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(54) Title: IMPROVED PLUG AND PLUG SEAT SYSTEM

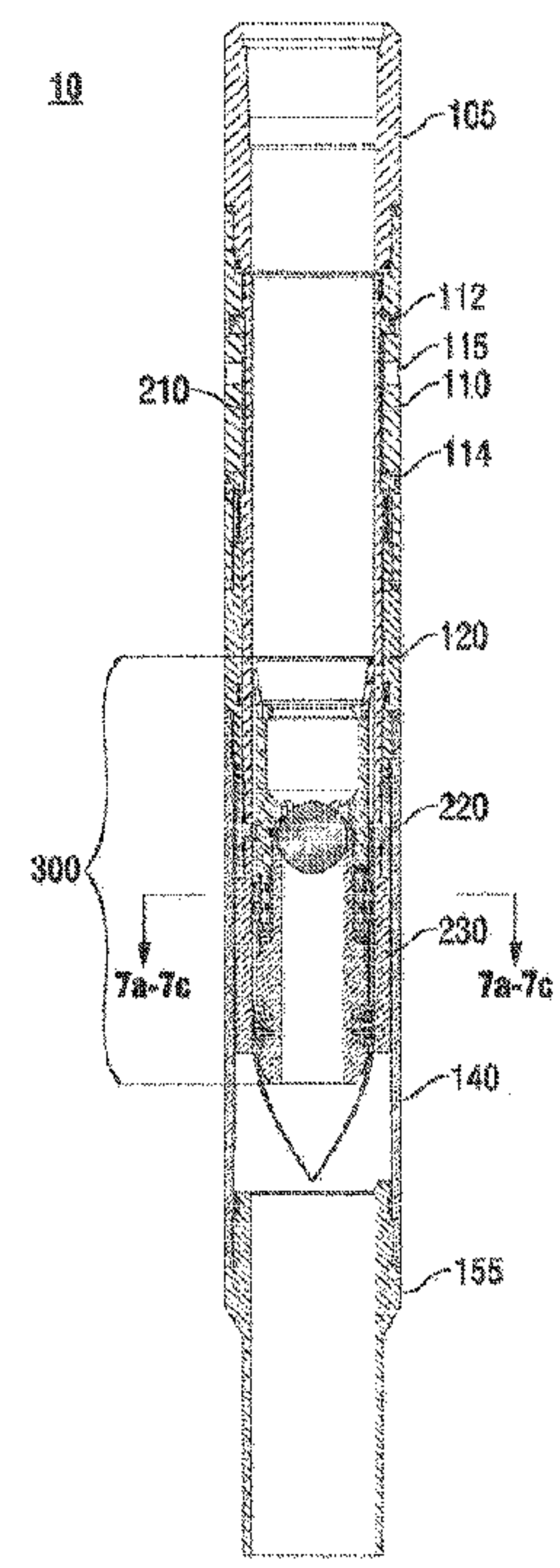

FIG. 1

(57) Abrégé/Abstract:
Plug and plug seat valves with selective orientation and engagement systems permit plugs to pass through a series of identically or similarly sized seats without the plugs mating with any of such seats before passing therethrough. Orientation systems may be employed in these valves such that the plug passes through each plug seat in a specific orientation in relation to the seat. The orientation systems may employ a steering track, such as rotational guide, to establish a desired relationship between features around the outer surface of the plug and the inner surface of the plug seat. Engagement systems may comprise one or more retractable elements on the plug which complement a receiving element of the plug seat. The orientation system may misalign the elements of the engagement system allowing a plug to pass an otherwise complementary plug seat.

