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- (54) **DOWNHOLE TOOL PISTON ASSEMBLY**
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**Related U.S. Patent Documents**

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- Filed: **Feb. 10, 2012**

U.S. Applications:

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**E21B 7/06** (2006.01)  
**E21B 10/62** (2006.01)

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- (58) **Field of Classification Search**  
CPC ..... E21B 17/1014; E21B 10/62; E21B 7/06; E21B 27/00  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,593,810	A *	7/1971	Fields	.....	E21B 7/06
					175/61
4,117,897	A *	10/1978	Lloyd	.....	175/106
4,693,328	A *	9/1987	Furse	.....	E21B 17/1014
					175/275
4,848,490	A *	7/1989	Anderson	.....	E21B 7/06
					175/323
4,947,944	A *	8/1990	Coltman et al.	.....	175/73
5,511,627	A *	4/1996	Anderson	.....	175/73
5,553,678	A	9/1996	Barr et al.	.....	E21B 47/01
					175/73
6,290,002	B1 *	9/2001	Comeau	.....	E21B 7/067
					175/61
6,550,548	B2	4/2003	Taylor		
7,849,936	B2 *	12/2010	Hutton	.....	175/61
8,087,479	B2	1/2012	Kulkarni et al.		
8,141,657	B2 *	3/2012	Hutton	.....	175/61
8,205,686	B2	6/2012	Beuershausen		
2004/0206549	A1	10/2004	Dewey et al.		
2004/0222022	A1 *	11/2004	Nevlud et al.	.....	175/57
2006/0157283	A1	7/2006	Hart		
2007/0145131	A1 *	6/2007	Perkin et al.	.....	235/385

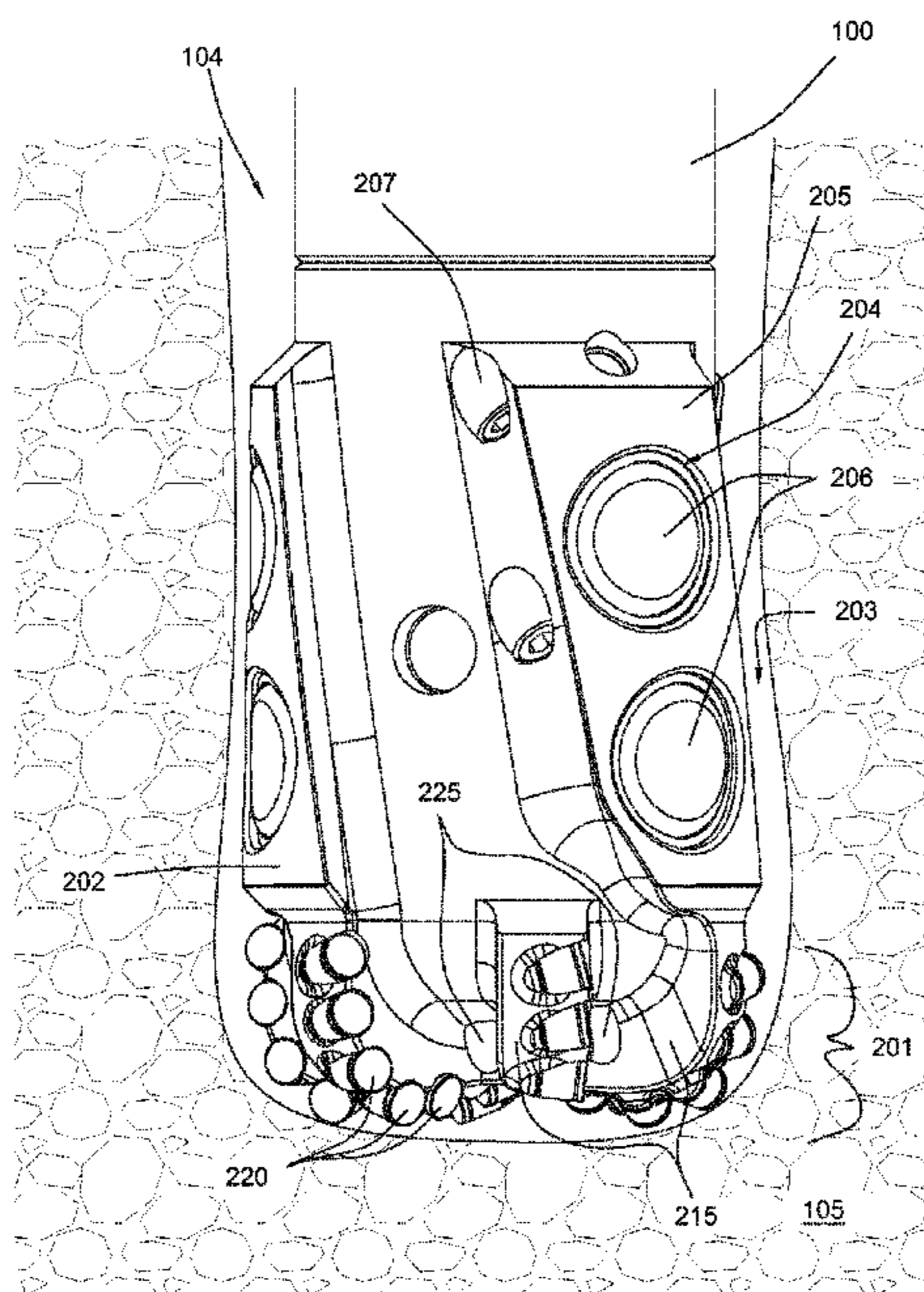
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Primary Examiner — Catherine S Williams

(57) **ABSTRACT**

A piston assembly may comprise a housing with a wall, and at least one chamber formed in the wall. A piston may be disposed within the chamber and at least one passageway may pass through the piston. At least one pin may be disposed within the passageway and attached to the chamber, and the piston may be free to translate relative to the pin.

**26 Claims, 15 Drawing Sheets**



(56)

**References Cited**

U.S. PATENT DOCUMENTS

2008/0000693	A1	1/2008	Hutton	
2009/0044979	A1	2/2009	Johnson et al.	
2009/0133931	A1	5/2009	Rolovic	
2009/0223716	A1*	9/2009	Eppink .....	175/25
2009/0223717	A1*	9/2009	Eppink .....	175/25
2009/0277689	A1*	11/2009	Lee .....	175/57
2010/0071962	A1	3/2010	Beuershausen	
2010/0139980	A1	6/2010	Neves et al.	
2011/0162890	A1	7/2011	Radovan	
2012/0168229	A1*	7/2012	Lee .....	175/265
2013/0206390	A1*	8/2013	Hall et al. ....	166/107

