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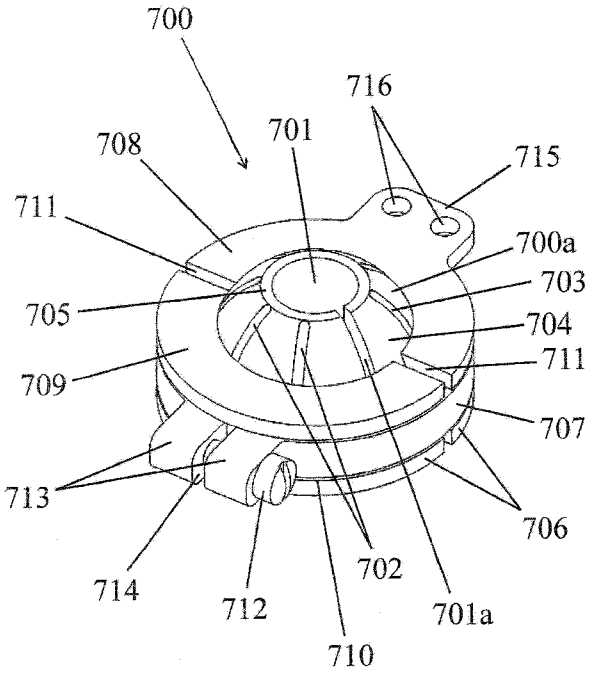

Fig. 7

(57) Abstract: A spherical bearing allows for releasably immobilizing an attachment to a shaft or other external object. The spherical bearing comprises a truncated flexible spherical core with an annular hole through the center of the spherical core for appending the core on the shaft or external object. Segments around the spherical core are created by relief cuts in the spherical core, and deflection flexure points displaced from the annular hole are formed by the relief cuts in the core. A two-piece housing and strap clamp provides compression against the core and immobilization of the shaft or other external object.

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APPARATUS FOR RELEASABLY IMMOBILIZING AN ATTACHMENT TO AN EXTERNAL OBJECT

BACKGROUND

[0001] When working with a mechanical apparatus, it is often desirable to connect an element of the apparatus or the entire apparatus to an external object such as a shaft. The connected object or shaft can arise from nearly any source and range from a free standing or floating shaft to a securely positioned shaft or other object specifically designed for mounting an apparatus. A shaft can even be an element of another apparatus.

[0002] Depending on the mechanical situation, it is often desirable not only to make a connection to a shaft but to lock whatever is connected to the shaft in a particular orientation with respect to the shaft at least temporarily. Subsequently, it can become desirable to change the orientation of the connected or mounted element. To do this various kinds of locking devices have been provided in the past which can be locked in place and released for adjustment.

[0003] In general the state of the art for rotating and then locking a device at any point along a shaft is to use three separate mechanisms: one that allows translation along and rotation about the shaft, and two others that allow rotation about two mutually perpendicular axes that are themselves perpendicular to the axis of the shaft.

[0004] The complexity and size of an assembly of mechanisms to do this, along with the inefficiency of having to orient and then lock three mechanisms to achieve a particular position or orientation is cumbersome at best and can be frustrating for the operator as the operator attempts to align a connection in a three dimensional space. A single mechanism that concurrently allows rotation about all three axes and translation along the axis of the shaft in a single motion and is then fixed in place by a single locking motion is sometimes used.

[0005] Commonly, such a solution would use a spherical alignment bearing or joint with the bearing housing and the spherical core both split and would incorporate a clamping mechanism on the housing to tighten the housing on the core and consequently the core on the shaft. However, to achieve maximum clamping pressure of the bearing on the shaft, the split in the housing and the split in the core need to be aligned in substantially the same plane.

[0006] This again makes such a system difficult to use causing frustration by the user and unreliable clamping with variable clamping forces needed depending on how the core is aligned with the clamp. A better method is needed for clamping releasably, reliably and adjustably while aligning and maintaining alignment of the apparatus that is being clamped and positioned together without the need to focus on alignment of the elements comprising the core and clamping mechanism.

BRIEF DESCRIPTION OF THE INVENTION

[0007] A spherical bearing for releasably immobilizing an attachment to a shaft or other external object is provided. The spherical bearing comprises a truncated flexible spherical core with an annular hole through the center of the spherical core for appending the core on the shaft or external object. Segments around the spherical core are created by relief cuts in the spherical core, and deflection flexure points displaced from the annular hole are formed by the relief cuts in the core.

[0008] A housing surrounds the spherical core. The housing is designed to compress the core when a releasable clamping mechanism is applied to the housing. The clamping mechanism causes the segments of the core to deflect about the deflection flexure points toward the shaft immobilizing the core on the shaft and immobilizing the housing on the core. The spherical core generally has a spherical core diameter and the shaft or external object generally has a shaft or object diameter wherein the ratio of the spherical core diameter to shaft/object diameter is greater than about 1.5.

[0009] A method for releasably immobilizing an attachment to a shaft is provided. The method comprises providing a spherical core for a spherical bearing and boring an annular hole through the center of the core. Segments are created around the spherical core by making relief cuts in the core and arranging the relief cuts to provide deflection flexure points displaced from the annular hole.

[0010] A housing is provided that surrounds the spherical core and comprises a clamping mechanism for compressing the spherical core. An attachment is appended to the housing, and the shaft is disposed in the annular hole. The housing and the spherical core are compressed using the clamping mechanism. The clamping pressure deflects the segments about the deflection flexure points toward the shaft immobilizing the core on the shaft, the housing on the core and the attachment on the housing. Releasing the clamping mechanism releases the immobilization of the attachment when mobility of the attachment is desired.

[0011] In some contemplated embodiments, a two-piece housing is provided that is compressed around the spherical core with a strap clamp having a tightening mechanism. Such embodiments allow for enhanced hoop compression of the sphere for immobilization of an immobilized object such as a shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Fig. 1 is a perspective view of a spherical bearing core with a relief cut pattern according to one embodiment of the invention;

[0013] Fig. 2 is a perspective view of a spherical bearing comprising a bearing core in a bearing housing according to one embodiment of the invention;

[0014] Fig. 3 is a top view of a spherical bearing with a screw disposed in the housing ears according to one embodiment of the invention;

[0015] Fig. 4 is a top cross sectional view of a spherical bearing comprising an attachment mounting hole in the housing according to one embodiment of the invention;

[0016] Fig. 5 is perspective view of a spherical bearing with a hinged housing according to one embodiment of the invention;

[0017] Fig. 6 is a top cross sectional view of a spherical bearing core with structural modifications according to one embodiment of the invention;

[0018] Fig. 7 is a perspective view of a spherical bearing assembly according to one embodiment of the invention;

[0019] Fig. 8 is an exploded view of the spherical bearing assembly of Fig. 7;

[0020] Fig. 9 is a perspective view of a spherical core according to one embodiment of the invention;

[0021] Fig. 10 is a perspective view of a spherical core according to one embodiment of the invention;

[0022] Fig. 11 is a perspective view of a spherical core according to one embodiment of the invention;

[0023] Fig. 12 is a perspective view of a spherical core according to one embodiment of the invention;

[0024] Fig. 13 is a perspective view of a spherical bearing assembly according to one embodiment of the invention;

[0025] Fig. 14 is a perspective view of a spherical core according to one embodiment of the invention;

[0026] Fig. 15 is a perspective view of a spherical bearing assembly according to one embodiment of the invention;

[0027] Fig. 16 is an exploded view of the spherical bearing assembly of Fig. 15;

[0028] Fig. 17 is a perspective view of a spherical bearing assembly according to one embodiment of the invention; and

[0029] Fig. 18 is a perspective view of a spherical bearing assembly according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0030] A spherical bearing, sometimes called a spherical joint, is provided that permits not only ease of alignment but also easily maintained alignment when releasably immobilizing an attachment to a shaft. The joint comprises a spherical inner core which is surrounded by a housing around the core. The joint apparatus does not require careful alignment of the housing and core to efficiently perform its function. To overcome the problem of maintaining alignment and/or immobilization of the item attached to the bearing, the spherical inner core is modified with a series of structural modifications called relief cuts to assure maximum immobility when the bearing or joint is clamped on the shaft regardless of the orientation of the core relative to the clamp housing.

[0031] Fig. 1 shows an embodiment of such a spherical core **100** providing an annular hole **101** through the center of the core **100** for securing to an example external object, in this case a mounting shaft **109** that is round in shape, depicted with dotted lines to represent one possible attachment to the spherical core **100** according to the invention. As can be seen in Fig. 1, the core **100** is in the form of a truncated sphere **100**. The truncated sphere **100** of Fig. 1 is truncated both on top and similarly on the bottom of the sphere **100**. A truncated sphere is most commonly used for the core of the spherical bearing, and its depiction in Fig. 1 allows the structural modifications made to the sphere to be easily seen.

[0032] The spherical core **100** has a spherical core diameter and the shaft **109** has a shaft diameter or "object diameter" wherein the ratio of the spherical core diameter to the shaft/object diameter is greater than about 1.5. This relatively higher diameter ratio has at least two major advantages. First, the relatively higher spherical core to shaft/object diameter ratio allows for greater angular movement of the shaft **109** during initial positioning and prior to immobilization by the bearing. Second, the larger sphere size allows for a larger moment arm to resist angular tilting and side loads on the shaft.

[0033] Fig. 1 shows one pattern **102** that can be used for the relief cuts **103** in the spherical core **100**. Though not passing through the core **100** from the annular hole to the outside of the core **100**, the relief cuts **103** in the core **100** are made through the entire thickness of the core **100** from top to bottom so that both the inner and outer relief cut slot bottoms **106**, **107** are substantially parallel to the axis of the annular hole **101** through the core **100**. In the case of relief cut **108** the cut does pass through the core **100** from the annular hole **101** to the outside of the core **100** as shown in Fig. 1. However, relief cuts **103** on the outer spherical surface of the core **100** extend fully from the top to the bottom of the core **100**.

[0034] The pattern of relief cuts **102** creates a series of effective deflection flexure points **105** for the spherical core segments **104**. The flexure points **105** are displaced from the centerline of the annular hole **101** such that pressure on the segments **104** will always cause them to deflect toward the

shaft. This has several advantages among which are providing improved immobilization by uniform contact of the segments **104** with the shaft and permitting effective immobilization with minimal clamping pressure. Because the clamping pressure required can be minimal, the releasability of the core is also enhanced.

[0035] Fig. 2 shows a spherical bearing assembly **200** comprising an outer member or housing **201** where both the outer member or housing **201** and the inner member, the spherical core **202**, are split **203**, **204** on planes passing substantially through the centerline of the annular hole **206** by relief cuts. The relief cuts constitute structural modifications, and the term can apply to the housing as well as the core. The housing **201** is provided with a clamping mechanism **205** that, when tightened, will compress the spherical core **202** causing it to tighten on a shaft **207** passing through the annular hole **206** of the core **202**. The resulting friction in the clamped components immobilizes the shaft in the core **202** and the core **202** in the housing **201** creating in effect a friction locked spherical joint. Unique to this design are a series of radial relief cuts in the core **202**, passing substantially through the axis of the annular hole **206**, that cause the core **202**, when compressed, to deflect uniformly around the shaft **207** regardless of the orientation of the split **203** in the core relative to the split **204** in the housing. The relatively high core diameter to shaft diameter ratio of greater than 1.5 contributes to the securement of the bearing.

[0036] Fig. 3 is an embodiment of an assembled bearing assembly **300** showing a spherical core **301** encased in a bearing housing **302**. In Fig. 3 the housing is clamped down by a screw **303** that runs through the ears **304** of the clamp housing and is threaded into one of the ears **304** providing, when tightened, the pressure on the ears **304** that is necessary immobilize the core **301**.

[0037] Although in Fig. 3 a screw **303** is used to provide the force needed to close the housing **302** and render the core **301** immobile, any other sufficiently robust closing mechanism could be used to draw the housing together. For example, a bolt or a "C" clamp could be used to draw the ears **304** together.

[0038] Returning to the Fig. 3 embodiment, the bearing housing **302** is solid except for the split **305** as shown. Nonetheless, the force provided by the closing mechanism **303**, in this case a threaded screw **303**, is sufficient to effectively immobilize the bearing when tightened and release the bearing when loosened. This immobilization is optimized given the greater than 1.5 core diameter to shaft diameter ratio.

[0039] In Fig. 3 consider the arrangement of the relief cuts **306**, **307**. The inner relief cuts **306** substantially radiate out from the central annular hole **308** with a core split **312** also present to allow the core **301** to deform slightly when the housing **302** is tightened. The cuts **306** segment the inner core surface and the inner segments **309** so formed can engage the surface of a shaft passing through the annular hole **308** as the core **301** is deformed by the closing pressure caused by the bearing

housing **302**. In like manner the outer relief cuts **307** provide segments **310** that allow flexure of the core **301** and still allow the outer surface of the core **301** to engage the inner surface of the clamp housing **311** when the housing **302** is tightened.

[0040] One purpose of the relief cuts **306**, **307** is to increase the flexibility of the core **301** so that it can flexibly engage the shaft and the bearing housing **302** surface. The cuts **306**, **307** also provide extra room inside the bearing assembly **300** for flexing to occur and minimize the closing force needed to immobilize the core **301**.

[0041] In Fig. 3 the inner relief cuts **306** are opposite the outer relief cuts **307**. Although such an arrangement is not necessary for the invention to successfully operate, making the relief cuts in this manner provides additional flexibility.