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(54) Title: IMPROVED PLUG AND PLUG SEAT SYSTEM

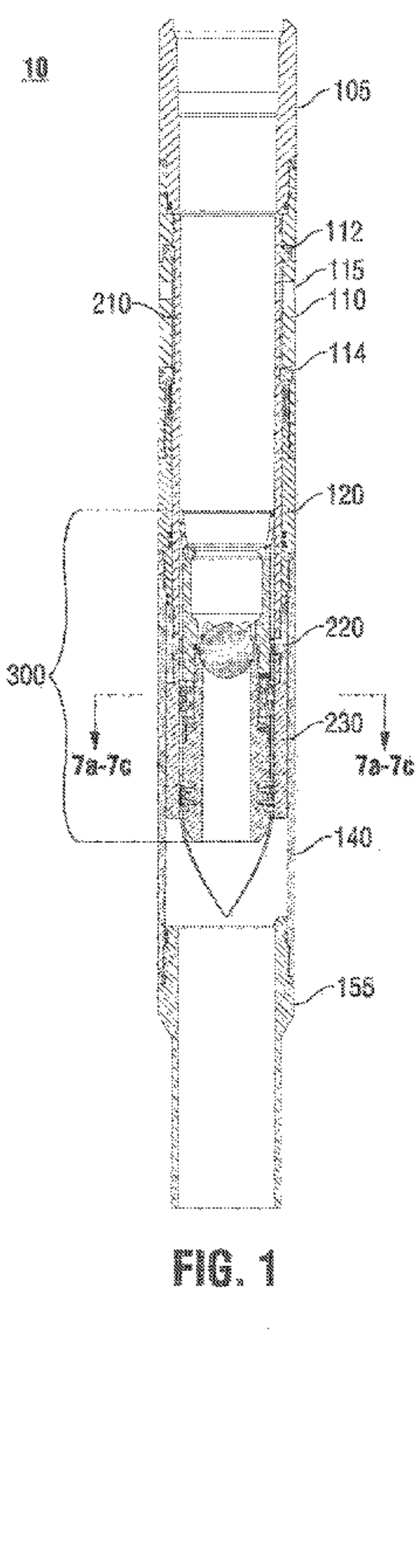

FIG. 1

(57) Abstract: Plug and plug seat valves with selective orientation and engagement systems permit plugs to pass through a series of identically or similarly sized seats without the plugs mating with any of such seats before passing therethrough. Orientation systems may be employed in these valves such that the plug passes through each plug seat in a specific orientation in relation to the seat. The orientation systems may employ a steering track, such as rotational guide, to establish a desired relationship between features around the outer surface of the plug and the inner surface of the plug seat. Engagement systems may comprise one or more retractable elements on the plug which complement a receiving element of the plug seat. The orientation system may misalign the elements of the engagement system allowing a plug to pass an otherwise complementary plug seat.

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[Continued on next page]

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TITLE

Improved Plug and Plug Seat System

BACKGROUND

Field

[0001] Sliding sleeve actuated tools, such as ported valves, may be used for accessing and/or treating subterranean formations penetrated by a well or wellbore. Such ported valves provide fluid communication between the interior flowpath of the tubing string and the exterior of the tubing at a selected location. Such valves are typically opened by pressure differential across a plug or ball landed on a corresponding plug seat. The force applied by such pressure differential overcomes a shear pin, shear ring, spring or other retaining device, causing the plug seat to move and to actuate the valve, such as by moving a sliding sleeve to expose a housing port.

Description of Related Art

[0002] Prior art sliding sleeves most often operate based on the size of the plug seat and the plug. A series of valves with progressively smaller seats (top to bottom) is placed along the tubing string. The smallest plug, typically a ball, is placed into the tubing string and falls, or is carried, to its complementary plug seat. Pressure on the plug and plug seat combination moves the sliding sleeve and actuates the tool, such as by opening the ported valve to permit fluid communication from inside the tubing to the subterranean formation adjacent to the valve. The next smallest plug is then dropped to actuate the next tool. This cycle may be repeated until the largest plug/plug seat pair are utilized.