\* cited by examiner

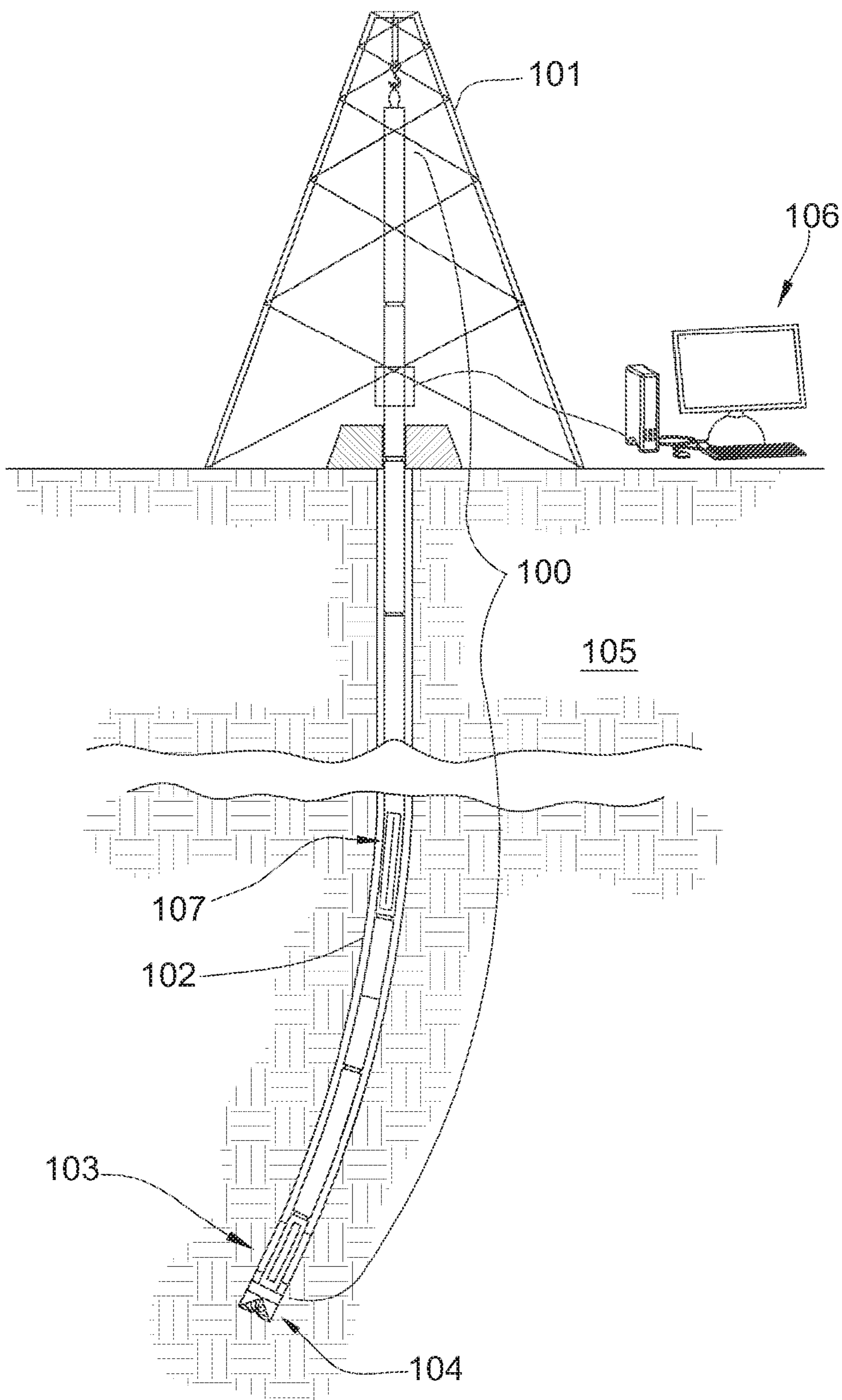


Fig. 1

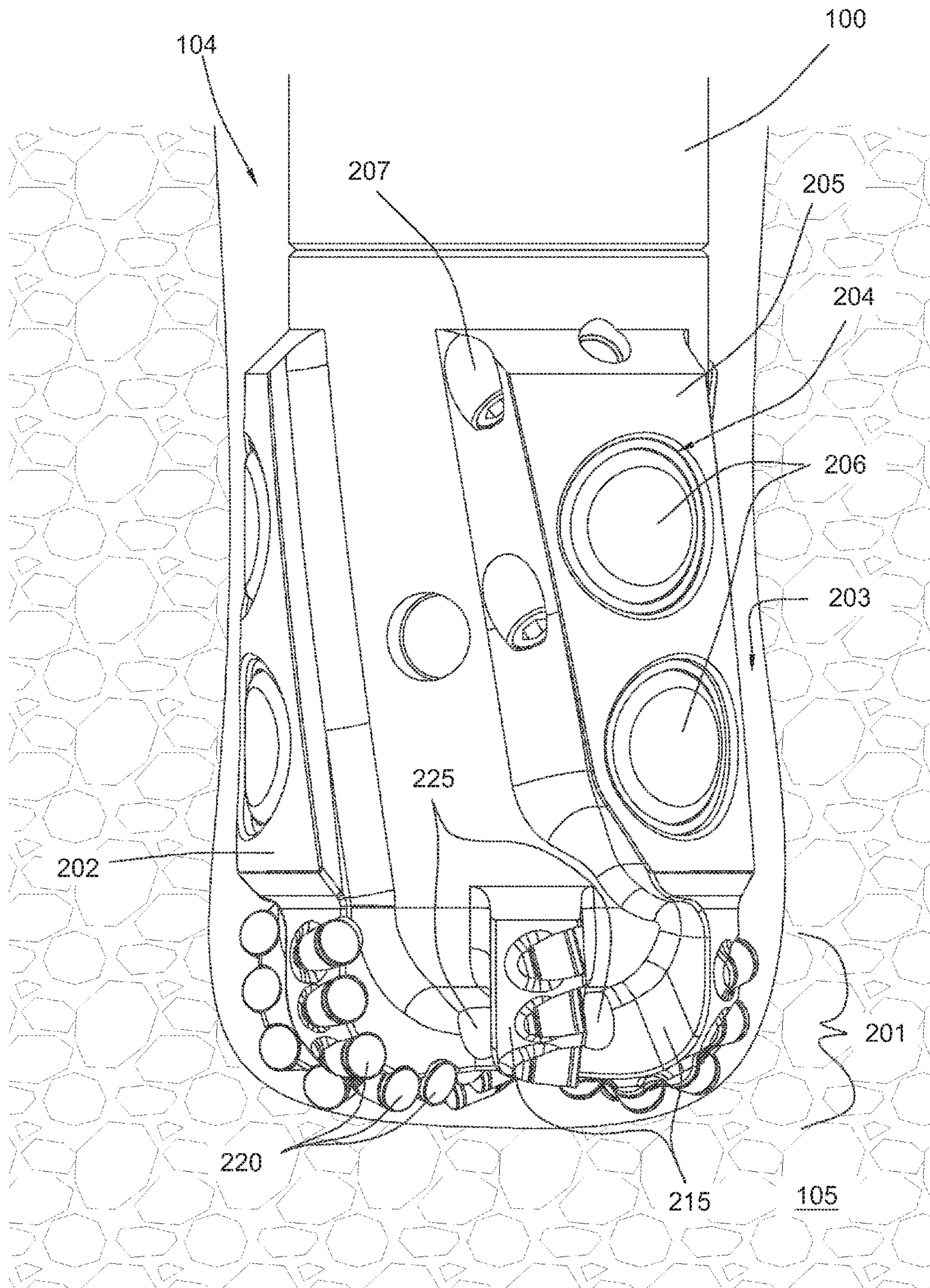


Fig. 2

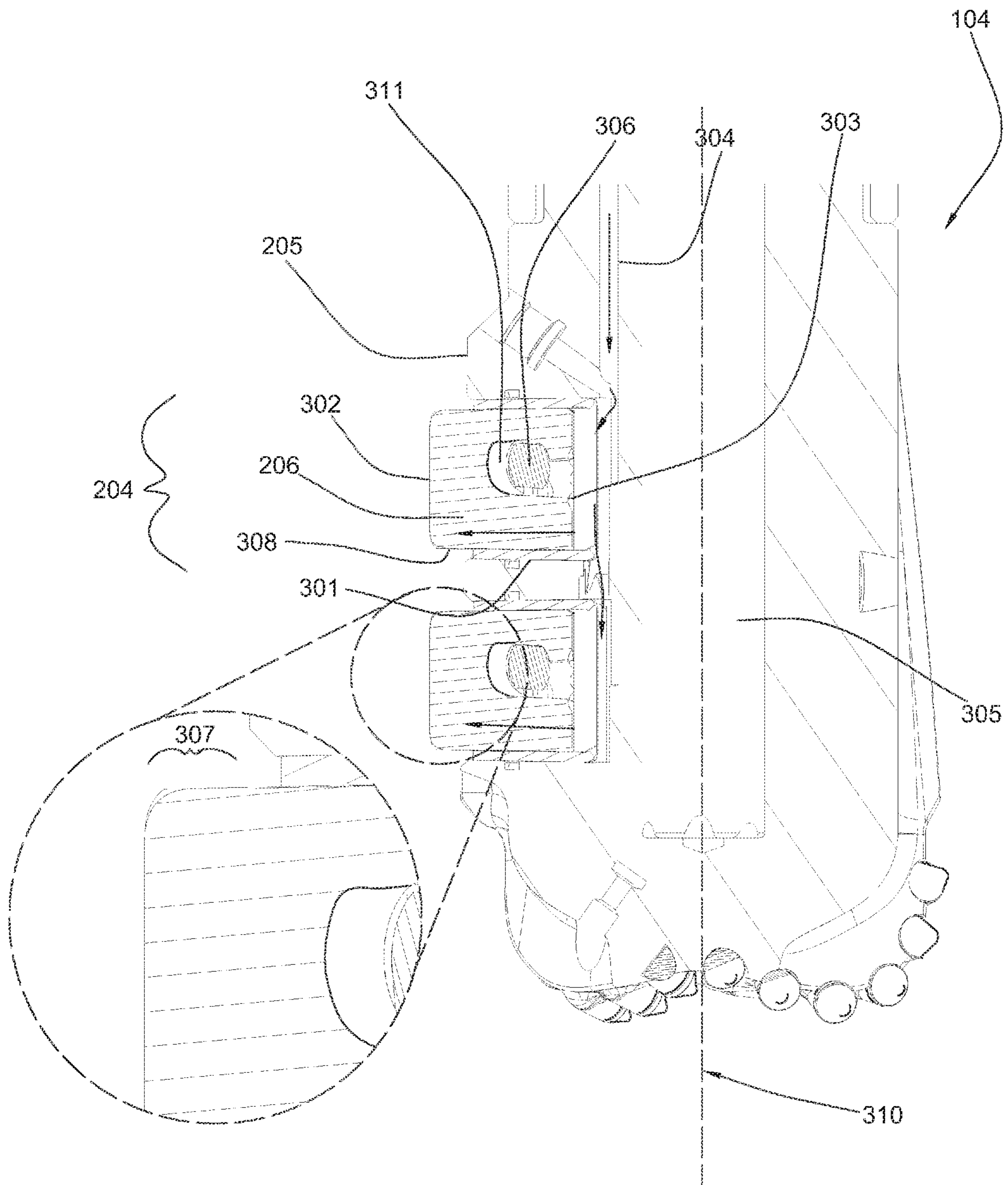


Fig. 3

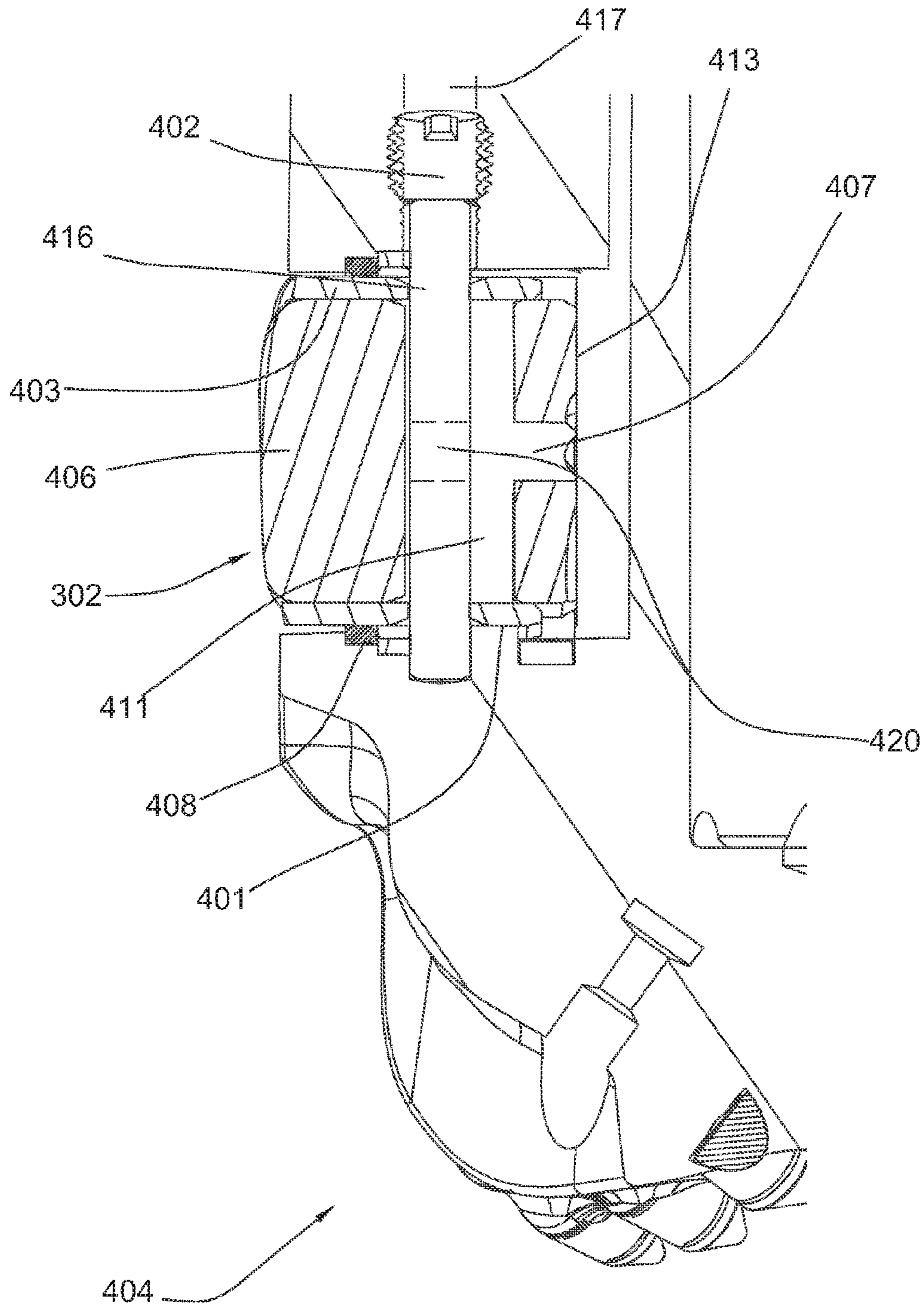


Fig. 4

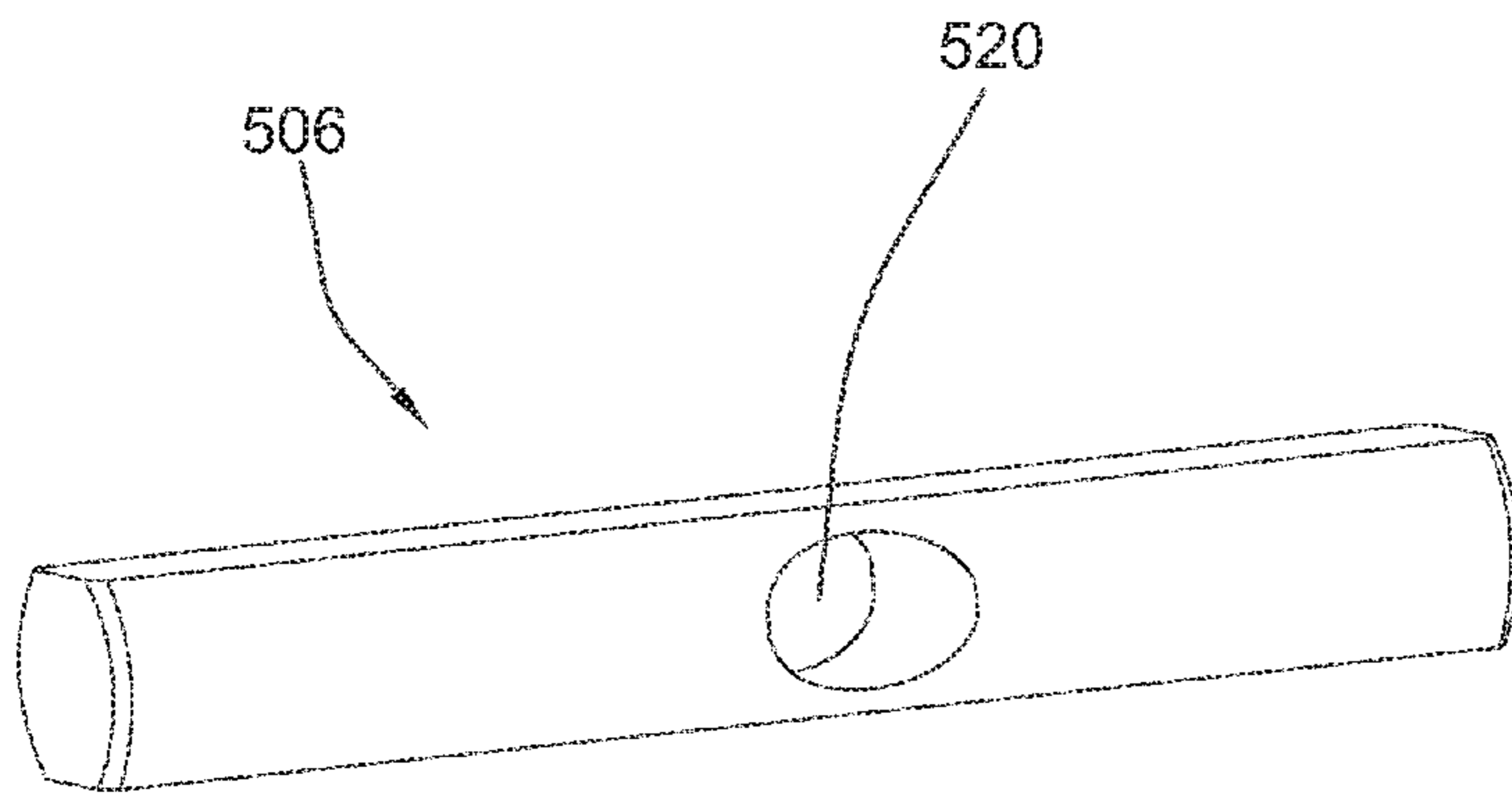


Fig. 5a

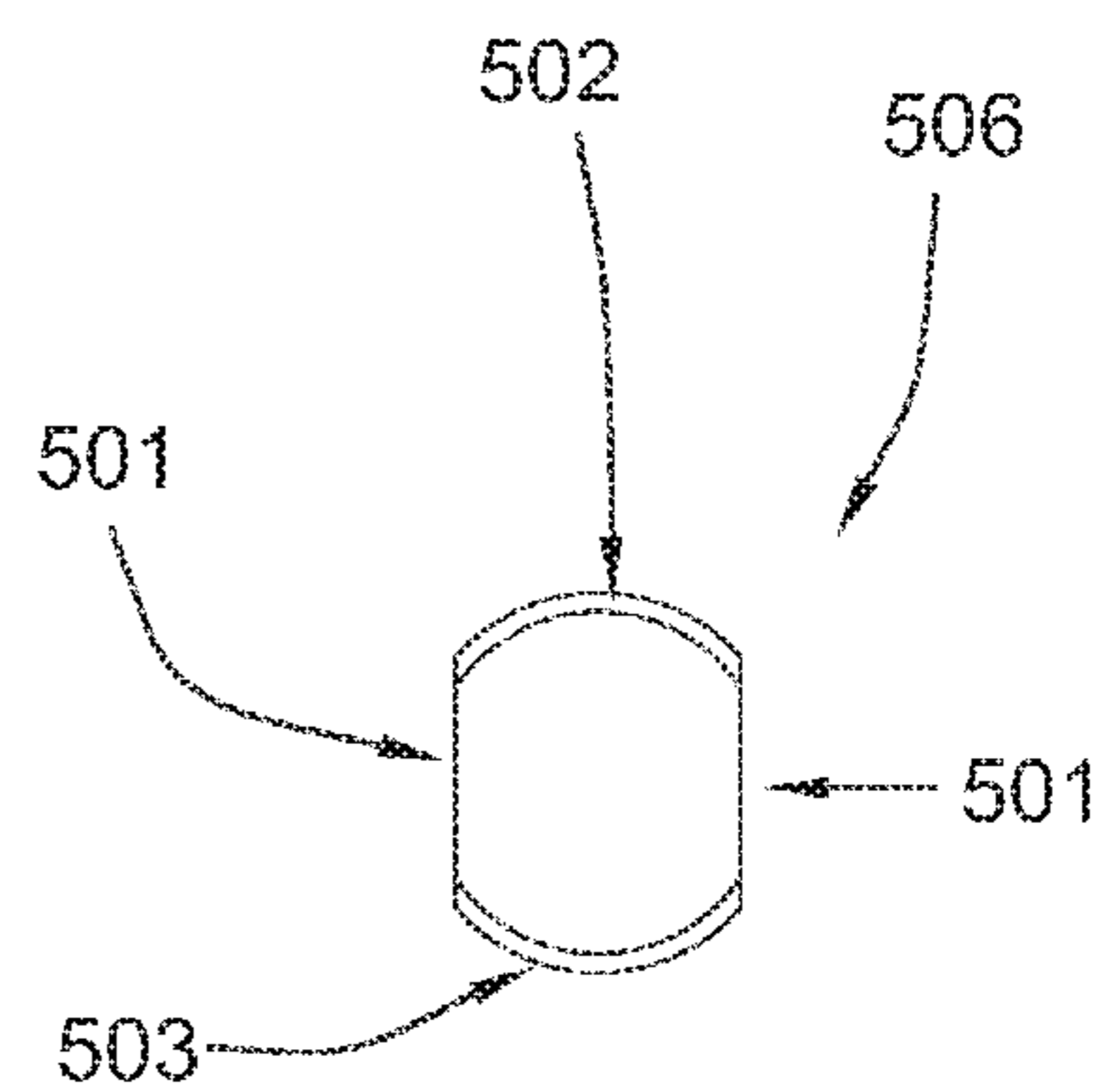


Fig. 5b

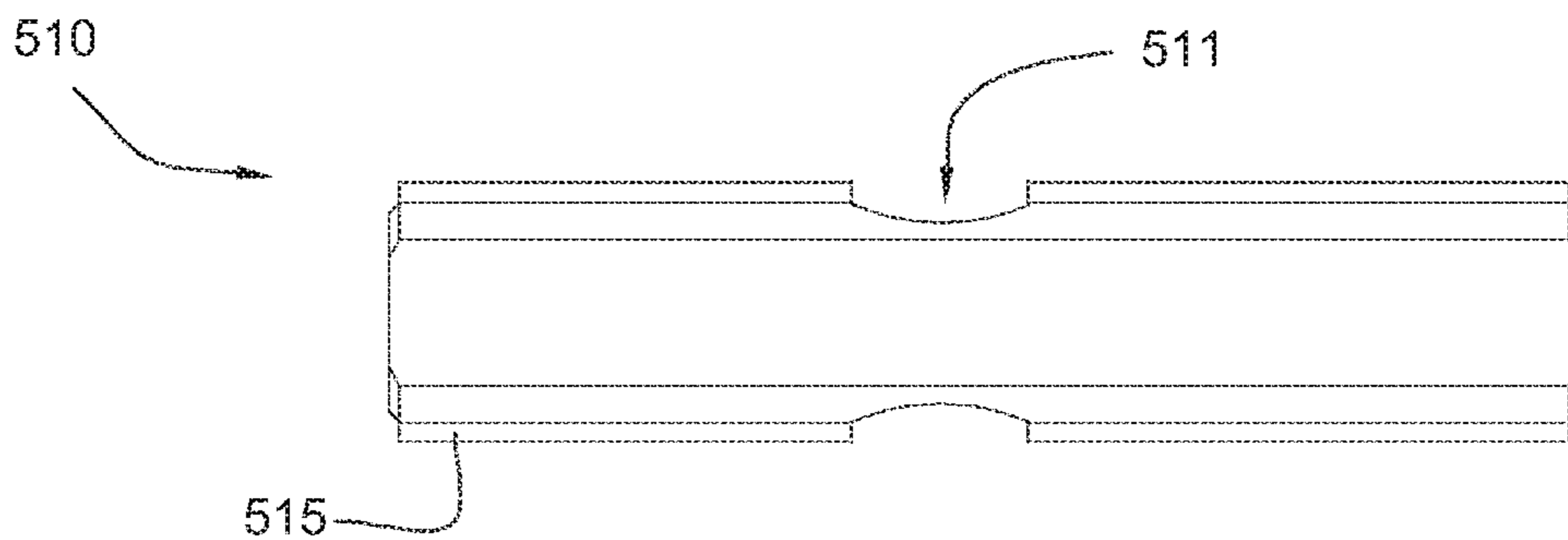


Fig. 5c

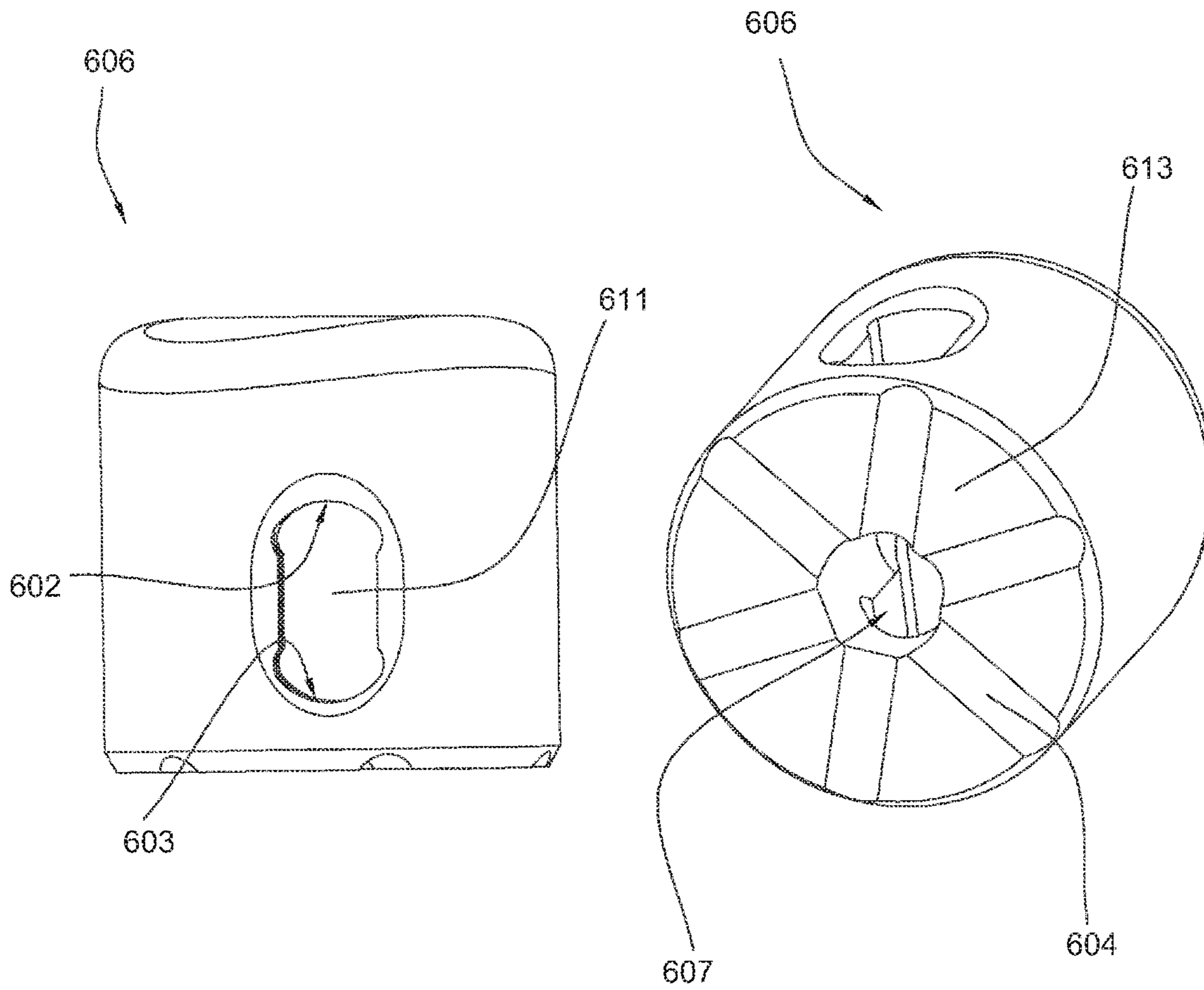


Fig. 6a

Fig. 6b



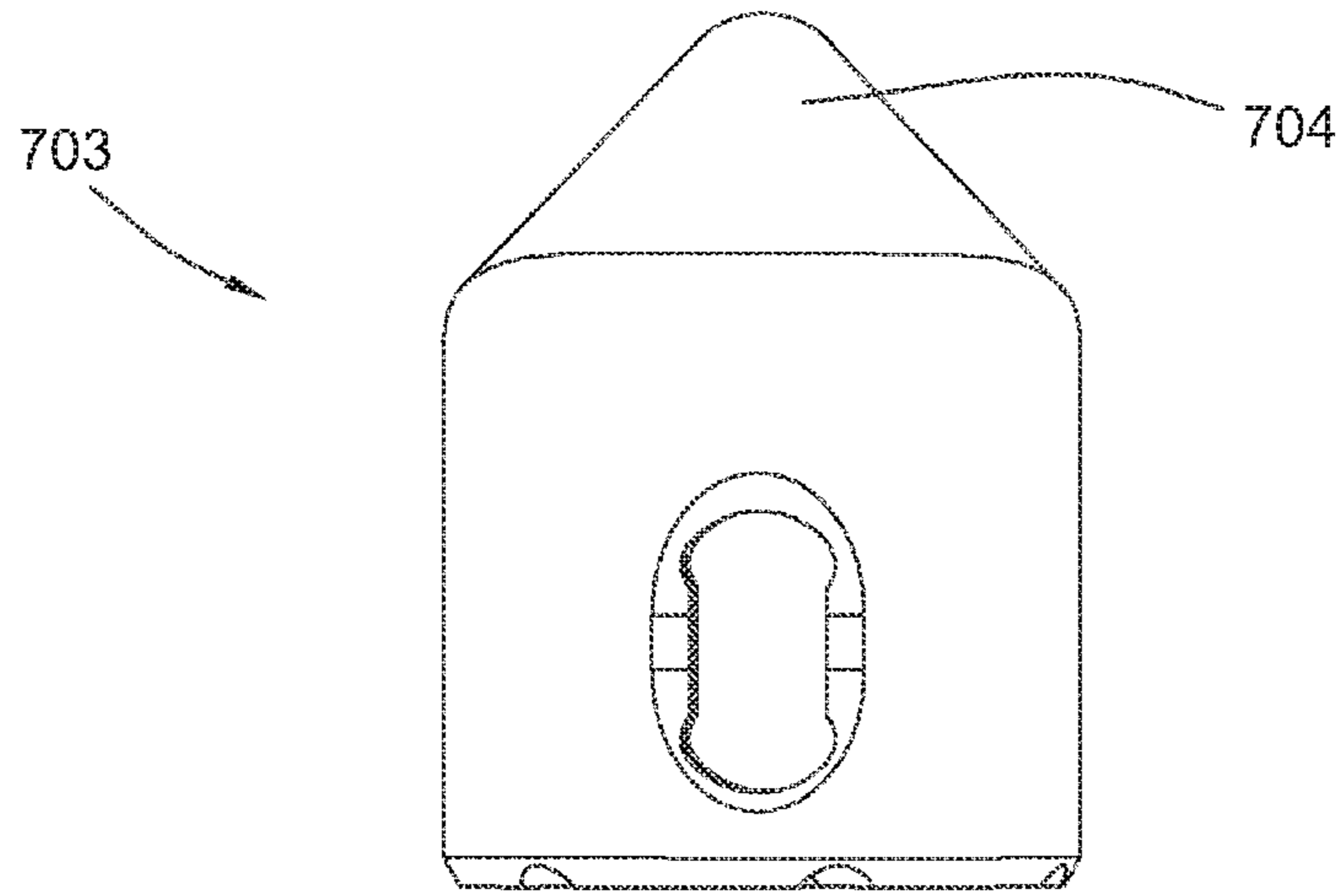


Fig. 7a

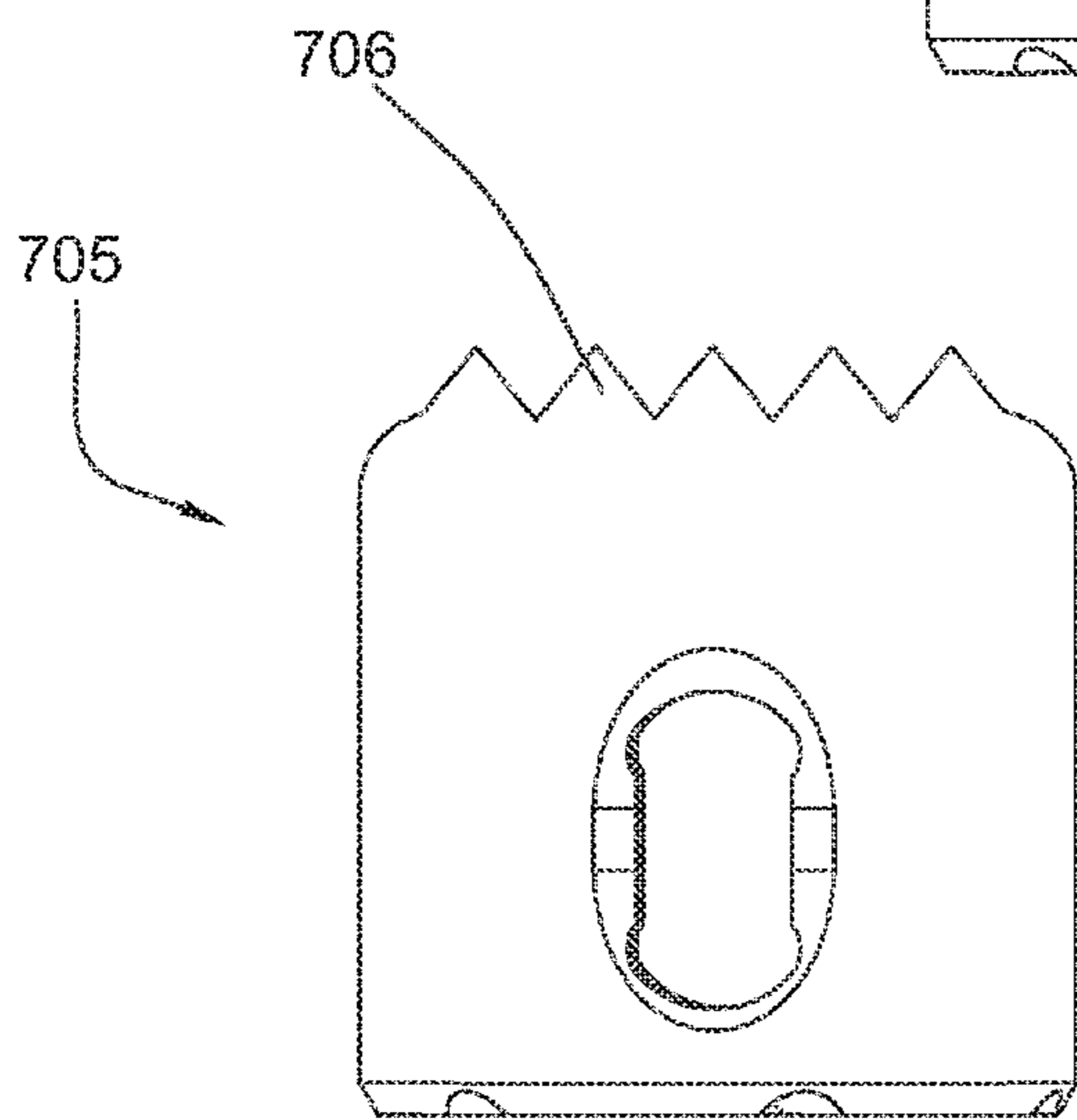


Fig. 7b

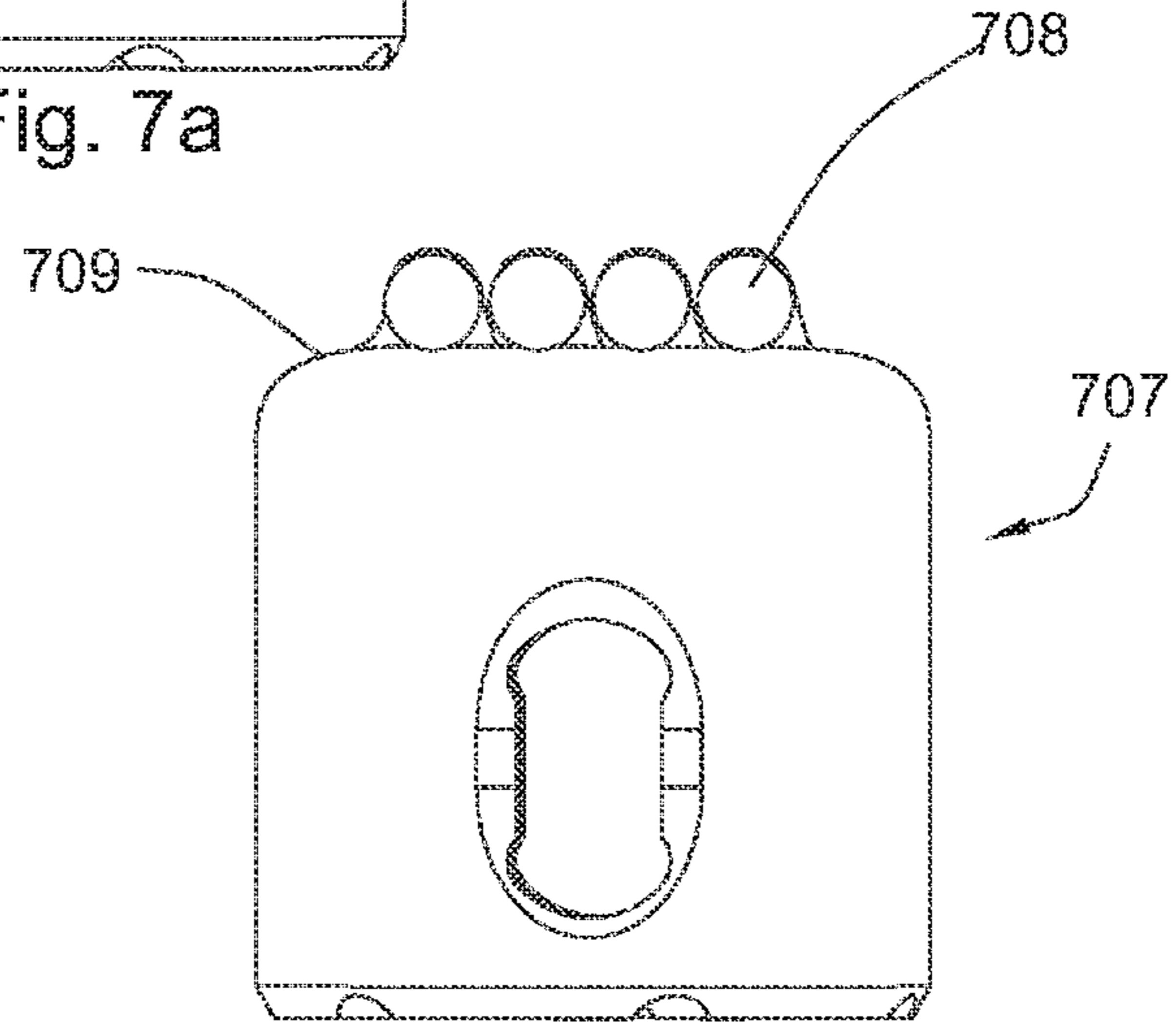


Fig. 7c

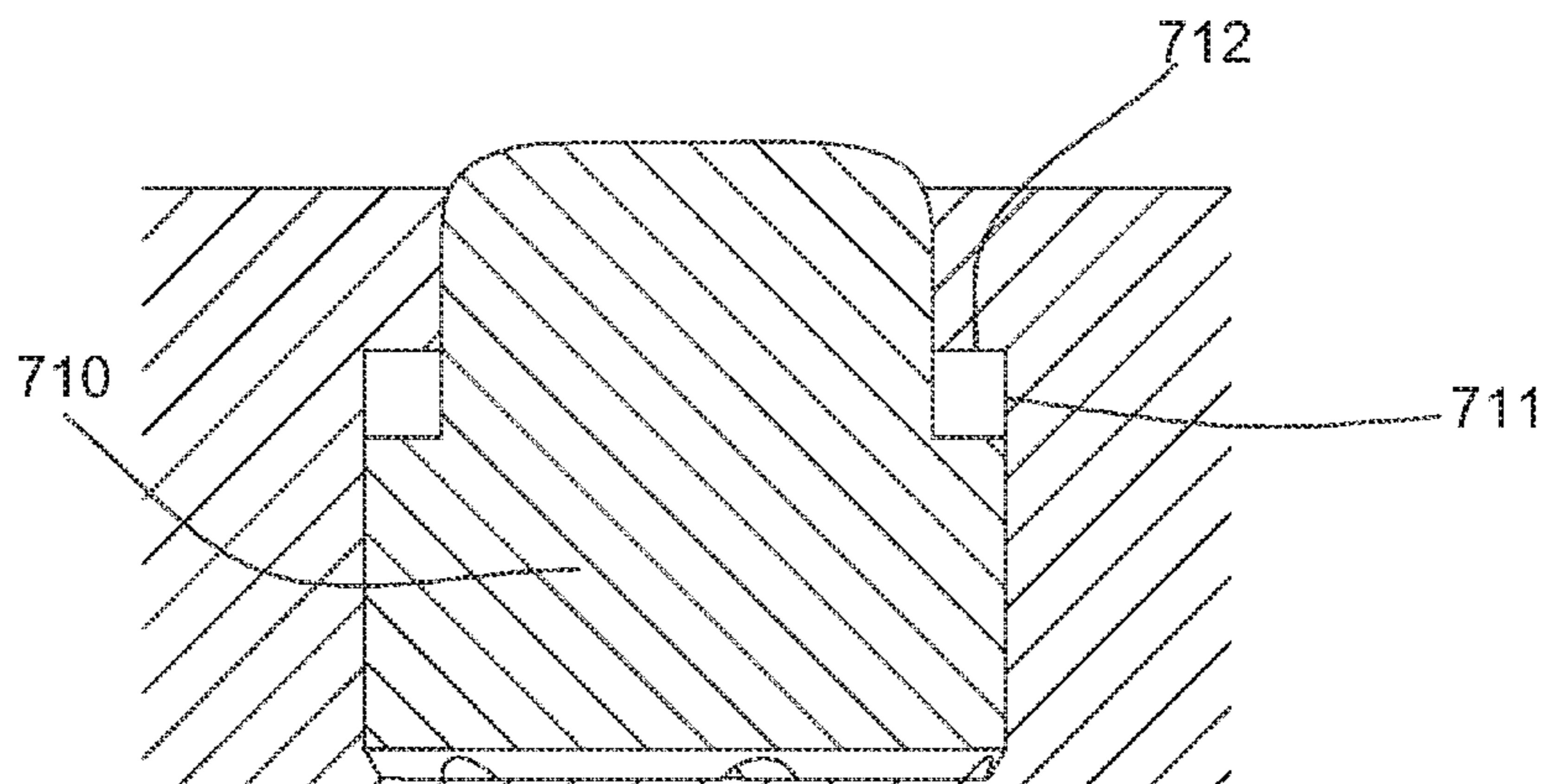


