second interconnectable construction element, the first interconnectable construction element comprising a body section and a socket coupled to the body section, the socket comprising a recess in communication with an opening for rotatably receiving a connection portion of the second interconnectable construction element, the opening extending from a first lateral side of the recess at least to a distal end thereof; the rotation-limiting element comprises: an engagement structure for engaging an engagement section of the first interconnectable construction element for removably coupling the rotation-limiting element to the first interconnectable construction element; and a first tail section extending from the engagement structure, said first tail section having a length such that, when the rotation-limiting element is coupled to the first interconnectable construction element, the first tail section extends to a position about the opening of the first interconnectable construction element.

[0022] In some embodiments, the engagement structure comprises a recess for engaging an expansion structure on the body section of the first interconnectable construction element, the expansion structure having a maximum diam-

eter greater than that of the body section and acting as the engagement structure of the first interconnectable construction element.

[0023] In some embodiments, the rotation-limiting element comprises an injection-molded thermoplastic material, metal, carved wood, composite materials, or a combination thereof.

[0024] In some embodiments, the first tail section comprises a spherical secondary recess about a distal end thereof and one side facing the opening of the first interconnectable construction element when the rotation-limiting element is coupled to the first interconnectable construction element.

[0025] In some embodiments, the rotation-limiting element is for coupling to a head-to-socket connection.

[0026] In some embodiments, the recess of the engagement structure is a spherical recess.

[0027] In some embodiments, the rotation-limiting element further comprises a second tail section extending from the engagement structure on a side thereof longitudinally opposite to the first tail section.

[0028] According to some aspects of this disclosure, there is provided a construction system comprising: a plurality of above-described interconnectable construction elements.

[0029] In some embodiments, the construction system further comprises: one or more above-described interconnectable rotation-limiting elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. **1**A is a perspective view of a construction element, according to one embodiment of this disclosure;

[0031] FIG. **1**B is a side view of the construction element shown in FIG. **1**A;

[0032] FIG. **1**C is a front view of the construction element shown in FIG. **1**A;

[0033] FIG. **2** is a perspective view of a construction element according to another embodiment of this disclosure, the construction element being similar to that shown in FIG. **1**A and further comprising a magnetic ball;

[0034] FIG. **3**A is a perspective view of a construction element according to yet another embodiment of this disclosure;

[0035] FIG. **3**B is a rear view of the construction element shown in FIG. **3**A;

[0036] FIG. **3**C is a front view of the construction element shown in FIG. **3**A;

[0037] FIG. **3**D is a side view of the construction element shown in FIG. **3**A;

[0038] FIG. **3**E is a plan view of the construction element shown in FIG. **3**A;

[0039] FIG. **4** is a perspective view of a construction element according to still another embodiment of this disclosure, the construction element being similar to that shown in FIG. **3**A and further comprising a magnetic ball;

[0040] FIGS. **5** to **15** are plan views of a construction element in various embodiments;

[0041] FIGS. **16**A to **16**C show the coupling of two construction elements with a head-to-socket connection, according to one embodiment of this disclosure;

[0042] FIGS. **17**A to **17**C show the coupling of two construction elements with a socket-to-socket connection, according to another embodiment of this disclosure;

[0043] FIGS. **18**A and **18**B show the coupling of two construction elements with a socket-to-socket connection and a ball received in the engaged sockets, according to another embodiment of this disclosure;

[0044] FIGS. **19**A to **19**C show the engagement of two construction elements, according to another embodiment of this disclosure;

[0045] FIGS. **20** and **21** show the attachment of an assembled apparatus to an anchoring structure, according to different embodiments of this disclosure;

[0046] FIGS. **22**A and **22**B show the coupling of two construction elements, according to another embodiment of this disclosure;

[0047] FIG. **23** shows a bracelet assembly built from a plurality of plastic construction elements;

[0048] FIG. **24**A is a perspective view of a rotation-limiting element, according to one embodiment of this disclosure;

[0049] FIG. **24**B is a front view of the rotation-limiting element shown in FIG. **24**A;

[0050] FIG. **24**C is a rear view of the rotation-limiting element shown in FIG. **24**A;

[0051] FIG. **24**D is a side view of the rotation-limiting element shown in FIG. **24**A;

[0052] FIG. **24**E is a plan view of the rotation-limiting element shown in FIG. **24**A;

[0053] FIG. **24**F is a bottom view of the rotation-limiting element shown in FIG. **24**A;