[0042] This pattern of relief cuts **306**, **307** creates a series of effective deflection flexure points **313** for the spherical core segments **309**, **310**. The flexure points **313** are displaced from the centerline of the shaft bore **308**, that is the annular hole **308**, such that pressure on the segments **309**, **310** will always cause them to deflect toward the shaft, and the deflection flexure points **313** so formed will allow the spherical core **301** to accommodate minor variations in the shape of the central shaft used and in the shape of the bearing housing **302** while maximizing the contact surface area between the inner core segments **309** and the shaft and the outer core segments **310** and the housing **302**. This provides improved immobilization by uniform contact of the segments **309**, **310** permitting effective immobilization with minimal clamping pressure. Because the clamping pressure required can be minimal, especially with the greater than 1.5 core diameter to shaft diameter ratio, the reliability and releasability of the bearing assembly **300** are enhanced.

[0043] Because the inner and outer relief cut bottoms **314**, **315** are parallel with each other and with the annular hole **308** axis, from another perspective the effect of this arrangement is to provide a flexible cylindrical band that envelops within the core **301** and is defined by the outer ends **314** of the inner relief cuts **306** and the inner ends **315** of the outer relief cuts **307** and accommodates imperfections in the shaft (not shown in Fig. 3) or in the bearing housing **302**.

[0044] Further, in the event a shaft is used that is not substantially round, the bearing assembly **300** can accommodate and maximize its ability to immobilize the shaft.

[0045] In another embodiment Fig. 4 shows a bearing assembly **400** where the bearing housing **401** comprises a threaded mounting receptacle **402**. This embodiment demonstrates how the bearing housing **401** could be modified to allow the assembled bearing **400** to be affixed to another piece of apparatus allowing the other piece of apparatus to be mounted on the bearing assembly **400** or allowing the bearing assembly **400** to be mounted on another piece of apparatus. In this way the bearing assembly **400** can be used to join two or more pieces of apparatus together. To do so one includes additional mounting receptacles.

[0046] As shown in Fig. 4 the mounting receptacle **402** runs through the bearing housing **401** and extends to the outer surface **403** of the bearing **404** and can be used, if needed, to help immobilize the bearing when a threaded apparatus actually contacts the surface of the core **403**.

[0047] In yet another embodiment Fig. 5 shows a bearing assembly **500** where a hinge **501** comprises a part of the bearing housing **502**. This is another example of the flexibility in design of which the invention is capable. Fig. 5 depicts a shaft **506** that is not round in shape, depicted with dotted lines to represent one possible interface with the bearing core **504** according to the invention.

[0048] In some applications it is necessary to assemble the bearing with the bearing housing at the point of use, as where fit or size place restrictions on the installation. Fig. 5 demonstrates an embodiment of this flexibility. In this embodiment the hinge **501** has been added so that if the bearing core **504** is already installed on a shaft **506**, the housing **502** can be installed without the need to slide the housing **502** along the shaft. Rather, the housing **502** can be installed over the bearing core **504** from a position perpendicular to the shaft **506**.

[0049] From another aspect the housing can be constructed in two parts and secured using two sets of ears similar to elements **304** shown in Fig. 3. An example of such an arrangement could be a pillow block that is mounted on a surface. The pillow block has a bearing core secured between the pillow block base on one side and the pillow block retainer on the other side. Both ends of the pillow block can be secured together with screws similar to the ear **304** and screw **303** arrangement of Fig. 3.

[0050] In embodiments where the bearing core **504** is made of sufficiently flexible material, the bearing core **504** can be slipped over a shaft, because the bearing core **504** includes a split **505**. The housing **502** can then be installed over it even if the housing is made of non-flexible material. Such flexibility is very useful when the ends of a shaft are inaccessible, but a spherical bearing needs to be installed.

[0051] In another embodiment the core can be cut through as in drawing element **108** shown in Fig. 1 but in several different places, and the multi-piece core can be used to surround a shaft and can be held in place by the housing. The housing can then be clamped and tightened to releasably immobilize the bearing on the shaft.

[0052] In yet another embodiment the core can be hinged for placement around a shaft with a clampable housing placed over the hinged core to immobilize the bearing on the shaft.

[0053] Returning to the embodiment shown in Fig. 5, the side of the housing **502** is flattened **503** to allow the bearing **500** to be mounted on a flat surface. In other embodiments the housing can similarly be modified in many different ways to accommodate the practical needs of the application.

[0054] For example, in a different embodiment where space is limited the housing can be split into two or more pieces that can be assembled around a core and strapped together with a strap clamp.

Tightening the strap clamp then compresses the housing around the core and can immobilize or free the bearing depending on how tightly the strap clamp is adjusted.

[0055] In yet another embodiment Fig. 6 shows how the spherical core **600** can be modified to provide enhanced flexibility and to enhance the banding effect discussed above in reference to Fig. 3. In this embodiment the outer ends **614** of the inner relief cuts **601** and the inner ends **615** of the outer relief cuts **602** are broadened to increase the flexibility of the spherical core **600**. By choosing the design of the relief cuts, different properties of flexibility can be achieved and other effects such as enhanced band strength, deflection, flexure and shaft or housing contact pressure distributions can be achieved.

[0056] In other embodiments a bearing assembly can comprise different materials to modify the performance of the bearing assembly.

[0057] For example, different materials can be chosen to cause the bearing to provide more or less "lash." In one example a very flexible bearing material can be chosen to allow the bearing to absorb limited amounts of force when a torque is suddenly imposed on either a central shaft or the bearing housing.

[0058] In another embodiment, combinations of materials can be chosen to provide the contact surfaces of the inner segments and the outer segments different coefficients of friction thus allowing controlled slippage of the joint if desired. Additionally, the materials used for the bearing housing can also be chosen to provide specific frictional and/or torque response properties.

[0059] In another embodiment the surface finish of the annular hole and/or the spherical surfaces can be modified to provide specific frictional response. For example, the surfaces can be modified or coated to enhance frictional binding when the bearing is clamped.

[0060] It will be appreciated that in some anticipated embodiments of the invention, the housing can be constructed without ears **304** as in the embodiment depicted in Fig. 3, but instead with one or more relief cuts splitting the housing. For example, Fig. 7 depicts a spherical bearing assembly **700** including a spherical core **700a** having a core split **701a**, a chamfered truncation **705** at each opening of an annular hole **701**, and a pattern **702** of relief cuts **703** creating spherical core segments **704**. A strap clamp **707** surrounds the bearing housing **706** to compress the housing **706** on the bearing core **700a**.

[0061] Compare Fig. 7 to the exploded view of the same spherical bearing assembly **700** of Fig. 8. The relief cuts **703** extend fully from the chamfered truncation **705** at the top of the core **700a** to matching truncation (not shown in Figs. 7 and 8) at the bottom of the core **700a**. The bearing housing **706** is divided into housing base **708** and housing cap **709** portions separated by a housing split **711**. The strap clamp **707** is positioned to fit, when attached to the bearing assembly **700**, into a circular recess **710** that extends around both the housing base **708** and housing cap **709** to secure the base **708**

and cap **709** together such that when a sufficient clamping force is applied to the strap clamp **707**, the bearing is immobilized. A tightening screw **712** extends through two ears **713** at a clamp split **714** to allow for tightening of the strap clamp **707** to sufficient clamping force for immobilization. The housing base **708** includes a mounting flange **715** with mounting holes **716** to allow for fixed engagement of the housing base **708** to an external object such that any shaft or other engaged member will remain in a relative fixed position when immobilized by the bearing assembly **700**.

[0062] The versatility of the invention is demonstrated in the embodiments depicted in Figs. 7 and 8. The depicted spherical joint bearing **700** utilizes a two piece housing **706** and strap clamp **707** coupled with a simplified spherical core **700a** to achieve enhanced strength, functionality, and manufacturing efficiency. The housing base **708** and housing cap **709** used in conjunction with the strap clamp **707** provide a flexible housing configuration with optimal conformity to the spherical core **700a**. When tightened, the strap clamp **707** develops uniform hoop tension which, when applied to the nearly constant cross section housing base and cap **708** and **709** separated by housing split **711**, works to reduce the diameter of the housing **706** and compresses the spherical core **700a** in a very uniform, belt-like manner. This uniform compression of the spherical core **700a** allows the use of a simplified spherical core **700a** which contains only outer relief cuts **703**.

[0063] In a typical spherical core **100**, as depicted in Fig. 1, flexure points **105** created between the inner and outer relief cuts **103** form a functional flexure ring in the spherical core. When stiffer housing configurations are used, it becomes increasingly advantageous to increase the diameter of this flexure ring, which in essence moves the flexure points **105** closer to the outer diameter of the spherical core **100**. Consider the use of a relatively rigid housing, such as in the context of the housing **200** in Fig. 2 or the housing created by the bearing assembly **502** and hinge **501** in Fig. 5. Such a housing when compressed to a reduced diameter by a clamping mechanism, such as the clamping mechanism **205** depicted in Fig. 2, will tend to deflect unevenly with a greater diameter reduction sideways than lengthwise, thus squeezing the spherical core **202** (**504** in Fig. 5) in a more nutcracker-like fashion. For these types of housings, a spherical core with a maximized diameter flexure ring is desirable since wider spaced flexure points allow the spherical core segments to deflect more easily toward the contained external object such as a shaft. In comparison, a less rigid strap clamp type housing such as the housing **706** in Fig. 7 applies a near uniform compression load to all spherical core segments **704** irrespective of the flexure ring diameter. Thus, with further reference to Fig. 7, the spherical core **700a** used in conjunction with the strap clamp housing **706** incorporates a minimum diameter flexure ring located directly adjacent the shaft annular hole **701**, effectively eliminating the inner relief cuts.

[0064] It follows that strap clamp embodiments of the invention, such as those shown and described in Figs. 7 and 8, not only provide optimum housing-to-spherical bearing conformance and

spherical bearing-to-shaft/external object conformance, but such embodiments also utilize geometric configurations that have lower manufacturing costs. For example, in Figs. 7 and 8, the depicted two piece housing **706** can be more easily machined or molded since it does not contain an enclosed spherical cavity such as the housing **201** depicted in Fig. 2. Similarly, the spherical core **700a** can be more efficiently machined or molded since inner relief cuts have been completely eliminated. In addition, usable strap clamps of the type contemplated to be used with the current invention are also commercially available and relatively inexpensive.

[0065] Although embodiments of the invention have been shown and described in Figs. 7 and 8 as including a spherical core **700a** having a chamfered truncation **705**, it will be appreciated that spherical cores lacking such chamfers or otherwise with minimal additional truncation are also contemplated within the intended scope of the invention. For example, Fig. 9 depicts a spherical core **800** having spherical core segments **804** separated by a pattern **802** of relief cuts **803** wherein the spherical outer surfaces of the segments **804** and core split **801a** extend to an edge **805** of the annular hole opening **801** with no truncated chamfer separating the edge **805** from the spherical outer surfaces of the segments **804**, such that the amount of sphere truncation is minimized to that required to accommodate a shaft or other immobilized object. Such minimized truncation also maximizes the sphere area captured within the housing when the core **800** and its immobilized object within the bearing assembly are positioned in a maximum rotation position prior to immobilization.

[0066] It will be further appreciated that similar minimally truncated spheres can also include both inside and outside relief cuts. For example, Fig. 10 depicts a spherical core **900** having spherical core segments **904** separated by a pattern **902** of inner relief cuts **906** and a pattern **908** of outer relief cuts **907** wherein the spherical outer surfaces of the segments **904** and core split **901a** extend to an edge **905** of the annular hole opening **901**, with no truncated chamfer separating the edge **905** from the spherical outer surfaces of the segments **904**. Sphere truncation is also minimized in this embodiment to that required to accommodate a shaft or other immobilized object.

[0067] The invention also contemplates a combination of inside and outside relief cuts in the context of truncated spheres. For example, Fig. 11 depicts a spherical core **1000** of the invention having spherical core segments **1004** similarly separated by a pattern **1002** of inner relief cuts **1006** and a pattern **1008** of outer relief cuts **1007** wherein the spherical outer surfaces of the segments **1004**, annular hole **1001**, and core split **1001a** extend to a flat truncation surface **1005** separating the spherical outer surfaces of the segments **1004** from the annular hole **1001**.

[0068] The invention further contemplates a combination of inside and outside relief cuts in the context of highly truncated spheres. For example, Fig. 12 depicts a spherical core **1100** of the invention having spherical core segments **1104** similarly separated by a pattern **1102** of inner relief cuts **1106** and a pattern **1108** of outer relief cuts **1107** wherein the spherical outer surfaces of the

segments **1104**, annular hole **1101**, and core split **1101a** extend to a flat high truncation surface **1105** separating the spherical outer surfaces of the segments **1104** from the annular hole **1101**. Both inner relief cuts **1106** and outer relief cuts **1107** extend from the top flat truncation surface **1105** to a matching flat truncation surface (not shown in Fig. 12) at the bottom of the core **1100**.

[0069] Compare the spherical core **1100** of Fig. 12 with the highly truncated core **100** of Fig. 1. From such comparison, it will be appreciated that the invention contemplates that outer relief cuts, such as the outer relief cuts **1107** of Fig. 12 can extend into either the slightly or highly truncated surfaces of a sphere, such as into the high truncation surface **1105** of Fig. 12, or be limited to extending only within outer spherical surfaces of the segments, such as in the outer relief cuts **103** of Fig. 1. However, in general, spherical core flexibility is increased by moving flexure points (or flexure ring) farther away from the center of the core.

[0070] For example, the positioning of the flexure points **105** in Fig. 1 closer to the outer spherical surfaces of the segments **104** in Fig. 1 would tend to increase flexibility versus the more inside positioning of the flexure points **1103** in Fig. 12, provided both cores **100** and **1100** utilized similar construction materials and dimensioning.