Fig. 7d

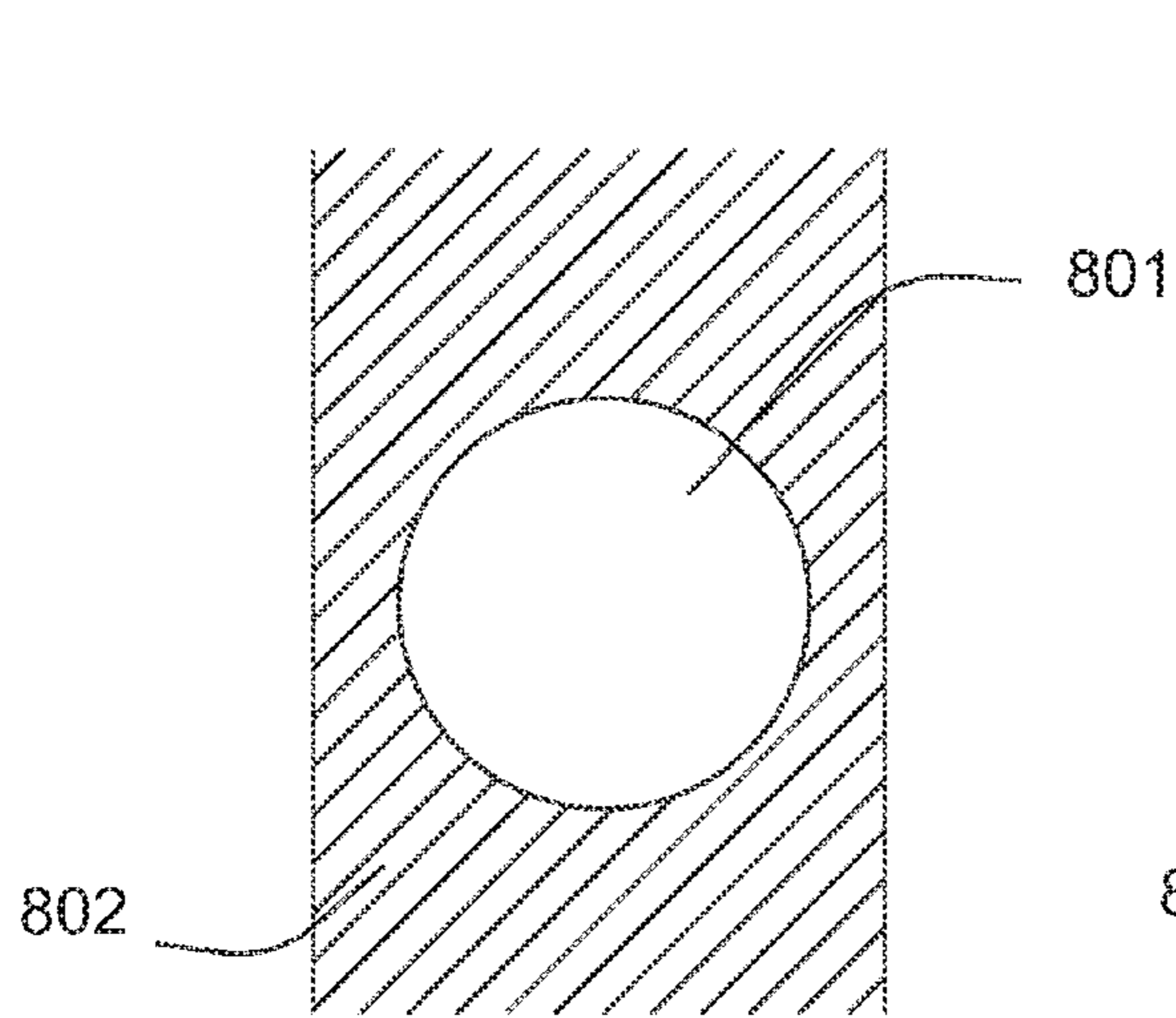


Fig. 8a

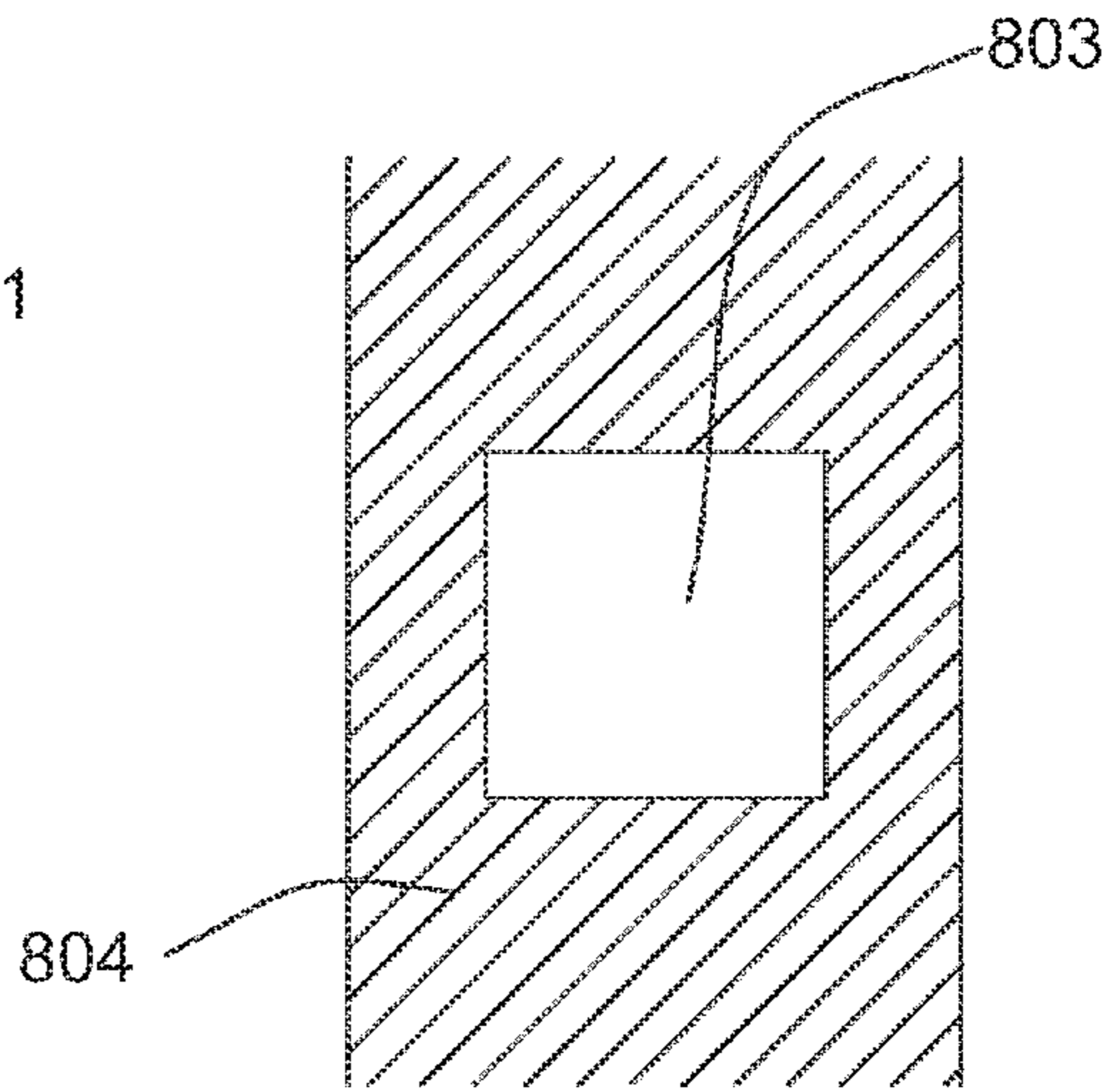


Fig. 8b

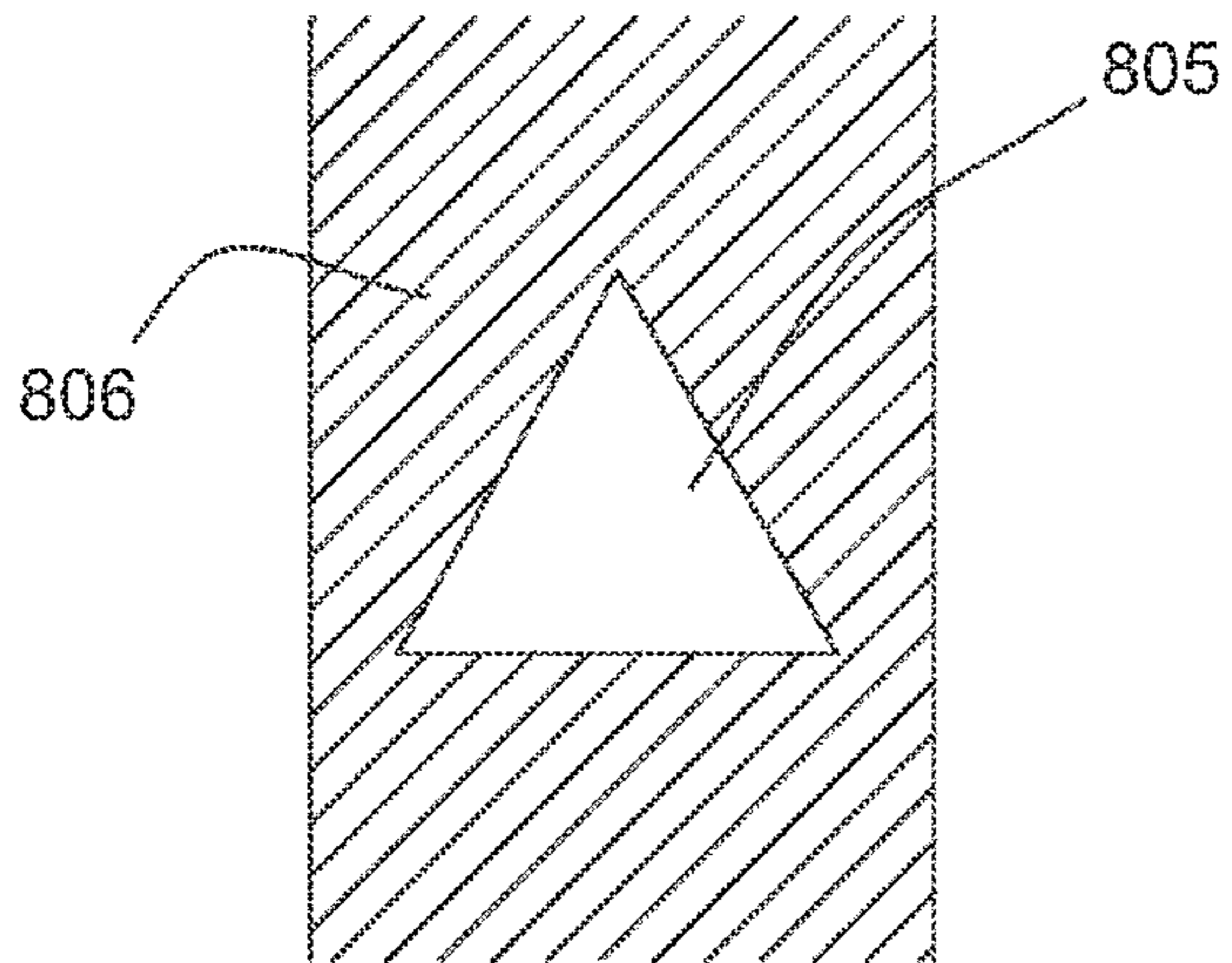


Fig. 8c

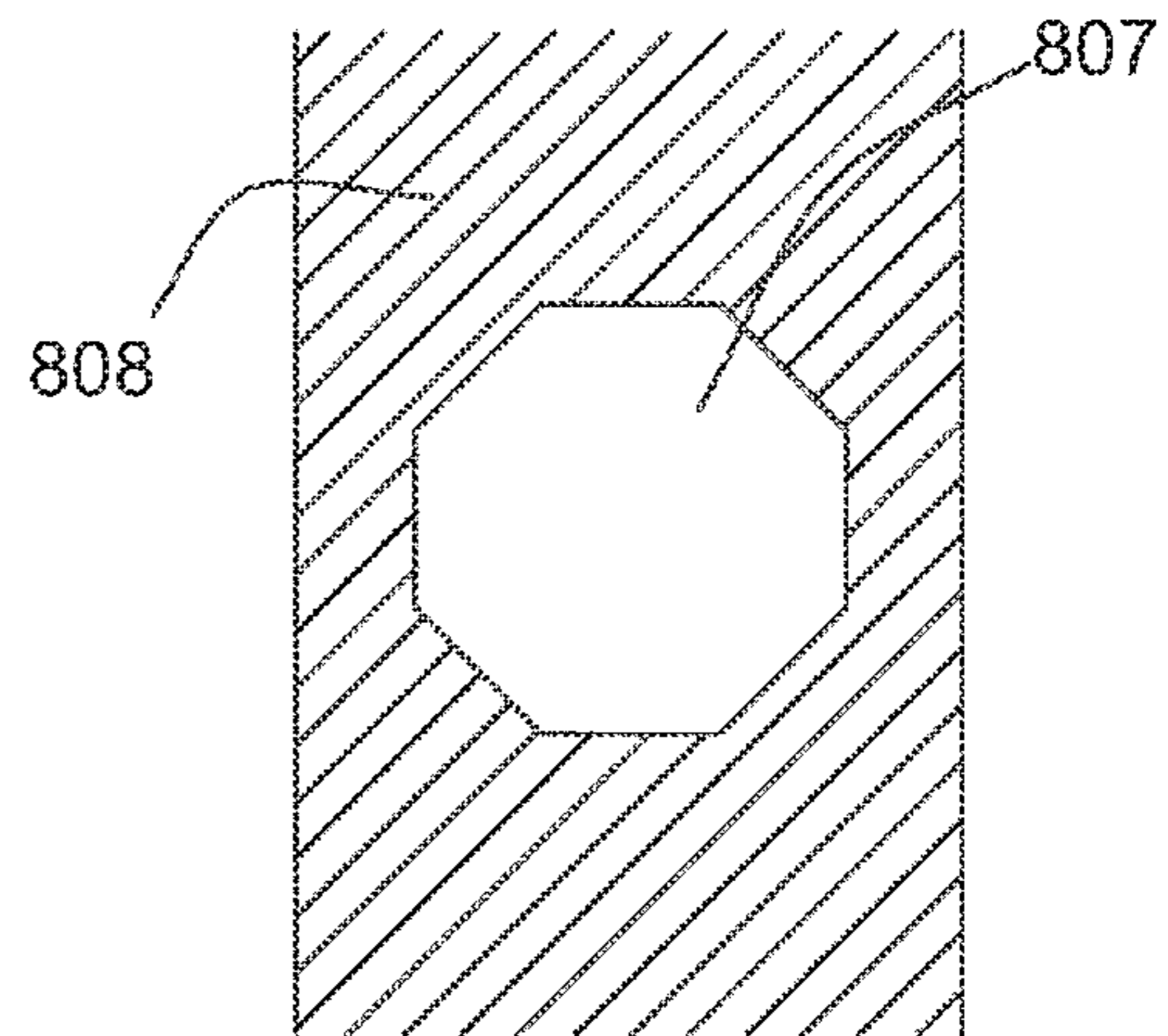


Fig. 8d

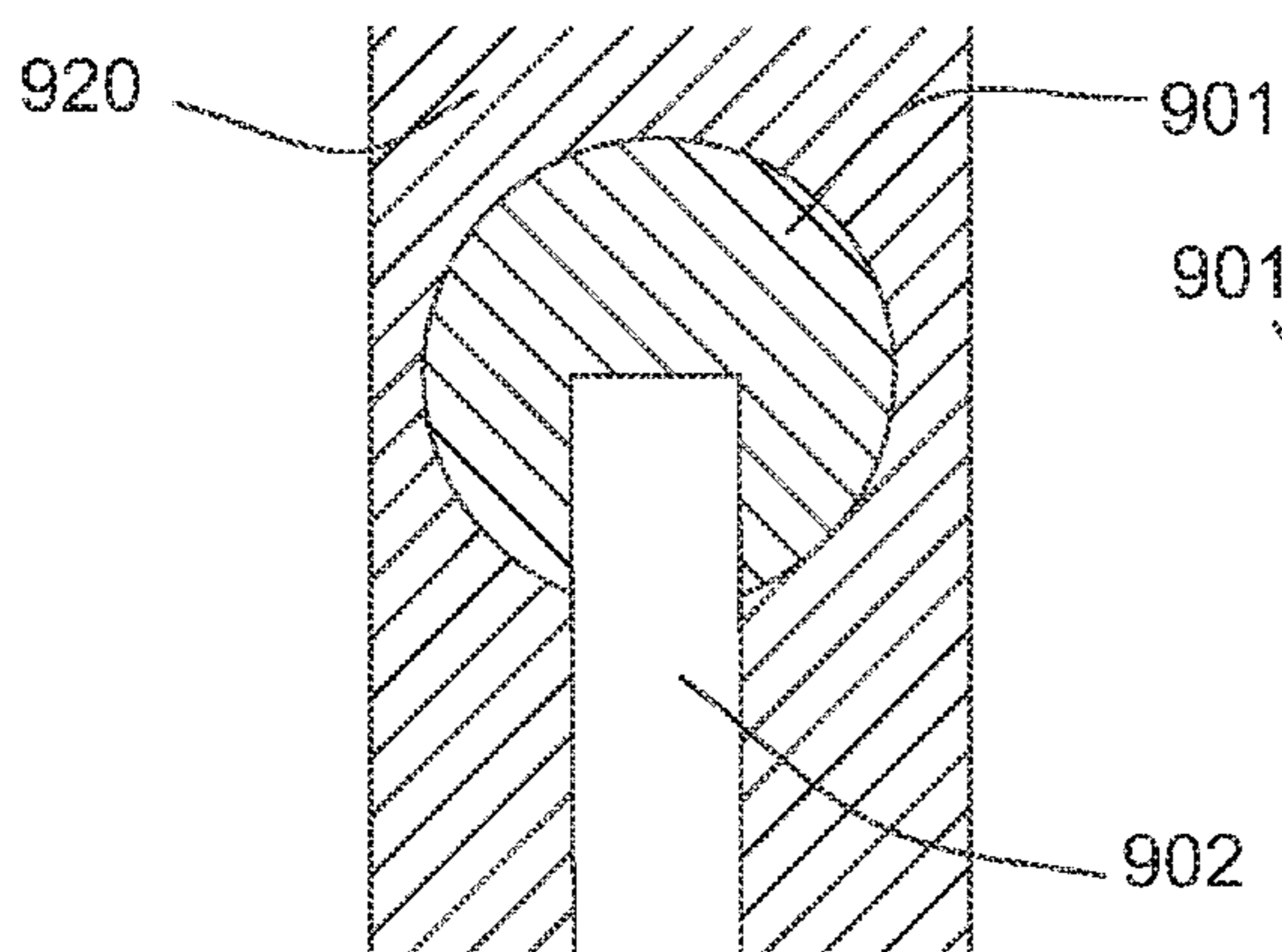


Fig. 9a

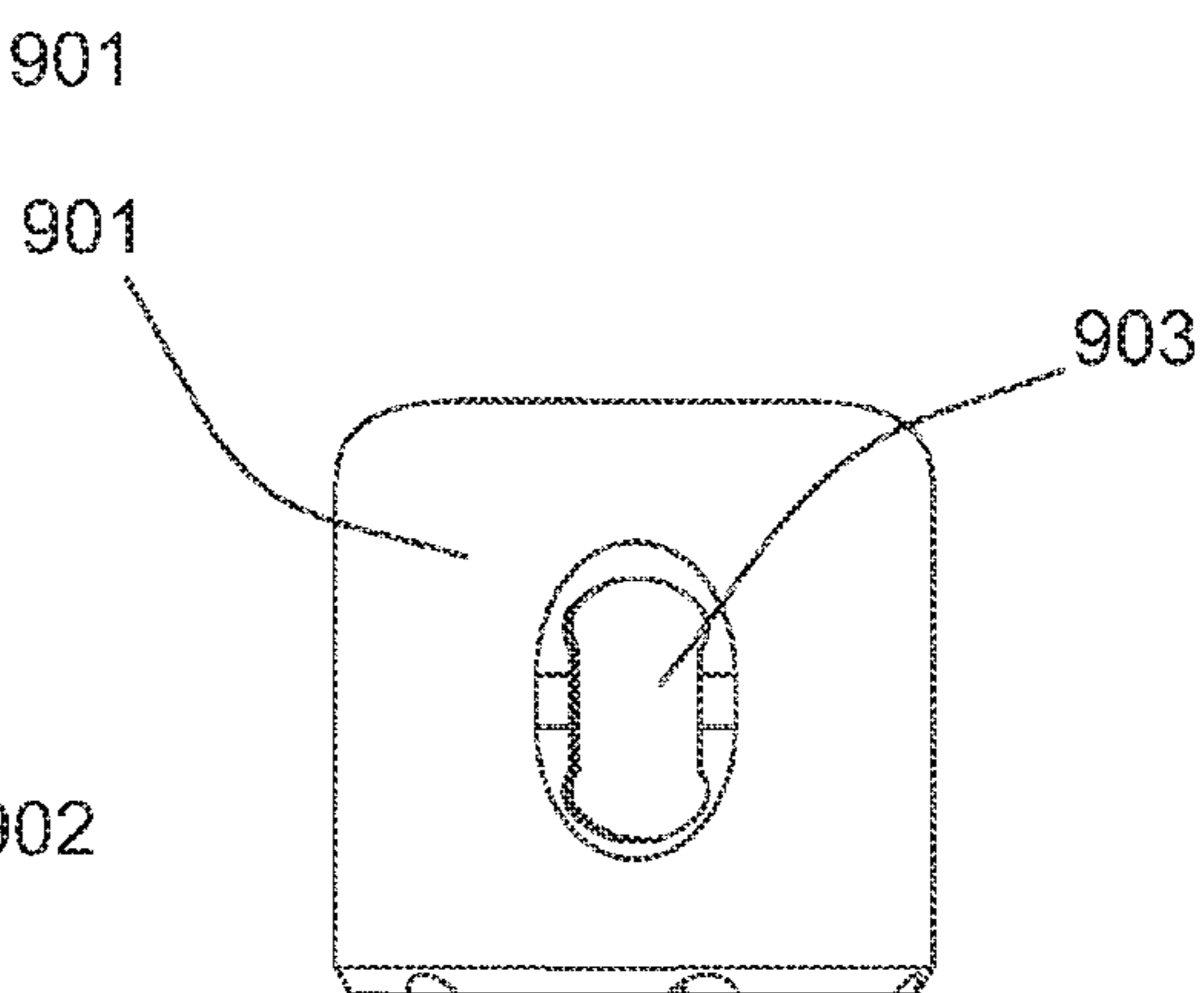


Fig. 9b

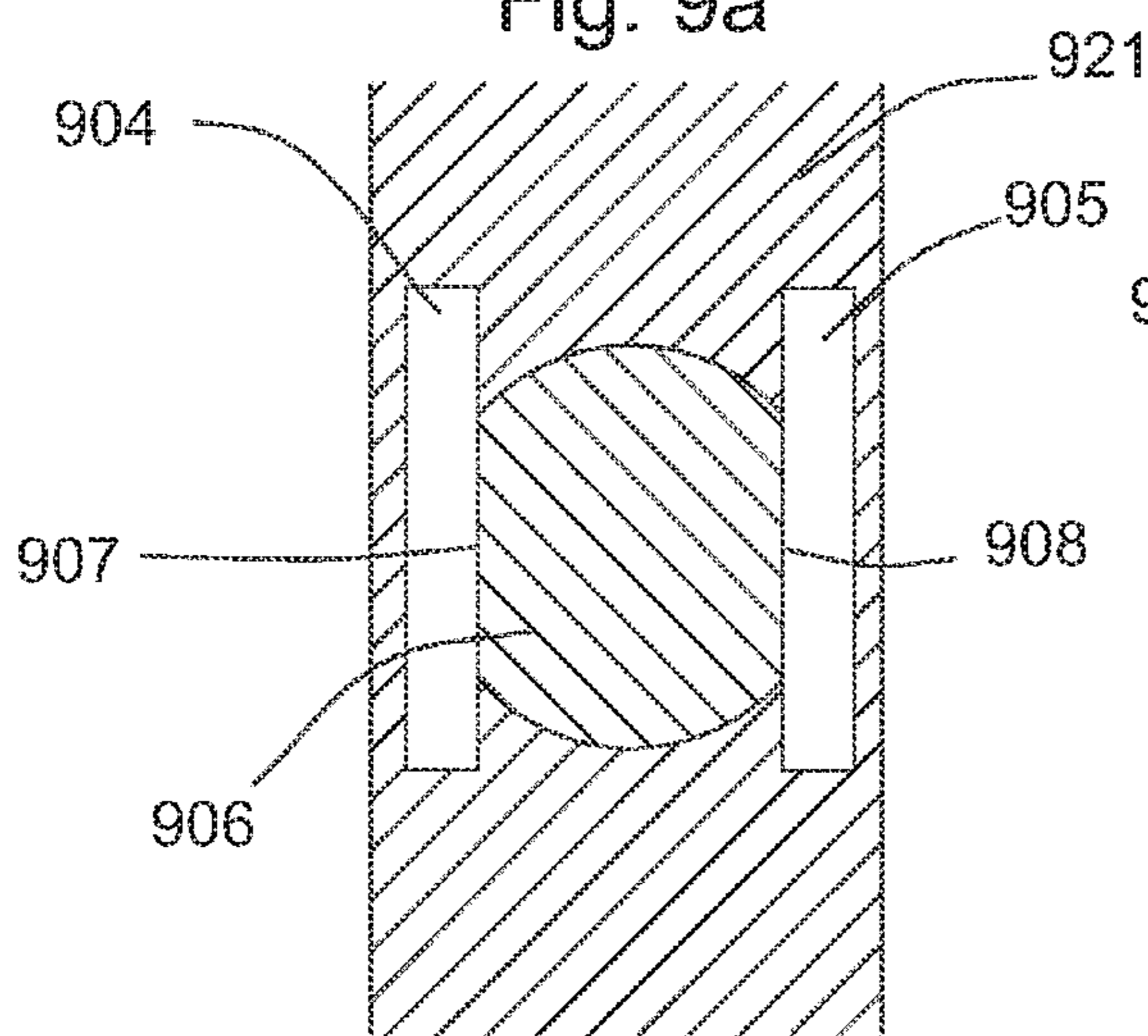


Fig. 9c

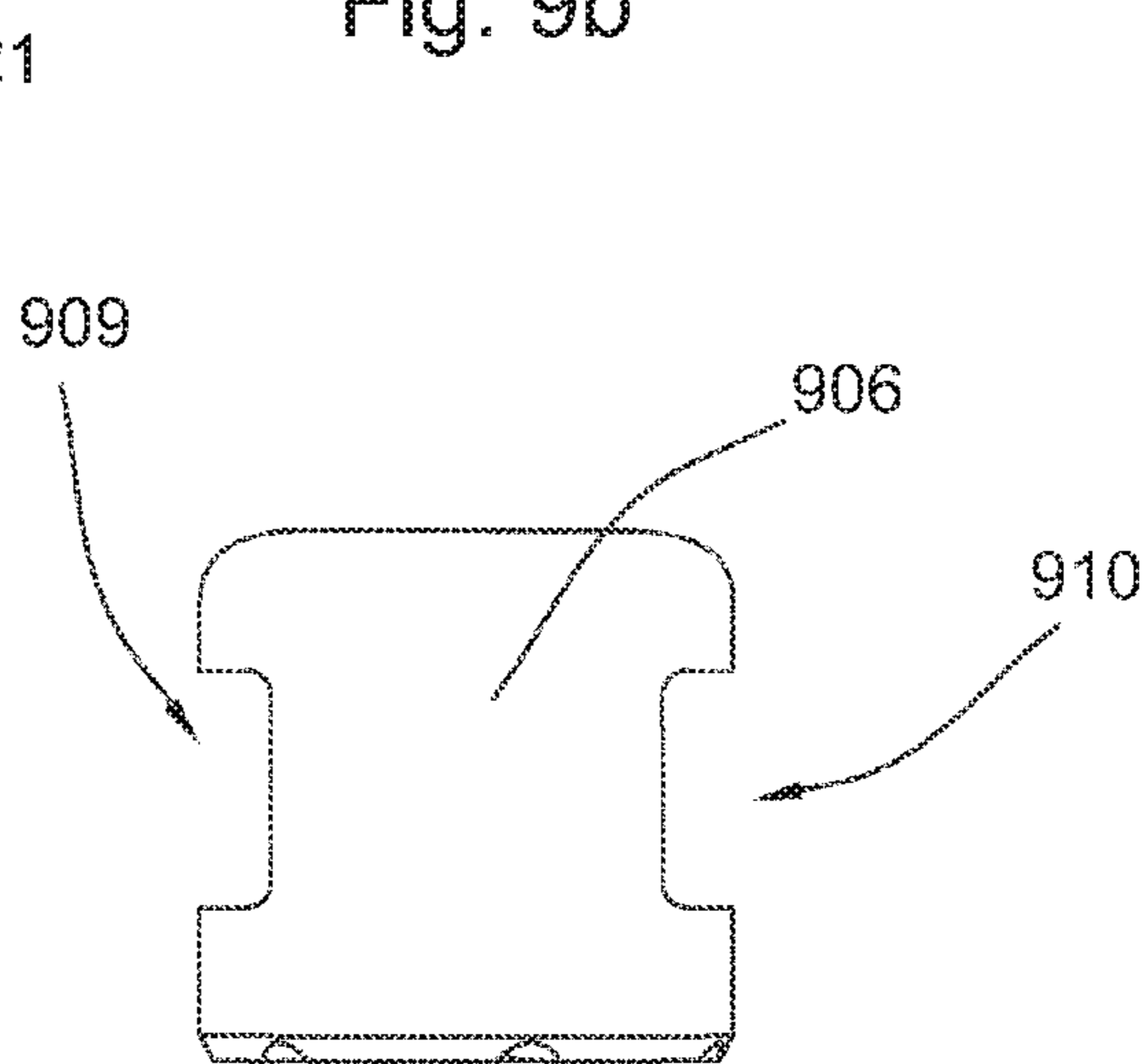


Fig. 9d

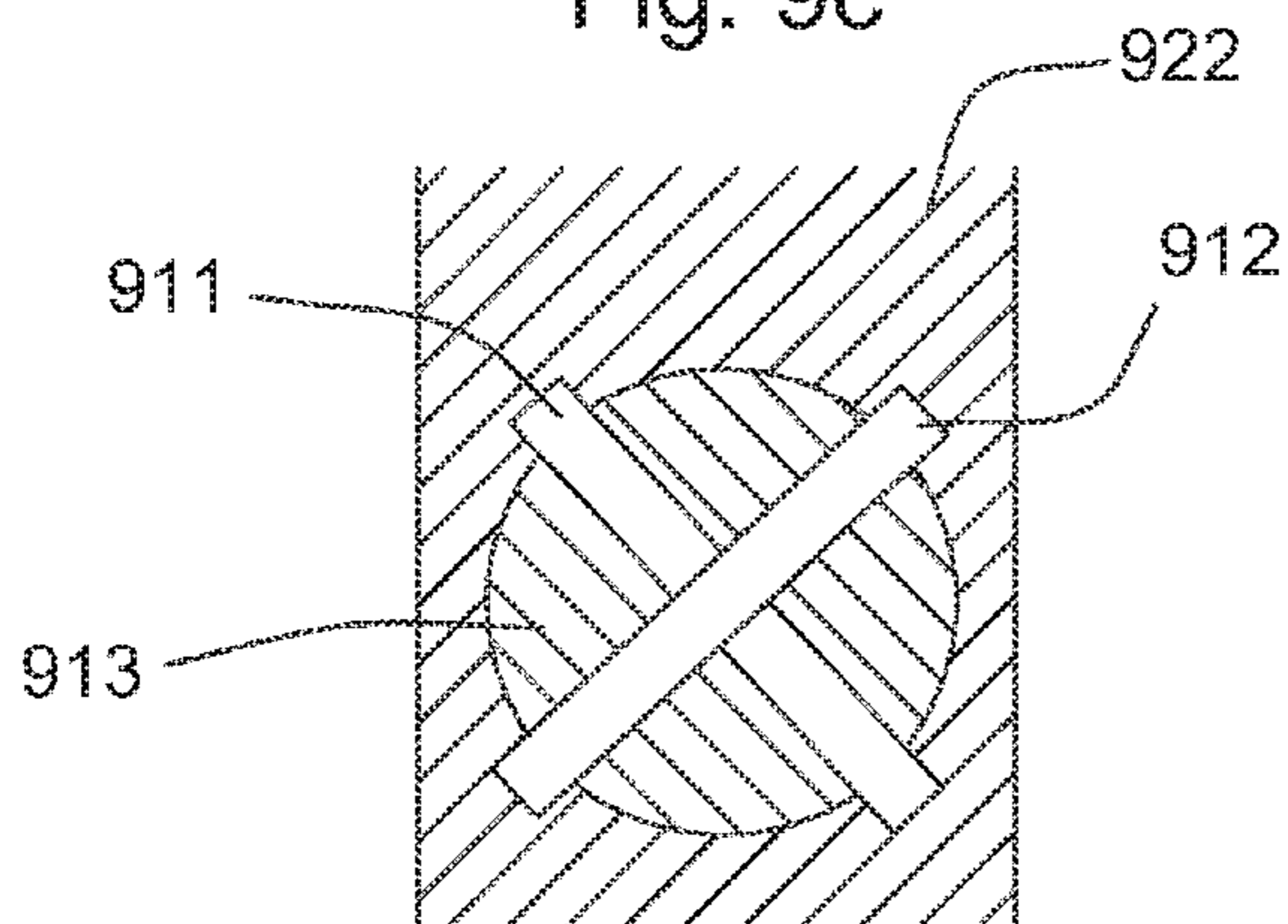


Fig. 9e

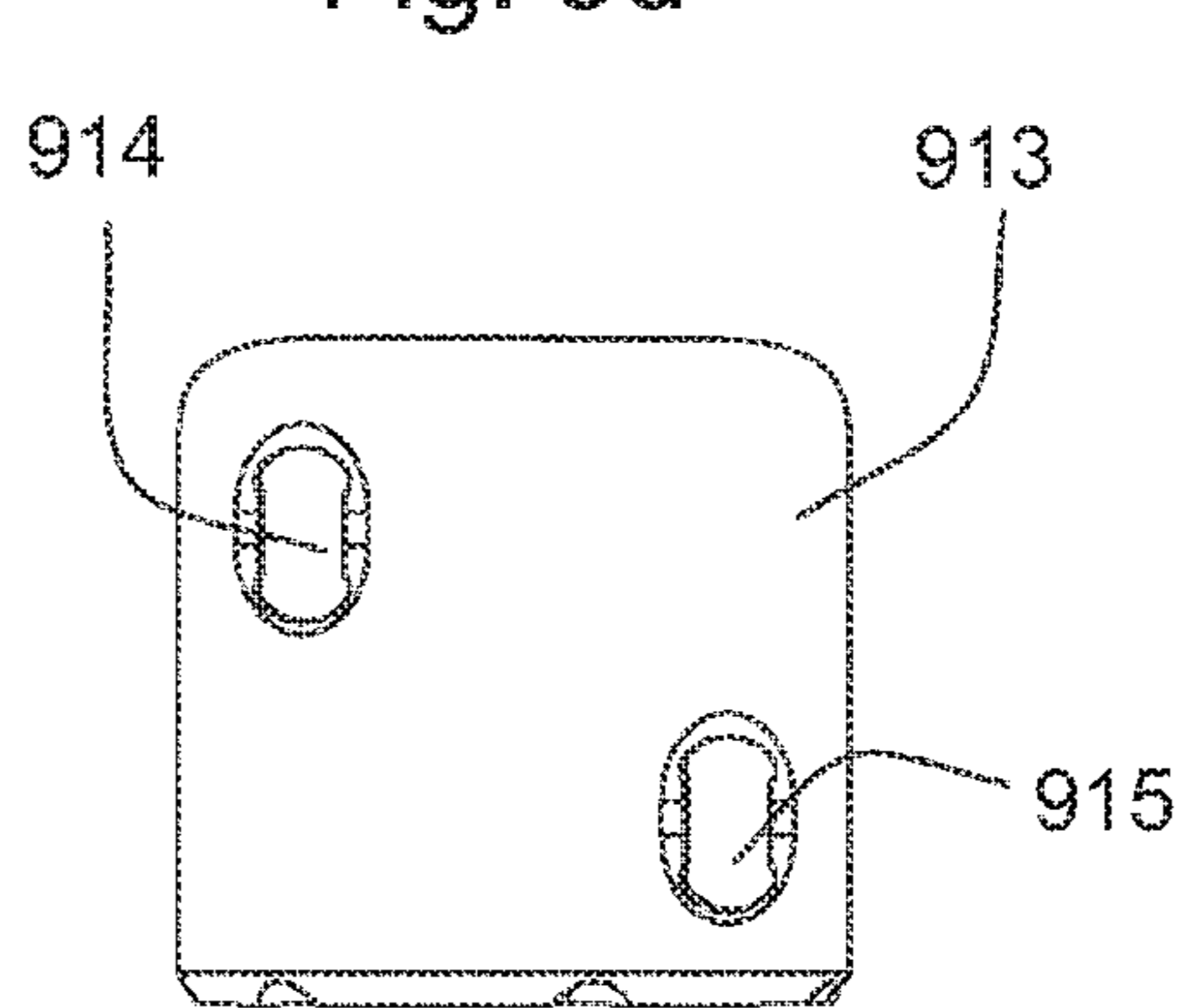


Fig. 9f

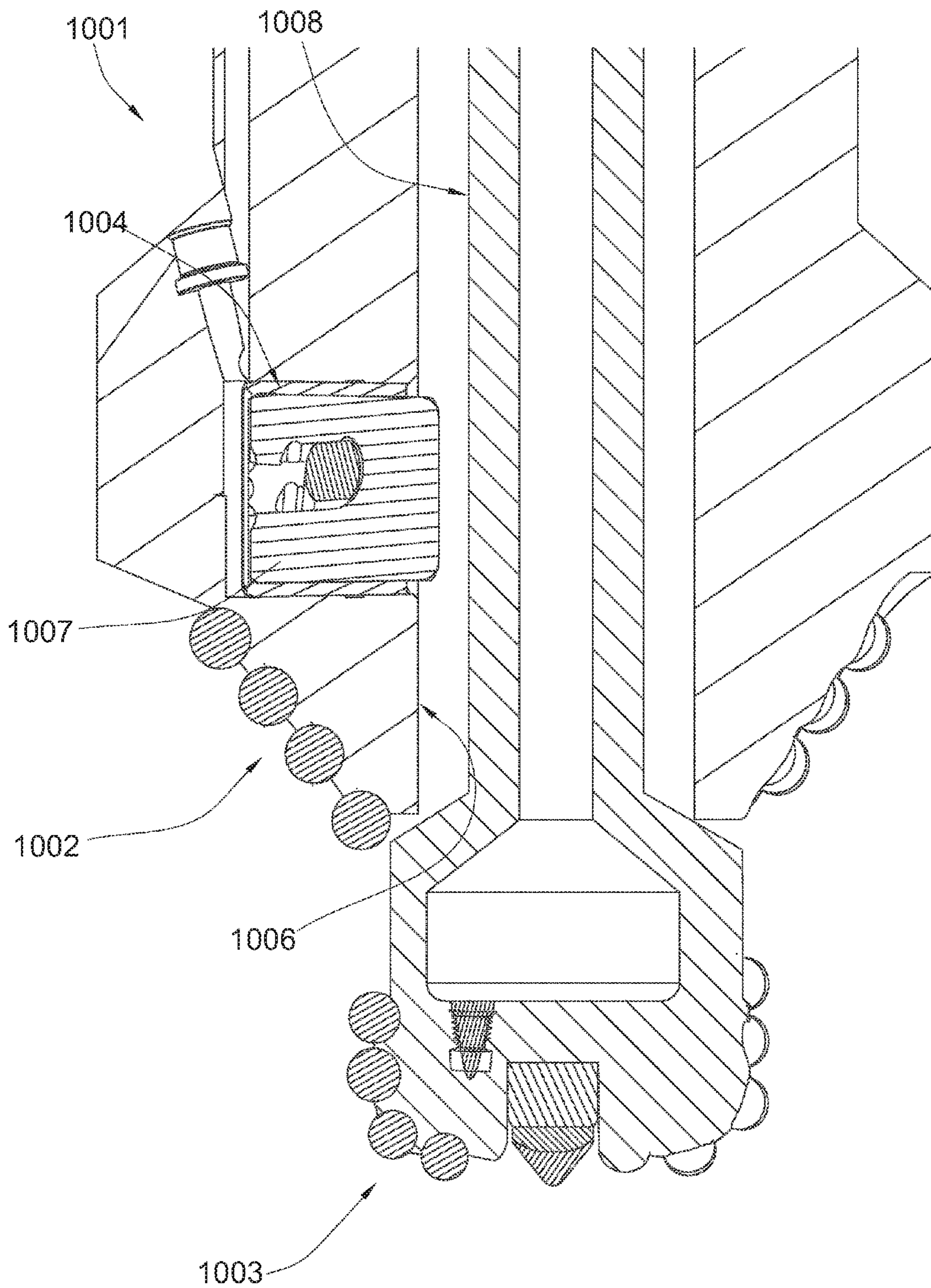


Fig. 10

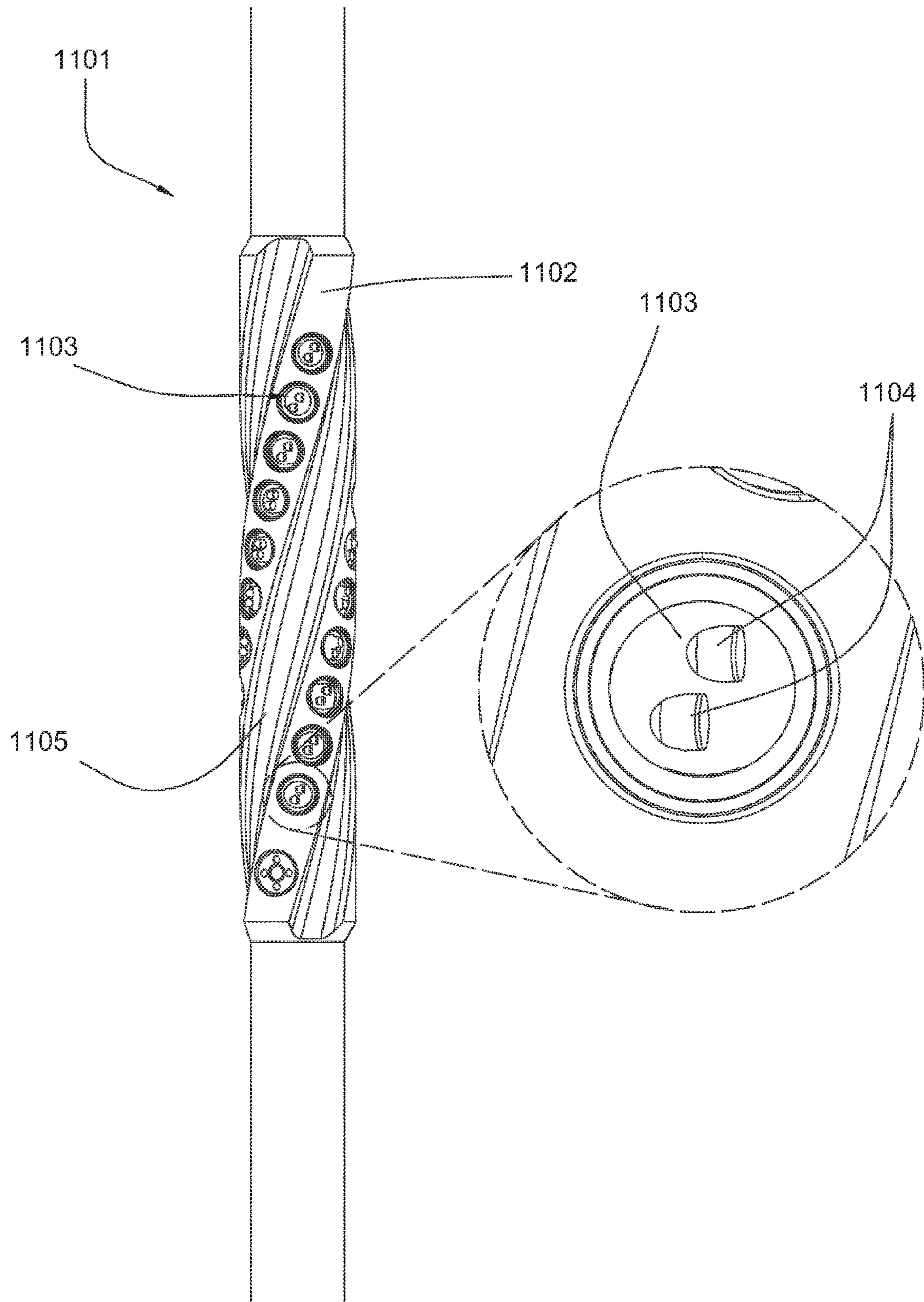