[0054] FIGS. **25**A and **25**B are a plan view and a perspective view, respectively, of two coupled construction elements with a rotation-limiting element shown in FIG. **24**A attached thereto for limiting the range of rotation thereof;

[0055] FIG. **26**A is a perspective view of a rotation-limiting element, according to another embodiment of this disclosure;

[0056] FIG. **26**B is a plan view of the rotation-limiting element shown in FIG. **26**A;

[0057] FIG. **26**C is a bottom view of the rotation-limiting element shown in FIG. **26**A; and

[0058] FIG. **27** is a plan view of two coupled construction elements with a rotation-limiting element shown in FIG. **26**A attached thereto for limiting the range of rotation thereof.

DETAILED DESCRIPTION

[0059] Embodiments disclosed herein relate to a construction system using a plurality of interconnectable, interlockable, or otherwise linkable construction elements for assembling or otherwise building an apparatus such as a toy, an educational tool, an adornment, or the like. Each construction element may comprise a socket, a connection head, or both.

[0060] FIGS. **1**A to **1**C show an interconnectable construction element **100** according to one embodiment of this disclosure. In this embodiment, the construction element **100** may be made of or comprise Acetal such as Polyoxymethylene Copolymer (POM-C). Of course, those skilled in the art will appreciate that, in other embodiments, the construction element **100** may be made of or comprise any suitable material such as injection-molded thermoplastic, metal, carved wood, composite materials, and/or the like.

[0061] The construction element **100** comprises an elongated substantially cylindrical body section **102**, with a connection head **104** on a first end **106** thereof and a socket or jaw **108** on a second end **110** of the body section **102** opposite to the first end **106**.

[0062] As shown in FIG. **1**A, the socket **108** in this embodiment comprises two opposing petals **122** and an opening **124** laterally extending from a first side **126** of the petals **122** to an opposing second side **128** through a distal end **130** thereof.

[0063] The petals **122** form a recess **132** having an inner surface **134** with a shape substantively complementary to that of at least a portion of the connection head **104** and a diameter equal to or slightly smaller than that of the connection head **104**, for removably and rotatably receiving therein the connection head **104** of another construction element. The opening **124** has a dimension along any direction smaller than that of the connection head **104** of another construction element received in the recess **132** along a corresponding direction for preventing the received connection head **104** from accidentally falling out of the recess **132**.

[0064] In this embodiment, the socket **108** comprises a crest **136** extending along the edge of the petals **122**. The crest **136** defines a radially outwardly facing chamfer **138** at the edge of the recess **132** for facilitating the snapping-in of the spherical connection head **104** of another construction element, and also forms the perimeters of the petals **122** and opening **124** with a shape such that the perimeter of the opening **124** is the reverse image of that of the petals **122** (in other words, the opening **124** has a profile complementary to that of the petals **122**) for allowing a socket-to-socket connection. Moreover, the petals **122** comprise a maximum width greater than that of the entrance of the opening **124** to prevent the interconnected sockets from accidentally disengaging.

[0065] As shown in FIG. **4**, the interconnectable construction element **100** in another embodiment may further comprise an individual magnetic ball **142** made of a suitable material such as neodymium-iron-boron (NIB) with a size equal to or slightly smaller than the spherical connection head **104** such that the magnetic ball **142** may be removably or releasably snapped into the recess **132** of the socket **108**. In some embodiments, the magnetic ball **142** may be freely rotatable in the recess **132** of the socket **108** after snapping thereinto. Similar to the description above, the opening **124** has a dimension along any direction smaller than that of the magnetic ball **142** received in the recess **132** along a corresponding direction for preventing the received magnetic ball **142** from accidentally falling out of the recess **132**.

[0066] In various embodiments, various interconnectable construction elements **100** may be formed by combining the connection head **104**, the socket **108**, the body section **102**, and the magnetic ball **142**. For example, FIGS. **3**A to **3**E show an interconnectable construction element **100** in one embodiment that only comprises the socket **108**.

[0067] FIG. **4** shows an interconnectable construction element **100** in another embodiment. The interconnectable construction element **100** in this embodiment is similar to that shown in FIGS. **3**A to **3**E except that the interconnectable construction element **100** in this embodiment further comprises a magnetic ball **142** rotatably receivable into the recess **132**.