[0003] The number of stages available in such systems is limited by the ability of the plug/plug seat pairs to hold required pressures, which may be quite high in some operation, together with the requirement that each plug must pass through all upwell seats before reaching its complementary seat. If the tubing is sufficiently large, 60 or more stages may be treated using systems in which the individual ball and seats are matched, and their tools actuated, based on their diameter. However, such systems require substantial size restrictions in the tubing string's interior flowpath, due to the progressive reduction seat size, to maximize the number of stages. Such flow restrictions may create challenges during treatment of the formation and restrict fluid flow from the wellbore to the surface. In cemented systems, such restriction complicates cementing operations because the wiper plugs or other devices used to force cement out of the tubing and into the annulus must pass through the restricted openings of the smaller plug seats while remaining capable of wiping cement along the inner diameter of the tubing.

[0004] In certain systems, complex plug seats may be used to increase the number of stages. Some systems, such as expanding ball seats with indexing sliding sleeves, allow for “catch and release” arrangement of plugs and plug seats. A plug lands on a corresponding plug seat and a pressure differential is formed across the combined plug and seat. Such pressure differential causes a counter to index by one and then the plug is released to engage the next downwell seat. After a set number of plugs are caught and released, the valve will open in response to its final plug. Other systems may use electronic counters, RFID, or other features in the tubing string so that series of adjacent tool may be actuated sequentially using balls or plugs of the same size.

[0005] A common feature of such complex plug seat systems is the larger number of parts for the plug seats. The indexing systems, electronics, flowlines, or other components of these plug seats are run in as part of the tubing string and may be subjected to the twisting, reciprocating and other processes of running thousands of feet of tubing into an often tortuous tunnel through the geological formation. Further, the systems are subjected to cement, sand, and treating fluids which may cause parts to jam and prevent the components from functioning properly. For these reasons, plug seats without such complex features may be subject to fewer failures.

[0006] The present disclosure relates to plug and plug seat systems for use in tubing, particularly tubing installed in a subterranean well. Embodiment plug/plug seat combinations as disclosed herein permit multiple plugs of substantially identical size to pass through a series of plug seats in the tubing without requiring the plug seat to separately actuate, to index, or to mechanically release such plugs. Orientation systems and engagement systems of such plug/plug seat combinations may be utilized separately or in combination to provide a desired number of stages in such systems. Embodiment valves having such plug seats according to the disclosure herein may be placed in series and opened as desired from the bottom to the top of the well by sequentially introducing embodiment plugs that successively match—have engagement and orientation elements complimentary to—the next valve to be actuated.

BRIEF SUMMARY

[0007] Embodiments of the present disclosure comprise plug/plug seat arrangements with selective orientation and engagement systems permitting the plugs to pass through a series of identically or similarly sized seats without the plugs mating with any of such seats before passing therethrough. Orientation systems may be employed such that the plug passes through each plug seat in a specific orientation in relation to the seat. The orientation systems may employ a a steering track, such as rotational guide, to establish a desired relationship between features around the outer surface of the plug and the inner surface of the plug seat. Engagement systems may comprise one or more retractable elements on the plug which complement a receiving element of the plug seat. The orientation system may misalign the plug elements of the engagement system relative to the receiving element of the plug seat. Thus, the plug may pass an otherwise complementary plug seat because the orientation system prevents matching of their respective engagement elements.

[0008] Further, embodiment engagement systems may include varying sets of complementary engagement elements, e.g plug engagement elements and plug seat engagement elements having similar or same shapes but different sizes, or elements incorporating a variety of shapes. Still further, the engaging elements may be positioned longitudinally along the plug and plug seat to increase the number of non-complementary engaging element combinations. Embodiment valves as described herein permit a significant number of valves to be placed in series in a tubing string without reducing the string's inner diameter or using valves with reciprocating or other index systems.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0009] Fig 1 is a cross sectional view of an embodiment plug/plug seat pair according to the present disclosure.

[0010] Fig. 2 is an exterior view of an embodiment plug according to the present disclosure.

[0011] Fig. 3 is an exterior view of another embodiment plug according to the present disclosure.

[0012] Fig. 4 is a cross sectional view of another embodiment plug according to the present disclosure.