Fig. 11

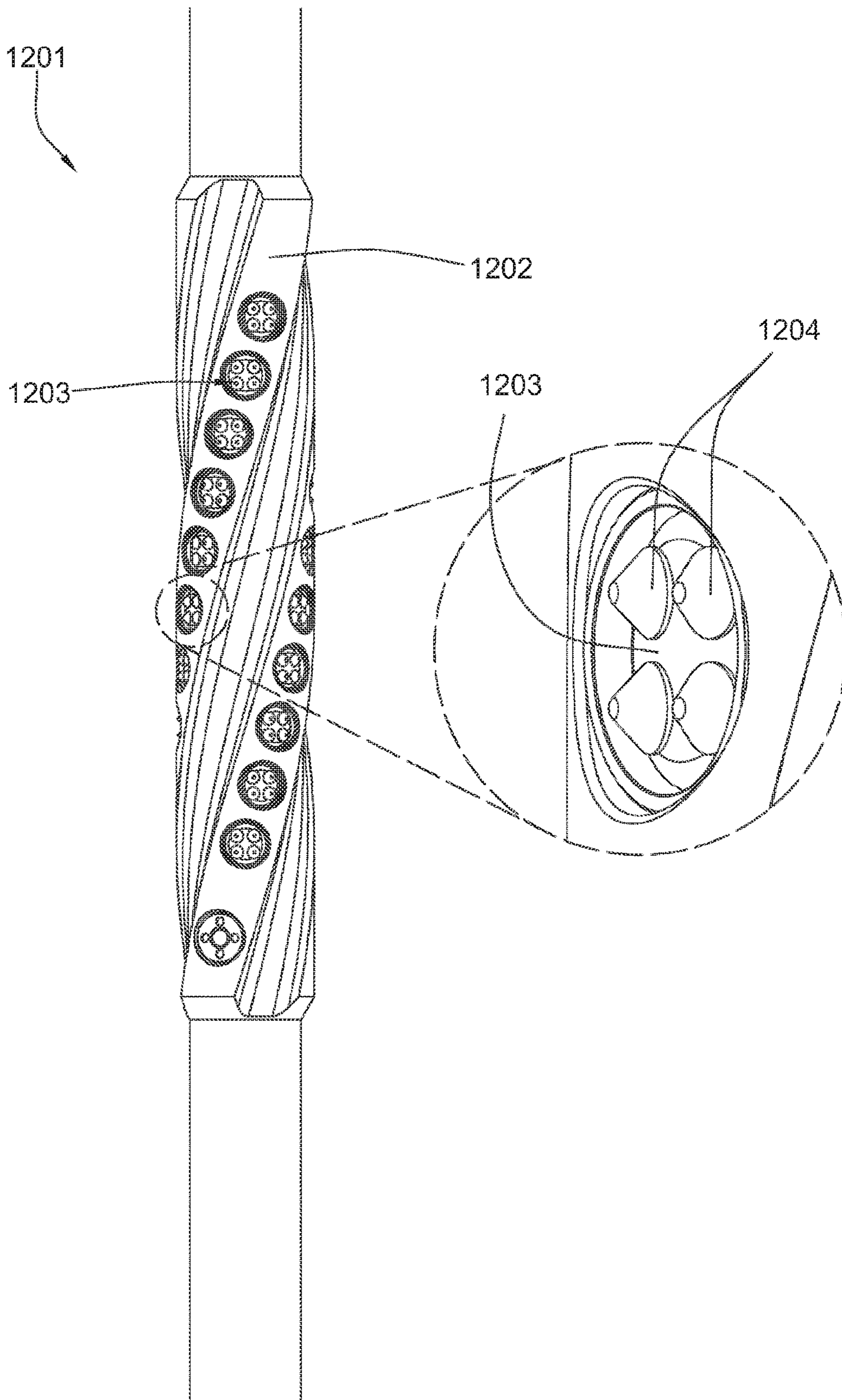


Fig. 12

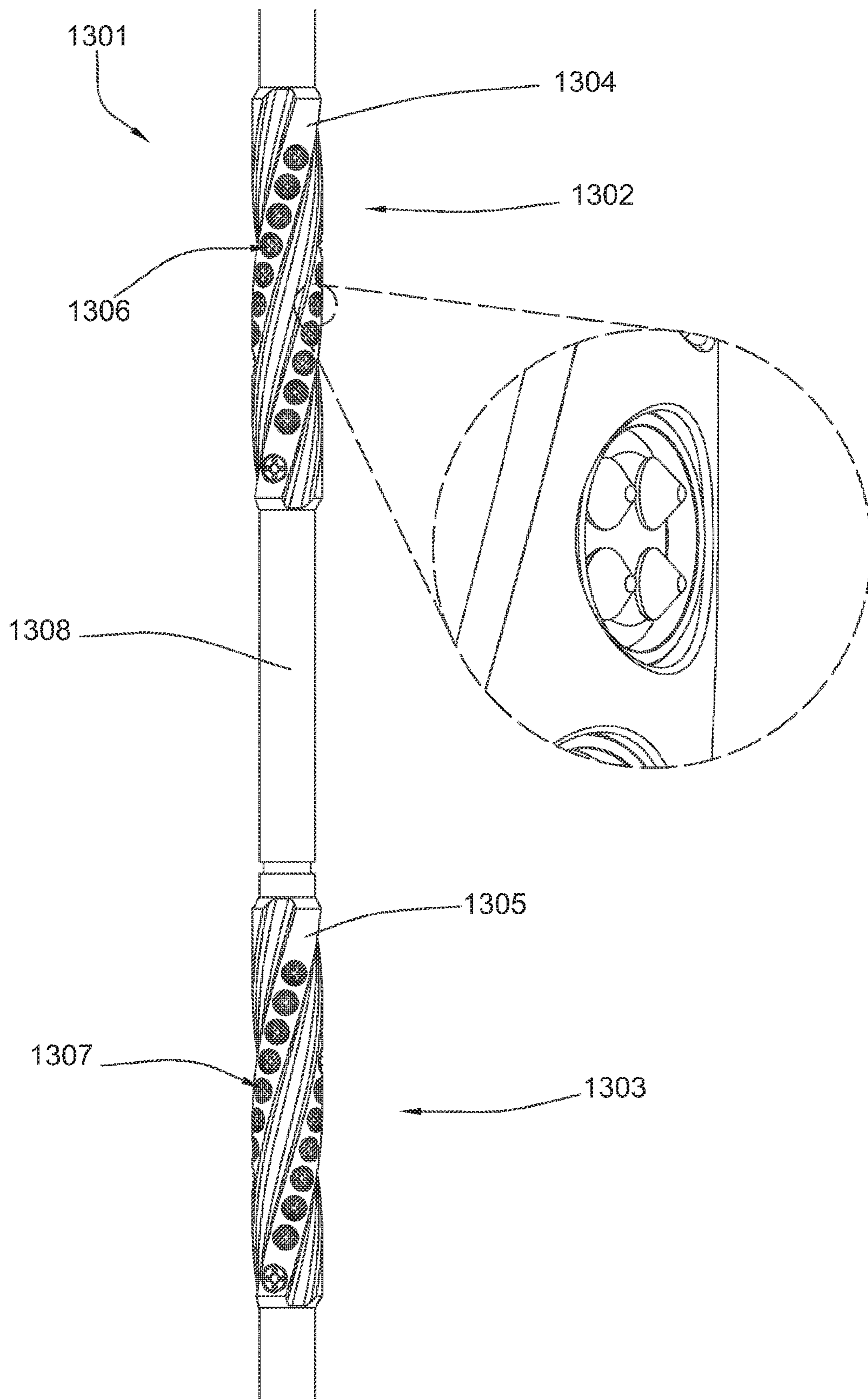


Fig. 13

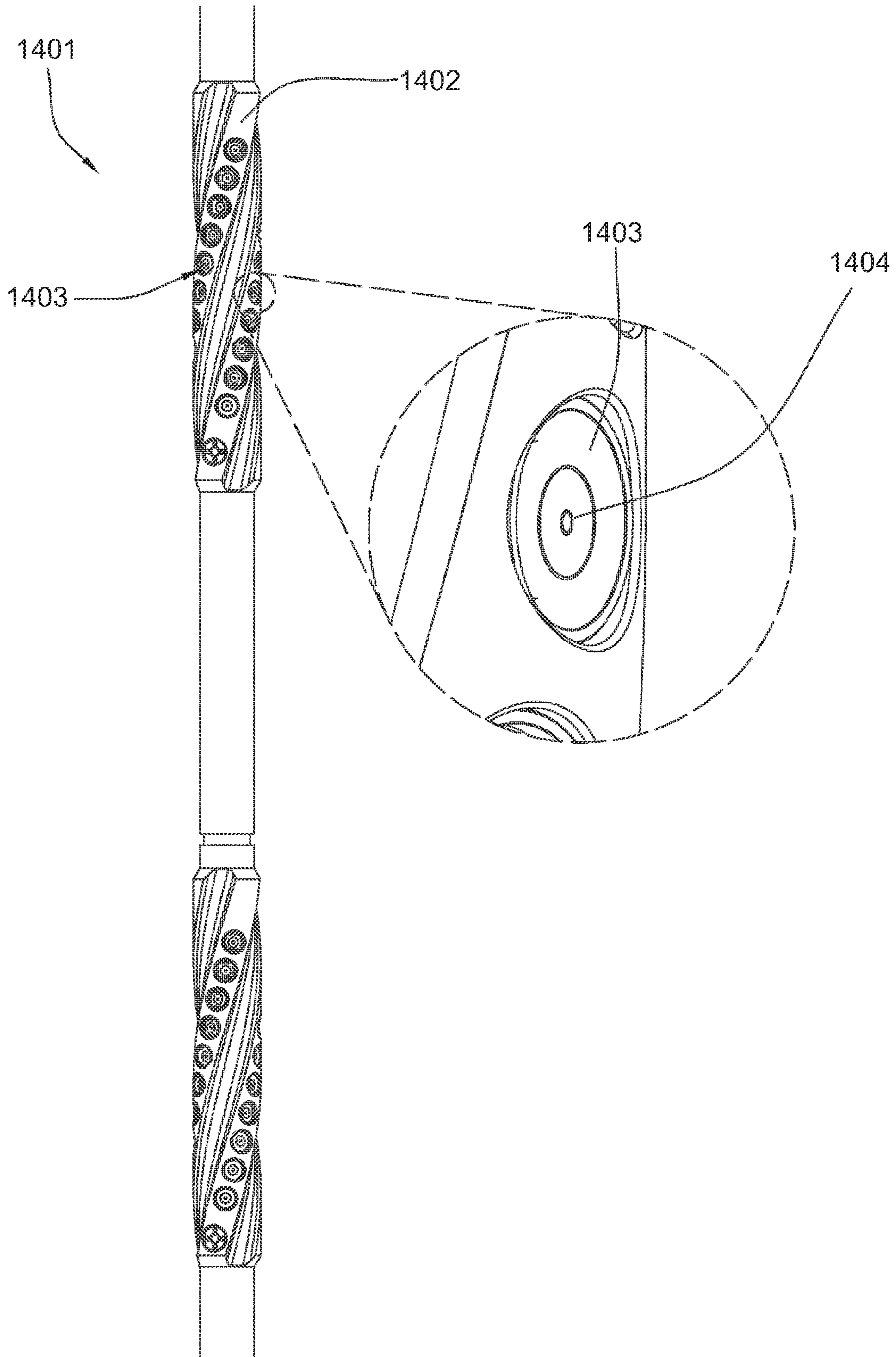


Fig. 14



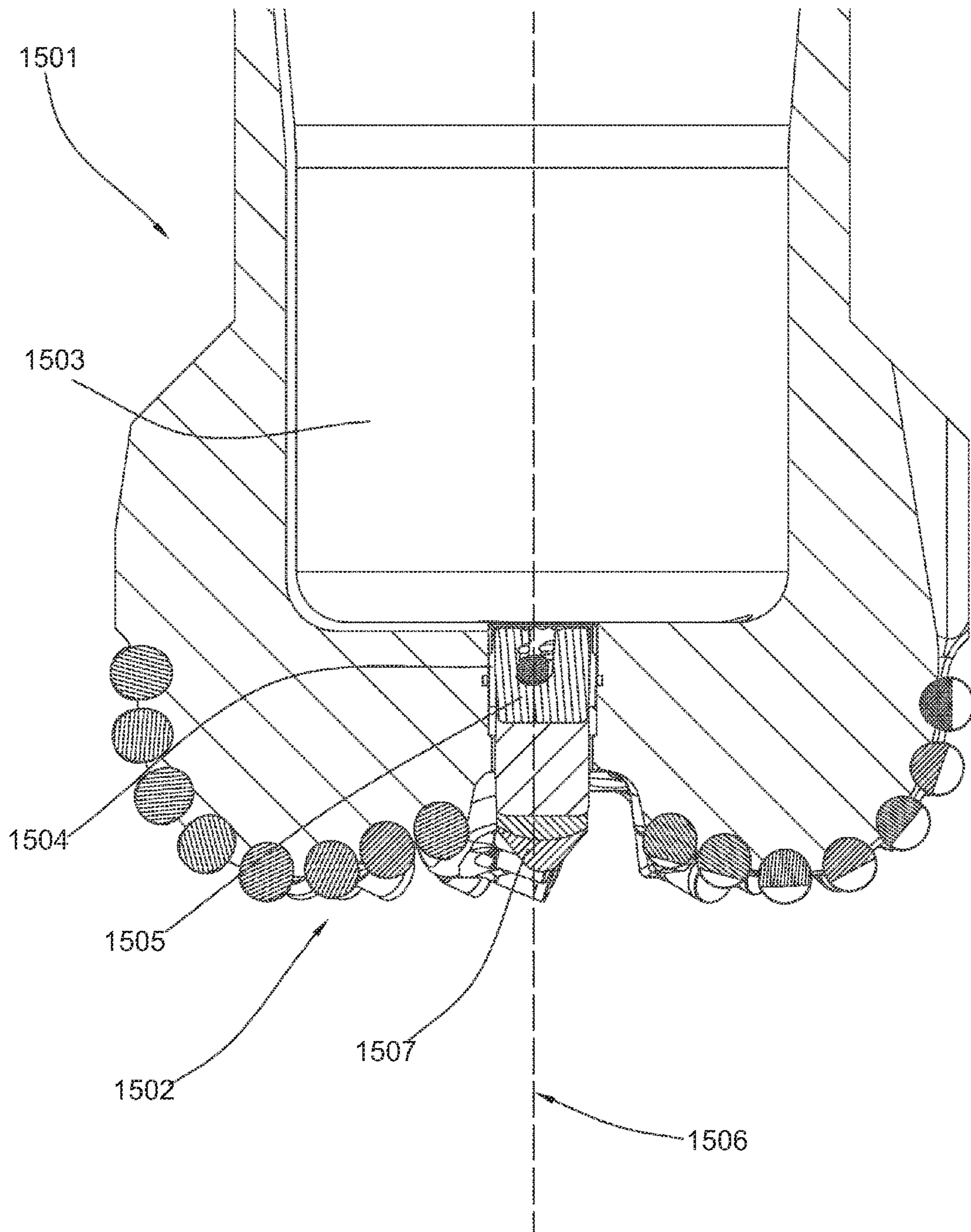


Fig. 15

## DOWNHOLE TOOL PISTON ASSEMBLY

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.**

*Notice: More than one reissue application has been filed for the reissue of U.S. Pat. No. 9,085,941. The reissue applications are application Ser. Nos. 15/164,663 and 16/150,875 (the present application). The present application is a divisional reissue of U.S. Pat. No. 9,085,941 and application Ser. No. 15/164,663 is a reissue of U.S. Pat. No. 9,085,941.*

## CROSS-REFERENCE TO RELATED APPLICATIONS

*This application is a divisional reissue application of U.S. patent application Ser. No. 15/164,663, filed May 25, 2016, which is a reissue of U.S. Pat. No. 9,085,941, issued on Jul. 21, 2015. This application is also a reissue application of U.S. Pat. No. 9,085,941, issued on Jul. 21, 2015.*

## BACKGROUND OF THE INVENTION

The present invention relates to the fields of downhole oil, gas, and/or geothermal exploration and more particularly to piston assemblies for actuating downhole tools. There exists in the art a variety of downhole tools comprising piston assemblies configured to actuate downhole tools to protrude and retract. One such downhole tool may be a directional steering mechanism. In directional drilling operations, a piston may extend a pad that contacts a formation and causes the drill string to move in a direction. Other such tools include expandable tools configured to enlarge the diameter of a wellbore and/or stabilize a drill string. The expandable tools may contain arms or blades which extend from the sides of the drill string and contact the formation. Examples from the prior art of such piston assemblies used in downhole tools are given below.