[0068] FIG. **5** shows an interconnectable construction element **100** in yet another embodiment that comprises two sockets **108** coupled together directly or via a body section **102** of a short length (compared to, e.g., that of the body section **102** shown in FIG. **1**A). For ease of description, a longitudinal axis **146** is defined for each socket **108** as the axis about which the two petals **122** are symmetrical and oriented in a direction towards the distal end **130** thereof. In this embodiment, the two sockets **108** are arranged in a "back to back" manner, i.e., the longitudinal axes **146** thereof are opposite to each other.

[0069] In some embodiments similar to that shown in FIG. **5**, the interconnectable construction element **100** may further comprise one or two magnetic balls **142** rotatably receivable into one or both of the recesses **132** of the sockets **108**.

[0070] FIG. **6** shows an interconnectable construction element **100** in another embodiment. The interconnectable construction element **100** in this embodiment comprises two sockets **108** arranged in a perpendicular manner (i.e., the longitudinal axes **146** thereof are perpendicular to each other) and coupled together with a body section **102** of a minimum length.

[0071] In some embodiments similar to that shown in FIG. **6**, the interconnectable construction element **100** may further comprise one or two magnetic balls **142** rotatably receivable into one or both of the recesses **132** of the sockets **108**.

[0072] FIG. **7** shows an interconnectable construction element **100** in another embodiment. The interconnectable construction element **100** in this embodiment comprises two sockets **108** arranged in an angled manner (i.e., the longitudinal axes **146** thereof are at an angle (e.g., 45°) to each other) and coupled together with a body section **102** of a minimum length.

[0073] In some embodiments similar to that shown in FIG. **7**, the interconnectable construction element **100** may further comprise one or two magnetic balls **142** rotatably receivable into one or both of the recesses **132** of the sockets **108**.

[0074] FIG. **8** shows an interconnectable construction element **100** having three connection heads **104** and one socket, according to another embodiment of this disclosure. As shown, the interconnectable construction element **100** is similar to that shown in FIGS. **1**A to **1**C except that the interconnectable construction element **100** in this embodiment further comprises two connection heads **104** extending from the two petals **122**.

[0075] In some embodiments similar to that shown in FIG. **8**, the interconnectable construction element **100** may further comprise a magnetic ball **142** rotatably receivable into the recess **132** of the socket **108**.

[0076] FIG. **9** shows an interconnectable construction element **100** in another embodiment. As shown, the interconnectable construction element **100** is similar to that shown in FIG. **5** except that the interconnectable construction element **100** in this embodiment further comprises two connection heads **104** extending from the two petals **122** of one of the sockets **108**.

[0077] In some embodiments similar to that shown in FIG. **9**, the interconnectable construction element **100** may further comprise one or two magnetic balls **142** rotatably receivable into one or both of the recesses **132** of the sockets **108**.

[0078] FIG. **10** shows an interconnectable construction element **100** in another embodiment. As shown, the interconnectable construction element **100** comprises four (4) sockets **108** circumferentially uniformly distributed on and coupled to a circular body section **102**. The circular body section **102** comprises a central hole **152** with a size suitable

for rotatably receiving therein a connection head **104** of another construction element.

[0079] In some embodiments similar to that shown in FIG. **10**, the interconnectable construction element **100** may further comprise one or more magnetic balls **142** rotatably receivable into the recesses **132** of the sockets **108** and/or the central hole **152** of the circular body section **102**.

[0080] FIG. **11** shows an interconnectable construction element **100** in another embodiment. As shown, the interconnectable construction element **100** comprises two (2) connection heads **104** connected by a body section **102**.

[0081] FIG. **12** shows an interconnectable construction element **100** in yet another embodiment. As shown, the interconnectable construction element **100** comprises more than two (e.g., eight) connection heads **104** circumferentially uniformly distributed on a circular body **154** and coupled thereto via respective body sections **102**. The circular body **154** comprises a central hole **152** with a size suitable for rotatably receiving therein a connection head **104** of another construction element.

[0082] In some embodiments similar to that shown in FIG. **12**, the interconnectable construction element **100** may further comprise a magnetic ball **142** rotatably receivable into the central hole **152** of the circular body section **102**.

[0083] FIG. **13** shows an interconnectable construction element **100** in still another embodiment. Similar to that shown in FIG. **5**, the interconnectable construction element **100** in this embodiment comprises two sockets **108** coupled by a body section **102** of a suitable length. The body section **102** comprises a spherical expansion **162** at a location thereof intermediate the two sockets **108** and having a maximum diameter greater than that of the body section **102**. The spherical expansion **162** has a size suitable for being received in a recess **132** of another construction element. As will be described in more detail later, the spherical expansion **162** may be used for engaging the recess **132** of another construction element.