[0013] Fig. 5 is an exterior view of an embodiment plug seat according to the present disclosure.

[0014] Fig. 6 is a cross sectional view of an embodiment plug seat according to the present disclosure.

[0015] Fig. 7a is a cross sectional view of a plug according to the present disclosure engaged on its corresponding plug seat.

[0016] Fig. 7b is a cross sectional view of another plug according to the present disclosure within the plug seat of Fig. 7a.

[0017] Fig. 7c is a cross section view of the plug of Fig. 7b engaged on its corresponding plug seat.

[0018] Fig. 7d is a cross section of the embodiment plug in Figure 7a within another embodiment plug seat.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0019] Figure 1 shows a cross-sectional view of a ported valve 10 comprising an embodiment plug 300 and plug seat 230 combination as it might be installed in a well or wellbore. The valve may be placed into a well as part of a tubing string (not shown) such as by connecting top connection 105 and bottom connection 155 with adjacent tubulars in the tubing string. Multiple valves may be placed along the string spaced out using other tubulars so that each ported valve is placed at its desired locations within the well.

[0020] The valve of figure 1 further comprises a ported housing 110, housing crossover outlet 120, and seat housing 140. Shifting sleeve 210 connects to plug seat 230 through sleeve crossover 220, such that downward force on plug seat 230 applies downward force on shifting sleeve 210. One or more shear pins 112 may connect the ported housing 110 to the shifting sleeve 210 preventing movement of shifting sleeve 210 until sufficient force is applied to shifting sleeve 210 to break the shear pins and release shifting sleeve 210. Shifting sleeve 210, 220, and plug seat 230 each move down, exposing ports 115 in ported housing 110 to fluid on the interior of valve 10. Such exposure allows fluid to flow from the interior of valve 10 to the exterior of valve 10 with the plug 300 on plug seat 230 preventing fluid from moving past the valve 10 and further down the tubing string.

[0021] In some embodiments, ported housing 110 may have guide pins 114 which engage slots or grooves in shifting sleeve 210 to prevent spinning of shifting sleeve 210 or to limit travel of shifting sleeve 210, as well as sleeve crossover 220 and plug seat 230, within the tubing string.

[0022] Figures 2 and 3 illustrate two embodiment plugs according to present disclosure. Darts 300a and 300b have a body comprised of leading section 330, engagement section 340, and a lagging section 320. Leading section 330 may have one or more orienting lugs 332connected thereto. Engagement section 340 may have a plurality of spring loaded bars (Fig. 2, 342a and Fig. 3 342b), and an orientation selection element comprising selection screws 346 and holes (not shown in Figs 2 and 3) for receiving the selection screws. Orientation indicators, visible as an arrow on the leading section 330 in Fig. 2 and as numerals on the engagement section 340, may be included to identify the plug's engagement orientation, the selection of which is further described below. Darts 300 may also comprise an elastomeric seal element 310 to assist in pumping the dart 300 along a non-horizontal section of a well or wellbore and for creating a pressure seal when the dart 300 engages an appropriately configured plug seat such as plug seat 230 or other device in the well. Such seal element 310 may be a swab cup, a hydraulically compressed, extrudable seal element, or any other arrangement providing a sufficient fluid seal across the plug and the tubing or tool, as applicable, within which the dart is contained. It will be appreciated that bars 342a are of a different size than bars 342b. Specifically, bars 342a are wider (e.g. have a larger arc length) than bars 342b.

[0023] Fig. 4 is a cross sectional view of an embodiment dart according to the present disclosure. Leading section 330 with orienting lugs 332, engagement section 340 with bars 342, lagging section 320, and sealing element 310 are generally as described for Figs 2 and 3. Springs 344 may be disposed between bars 342 and engagement section 340 providing force to extend bars 342 radially outwardly.