U.S. Patent Publication No. 2010/0071962 to Beuershausen, which is herein incorporated by reference for all that it contains, discloses a drill bit that includes at least one blade profile having a side section and an adjustable pad on the side section that is configured to extend from the side section to cause the drill bit to alter a drilling direction when the drill bit is used to drill a wellbore.

U.S. Patent Publication No. 2010/0139980 to Neves et al., which is herein incorporated by reference for all that it contains, discloses a ball piston steering device and methods for use of ball piston devices. One aspect of the invention includes: a sleeve in fluid communication with a fluid source and a ball received within the sleeve. The ball is movable within the sleeve from a recessed position and an extended position.

U.S. Patent Publication No. 2006/0157283 to Hart, which is herein incorporated by reference for all that it contains, discloses a bias unit comprising at least one bias pad moveable by a piston between retracted and extended positions wherein the piston is of non-circular effective cross-sectional shape.

U.S. Patent Publication No. 2004/0206549 to Dewey et al., which is herein incorporated by reference for all that it contains, discloses a downhole tool that functions as an underreamer or as a stabilizer in an underreamed borehole.

The tool includes one or more moveable arms disposed within a body having a flowbore therethrough in fluid communication with the wellbore annulus. The tool alternates between collapsed and expanded positions in response to differential fluid pressure between the flowbore and the wellbore annulus. In one embodiment, the tool moves automatically in response to differential pressure. In a second embodiment, the tool must be selectively actuated before it is moveable. The tool may include borehole engaging pads that comprise cutting structure or wear structures or both, depending upon the function of the tool.

Despite the advancements as shown in the prior art, it is believed that there is still a need to develop improved piston assemblies used in downhole drill strings.

## BRIEF SUMMARY OF THE INVENTION

In one aspect of the present invention, a piston assembly may comprise a housing with a wall, and at least one chamber formed in the wall. A piston may be disposed within the chamber and at least one passageway may pass through the piston. At least one pin may be disposed within the passageway and be attached to the chamber, and the piston may be free to translate relative to the pin.

The housing may be selected from a group consisting of drill bits, calipers, reamers, shock absorbers, jars, clamps, tractors, stabilizers, fishing tools, and combinations thereof. When the housing consists of a drill bit, the wall and the chamber may be disposed on a gauge surface of the drill bit. The housing may comprise a tube and the wall may be disposed within or on a surface of the tube. The chamber may be in fluid communication with a fluid source.

The chamber may comprise a cross section selected from the group consisting of a circle, oval, polygon, star, rectangle with circular ends, and annulus. The chamber may be lined with a sleeve and the chamber and the sleeve may comprise openings to allow passage of the at least one pin. The chamber openings may also allow fluid communication with the chamber. A seal may be disposed between the chamber and the piston, the piston and the sleeve, or the chamber and the sleeve.

The piston may comprise a cross sectional shape similar to the chamber. The piston may comprise a working surface adjacent the wall, a base surface opposite the working surface, and an intermediate surface joining the working surface and the base surface. The working surface may comprise wear resistant elements disposed thereon. The base surface may be nonplanar and comprise a topography selected from the group consisting of grooves, dimples, flutes, fins, troughs, and protrusions. The base surface may also comprise an opening to the passageway. The passageway may intersect at least one of the intermediate surface and the base surface.

The pin may comprise a cross section selected from the group consisting of a circle, oval, polygon, star, rectangle with circular ends, and annulus. The pin may also comprise a sleeve surrounding at least a portion of the pin, and an aperture there through. The passageway may comprise a cross-sectional area greater than a cross-sectional area of the pin.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an orthogonal view of an embodiment of a drilling operation.

## 3

FIG. 2 is an orthogonal view of an embodiment of a drill bit comprising a plurality of pistons disposed on its outer wall.

FIG. 3 is a cross-sectional view of an embodiment of a drill bit with a plurality of pistons in an extended position. 5

FIG. 4 is a cross-sectional view of an embodiment of a piston disposed within a drill bit.

FIG. 5a is a perspective view of an embodiment of a pin with an aperture.

FIG. 5b is a cross-sectional view of an embodiment of a pin. 10

FIG. 5c is an orthogonal view of an embodiment of a pin with a groove.

FIG. 6a is an orthogonal view of an embodiment of a piston with a passageway disposed in the center of the piston. 15

FIG. 6b is a perspective view of another embodiment of a piston.

FIG. 7a is an orthogonal view of an embodiment of a piston with a pointed working surface. 20

FIG. 7b is an orthogonal view of an embodiment of a piston with a serrated working surface

FIG. 7c is an orthogonal view of an embodiment of a piston comprising at least one cutting element. 25

FIG. 7d is an orthogonal view of an embodiment of a piston retained in a tool by a shoulder.

FIG. 8a is an orthogonal view of an embodiment of a chamber comprising a round shape. 30

FIG. 8b is an orthogonal view of an embodiment of a chamber comprising a quadrilateral shape.

FIG. 8c is an orthogonal view of an embodiment of a chamber comprising a triangular shape.

FIG. 8d is an orthogonal view of an embodiment of a chamber comprising a polygonal shape. 35

FIG. 9a is a cross-sectional view of an embodiment of piston with a pin intruding therein.

FIG. 9b is an orthogonal view of an embodiment of a piston comprising an opening for the intruding pin. 40

FIG. 9c is a cross-sectional view of an embodiment of a piston with two pins disposed on opposite edges of the piston.

FIG. 9d is an orthogonal view of an embodiment of a piston with two recesses disposed on opposite edges of the piston. 45

FIG. 9e is a cross-sectional view of an embodiment of a piston with two pins disposed therein and perpendicular with respect to each other.

FIG. 9f is an orthogonal view of an embodiment of a piston with two openings for the perpendicular pins. 50

FIG. 10 is a cross-sectional view of an embodiment of a drill bit assembly with a piston disposed within and configured to push against an inner bit.

FIG. 11 is an orthogonal view of an embodiment of a plurality of pistons disposed on a drill string forming a reamer tool. 55

FIG. 12 is an orthogonal view of an embodiment of a plurality of pistons disposed on a drill string forming a clamping tool. 60

FIG. 13 is an orthogonal view of an embodiment of a plurality of pistons disposed on a drill string, forming a crawler tool.

FIG. 14 is an orthogonal view of an embodiment of a plurality of pistons disposed on a drill string and the pistons comprise at least one sensor. 65

## 4

FIG. 15 is a cross-sectional view of an embodiment of piston disposed within a cutting face of a drill bit.

#### DETAILED DESCRIPTION OF THE INVENTION AND THE PREFERRED EMBODIMENT

Referring now to the figures, FIG. 1 discloses an embodiment of a drilling operation comprising a downhole tool string 100 suspended by a derrick 101 in a wellbore 102. A steering assembly 103 may be located at the bottom of the wellbore 102 and may comprise a drill bit 104. As the drill bit 104 rotates downhole, the downhole tool string 100 may advance farther into a subterranean formation 105. The steering assembly 103 may be adapted to steer the drill string 100 in a desired trajectory. The drill string 100 may also comprise other tools 107. The tools 107 may be expandable tools used for enlarging the wellbore 102 or stabilizing the drill string 100 in the formation 105. The downhole tool string 100 may comprise electronic equipment able to send signals through a data communication system to a computer or data logging system 106 located at the surface.

FIG. 2 discloses an orthogonal view of an embodiment of the drill bit 104 connected to the drill string 100. The drill bit 104 may comprise a cutting face 201 and a gauge surface 202. The drill bit 104 may comprise a plurality of blades 215 converging at a center of the cutting face 201 and diverging at the gauge surface 202. The blades 215 may be equipped with cutting elements 220 configured to degrade the formation 105. Fluid from drill bit nozzles 225 may remove formation fragments from the bottom of the wellbore and carry them up an annulus 203 of the wellbore.

The present embodiment discloses the drill bit 104 configured to be a housing for a piston assembly 204. At least one chamber (hidden from view) may be formed in a wall 205 of the housing on the gauge surface 202. A piston 206 may be disposed within each chamber and may be configured to translate relative to a pin (hidden front view). The pin may be inserted into the piston 206 to retain the piston 206 in the piston assembly 204. The pin may be inserted through at least one entry passageway 207 and attached to the chamber. 30

The piston assembly 204 may be part of a steering mechanism configured to steer the drill string 100. The piston assembly 204 may steer the drill string 100 by extending and retracting the pistons 206 which may push against the formation 105 forcing the drill string 100 to move in a desired direction. At least one chamber may be disposed relative to a desired turning radius of the drill bit 104. It is believed that the closer the pistons 206 are disposed to the cutting face 201, the greater a build rate can be for the steering mechanism. A 2.5 inch difference in placing the pistons 206 relative to the cutting face 201 may affect the steering capability by approximately 3 degrees per 100 feet. The steering mechanism of the present invention may dispose the pistons closer to the cutting face than the steering mechanisms in the prior art due to the present invention comprising substantially less working parts. Geometry constraints associated with the amount of working parts is a major limitation in placement of the steering mechanisms. The present invention also comprises smaller components that allow for larger junk slot volume leading to less restricted mud flow. 45

FIG. 3 discloses an embodiment of the drill bit 104 comprising at least one piston assembly 204, each piston assembly 204 comprising a chamber 301 and a piston 206 disposed therein. Each chamber 301 may comprise a cylin-

## 5

der or other cavity and may be configured to open to a wall **205**. The piston **206** may comprise a working surface **302** adjacent to the wall **205** and configured to come into contact with the formation. The working surface **302** may be convex and configured to match a curvature of the wall **205**.

It is believed that a plurality of chambers and pistons disposed in a drill bit may be advantageous in that it provides redundancy. If one piston becomes jammed or dysfunctional, then another piston may not be affected and the piston assembly may still perform effectively. A plurality of pistons may also be configured to actuate independently and/or in combination with each other. By acting independently and/or in combination with each other, the pistons may extend and retract at specified time periods that may maximize the effectiveness of the piston assemblies. In some embodiments, each piston in the plurality may be configured to actuate individually but at determined time intervals which may allow the pistons to work off of each other. In some embodiments, the pistons may act in uniform which may increase the push force on the formation.

The piston **206** may also comprise a base surface **303** disposed opposite the working surface **302** and an intermediate surface **308** joining the working surface **302** and the base surface **303**. In some embodiments a retaining passageway **311** may intersect at least one of the intermediate surface and base surface **303**. The base surface **303** may be nonplanar and comprise a topography selected from a group consisting of grooves, dimples, flutes, fins, troughs, and protrusions which may be in fluid communication with a fluid source such as a bore **305** via fluid channels **304**. The fluid may be drilling mud that is sent through the bore **305** of the drill string during normal operation. A valve (not shown) may redirect a portion of the drilling mud to the fluid channels **304** thus causing the piston **206** to actuate. In some embodiments, the fluid may be air, gas, foam, oil, water, or a combination thereof.

A pin **306** may retain the piston **206** within the chamber **301**. The pin **306** may be inserted into the retaining passageway **311** within the piston **206**. The pin **306** may allow the piston **206** to translate in a direction normal to a rotational axis **310** of the drill bit **104** but may prevent the piston **206** from rotating within the chamber **301**. By preventing the piston **206** from rotating, the degrees of freedom for the piston **206** are decreased to only linear movement. The pin **306** may be comprised of tungsten carbide or other hard material that can withstand the rotational loads that may act upon the piston **206** during normal operations.

Fluid may push the piston **206** into an extended position and the pin **306** may be configured to keep the piston **206** within the chamber **301** by allowing the piston **206** to translate a specified distance. The retaining passageway **311** may comprise an edge or other stopping device that comes into contact with the pin **306** and inhibits further translational movement of the piston **206**. The pin **306** may be adjusted to allow the piston **206** to translate within a range of 0.010 inch to 0.500 inch. The present embodiment discloses a magnified view of the piston **206** extending a distance **307** away from the wall **205**.

FIG. 4 discloses another embodiment of a piston **406** disposed in a drill bit **404**. This embodiment shows a pin **416** disposed within a retaining passageway **411** in the piston **406** and attached to a chamber **401**. The retaining passageway **411** may traverse the piston **406** such that the pin **416** passes through the piston **406**. The piston **406** and chamber **401** may comprise openings that allow passage of the pin **406**. The pin **406** may be inserted into the retaining passageway **411** through an entry passageway **417** and a plug

## 6

**402** may be inserted behind the pin **416** to prevent the pin **416** from moving during normal operation.

The chamber **401** may be lined with a sleeve **403** which may also comprise openings to allow passage of the pin **416**. The sleeve **403** may comprise a finish that allows the piston **406** to translate without having to overcome a substantial amount of friction. The sleeve **403** may also increase the life of the piston assembly. During normal operation, the piston **406** may translate back and forth causing the sleeve **403** to wear down over time. After the sleeve has worn down a specified amount, the sleeve **403** can be replaced. In other embodiments, the walls of the chamber **401** may be in direct contact with the piston **406**. However, when the walls of the chamber **401** are worn down, the whole piston assembly may not be functional.

The piston **406** and sleeve **403** may collectively comprise a tight tolerance, around 0.001 inch diametrical difference between the two, that small particles may be prevented from jamming the system. The piston **406** and the sleeve **403** may be composed of the same material allowing them to maintain the tight tolerance under large temperature changes.

During normal operations when the piston **406** is extending and retracting, fluid may become trapped within the piston **406**. The pin **416** may comprise at least one aperture **420** that is configured to allow passage for the trapped fluid. Trapped fluid may be exhausted by an opening, to the passageway **407** disposed in a base surface **413** of the piston **406**. It is believed to be important to exhaust fluid from inside the piston **406** as trapped fluid may not allow the piston assembly to function properly.

The current embodiment also discloses a seal **408** disposed around the chamber **401**. The seal **408** may be disposed between the chamber **401** and the sleeve **403**. In other embodiments a seal may be disposed between the chamber and the piston, or the piston and the sleeve. When operating in high pressure environments, fluid may enter or exit the piston assembly between the sleeve **403** and chamber **401**. The seal **408** may be configured to prevent fluid from passing through the piston assembly. In some embodiments a seal may not be necessary if the parts of the piston assembly have a tight tolerance; in other embodiments more than one seal may be needed.

FIGS. 5a and 5b disclose different views of an embodiment of a pin **506**. FIG. 5a discloses a perspective view of the pin **506** comprising an aperture **520**. The aperture **520** may be configured to allow trapped fluid to exhaust from the piston assembly.

FIG. 5b discloses a cross-sectional view the pin **506**. The pin **506** may have a non-circular or partially circular cross section and may comprise flats **501** along its length. As shown in the present embodiment, a top **502** and bottom **503** may comprise a partially circular cross section and be configured to secure the pin **506** within a piston. The flats **501** may be disposed between the top **502** and bottom **503**, may comprise a non-circular cross section, and may be parallel to each other. The flats **501** may be configured to allow the piston to translate a specified distance. In some embodiments, the pin may comprise a cross section selected from the group consisting of a circle, oval, polygon, star, rectangle with circular ends, and annulus.

FIG. 5c discloses an embodiment of a pin **510** comprising a groove **511**. The groove **511** may form a smaller cross section than the rest of the pin **510** and may be configured to allow passage of trapped fluid from the piston assembly similar to the aperture as described in FIG. 5a. In this embodiment the pin **510** also comprises a sleeve **515** surrounding at least a portion of the pin **510**.

FIGS. 6a and 6b disclose different views of an embodiment of a piston 606. FIG. 6a discloses the piston 606 comprising a retaining passageway 611. The retaining passageway 611 may comprise a substantially similar shape to a pin and a cross-sectional area greater than a cross-sectional area of the pin. As the piston 606 translates, the pin may limit the translational movement of the piston 606 as the pin comes into contact with a top edge 602 or a bottom edge 603 of the retaining passageway 611.

FIG. 6b discloses a perspective view of an embodiment of the piston 606. The piston 606 may comprise an opening 607 to the retaining passageway 611 and topography on a base surface 613. Fluid channels 604 on the base surface 613 may allow fluid to flow underneath the piston 606 so that the fluid can push the piston 606 into an extended position.

FIGS. 7a, 7b, 7c, and 7d each disclose alternate embodiments of pistons. FIG. 7a discloses an embodiment of a piston 703 comprising a pointed working surface 704. FIG. 7b discloses an embodiment of a piston 705 comprising a serrated working surface 706. The embodiments disclosed in FIG. 7a and FIG. 7b may be effective when it is desired that the piston grips a formation. An example of when it may be desirable for the piston to grip the formation is when the piston assembly is mounted on a downhole tractor tool.