[0071] As an example of a further combination of elements as contemplated by the invention, Fig. 13 depicts a spherical bearing assembly **1200** of the invention having a spherical core **100** of the type depicted in Fig. 1 combined with a bearing housing **706**, housing base **708**, housing cap **709**, and strap clamp **707** of the types depicted in Fig. 7.

[0072] The invention also contemplates spherical cores having inner relief cuts only. For example Fig. 14 depicts a highly truncated spherical core **1300** having spherical core segments **1304** separated by a pattern **1302** of inner relief cuts **1306** wherein the segments **1304** are separated only by the inner relief cuts **1306** and a pattern of outer relief cuts is absent along the spherical outer surfaces of the segments **1304** except at the core split **1301a**, the annular hole **1301** being separated from the spherical outer surfaces of the segments **1304** by the high truncation surface **1305**.

[0073] It will be appreciated that the strap clamps can incorporate different types of tightening mechanisms within the intended scope of the invention. In addition, joint assemblies of the invention can also incorporate different type of mounting features to enable fixed immobilization of immobilized objects.

[0074] For example, Fig. 15 depicts a spherical bearing assembly **1400** of the invention utilizing a spherical core **700a** of the type depicted in Fig. 7 having a pattern **702** of outside relief cuts **703** only that extend up to a low truncation surface **705** near the opening of the annular hole **701**. The housing base **1408** and housing cap **1409** of the bearing housing **1406** are compressed around core **700a** with a strap clamp **1407** that engages both the base **1408** and cap **1409** and compresses the housing **1406** at a recess **1410** to compress and immobilize the core **700a**. The strap clamp **1407** is tightened using a T-

bolt **1413** extending through two strap ears **1417** located at the strap split **1414** and adjusted to an immobilization tightness with a tightening knob **1412**. Fig. 16 is an exploded view of the bearing assembly **1400** of Fig. 15, with the base **1408** and **1409** separated from each other at the housing split **1411** depicted in Fig. 15.

[0075] Comparing Figs. 15 and 16, the housing base **1408** includes multiple mounting legs **1415** each having a threaded hole **1416**. In the embodiment depicted, the mounting legs **1415** are formed directly into the structure of the base **1408** and commonly orient the threaded holes **1416** to allow for engagement of a common planar surface (not shown). This arrangement allows the bearing assembly **1400** to immobilize an immobilized object in a fixed relation to the planar surface once the immobilization has been completed by tightening the strap clamp **1407** with the T-bolt **1413**. The particular arrangement of four mounting legs **1415** in a square pattern is particularly useful in that it allows for easy detachment and 90-degree or 180-degree rotation of the housing **1408** from the planar surface with appropriate threaded hardware (not shown). Although the invention is shown and described using a four-legged attachment arrangement, it will be appreciated that other fixed attachment arrangements are also within the anticipated scope of the invention.

[0076] Fig. 17 depicts a bearing assembly **1500** of the invention also utilizing a spherical bearing core **700a** of the type depicted in Figs. 7, 15, and 16 and having bearing housing **1406** of the type depicted in Figs. 15 and 16, including a housing base **1408** separated from a housing cap **1409** by a housing split **1411**, with four mounting legs **1415** positioned on the housing base **1408**. A strap clamp comprises a hose clamp **1507** that compresses the base **1408** and cap **1409** of the housing around the recess **1410**, but is tightened using a tightening screw **1512** that engages notches **1513** located along portions of the length of the clamp **1507**.

[0077] Although embodiments of the invention utilizing a strap clamp for compressing the housing around the core have been shown incorporating flat, belt-like straps, it will be appreciated that other strap-equivalent structures can also be used for effecting hoop compression around the housing, such as wires, chains, ropes, cables, high-tensile strength bands, and other circular linkages. For example, Fig. 18 depicts a bearing assembly **1600** of the invention having a spherical core **100** with high truncation of the type depicted in Figs. 1 and 13. The housing base **1608** and housing cap **1609** of the bearing housing **1606** include a deep recess **1610** to accommodate a cable clamp **1607** having a cable **1612** and a cable tensioning mechanism **1613** to provide immobilizing hoop compression against the housing **1606** and core **100**. The cable tensioning mechanism **1613** includes a cable tightening screw **1616** at the cable split **1614** to allow for tensioning of the cable clamp **1607** with resulting compression of the housing **1606**. The housing base **1608** includes a mounting flange **1615** with mounting holes **1617** to allow for fixed engagement of the housing base **1608** to an external object and for relative immobilization of an object immobilized by the bearing assembly **1600**.

[0078] Those skilled in the art will realize that this invention is capable of embodiments different from those shown and described. It will be appreciated that the detail of the structure of the disclosed apparatuses and methodologies can be changed in various ways without departing from the invention itself. Accordingly, the drawings and detailed description of the preferred embodiments are to be regarded as including such equivalents as do not depart from the spirit and scope of the invention.

CLAIMS

1. A spherical bearing for releasably immobilizing an attachment to an external object, said bearing comprising:

a spherical core having a top, a bottom, a center, a spherical outer periphery, and an annular hole through said center of said core for appending said core to the external object, the spherical core further comprising:

said annular hole extending from said top to said bottom of said spherical core, said spherical outer periphery extending to said annular hole, and a plurality of segments positioned radially around said annular hole, said segments being defined by at least one of a plurality of outer relief cuts formed in said spherical outer periphery and a plurality of inner relief cuts formed around said annular hole; and

a plurality of deflection flexure points, each said point formed at at least one of an inner end of one said outer relief cut and an outer end of one said inner relief cut in said core;

a two-piece flexible housing surrounding said spherical core;

a releasable clamping mechanism for radially clamping said flexible housing to compress said spherical core, said clamping mechanism comprising a strap clamp and being positioned to provide compression and reduce the diameter of said flexible housing when said clamping mechanism is tightened to cause said segments to deflect about said deflection flexure points and conform to the outer surface of the external object, thereby immobilizing said core on the external object and immobilizing said housing on said core; and

said spherical core having a spherical core diameter and the external object having an object diameter wherein the ratio of said spherical core diameter to said object diameter is greater than about 1.5.

2. A spherical bearing for releasably immobilizing an attachment to an external object, said bearing comprising:

a truncated spherical core having opposing top and bottom surfaces connected by a spherical outer periphery, and further comprising an annular hole through the center of said core for appending said core to the external object, the core further comprising:

a plurality of segments positioned radially around said annular hole, said segments being defined by a plurality of outer relief cuts formed in said spherical outer periphery and around said annular hole; and

a plurality of deflection flexure points, each said point formed at an inner end of one said outer relief cut in said core;

a two-piece flexible housing surrounding said spherical core;

a releasable clamping mechanism for radially clamping said flexible housing to compress said spherical core, said clamping mechanism comprising a strap clamp and being positioned to reduce the diameter of said flexible housing when said clamping mechanism is tightened to cause said segments to deflect about said deflection flexure points and conform to the outer surface of the external object, thereby immobilizing said core on the external object and immobilizing said housing on said core; and

said spherical core having a spherical core diameter and the external object having an object diameter wherein the ratio of said spherical core diameter to said object diameter is greater than about 1.5.

3. A spherical bearing for releasably immobilizing an attachment to an external object, said bearing comprising:

a truncated spherical core having opposing top and bottom surfaces connected by a spherical outer periphery, and further comprising an annular hole through the center of said core for appending said core to the external object, the core further comprising:

a plurality of segments positioned radially around said annular hole, said segments being defined by a plurality of inner relief cuts formed around said annular hole; and

a plurality of deflection flexure points, each said point formed at an outer end of one said inner relief cut in said core;

a two-piece flexible housing surrounding said spherical core;

a releasable clamping mechanism for radially clamping said flexible housing to compress said spherical core, said clamping mechanism comprising a strap clamp and being positioned to reduce the diameter of said flexible housing when said clamping mechanism is tightened to cause said segments to deflect about said deflection flexure points and conform to the outer surface of the external object, thereby immobilizing said core on the external object and immobilizing said housing on said core; and

said spherical core having a spherical core diameter and the external object having an object diameter wherein the ratio of said spherical core diameter to said object diameter is greater than about 1.5.

4. A spherical bearing for releasably immobilizing an attachment to an external object, said bearing comprising:

a spherical core having a top, a bottom, a center, a spherical outer periphery, and an annular hole through said center of said core for appending said core to the external object, the spherical core further comprising:

said annular hole extending from said top to said bottom of said spherical core, said spherical outer periphery extending to said annular hole, and a plurality of segments positioned radially around said annular hole, said segments being defined by at least one of a plurality of outer relief cuts formed in said spherical outer periphery and around said annular hole; and

a plurality of deflection flexure points, each said point formed at an inner end of one said outer relief cut in said core;

a two-piece flexible housing surrounding said spherical core;

a releasable clamping mechanism for radially clamping said flexible housing to compress said spherical core, said clamping mechanism comprising a strap clamp and being positioned to reduce the diameter of said flexible housing when said clamping mechanism is tightened to cause said segments to deflect about said deflection flexure points and conform to the outer surface of the external object, thereby immobilizing said core on the external object and immobilizing said housing on said core; and

said spherical core having a spherical core diameter and the external object having an object diameter wherein the ratio of said spherical core diameter to said object diameter is greater than about 1.5.

5. A spherical bearing for releasably immobilizing an attachment to an external object, said bearing comprising:

a spherical core having a top, a bottom, a center, a spherical outer periphery, and an annular hole through said center of said core for appending said core to the external object, the spherical core further comprising:

said annular hole extending from said top to said bottom of said spherical core, said spherical outer periphery extending to said annular hole, and a plurality of segments positioned radially around said annular hole, said segments being defined by a plurality of inner relief cuts formed around said annular hole; and

a plurality of deflection flexure points, each said point formed at an outer end of one said inner relief cut in said core;

a two-piece flexible housing surrounding said spherical core;

a releasable clamping mechanism for radially clamping said flexible housing to compress said spherical core, said clamping mechanism comprising a strap clamp and being positioned to reduce the diameter of said flexible housing when said clamping mechanism is tightened to cause said segments to deflect about said deflection flexure points and conform to the outer surface of the external object, thereby immobilizing said core on the external object and immobilizing said housing on said core; and

said spherical core having a spherical core diameter and the external object having an object diameter wherein the ratio of said spherical core diameter to said object diameter is greater than about 1.5.

6. A spherical bearing for releasably immobilizing an attachment to an external object, said bearing comprising:

a spherical core having a spherical outer periphery and an annular hole through said center of said core for appending said core to the external object, the spherical core further comprising:

said annular hole extending from said top to said bottom of said spherical core, said spherical outer periphery extending to said annular hole, and a plurality of segments positioned radially around said annular hole, said segments being defined by at least one of a plurality of relief cuts formed around said annular hole; and

a plurality of deflection flexure points, each said point formed at an end of one said relief cut in said core;

a housing surrounding said spherical core;

a releasable strap clamp, said strap clamp comprising:

a circumferential strap, said strap extending around the circumference of said housing; and

a strap tightener, said strap tightener positioned to reduce the diameter of said circumferential strap to exert hoop compression around said housing to compress said spherical core and reduce the diameter of said flexible housing when said clamping mechanism is tightened to cause said segments to deflect about said deflection flexure points and conform to the outer surface of the external object, thereby immobilizing said core on the external object and immobilizing said housing on said core; and

said spherical core having a spherical core diameter and the external object having an object diameter wherein the ratio of said spherical core diameter to said object diameter is greater than about 1.5.

7. The spherical bearing of claim 6 further comprising a two-piece housing having a housing base and a housing cap, said base and said cap being separated by a housing split therebetween when said housing is compressed by said strap clamp.

8. The spherical bearing of claim 6 further comprising:

a two-piece housing having a housing base and a housing cap, said base and said cap being separated by a housing split therebetween when said housing is compressed by said strap clamp; and

said housing base and said housing clamp having a recess for positioning said strap clamp when said housing is compressed by said strap clamp.

9. The spherical bearing of claim 6 wherein said strap tightener is at least one of a t-bolt, a tightening screw, a cable tensioning mechanism, a tightening nob, and a gear.

10. The spherical bearing of claim 6 wherein said strap of said strap clamp is at least one of a belt strap, a chain, a wire, a cable, a hose clamp, a rope, and a high-tensile strength band.

11. A spherical bearing for releasably immobilizing an attachment to an external object, said bearing comprising:

a spherical core having a spherical outer periphery and an annular hole through said center of said core for appending said core to the external object, the spherical core further comprising:

said annular hole extending from said top to said bottom of said spherical core, said spherical outer periphery extending to said annular hole, and a plurality of segments positioned radially around said annular hole, said segments being defined by at least one of a plurality of relief cuts formed around said annular hole, said relief cuts being at least one of inside cuts located adjacent said annular hole and outside cuts located along said spherical outer periphery of said core; and

a plurality of deflection flexure points, each said point formed at an end of one said relief cut in said core;

a two-piece housing surrounding said spherical core, said housing having a housing base and a housing cap, said base and said cap being separated by a housing split therebetween when said housing is compressed by said strap clamp;

a releasable strap clamp, said strap clamp comprising:

a circumferential strap, said strap extending around the circumference of said housing; and

a strap tightener, said strap tightener positioned to reduce the diameter of said circumferential strap to exert hoop compression around said housing to compress said spherical core and reduce the diameter of said flexible housing when said clamping mechanism is tightened to cause said segments to deflect about said deflection flexure points and conform to the outer surface of the external object, thereby immobilizing said core on the external object and immobilizing said housing on said core; and

said spherical core having a spherical core diameter and the external object having an object diameter wherein the ratio of said spherical core diameter to said object diameter is greater than about 1.5.