[0084] In some embodiments similar to that shown in FIG. **13**, the interconnectable construction element **100** may further comprise one or two magnetic balls **142** rotatably receivable into the recesses **132** of the sockets **108**.

[0085] FIG. **14** shows an interconnectable construction element **100** in another embodiment. The interconnectable construction element **100** in this embodiment comprises a socket **108** and a connection head **104** coupled by a body section **102** of a suitable length. Similar to that shown in FIG. **13**, the body section **102** comprises a spherical expansion **162** at a location thereof intermediate the socket **108** and the connection head **104**.

[0086] In some embodiments similar to that shown in FIG. **14**, the interconnectable construction element **100** may further comprise a magnetic ball **142** rotatably receivable into the recess **132** of the socket **108**.

[0087] FIG. **15** shows an interconnectable construction element **100** in another embodiment. The interconnectable construction element **100** is similar to that shown in FIG. **13** except that the body section **102** of the interconnectable construction element **100** in this embodiment comprises two spherical expansions **162** spaced from each other at locations thereof intermediate the socket **108** and the connection head **104**.

[0088] In some embodiments similar to that shown in FIG. **14**, the interconnectable construction element **100** may further comprise one or two magnetic balls **142** rotatably receivable into one or both of the recesses **132** of the sockets **108**.

[0089] In various embodiments, the above-described interconnectable construction elements **100** may be combined in any suitable manner. For example, FIGS. **16**A to **16**C show the connection or engagement of two construction elements **100**A and **100**B in one embodiment.

[0090] As shown in FIG. **16**A, the construction element **100**A is similar to that shown in FIG. **13** and comprises a pair of sockets **108**A and **108**B. The construction element **100**B is similar to that shown in FIG. **14** and comprises a socket **108** and a connection head **104**. One may push the connection head **104** of the construction element **100**B into the recess **132** of the socket **108**A of the construction element **100**A, as indicated by the arrow **172**.

[0091] As shown in FIG. **16**B, with a sufficient force, the petals **122** of the socket **108**A are slightly deflected thereby allowing the connection head **104** of the construction element **100**B to snap into the recess **132** of the socket **108**A of the construction element **100**A, thereby forming a joint with a head-to-socket connection.

[0092] As shown in FIG. **16**C, the engaged recess **132** and connection head **104** may be used as a pivot for construction elements **100**A and **100**B to rotate with respect to each other including a large rotation span (e.g., about 220° in some embodiments or 240° in some other embodiments) along the opening **124** of the socket **108**A as indicated by the arrow **166** and a relatively small rotation span towards the petals **122** of the socket **108**A as indicated by the arrow **168**.

[0093] FIGS. **17**A and **17**B show the connection or engagement of two construction elements **100**A and **100**B in another embodiment.

[0094] As shown in FIG. **17**A, the construction elements **100**A and **100**B are similar to that shown in FIG. **13** and each comprise a pair of sockets **108**A and **108**B. One may rotate the construction element **100**A about its longitudinal axis (not shown) to align the petals **122** of the socket **108**A thereof with the opposite sides of the petals **122** of socket **108**A of the construction element **100**B, and then push the socket **108**A of the construction element **100**A towards the socket **108**A of the construction element **100**B, as indicated by the arrow **172**.

[0095] As shown in FIG. **17**B, with a sufficient force, the petals **122** of the sockets **108**A and **108**B are slightly deflected and allow the sockets **108**A and **108**B of the construction elements **100**A and **100**B to snap to and engage with each other, thereby forming a socket-to-socket connection. Unlike the head-to-socket connection, the socket-to-socket connection does not allow the construction elements **100**A and **100**B to rotate with respect to each other.

[0096] As shown in FIG. **17**C, with sufficient force, the petals **122** of the sockets **108**A and **108**B may be forced past the socket-to-socket connection shown in FIG. **17**B and into an unstable, buckled state. From the unstable, buckled state, the construction elements **100**A and **100**B may be pulled backward (that is, along opposite directions) and snapped into a socket-to-socket connection.

[0097] FIGS. **18**A and **18**B show the connection or engagement of two construction elements **100**A and **100**B in yet another embodiment.