FIG. 7c discloses an embodiment of a piston 707 comprising at least one cutting element 708 disposed on a working surface 709. The cutting element 708 may contact and degrade a formation. An example of when it may be desirable for the cutting element 708 to be disposed on the working surface 709 is when the piston assembly is mounted on a downhole reamer tool. Cutting elements may be selected from a group consisting of steel, stainless steel, hardened steel, nickel-based alloys, cemented metal carbide, ceramic, diamond, polycrystalline diamond, diamond-like carbon, or combinations thereof.

FIG. 7d discloses an embodiment of a piston 710 disposed within a chamber 711. The piston 710 may be retained within the chamber 711 by a shoulder 712.

FIGS. 8a, 8b, 8c, and 8d each disclose different embodiments of a chamber. A chamber may comprise a cross section selected from the group consisting of a circle, oval, polygon, star, rectangle with circular ends, and annulus. A piston may be disposed within each chamber and may comprise a shape similar to that of the chamber.

FIG. 8a discloses an embodiment of a chamber 801 formed in a wall 802. The chamber 801 comprises a round shape. The round shape may be circular or oval. The round shape may be advantageous in that it may allow a similarly shaped piston to not have sharp points that may be susceptible of breaking during normal drilling operations. The round shape may also provide the maximum contact area for a given perimeter which may allow the piston to contact a formation with the maximum amount of force, and the forces may be distributed to the formation across the greatest area.

FIG. 8b discloses an embodiment of a chamber 803 comprising a quadrilateral shape formed in a wall 804. The quadrilateral shape may comprise any shape with four sides including a square and a rectangle. The quadrilateral shape may provide a reasonable amount of surface area for a piston disposed within the chamber 803 to contact a formation.

FIG. 8c discloses an embodiment of a chamber 805 comprising a triangular shape. The chamber 805 may be formed within a wall 806 and a piston may be disposed therein. The triangular shape may consist of being acute, obese, equilateral, equiangular, isosceles, or combinations thereof. FIG. 8d discloses an embodiment of a chamber 807

formed in a wall 808. The chamber 807 may comprise a polygonal shape; in the current embodiment the chamber 807 comprises an octagonal shape. A polygonal shape may be advantageous in that the chamber 807 may comprise any number of sides allowing the chamber 807 and piston to be formatted to have the most effective shape for a given application.

FIGS. 9a, 9b, 9c, 9d, 9e, and 9f disclose different embodiments of a piston comprising at least one opening configured to allow passage of at least one pin. The functions of the at least one pin are to keep the piston inside the piston assembly and to disallow the piston from rotationally moving.

FIGS. 9a and 9b disclose different views of an embodiment comprising a pin 902 intruding but not passing through a piston 901. FIG. 9a shows a cross-sectional view of the piston 901 disposed within a wall 920 and with a pin 902 partially disposed within the piston 901. In some embodiments, a plurality of pins may each be disposed partially within a piston at different angles around the piston. FIG. 9b shows an orthogonal view of the piston 901 comprising a retaining passageway 903. The retaining passageway 903 may allow passage of the pin 902 to be partially disposed within the piston 901.

FIGS. 9c and 9d disclose different views of an embodiment comprising two pins 904 and 905 disposed on opposite edges of a piston 906. FIG. 9c shows a cross-sectional view of the piston 906 disposed within a wall 921. Each pin 904 and 905 may comprise an inner side 907 and 908 respectively, that may pass through the piston 906 while the rest of each pin 904 and 905 is connected to the wall 921. FIG. 9d shows an orthogonal view of the piston 906 comprising two retaining passageways 909 and 910. The retaining passageways 909 and 910 may be disposed on opposite edges of the piston 906 and may be configured to allow passage to the pins 904 and 905 respectively.

FIGS. 9e and 9f disclose different views of an embodiment comprising two pins 911 and 912 passing through a piston 913 disposed within a wall 922. The pins 911 and 912 may each pass through the center of the piston 913 and may be disposed perpendicular with respect to each other. It is believed that the two pins 911 and 912 may effectively keep the piston 913 from rotating during normal drilling operations. FIG. 9f shows an orthogonal view of the piston 913 comprising two retaining passageways 914 and 915. The retaining passageways 914 and 915 may be configured to allow passage to the pins 911 and 912 respectively. The retaining passageways 914 and 915 may need to be disposed one higher than the other in order for both pins to pass through the piston 913.

FIG. 10 discloses a cross-sectional view of an embodiment of a drill bit assembly 1001 comprising an outer bit 1002 and an inner bit 1003. The inner bit 1003 may protrude from the outer bit 1002 such that the inner bit 1003 may be the first to come into contact with a formation. The inner bit 1003 may be advantageous in that it may weaken the formation before the outer bit 1002 begins to degrade the formation. The inner bit 1003 may also be configured to rotationally move and thus steer the drill string.

In the present embodiment, a housing comprises a tube and at least one chamber 1004 may be formed in an inside wall 1006 within the tube. The chamber 1004 may open to the inside wall 1006 thus allowing a piston 1007 disposed within the chamber 1004 to come into contact with a body 1008 of the inner bit 1003. As the piston 1007 extends and

retracts, the piston **1007** may push the body **1008** of the inner bit **1003** thus rotationally moving the inner bit **1003** and steering the drill string.

FIGS. **11**, **12**, **13**, and **14** each disclose different embodiments of a plurality of pistons disposed in different housings wherein the housings comprise a tube or drill string, and the wall may be disposed on a surface of the tube. The housings may be selected from a group consisting of drill bits, calipers, reamers, shock absorbers, jars, clamps, tractors, stabilizers, fishing tools, or combinations thereof.

The present embodiments disclose the pistons forming at least one extendable arm that is configured to extend away from the drill string and come into contact with a formation. The pistons may be configured to translate in a direction normal to a rotational axis of the housing and may be configured to actuate independently or in combinations with each other.

FIG. **11** discloses an embodiment of a drill string **1101** comprising at least one piston **1103** disposed in at least one wall **1102**. The wall **1102** may have a greater diameter than a diameter of the drill string **1101**. The piston **1103** may comprise a plurality of cutting elements **1104** and the cutting elements **1104** may be configured to contact and degrade a formation. With the cutting elements **1104** configured to degrade the formation, the piston **1103** may form a reamer which when in an extended position may enlarge the diameter of a wellbore. There are many instances in drilling operations, such as a collapse of the wellbore, that it is desirable for the wellbore diameter to be enlarged. The piston **1103** may extend and the drill string **1101** may rotate causing the cutting elements **1104** to degrade the formation.

Valleys **1105** may be formed between walls. The valleys **1105** may allow drilling mud and debris to travel between the drill string **1101** and the formation during normal drilling operations. The wall **1102** may be configured to partially curve or spiral around the drill string **1101**. The valleys **1105** may thus also curve or spiral around the drill string **1101** which may force the drilling mud and debris to spiral around the drill string **1101** as it travels up the annulus of the wellbore. By spiraling, the drilling mud may exert forces on the drill string **1101** which may help the drill string **1101** rotate.

FIG. **12** discloses an embodiment of a drill string **1201** comprising at least one piston **1203** disposed in at least one wall **1202**. Each piston **1203** may comprise a plurality of cutting elements **1204** and the cutting elements **1204** may be configured to grip a formation. As shown in the embodiment, the cutting elements **1204** may comprise a conical shape that is used to penetrate and clamp onto the formation. By clamping onto the formation, a portion of the drill string **1201** below the piston **1203** may become isolated from a portion of the drill string **1201** above the piston **1203**. The isolated portion of the drill string **1201** may not be subject to the rotational forces applied to the top portion of the drill string **1201** by a top drive disposed at the surface and thus be able to rotate as desired from motors or other power devices disposed in the isolated portion.

The piston **1203** may also be configured to clamp onto the formation with maximum efficiency due to the ability of the piston **1203** to actuate independently of other pistons. The formation may not comprise an even surface for the piston **1203** to clamp on to so actuating independently may allow the piston **1203** to clamp onto as much of the formation as possible.

Incorporated into the piston **1203** may be a formation hardness testing mechanism. It is believed that the type of formation may be determined by measuring its hardness.

The piston **1203** may extend and the cutting elements **1204** may contact the formation. The forces applied to the piston **1203** and the amount the cutting elements **1204** penetrate into the formation may be used to determine the hardness of the formation.

The piston **1203** may be configured to work in combination with each other such that the piston **1203** may push on one side of the formation forcing the drill string **1201** against the opposite side. Forcing the drill string **1201** against one side of the formation may be desirable when measurements, such as resistivity or seismic, are taken. With the drill string **1201** in contact with the formation, the measurements may be able to better identify signals as they propagate through the formation.

FIG. **13** discloses a drill string **1301** comprising walls in a plurality of different locations along the drill string **1301**. In this embodiment, two locations on the drill string **1301** each comprise at least one wall. A top location **1302** may be disposed closer to the surface, and a bottom location **1303** may be disposed closer to the drill bit. Each location may comprise walls **1304** and **1305** respectively with a plurality of pistons **1306** and **1307** disposed thereon. The pistons **1306** and **1307** at each location may comprise cutting elements that may be configured to grip into a formation. The plurality of locations **1302** and **1303** may operate mutually to form a crawler or tractor tool. A portion of the drill string **1308** may be disposed between the top and bottom locations **1302** and **1303** and may comprise telescoping capabilities. The crawler or tractor tool may function by the pistons **1306** in the top location **1302** extending and clamping onto the formation. Motors and other power devices may move the bottom location **1303** further into the wellbore and the telescoping portion of the drill string **1308** may elongate. After the bottom location **1303** has moved a desired amount, the pistons **1307** in the bottom location **1303** may extend and clamp onto the formation. The pistons **1306** in the top location **1302** may then retract and the telescoping portion of the drill string **1308** may contract. Through these movements, the drill string **1301** may move to a desired position within the wellbore.

In some embodiments, sensors, such as resistivity or seismic sensors may also be disposed within the telescoping portion of the drill string. The pistons at each location may extend and clamp onto the formation. The sensors disposed between the top location and the bottom location may identify signals traveling through the formation because of the contact of the top and bottom locations with the formation. The signals may propagate through the formation and pistons to the sensors.

FIG. **14** discloses an embodiment of a drill string **1401** comprising at least one piston **1403** disposed in at least one wall **1402**. The piston **1403** may comprise at least one sensor **1404**. The at least one sensor may come from a group consisting of pressure transducers, linear displacement variable transformers (LDVTs), resistivity sensors, seismic sensors, or combinations thereof. The piston **1403** may extend and contact the formation allowing the sensor **1404** to gather information from the formation.

In some embodiments, the piston **1403** may comprise calipers that may be configured to measure the distance that the piston **1403** extended before contacting the formation. Because the piston **1403** may act independently of other pistons, the diameter of the wellbore at the locations of the piston **1403** may be accurately measured.

FIG. **15** discloses a cross-sectional view of an embodiment of a drill bit **1501** comprising a cutting lace **1502**. The drill bit **1501** may also comprise a bore **1503** through which

11

drilling fluid may travel. At least one chamber 1504 may be formed on the bore 1503 such that it opens to the cutting face 1502. A piston 1505 may be disposed within the chamber 1504 and be configured to translate in a direction parallel to a rotational axis 1506 of the drill bit 1501. The piston 1505 may comprise an indenting element 1507 configured to contact the formation as the piston 1505 extends and retracts.

Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications apart from those shown or suggested herein, may be made within the scope and spirit of the present invention.

What is claimed is:

**[1.** A piston assembly, comprising:  
a housing comprising a wall;  
at least one chamber formed in the wall;  
a piston disposed within the chamber;  
wherein the piston comprises a working surface adjacent the wall, a base surface opposite the working surface, and an intermediate surface joining the working surface and the base surface;  
at least one passageway through the piston;  
wherein the base surface comprises an opening to the passageway;  
at least one pin disposed within the passageway and attached to the chamber; and  
wherein the piston is free to translate relative to the pin.]

**[2.** The assembly of claim 1, wherein the chamber is in fluid communication with a fluid source.]

**[3.** The assembly of claim 1, wherein the housing is selected from a group consisting of drill bits, calipers, reamers, shock absorbers, jars, clamps, tractors, stabilizers, fishing tools, and combinations thereof.]

**[4.** The assembly of claim 3, wherein the housing consists of a drill bit and the wall and the chamber are disposed on a gauge surface of the drill bit.]

**[5.** The assembly of claim 1, wherein the housing comprises a tube and the wall is disposed within the tube.]

**[6.** The assembly of claim 1, wherein the housing comprises a tube and the wall is disposed on a surface of the tube.]

**[7.** The assembly of claim 1, wherein the chamber comprises a cross section selected from the group consisting of a circle, oval, polygon, star, rectangle with circular ends, and annulus.]

**[8.** The assembly of claim 1, wherein the piston comprises a cross sectional shape similar to the chamber.]

**[9.** The assembly of claim 1, wherein the chamber comprises openings to allow passage of the pin and fluid communication with the chamber.]

**[10.** The assembly of claim 1, wherein the chamber is lined with a sleeve and the sleeve comprises openings to allow passage of the at least one pin.]

**[11.** The assembly of claim 1, wherein the passageway intersects at least one of the intermediate surface and base surface.]

**[12.** The assembly of claim wherein the working surface comprises wear resistant elements disposed thereon.]

**[13.** The assembly of claim 1, wherein the base surface is nonplanar and comprises a topography selected from the group consisting of grooves, dimples, flutes, fins, troughs, and protrusions.]

**[14.** The assembly of claim 1, wherein the pin comprises a cross section selected from the group consisting of a circle, oval, polygon, star, rectangle with circular ends, and annulus.]

12

**[15.** The assembly of claim 1, wherein the pin comprises an aperture there through.]

**[16.** The assembly of claim 1, wherein the pin comprises a sleeve surrounding at least a portion of the pin.]

**[17.** The assembly of claim 1, wherein the passageway comprises a cross-sectional area greater than a cross-sectional area of the pin.]

**[18.** The assembly of claim 1, further comprising a seal disposed between the chamber and the piston, the piston and the sleeve, or the chamber and the sleeve.]

*19. A piston assembly, comprising:*

*a housing comprising a wall, the housing having a longitudinal axis;*

*a first piston disposed within the wall and configured to translate relative to the housing; and*

*a second piston disposed within the wall and configured to translate relative to the housing, the second piston being offset from the first piston in a direction along the longitudinal axis, and at least a part of the second piston overlapping at least a part of the first piston about the longitudinal axis, wherein the first piston and the second piston are configured to actuate independently.*

**20.** *The piston assembly of claim 19, wherein the first piston is retained within the wall of the housing by contact with a shoulder.*

**21.** *The piston assembly of claim 19, further comprising a first chamber and a fluid channel in communication with at least the first chamber, the first piston positioned at least partially within the first chamber.*

**22.** *The piston assembly of claim 19, wherein the second piston is angularly aligned with the first piston relative to the longitudinal axis.*

**23.** *The piston assembly of claim 19, wherein the first piston and second piston are configured to translate relative to the housing at a specific time period.*

**24.** *The piston assembly of claim 19, further comprising a pin extending through the first piston and part of the housing, the pin configured to limit rotational and translational movement of the first piston relative to the housing.*

**25.** *The piston assembly of claim 19, wherein at least part of the first piston or second piston includes diamond.*

**26.** *The piston assembly of claim 25, further comprising at least one cutting element positioned on a working surface of the first piston or the second piston.*

**27.** *The piston assembly of claim 19, further comprising a seal positioned between the first piston and the wall of the housing.*

**28.** *The piston assembly of claim 19, wherein the housing is selected from a group consisting of drill bits, calipers, reamers, shock absorbers, jars, clamps, tractors, stabilizers, fishing tools, and combinations thereof.*

**29.** *The piston assembly of claim 19, wherein the first piston and the second piston are configured to actuate independently and in combination with each other.*

**30.** *A method of steering a drilling system, the method comprising:*

*positioning a piston assembly adjacent a formation, the piston assembly including a first piston and a second piston, the second piston being offset from the first piston along a longitudinal axis of the piston assembly;*

*opening a valve to redirect a portion of drilling fluid;*

*extending the first piston radially using the portion of the drilling fluid applied to a base surface of the first piston;*

*contacting the formation with the first piston;*

## 13

extending the second piston radially using the portion of the drilling fluid applied to a base surface of the second piston; and

contacting the formation with the second piston, wherein contacting the formation with the first piston and the second piston pushes the drilling system to move in a desired direction.

31. The method of claim 30, wherein extending the first piston and extending the second piston occur at different times.

32. The method of claim 30, wherein extending the first piston includes applying a fluid pressure to the base surface of the first piston.

33. The method of claim 30, wherein the first piston and the second piston are both extended by a fluid pressure of a single fluid source.

34. The method of claim 30, further comprising:

measuring a first distance traveled by the first piston while extending the first piston, wherein measuring the first distance includes measuring with a first set of calipers connected to the first piston; and

measuring a second distance traveled by the second piston while extending the second piston, wherein measuring the second distance includes measuring with a second set of calipers connected to the second piston.

35. The method of claim 30, wherein extending the first piston and extending the second piston occur at different times.

36. The method of claim 30, wherein the portion of the drilling fluid is applied to the base surface of the first piston and the portion of the drilling fluid is applied to the base surface of the second piston by activating the valve.

37. The method of claim 30, further comprising connecting a bit to the piston assembly.

## 14

38. A downhole tool comprising:

a body comprising a wall, the body having a longitudinal axis and an outer surface;

a first chamber in the wall and having an opening in the outer surface of the body;

a first piston positioned in the first chamber and configured to translate within the first chamber and relative to the body;

a second chamber in the wall and having an opening in the outer surface of the body;

a second piston positioned in the second chamber and configured to translate relative to the body, the second piston being axially displaced from the first piston along the longitudinal axis, and at least a part of the second piston angularly overlapping at least a part of the first piston about the longitudinal axis; and

a valve configured to redirect a portion of a drilling fluid to contact the first piston and the second piston to cause the first piston and the second piston to actuate.

39. The tool of claim 38, wherein the first piston includes at least one sensor.

40. The tool of claim 39, wherein the at least one sensor includes at least one of a pressure transducer, linear displacement variable transformer, resistivity sensor, or seismic sensor.

41. The piston assembly of claim 38, further comprising a cutting structure.

42. The piston assembly of claim 41, wherein the cutting structure includes a bit.

43. The piston assembly of claim 42, wherein the wall is on a gauge surface of the bit.

44. The piston assembly of claim 41, wherein the cutting structure includes at least one of a bit, a caliper, a reamer, a shock absorber, a jar, a clamp, a tractor, a stabilizer, or a fishing tool.

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