12. The spherical bearing of claim 11 wherein said housing base and said housing clamp have a recess for positioning said strap clamp when said housing is compressed by said strap clamp.

13. The spherical bearing of claim 11 wherein said strap tightener is at least one of a t-bolt, a tightening screw, a cable tensioning mechanism, a tightening nob, and a gear.

14. The spherical bearing of claim 11 wherein said strap of said strap clamp is at least one of a belt strap, a chain, a wire, a cable, a hose clamp, a rope, and a high-tensile strength band.

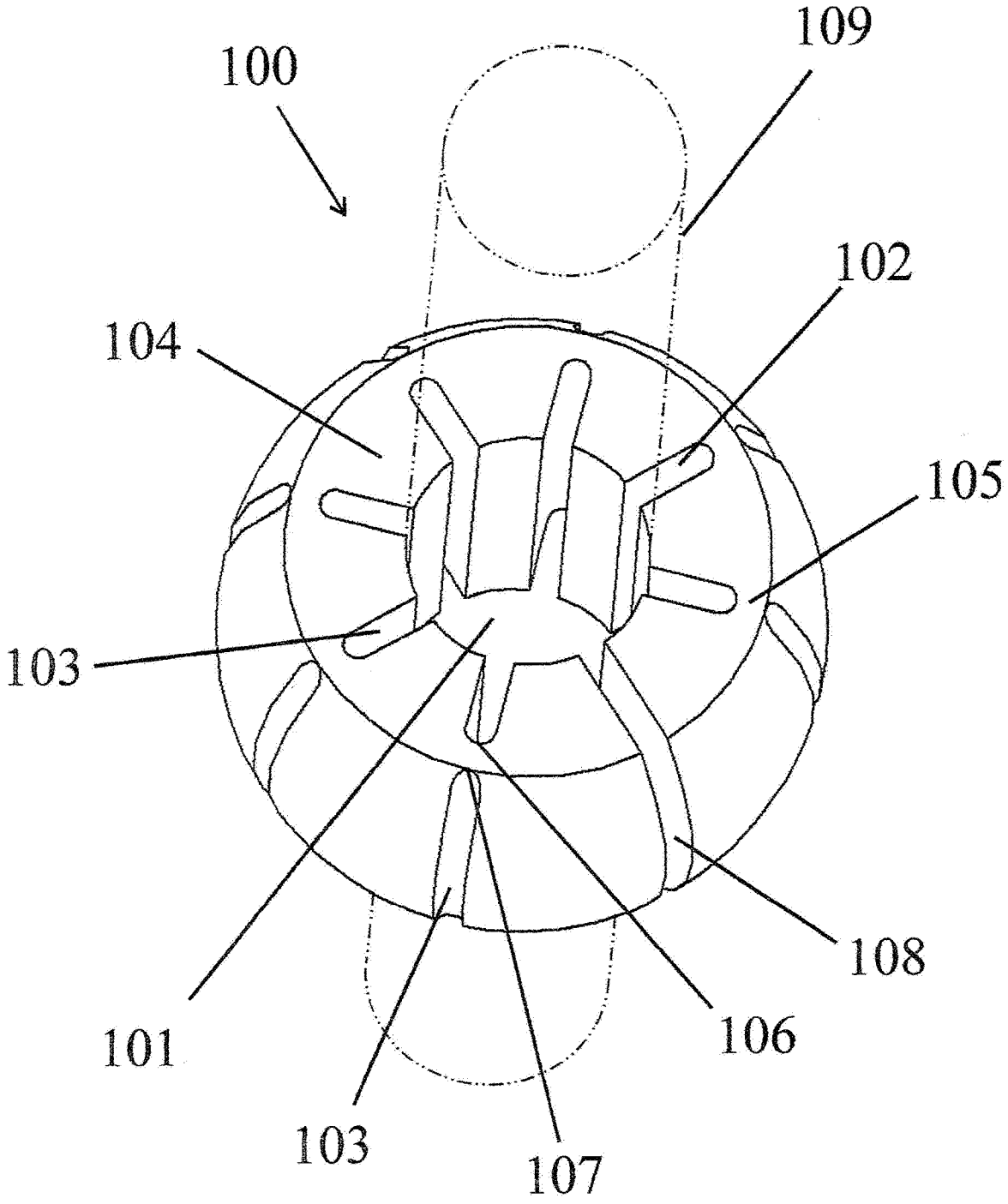

Fig. 1

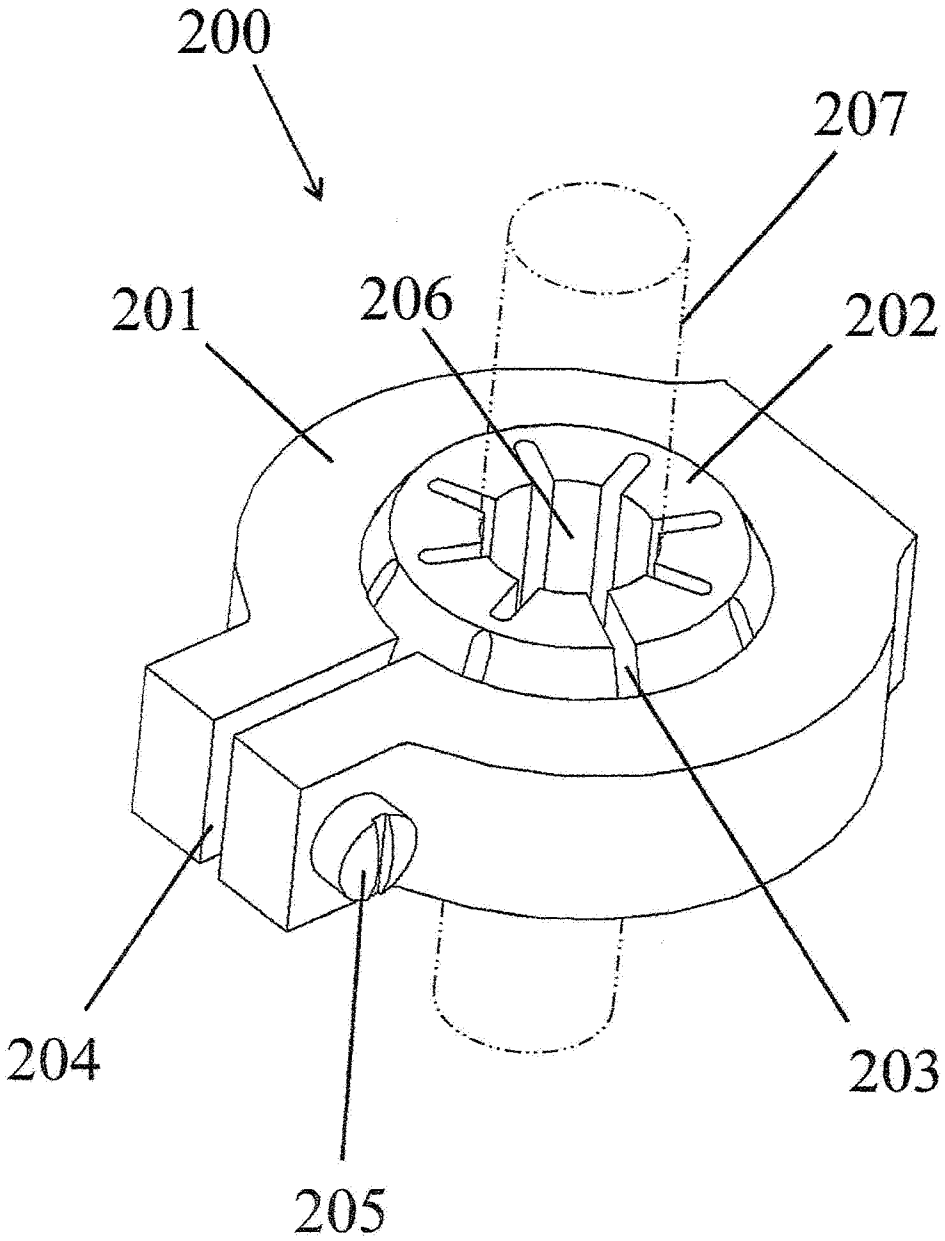

Fig. 2

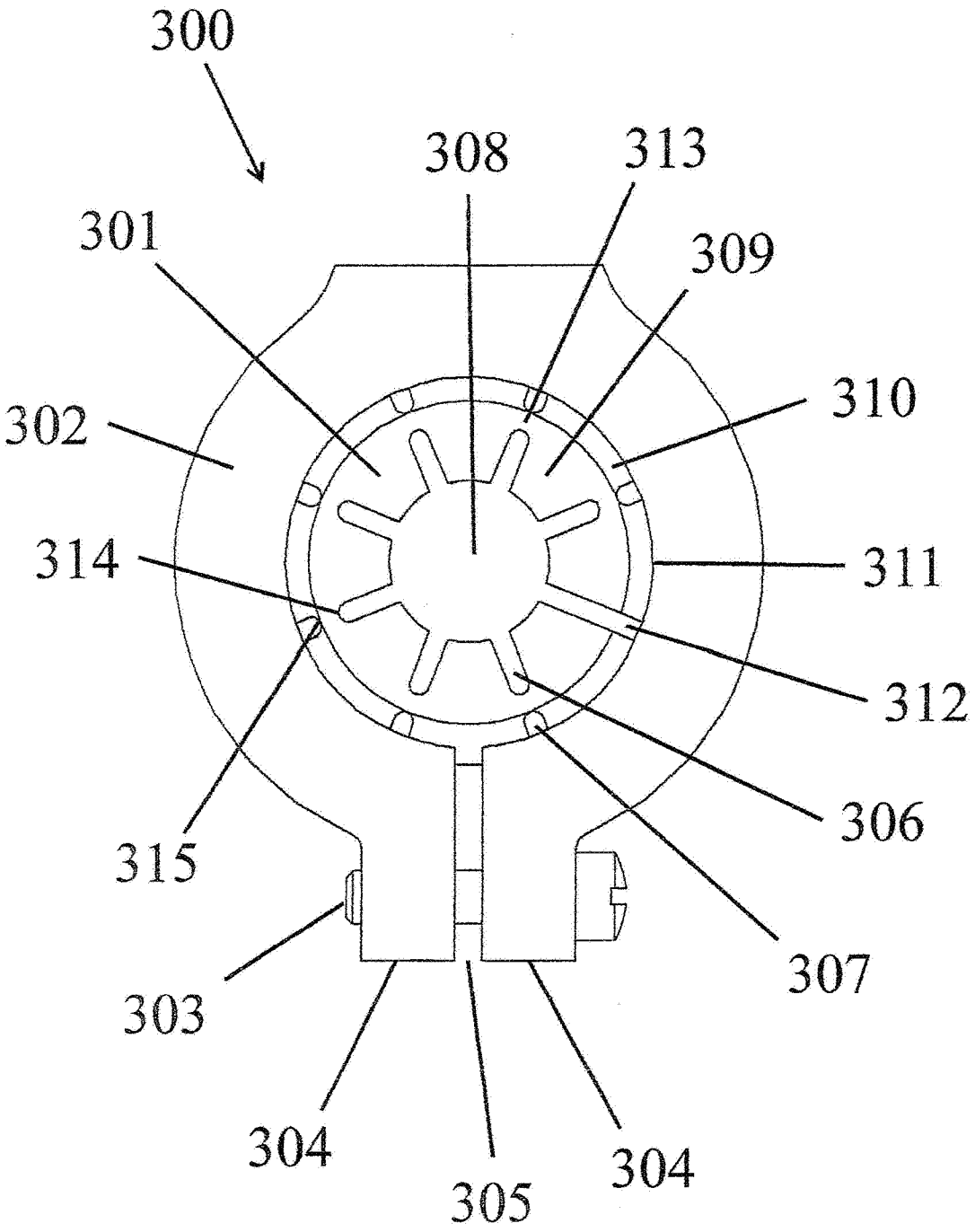
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Fig. 3