[0098] As shown in FIG. **18**A, the construction elements **100**A and **100**B are similar to those shown in FIGS. **17**A and **17**B. However, in this embodiment, the construction element

100B comprises a magnetic ball **142** received in the recess **132** of the socket **108**A thereof.

[0099] With an engagement process similar to that shown in FIGS. **17**A and **17**B, the sockets **108**A and **108**B of the construction elements **100**A and **100**B are snapped to and engage with each other with the magnetic ball **142** (indicated using broken line) received therein (see FIG. **18**B), thereby forming a socket-to-socket connection. In this embodiment, the magnetic ball **142** supports the engagement of the construction elements **100**A and **100**B.

[0100] FIGS. **19**A to **19**C show the connection or engagement of two construction elements **100**A and **100**B in still another embodiment.

[0101] As shown in FIG. **19**A, the construction elements **100**A and **100**B are similar to those shown in FIGS. **17**A and **17**B. However, in this embodiment, the construction elements **100**A and **100**B each comprise a magnetic ball **142** received in the recess **132** of the socket **108**A thereof.

[0102] One may rotate the construction element **100**A about its longitudinal axis (not shown) to align the petals **122** of the socket **108**A thereof with the opposite sides of petals **122** of the socket **108**A of the construction element **100**B, and then move the construction elements **100**A and **100**B towards each other as indicated by the arrow **172**. As the magnetic balls **142** are rotatable in the respective recesses **132** of the sockets **108**, the magnetic fields of the balls **142** force the balls **142** to automatically rotate and align to a mutually attracting orientation (i.e., the north pole of one ball **142** automatically aligned with the south pole of the other ball **142**).

[0103] As shown in FIGS. **19**B and **19**C, the two construction elements **100**A and **100**B are then coupled to each other by the magnetic force between the balls **412** thereof, thereby forming a joint with a magnetic connection.

[0104] Unlike the socket-to-socket connections shown in FIGS. **17**A to **18**B, the magnetic connection allows the two construction elements **100**A and **100**B to rotate with respect to each other. The strong magnetic force provided by the NIB magnetic balls **142** ensures reliable coupling of the construction elements **100**A and **100**B.

[0105] In various embodiments, the magnetic ball **142** may also facilitate an assembled apparatus to couple to an anchor structure.

[0106] For example, FIG. **20** shows an assembled or otherwise constructed apparatus **180** formed by interconnected construction elements **100**A to **100**C. The construction element **100**A comprises a magnetic ball **142** received in the recess **132** of the socket **108** thereof for attaching the assembled apparatus **180** to a ferromagnetic anchor such as a ferromagnetic rod **182**. As the magnetic ball **142** is rotatable in the respective recesses **132** of the sockets **108**, it may also be used to attach the assembled apparatus **180** to a magnetic anchor.

[0107] FIG. **21** shows a portion of an assembled apparatus **200** in the form of a robot. The robot **200** comprises two legs **202** assembled or otherwise constructed using a plurality of interconnected construction elements. The construction elements **100**A at the ends of the legs **202** each comprise a magnetic ball **142** received in the recess **132** of the socket **108** thereof for attaching the legs **202** to ferromagnetic anchors such as ferromagnetic rods **204** for maintaining the assembled apparatus **200** in a upright orientation. Similar to the description above, the magnetic ball **142** is rotatable in the respective recesses **132** of the sockets **108**, and may also be used to attach the assembled apparatus **200** to a magnetic anchor.

[0108] As shown in FIGS. **22**A and **22**B, one may snap the spherical expansion **162** of a construction element **100**A into the recess **132** of a socket **108** of another construction element **100**B (as indicated by the arrow **172**) to couple the construction element **100**A to the construction element **100**B.

[0109] FIG. **23** shows a bracelet assembly in faux jade finish which is assembled or built from a plurality of plastic construction elements **100**.

[0110] In one example, some measurements of the construction elements **100** described above are as follows, which are obtained through extensive experiments for achieving an improved performance of balancing of assembled apparatuses.

[0111] the recess **132** of the socket **108** has a diameter of about 6 millimeters (mm);

[0112] the connection head **104** has a diameter of about 6.1 mm;

[0113] the portion of the body section **102** connecting to the connection head **104** has a diameter of 3.4 mm, and the rest of the body section **102** has a diameter of about 4.9 mm or smaller;

[0114] the spherical expansion **162** has a diameter of about 6.0 mm;

[0115] the magnetic ball **142** has a diameter of about 5.9 mm;

[0116] the head-to-socket connection allows a pitch (rotation along the opening **124**) of at most 220° (e.g., at most 110° on each side); and

[0117] the head-to-socket connection allows a yaw (rotation towards the petals **122**) of no more than 20°.