[0024] Lead section 330 may be set by changing its relative rotation compared to engagement section 340. Orientation taps 336 in lead section 330 provide a plurality of connections for orientation screw 344. Fixing orientation screw 344 through the engagement section 340 and into a selected orientation tap 336 establishes the rotational position of leading section 330, and orientation lugs 332, relative to the engagement section 340 and bars 342. It will be appreciated that the series of orientation numbers on the exterior of the tool (shown in Fig. 2 and Fig 3) may align with or otherwise correspond to the series of orientation taps to provide a visual indication of the specific orientation/engagement arrangement for which a specific dart has been configured. In some embodiments, the orientation taps 336 may be spaced apart by three degrees though different spacing is within the scope of the present disclosure. Further, bars 342 may be spaced around the circumference of dart 300 with centers separated by 45 degrees, e.g. 8 bars equally spaced around the dart. A combination of three degree orientation tap 336 spacing and 45 degree bar 342 spacing provides 15 rotational orientation settings for a particular dart, as reflected by the orientation indicator numbers of Fig. 3.

[0025] Embodiment darts may be solid or, as illustrated in Fig. 4, may have a passage therethrough. A ball 350 or other element may seal the passage from the flow of fluids. Ball 350 may be made of any suitable material but is preferably made of a degradable material, sealing the passage through the dart 300 until ball 350 degrades, then permitting flow therethrough. Dart 300 may have structures, such as bypass grooves 322, to permit flow past the ball 350 in one direction while an interior ball seat may prevent fluid flow past the ball 350 in a second direction. The use of a degradable ball 350 in plug 300will decrease drill out time of the plug 300 because such ball eliminates material from the plug 300 that must be drilled. Other embodiments may incorporate an internal ball or other plug of composite or other easily millable materials. For solid plugs, drill out time is increased because of excess plug material. Such solid plugs may be desirable in certain applications due to cost or other factors and are with the scope of the present disclosure.

[0026] An exterior view of one embodiment plug seat 230 is illustrated in Fig. 5 and a cross sectional view of similar embodiment plug seat 230 is shown in Fig. 6. In the embodiments of Figs. 5 and 6, the orientation element of the plug seat 230 comprises upper guide 238, lug channel 233 and lower guide 232. The outer diameter of the upper guide 238 and lower guide 232 are smaller than the outer diameter of the seat body 235. Upper guide 238 is positioned within and may be against inner surface of sleeve crossover 220, positioning upper guide as a raised feature with respect to the inner sleeve crossover. Thus, upper guide 238 and lug channel 233 may be arranged such that orienting lugs 332 engage upper guide 238 as plug 300, and particularly leading section 330, approaches plug seat 230. Such engagement causes plug 300 to rotate relative to plug seat 230 as plug 300 travels along upper guide and orienting lugs 332 to align with, or maintain alignment with, and engage lug channels 233. Engagement of orienting lugs 332 with lug channels 233 fixes the rotational relationship of plug 300 to plug seat 230. In this embodiment, upper guide

238 and lug channels 233 function as a steering track while orienting lugs 332 serve as alignment guides.

[0027] As plug 300 passes through plug seat 230, bars 342 become longitudinally aligned with engagement slots 236. If engagement conditions are met, bars 342 may expand into engagement slots 236, joining the plug 300 to plug seat 230—similarly to a bolt expanding into its opening in a door jamb. Bars 342 may then press against an end of slots 236, which functions as a receiving surface for bars 342, and transmit force from plug 300 to plug seat 230. If engagement conditions are not met, plug 300 will not become joined to plug seat 230 as bars 342 will not expand into engagement slots 236. In some embodiments, engagement conditions may include matching shape and/or size of the bars 342 (e.g. compare bars 342a in Fig. 2 to bars 342b in Fig. 3) relative to shape and/or size of engagement slots 236. Some embodiments may include, or further include the rotational setting of the plug 300 to cause or prevent alignment of bars 342 with otherwise complementary engagement slots 236.

[0028] Embodiment tools may contain anti-rotation features to facilitate drill out of the dart and/or the seat, e.g. plug seat 230 may comprise anti-rotation slots 234 for mating with opposing crenels to prevent rotation. It will be appreciated that, if plug seat 230 is rotationally locked, then engagement of orientation lugs 332 with lug channels 233 will prevent rotation of plug 300.