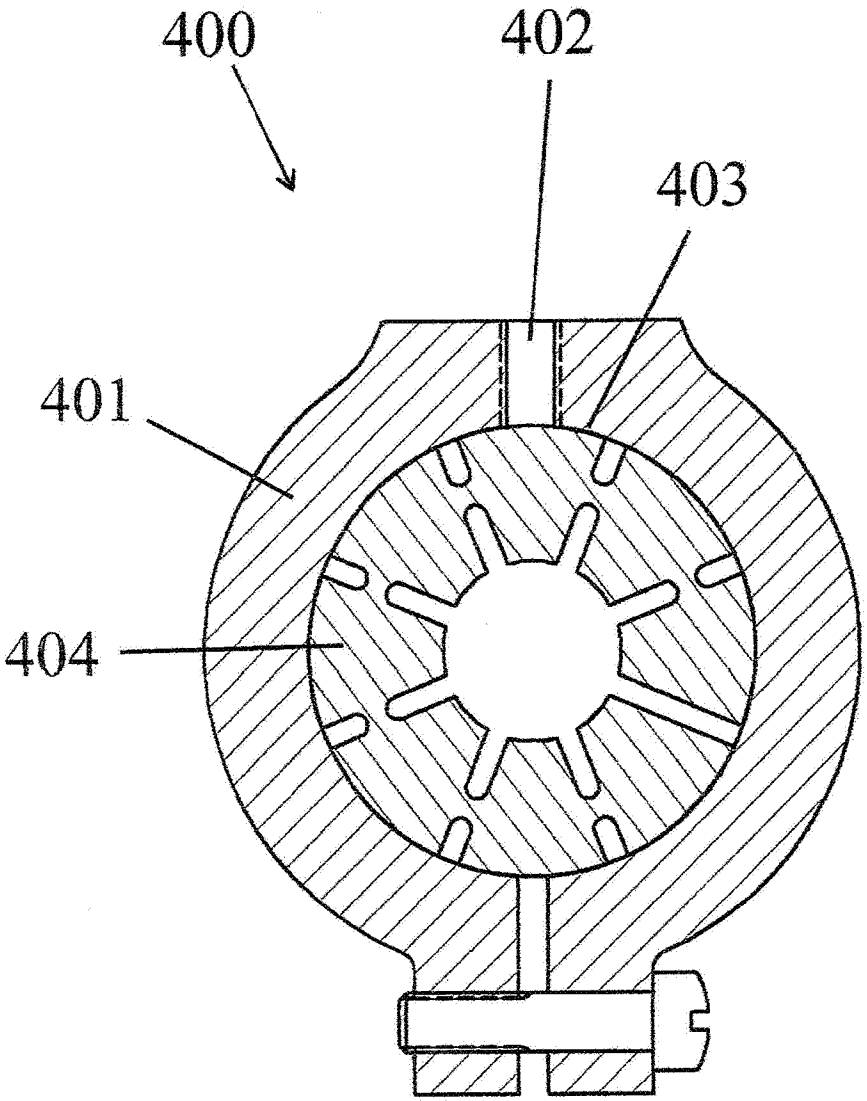

Fig. 4

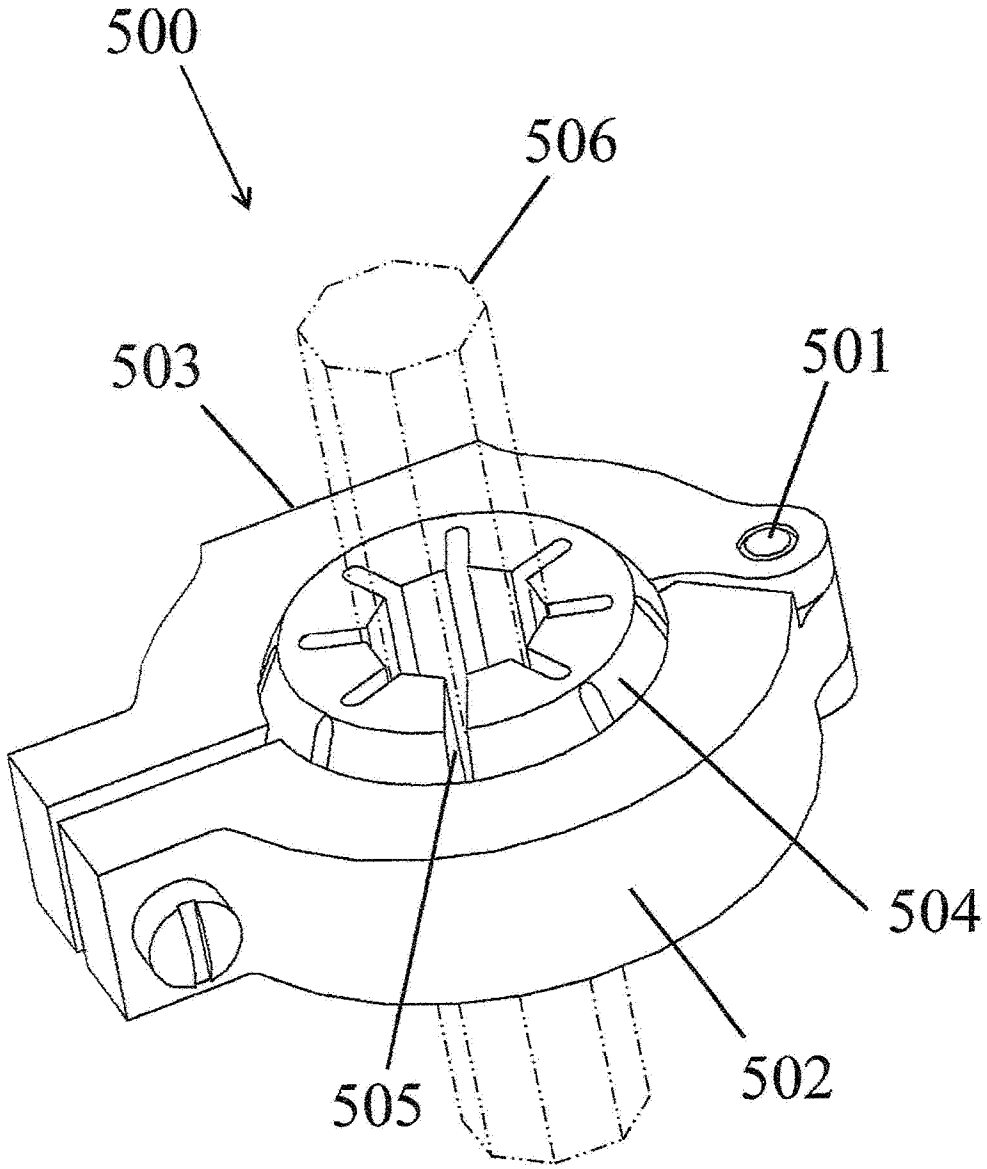

Fig. 5

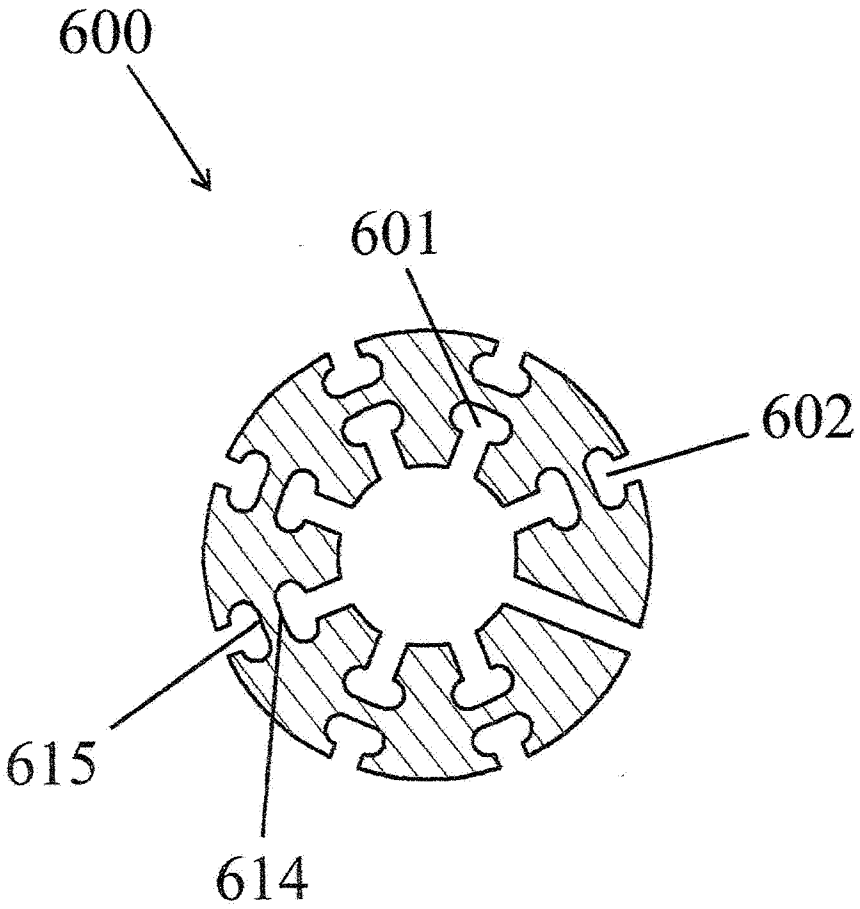

Fig. 6

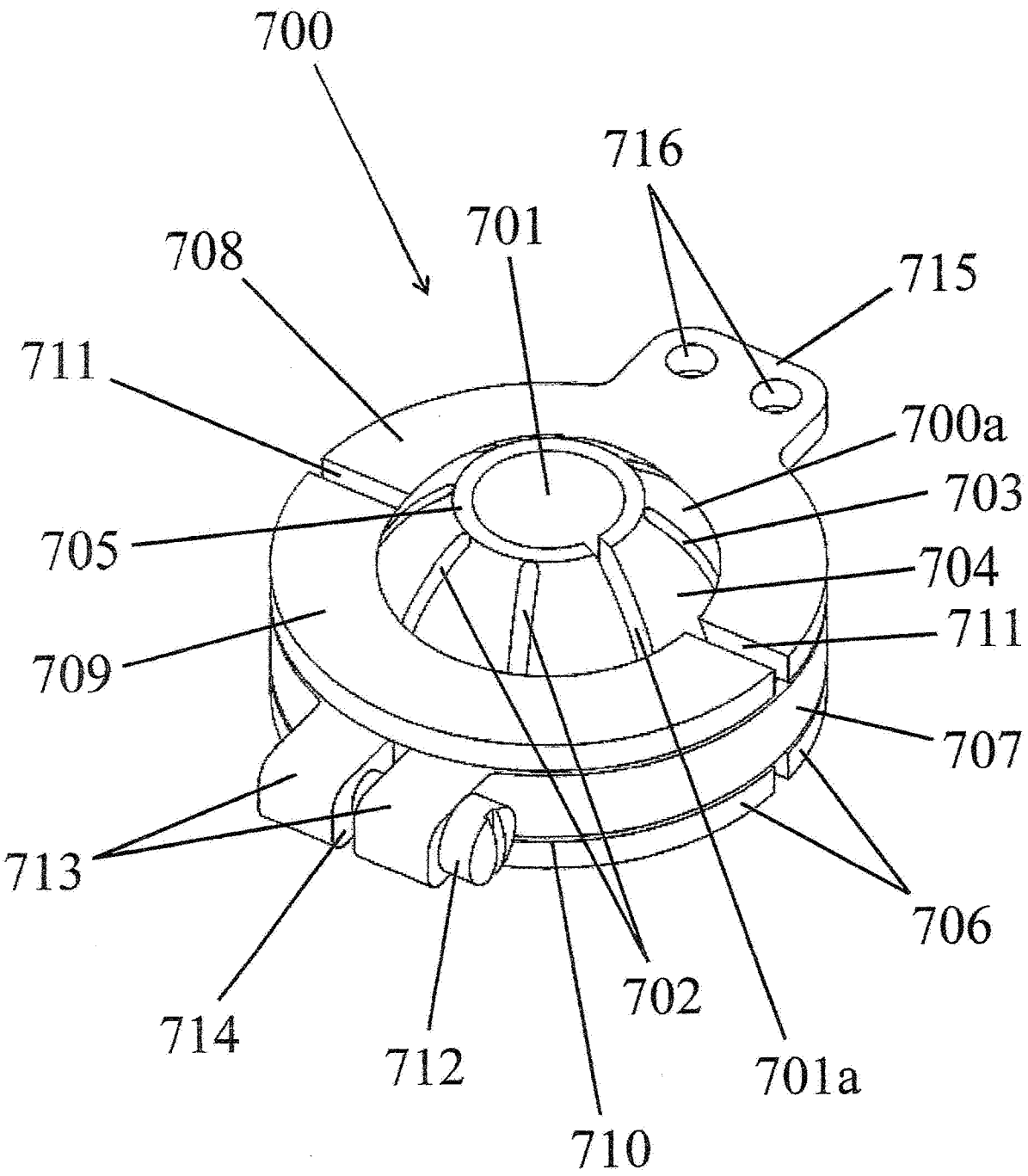
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Fig. 7