[0118] In some embodiments, the dimensions of the construction elements **100** may be:

[0119] the recess **132** of the socket **108** has a diameter of 5 mm to 6 mm;

[0120] the connection head **104** has a diameter of 6 mm to 6.4 mm;

[0121] the portion of the body section **102** connecting to the connection head **104** has a diameter of 3.2 mm to 3.6 mm, and the rest of the body section **102** has a diameter of 4.7 mm to 6 mm;

[0122] the spherical expansion **162** has a diameter of 6 mm to 6.4 mm;

[0123] the magnetic ball **142** has a diameter of about 5 mm to 6 mm;

[0124] the head-to-socket connection allows a pitch (rotation along the opening **124**) of at most 240° (e.g., at most 120° on each side); and

[0125] the head-to-socket connection allows a yaw (rotation towards the petals **122**) of 15° to 20°.

[0126] Of course, those skilled in the art will appreciate that the construction elements **100** described above may have any other suitable dimensions in other embodiments.

[0127] In some embodiments, it may be beneficial to limit the rotation range of an assembled joint with the head-to-socket connection. For example, such a limitation of rotation range may be particularly desirable for assembling or building a human-like toy with arms, legs, and the like that have limited rotation range at certain directions. Limiting rotation

range may be also advantageous in some embodiments such as in the assembling or construction of furniture or outdoor playground equipment.

[0128] FIGS. **24**A to **24**F show a rotation-limiting element **240** (also called a "joint guard") attachable to the head-to-socket connection for limiting the rotation range thereof. Similar to the construction element **100**, the rotation-limiting element **240** may be made of any suitable material such as injection-molded thermoplastic, metal, carved wood, composite materials, and/or the like.

[0129] As shown in FIG. **24**A, the rotation-limiting element **240** comprises an engagement structure **242** in the form of a socket or jaw and a tail section **244** extending therefrom. Similar to the socket **108** described above, the engagement structure **242** comprises two opposing petals **246** on the two lateral sides thereof defining a main recess **248** therebetween. In this embodiment, the recess **248** is substantially spherical and has a dimension equal to or slightly smaller than that of the spherical expansion **162** of a construction element **100**. A crest **250** extends around the perimeter of the petals **246** forming the perimeter of the petals **246** and the perimeter of the opening **252** between the petals **246**.

[0130] The tail section **244** longitudinally extends from the engagement structure **242** and comprises a spherical secondary recess **254** about a distal end thereof. The length L of the tail section **244**, measured longitudinally from the center of the main recess **248** to the center of the secondary recess **254** is about the same as the distance L between the center of spherical expansion **162** and the center of the recess **132** of a construction element **100** (see FIG. **13**).

[0131] As shown in FIGS. **25**A and **25**B, the rotation-limiting element **240** may be attached to a pair of construction elements **100**A and **100**B coupled using the head-to-socket connection for limiting the joint's range of rotation. As shown, the main recess **248** of the rotation-limiting element **240** engages the spherical expansion **162** of the construction element **100**A. The tail section **244** of the rotation-limiting element **240** extends to the first lateral side **126** of the opening **124** of the construction element **100**B with the secondary recess **254** of the rotation-limiting element **240** engaging the spherical connection head **104** of the construction element **100**B. As a result, the construction element **100**B may only rotate along the opening **124** between the distal end **130** and the second lateral side **128** thereof as indicated by the arrow **256**, and cannot rotate to the first lateral side **126** of the opening **124**.

[0132] In some alternative embodiments, the tail section **244** may have other suitable lengths L provided that, when the rotation-limiting element **240** is attached to a construction element **100** having a socket **108** with the main recess **248** engaging the spherical expansion **162**, the distal end of the tail section **244** extends to a position about the opening **124** such as the first lateral side **126** of the opening **124** of the construction element **100** for limiting the range of rotation thereof.

[0133] FIGS. **26**A to **26**C show a rotation-limiting element **240** in one embodiment. The rotation-limiting element **240** is similar to that shown in FIGS. **24**A to **24**F except that the rotation-limiting element **240** in this embodiment comprises two tail sections **244** on longitudinally opposite sides of the engagement structure **242**.

[0134] As shown in FIG. **27**, the rotation-limiting element **240** in this embodiment may be attached to a construction element **100**B having two sockets **108**A and **108**B on opposite ends thereof and coupled to two construction elements **100**A and **100**C using head-to-socket connections. The tail sections **244** of the rotation-limiting element **240** extend to the first lateral side **126** of the opening **124** of each socket **108**A, **108**B of the construction element **100**B for limiting the range of rotation thereof.

[0135] Although in above embodiments, the petals have continuous surfaces, in some alternative embodiments, the petals may be perforated and comprise a plurality of openings therethrough. In some other embodiments, the petals may have a mesh structure formed by a plurality of intersecting columns and rows.

[0136] Although in above embodiments, the recess **132** of the socket **108** is spherical and correspondingly the connection head **104** is also spherical, in various embodiments, at least one of the recess **132** and the connection head **104** may have other suitable shapes such as an egg shape. Furthermore, in some embodiments, the connection head **104** may have a suitable surface such as a smooth surface or a textured surface.

[0137] In some embodiments, one or more construction elements **100** may be made of a transparent or semi-transparent material with a light source such as a light-emitting diode (LED) embedded therein for emitting light with various colors.

[0138] A construction system using the above-described construction elements **100** and/or rotation-limiting elements **240** may be used for assembling or building various types of apparatus such as toys (e.g., action figures, plush toys, dolls, and the like), scientific modeling (e.g., molecular engineering), ergonomic, anatomical, and artistic modeling (e.g., poseable figures and armatures), and the like, for play, use, display (e.g., in store, museum, or office as wall mountings and/or shelving), and may be used for creating mannequins in the clothing industry. The construction system may also be used in outdoor playground equipment, sporting goods, jewelry or other clothing accessories, and the like. Moreover, the construction system may be used in prosthetics, robotics, and computer applications. For example, software may be developed whereby the construction system may be used in computer-aided modeling. It is contemplated that the system may be used to assemble or build a model connectable to a computer for creating a virtual three-dimensional (3D) version of the model. As another example, models made from the construction system may be connected to a computer and then manipulated to create real-time animation of the virtual version of a corresponding computer generated form.

[0139] Those skilled in the art will appreciate that other embodiments are also readily available. By way of non-limiting example, the body section **102** may be perforated; the body section **102** may have an I-beam configuration; or the body section **102** may comprise parallel cylinders of different diameters that relate to the scales of the system so that three different-scale jaws **108** can simultaneously engage the body section **102**.

[0140] In above embodiments, the socket **108** of the construction element **100** comprises a recess **132** in communication with an opening **124** that extends from the first lateral side **126** through the distal end **130** to the second lateral side **128**. In some alternative embodiments, the opening **124** may only extend from the first lateral side **126** to the distal end **130** (i.e., the petals **122** are connected on the

second lateral side **128**). In these embodiments, the rotation-limiting element **240** may be coupled to the first lateral side **126** of the construction element **100** for limiting its range of rotation.

[0141] In above embodiments, the expansion **162** on the body section **102** of a construction element **100** is spherical. In some alternative embodiments, the expansion **162** may have other suitable shapes such as a cylindrical shape. Accordingly, the main recess **248** of a rotation-limiting element **240** may having a corresponding cylindrical shape.

[0142] In above embodiments, the body section **102** of a construction element **100** is cylindrical. In some alternative embodiments, the body section **102** may have other suitable shapes (e.g., bones, branches, bamboo sections, bricks, the electron clouds of atomic bonds, and/or the like) and may be decorated to resemble plants, animals, man-made objects, and/or the like. The body section **102** may be made of any suitable material such as rubber, metal, foam, plush, and/or the like. In some embodiments, the construction elements disclosed herein may be used for architectural or engineering purposes, or to assemble or construct temporary, semi-permanent, or permanent structures.

[0143] In above embodiments, the rotation-limiting element **240** comprises an engagement structure **242** comprising a recess for engaging the spherical expansion **162** on the body section **102** of the interconnectable construction element **100**. In some embodiments, the engagement structure **242** may be any suitable structure for engaging a corresponding engagement section of the interconnectable construction element **100**. For example, the body section **102** of the interconnectable construction element **100** may comprise an engagement section in the form of a recess, and the engagement structure **242** of the rotation-limiting element **240** may comprise an extrusion for engaging the recess-shaped engagement section of the interconnectable construction element **100** to engage the rotation-limiting element **240** with the interconnectable construction element **100**.