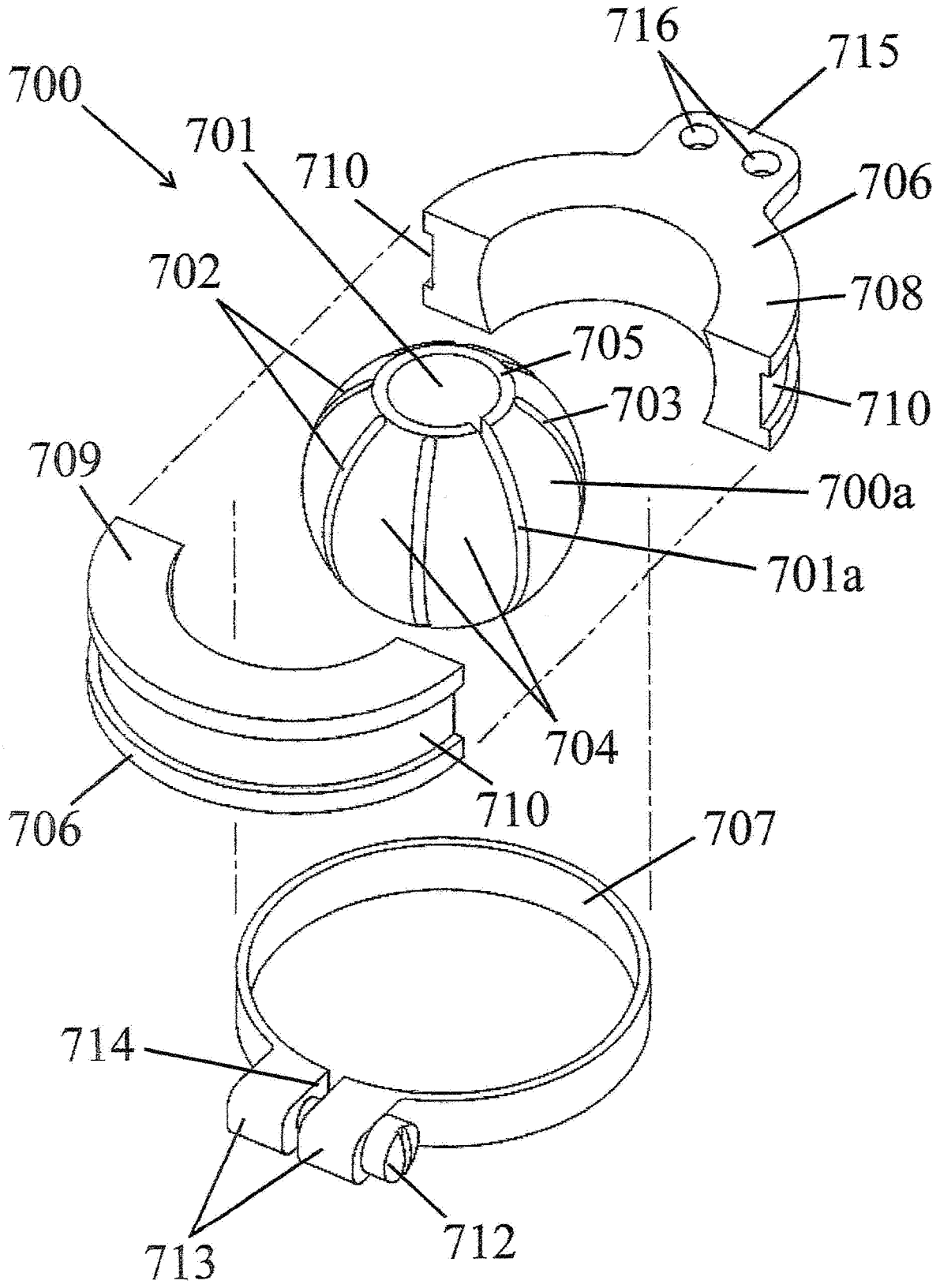
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Fig. 8

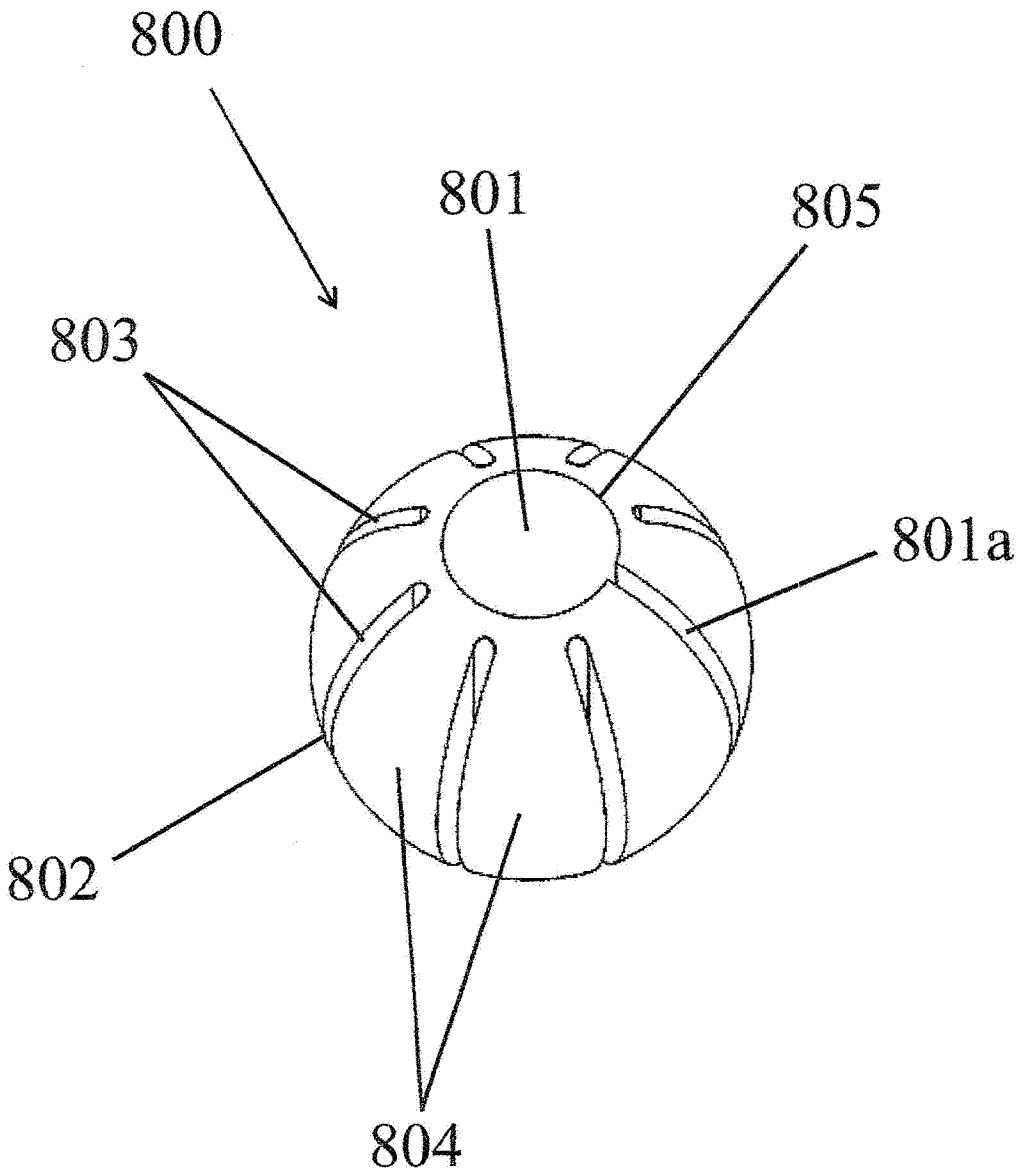

Fig. 9

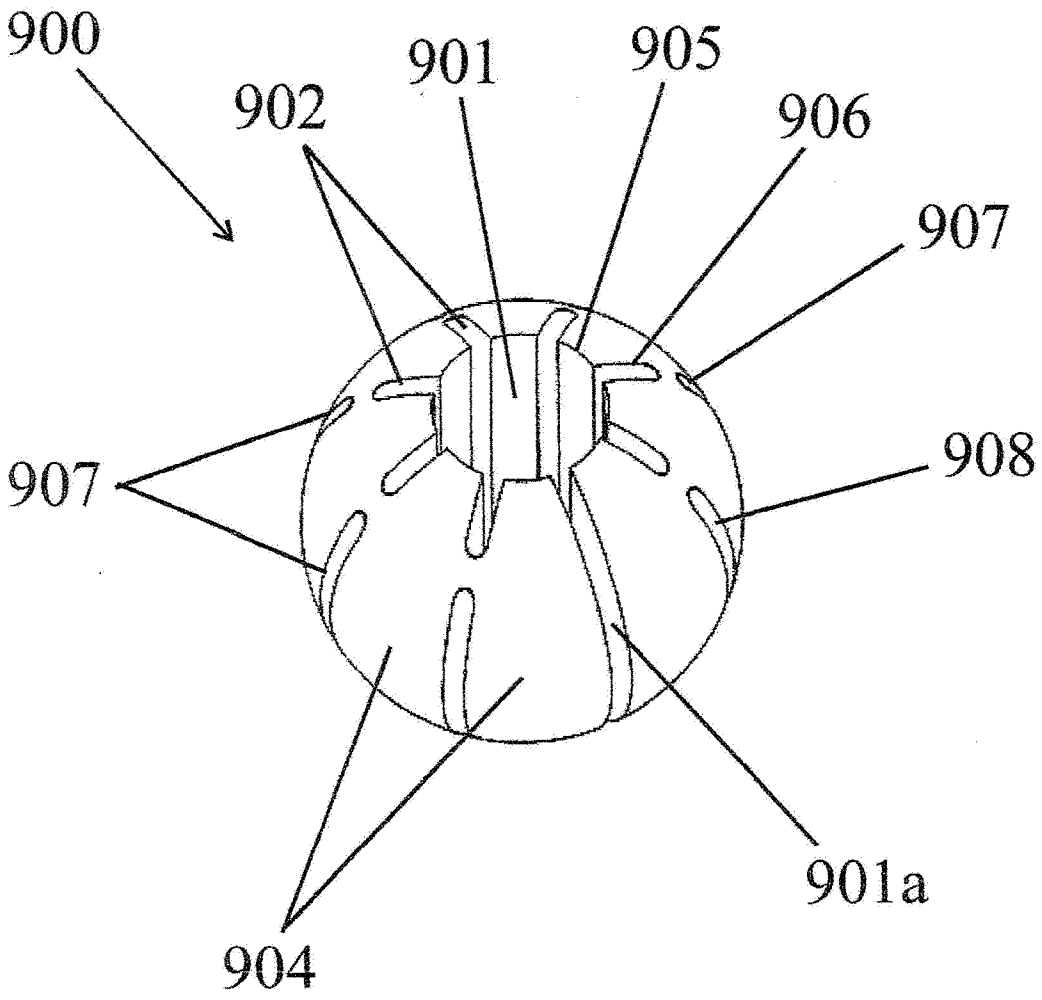

Fig. 10

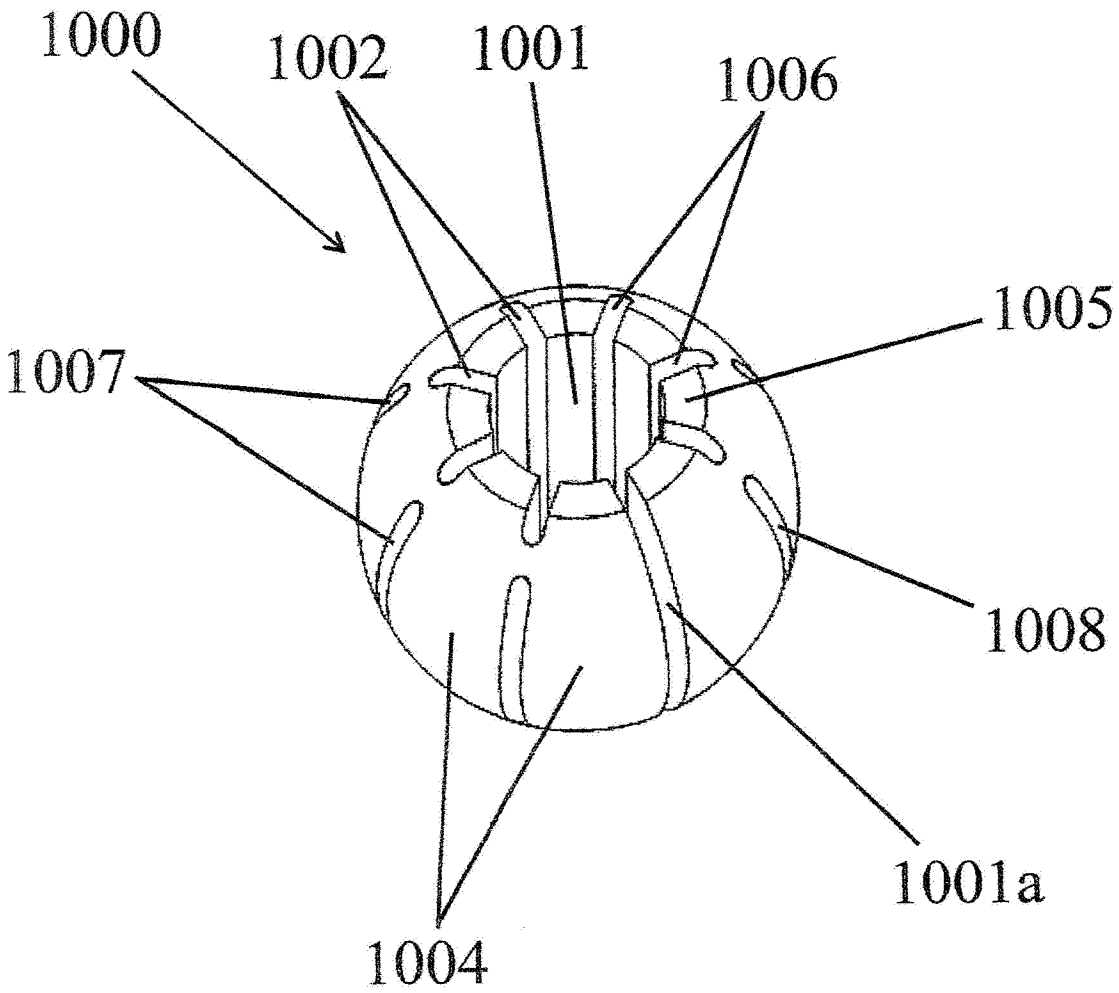

Fig. 11

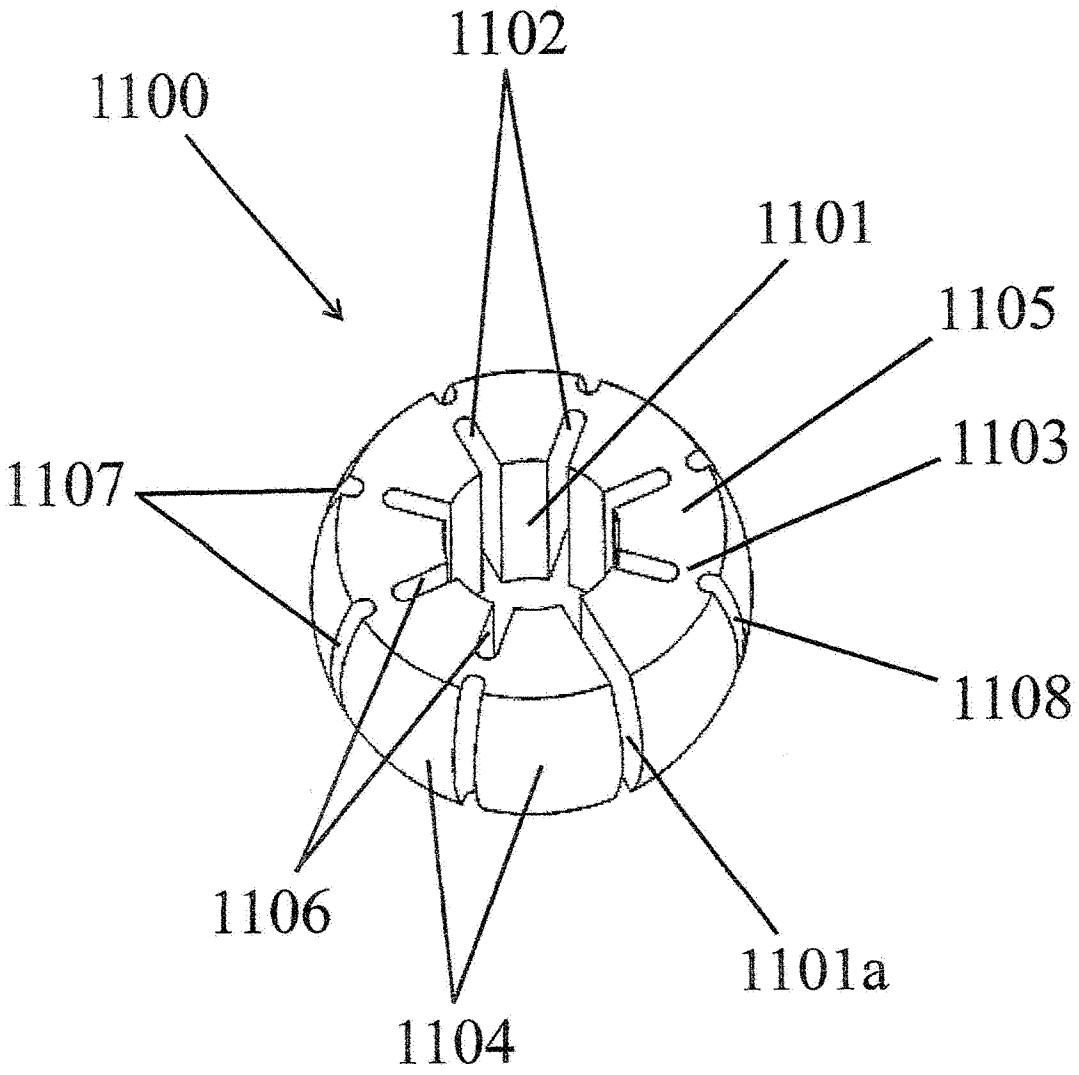

Fig. 12

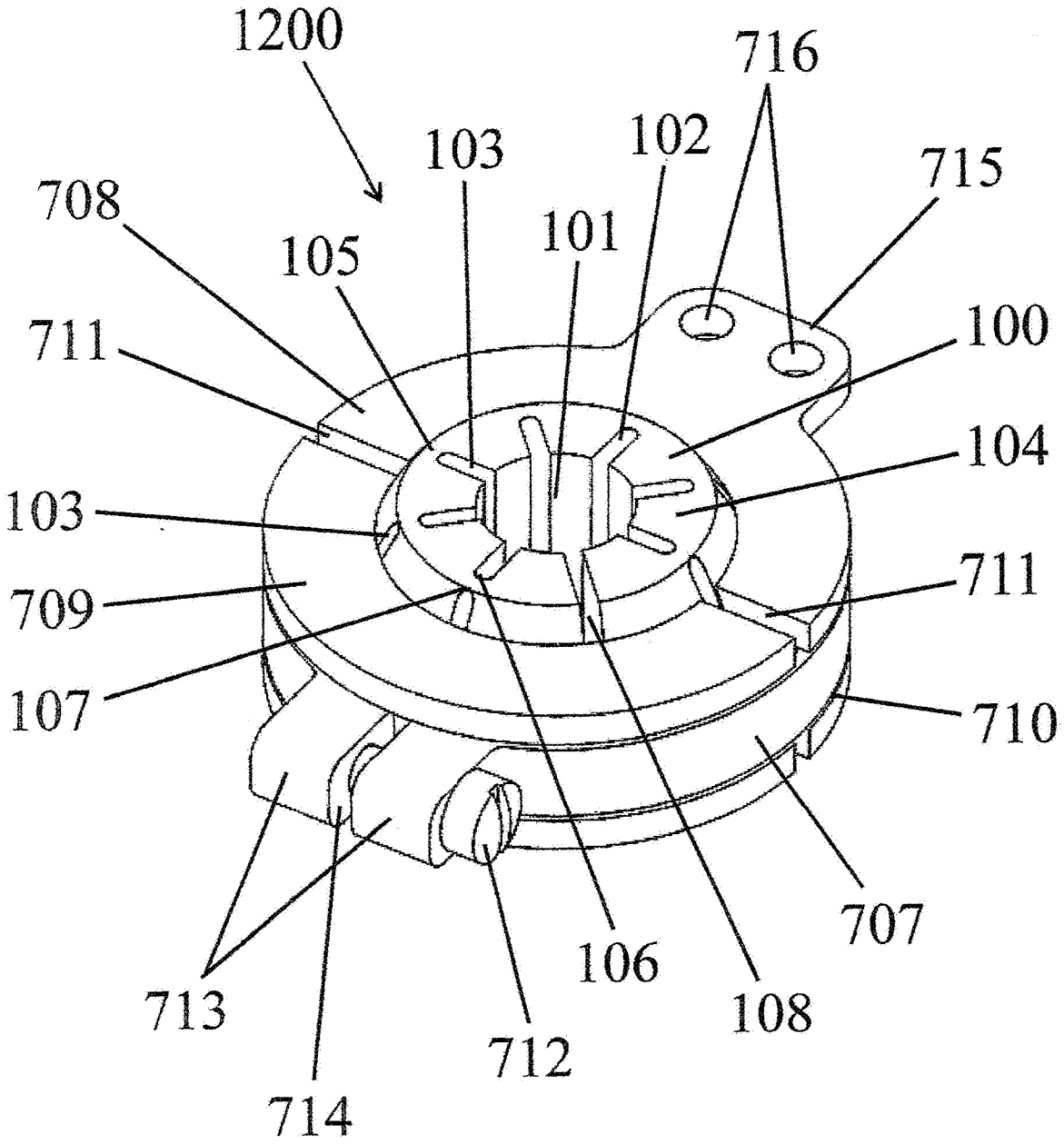
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Fig. 13

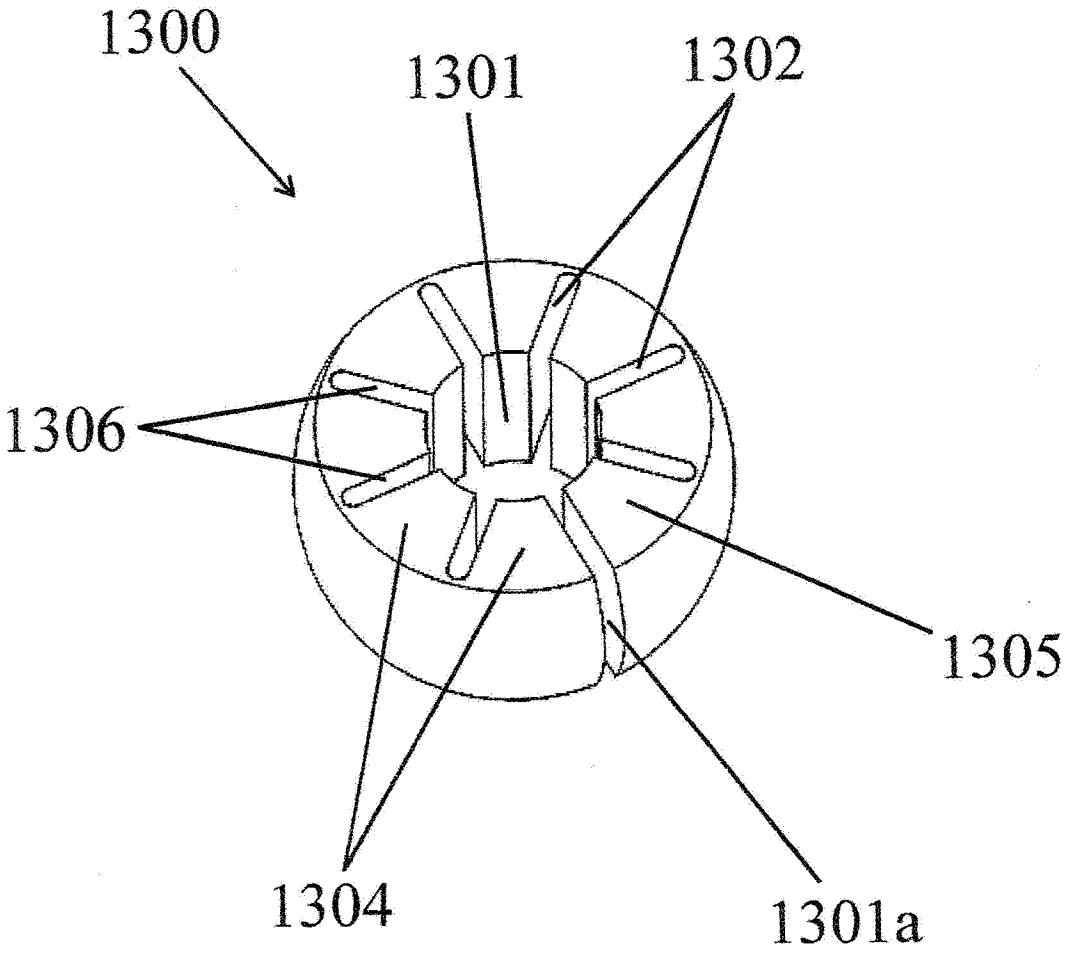

Fig. 14

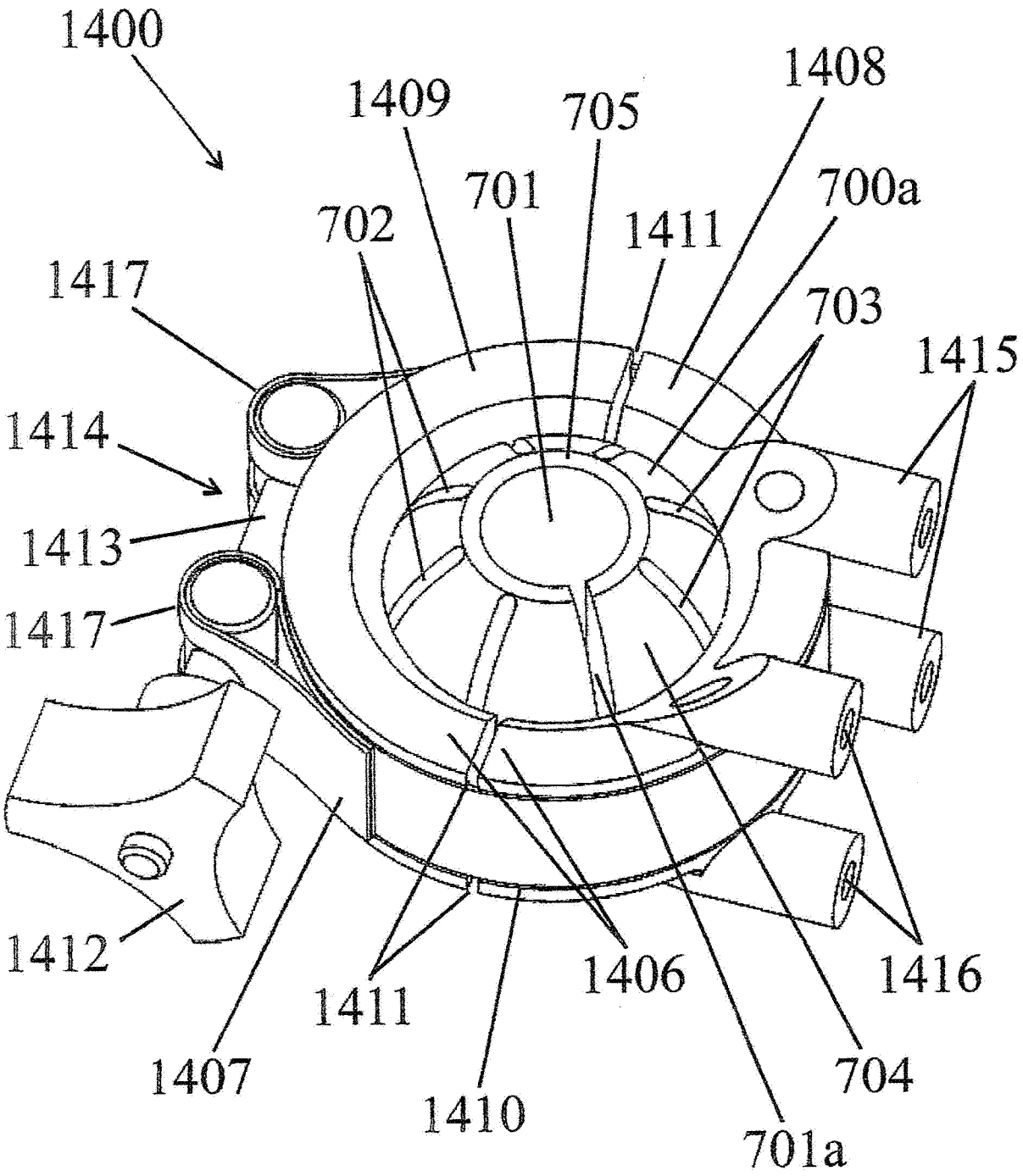
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Fig. 15