[0144] Although embodiments have been described above with reference to the accompanying drawings, those of skill in the art will appreciate that variations and modifications may be made without departing from the scope thereof as defined by the appended claims.

1. An interconnectable construction element comprising:

a body section;

a first socket coupled to a first end of the body section, the first socket comprising a recess in communication with an opening, the opening extending from a first lateral side of the first socket at least to a distal end thereof; and

a freely rotatable magnetic ball releasably receivable into the recess of the first socket without falling out therefrom for forming a magnetic connection with another interconnectable construction element having another magnetic ball, a magnetic anchor, and/or a ferromagnetic anchor.

2. The interconnectable construction element of claim **1**, wherein the magnetic ball is individually rotatably receivable in the first socket.

3. The interconnectable construction element of claim **1**, wherein the magnetic ball comprises a material of neodymium-iron-boron.

4. The interconnectable construction element of claim **1**, further comprising a second socket coupled to a second end of the body section.

5. The interconnectable construction element of claim **4**, wherein the body section comprises an expansion spaced from the first socket, the expansion having a maximum diameter greater than that of the body section.

6. The interconnectable construction element of claim **5**, wherein the expansion has a spherical shape.

7. The interconnectable construction element of claim **5**, wherein the expansion is located at a position intermediate the first and second sockets.

8. The interconnectable construction element of claim **5**, wherein the expansion is receivable into the recess of another interconnectable construction element.

9. The interconnectable construction element of claim **1**, wherein the magnetic connection is formed by automatic rotation and alignment of the one or more magnetic balls.

10. The interconnectable construction element of claim **1**, further comprising an injection-molded thermoplastic material, metal, carved wood, composite materials, or a combination thereof.

11. A rotation-limiting element for removably coupling to a first interconnectable construction element for limiting the range of rotation thereof when the first interconnectable construction element is connected to a second interconnectable construction element, the first interconnectable construction element comprising a body section and a socket coupled to the body section, the socket comprising a recess in communication with an opening for rotatably receiving a connection portion of the second interconnectable construction element, the opening extending from a first lateral side of the recess at least to a distal end thereof, the rotation-limiting element comprising:

an engagement structure for engaging an engagement section of the first interconnectable construction element for removably coupling the rotation-limiting element to the first interconnectable construction element; and

a first tail section extending from the engagement structure, said first tail section having a length such that, when the rotation-limiting element is coupled to the first interconnectable construction element, the first tail section extends to a position about the opening of the first interconnectable construction element.

12. The rotation-limiting element of claim **11**, wherein the engagement structure comprises a recess for engaging an expansion structure on the body section of the first interconnectable construction element, the expansion structure having a maximum diameter greater than that of the body section and acting as the engagement structure of the first interconnectable construction element.

13. The rotation-limiting element of claim **11** comprising an injection-molded thermoplastic material, metal, carved wood, composite materials, or a combination thereof.

14. The rotation-limiting element of claim **11**, wherein the first tail section comprises a spherical secondary recess about a distal end thereof and one side facing the opening of the first interconnectable construction element when the rotation-limiting element is coupled to the first interconnectable construction element.

15. The rotation-limiting element of claim **11**, wherein the rotation-limiting element is for coupling to a head-to-socket connection.

16. The rotation-limiting element of claim **15**, wherein the recess of the engagement structure is a spherical recess.

17. The rotation-limiting element of claim **11** further comprising a second tail section extending from the engagement structure on a side thereof longitudinally opposite to the first tail section.

18. A construction system comprising:

a plurality of interconnectable construction elements of claim **1**.

19. The construction system of claim **18**, further comprising:

one or more interconnectable rotation-limiting elements, wherein each rotation-limiting element is adapted for removably coupling to a first interconnectable construction element for limiting the range of rotation thereof when the first interconnectable construction element is connected to a second interconnectable construction element, the first interconnectable construction element comprising a body section and a socket coupled to the body section, the socket comprising a recess in communication with an opening for rotatably receiving a connection portion of the second interconnectable construction element, the opening extending from a first lateral side of the recess at least to a distal end thereof, the rotation-limiting element comprising:

an engagement structure for engaging an engagement section of the first interconnectable construction element for removably coupling the rotation-limiting element to the first interconnectable construction element; and

a first tail section extending from the engagement structure, said first tail section having a length such that, when the rotation-limiting element is coupled to the first interconnectable construction element, the first tail section extends to a position about the opening of the first interconnectable construction element.

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