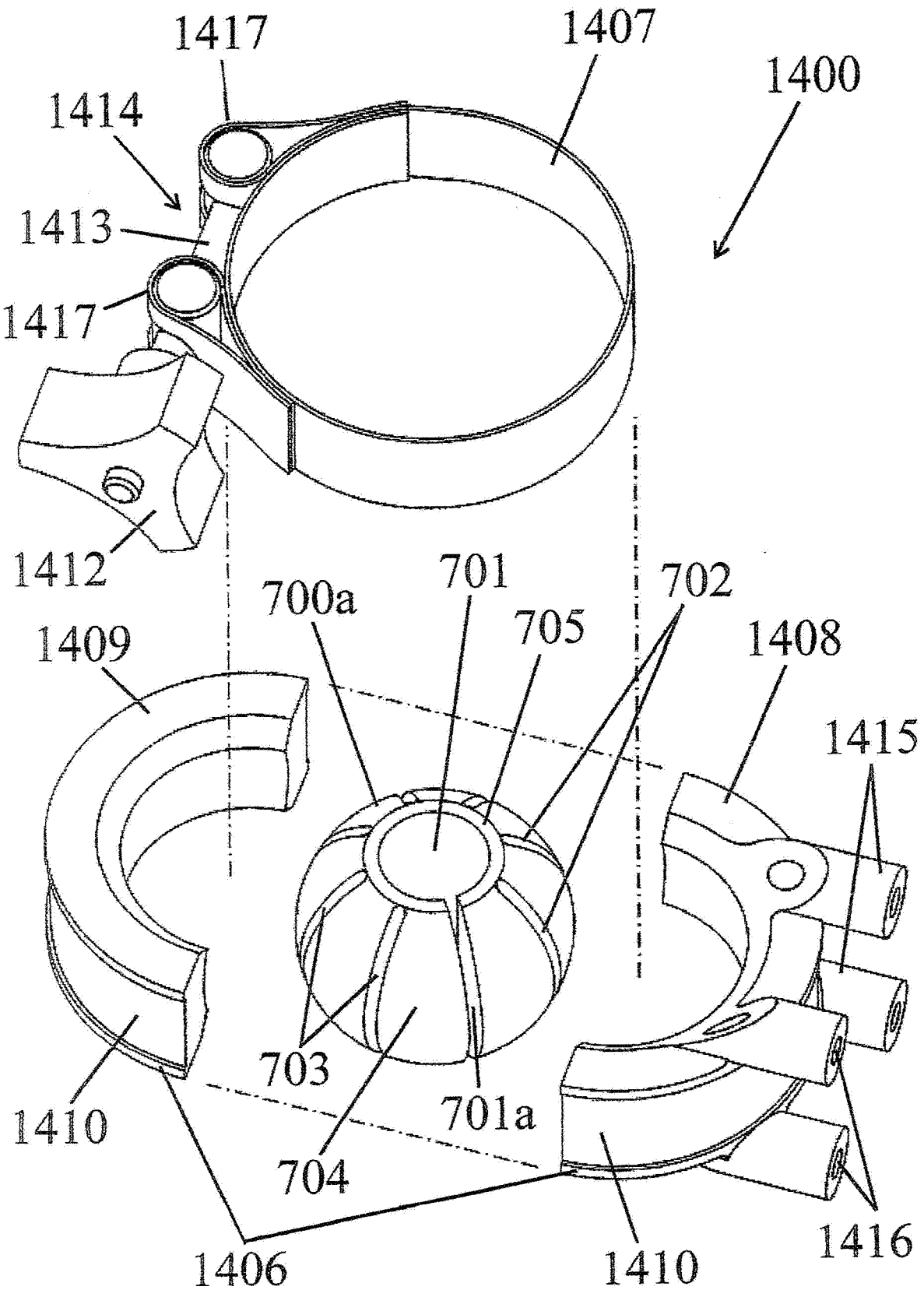
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Fig. 16

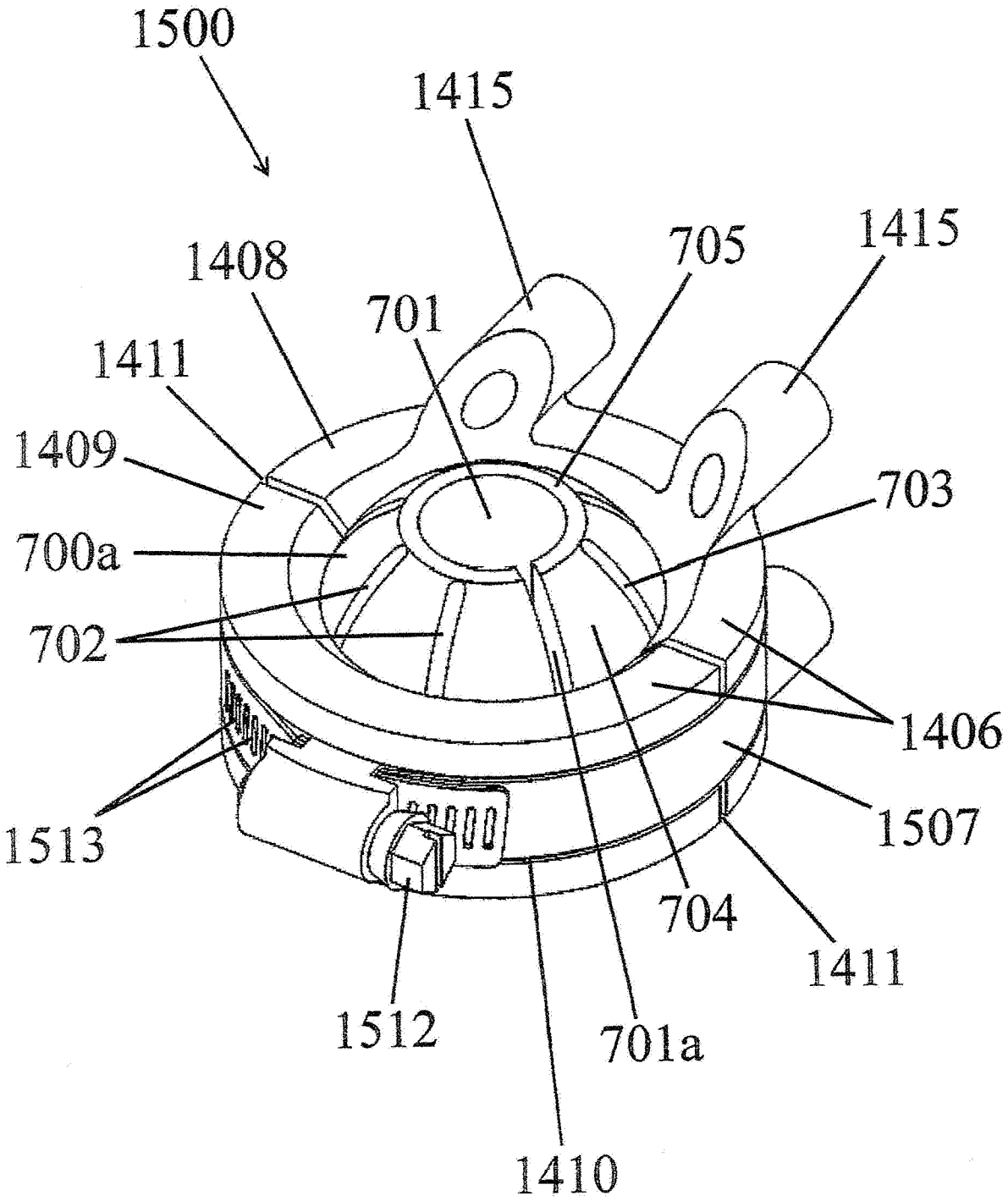
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Fig. 17

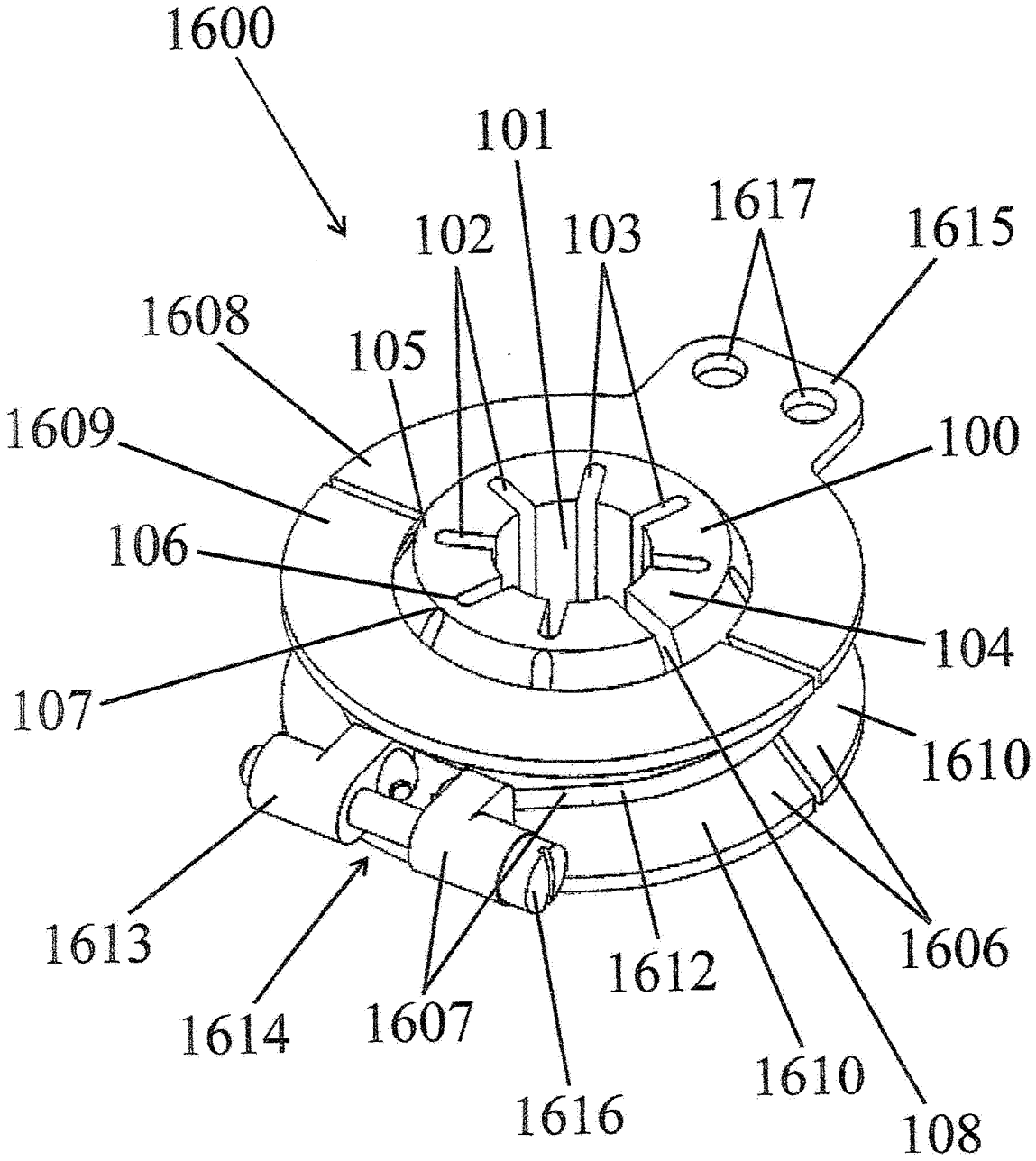
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Fig. 18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/043943

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F16C 11/08; F16C 11/06; F16C 11/10; F16M 11/14 (2016.01)
CPC - F16C 11/08; F16C 11/06; F16C 11/10; F16C 11/106; F16M 11/14 (2016.08)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC - F16C 11/06; F16C 11/08; F16C 11/10; F16M 11/14
CPC - F16C 11/06; F16C 11/08; F16C 11/10; F16C 11/106; F16M 11/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 29/898.04; 29/898.052; 248/127; 248/176.1; 248/181.1; 248/229.1; 248/288.31; 248/288.51; 362/421; 384/129; 384/203; 384/208; 384/209; 384/210; 403/119; 403/122 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Patbase, Google, Google Scholar, YouTube
Search terms used: compress, sphere, ball, clamp, bearing, bushing, flex, elastic, relief, cut, belt, chain, wire, cable, rope, band, flexure, point, segment, truncate, channel, notch, slot, bend, shaft, groove

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/0077904 A1 (JUNGEBERG) 28 March 2013 (28.03.2013) entire document	1-7, 11
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Y		8-10, 12-14
Y	US 5,857,782 A (WASKIEWICZ) 12 January 1999 (12.01.1999) entire document	8, 12
Y	US 2013/0112059 A1 (JUNGEBERG et al) 09 May 2013 (09.05.2013) entire document	9, 10, 13, 14
A	US 4,980,805 A (MAGLICA et al) 25 December 1990 (25.12.1990) entire document	1-14

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 September 2016	05 OCT 2016
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774