[0029] Figs 7a-7d are cross sections of example embodiment plugs and plug seats in both complementary and non-complementary pairs based on rotational orientation. In Fig. 7a, the plug—represented by engagement section 340, bars 342, and leading section 330--is positioned within and complementary to plug seat 230, which in turn lies within seat housing 140. In the embodiment shown in Fig. 7a, the plug is aligned such that selection screw is fastened into the orientation tap such that two opposing bars 342 are aligned with orienting lugs 332 and therefore 342 aligned with the opposing lug channels 233 of plug seat 230 (corresponding to orientation number 1 in Fig. 2). The remaining bars 342, which may be spaced circumferentially by 45 degrees, align with engagement slots 236 which are spaced circumferentially at 45 degrees from each other and from lug channels 233. In other words, the rotational spacing of bars 342 relative to lugs 332 matches the rotational spacing of engagement slots 236 relative to lug channel 233. Thus, in Fig. 7a, the orientation system of the plug seat 230 is complementary to the orientation system set for the plug, aligning the bars 342 and engagement slots 236. Further, the bars 342 are of a size and shape that allows bars 342 to fit into the orientation slots 236. It will be apparent that if the bars of Fig. 7a were wider (e.g. had a larger arc length), the bars 342 would not expand into the orientation slots 236.

[0030] Fig. 7b shows a cross section of a similar plug with a different orientation setting—the adjacent bars 342 are offset from the lugs 332 by approximately 15-20 degrees (orientation number 7 or 8 in Fig. 2)—positioned within the same plug seat 230 shown in Figure 7a. In this arrangement, bars 342 do not have the same circumferential relationship relative to lugs 332 as the engagement slots 236 have with lug channel 233. Bars 342 and engagement slots 236 therefore do not align, preventing joining of plug to plug seat, permitting the plug to pass through the plug seat and proceed to its complimentary plug seat down well.

[0031] Fig 7c illustrates a cross section of the plug 300 of Fig. 7b positioned within its complementary plug seat 230. Specifically, the alignment slots 236 are offset from lug channels 233 to the same degree as the bars 342 are offset from lugs 332 in the plug. Thus, while the plug of Fig. 7b can pass through the seat of Fig. 7b, it will join with the plug seat of Fig. 7c, allowing a pressure differential across this plug and to apply force to the plug seat and thereby actuate the tool in which such plug seat is installed. It will be appreciated that the plugs of Figs 7a and 7c have the same outer diameter and the plug seats of Fig. 7a and 7c have the same internal diameter. Thus, valves, or other downhole tools that are responsive to plugs may be sequentially and or selectively actuated by dropping progressively restricting the internal flowpath of the tubing string and without requiring more complex sleeve systems such as catch and release, timed hydraulic seat closure or others.

[0032] Figure 7d illustrates a cross of the plug of Fig. 7a positioned within a third embodiment plug seat. In the illustrated embodiment, the bars 342 closest to orientation lug 332 are offset from orientation lug by 45 degrees. The engagement slots 236 are offset from the lug channels 332 by 45 degrees as well. However, the embodiment plug seat 230 in Fig. 7d has engagement slots 236 narrower than the bars 342 of plug 300. Thus, even though the orientation of the plug matches that of the plug seat, the engagement elements are not complimentary and the plug and plug seat of Fig. 7d cannot join to actuate the tool.

[0033] Embodiment plugs and plugs seats of the present disclosure may be used to multiply the number of stages in plug actuated downhole systems. For example, using orientation systems with three degree rotational spacing and four different widths of bars 342, 60 different plug and plug seat pairs are possible. Further, bars and may be of cylindrical or other shapes, may be paired with plug seats based on the length of the bars and the engagement slots, may rely on penetration depth of the bars for joining the plug seat, or may have other characteristics to selectively join with its complementary sleeve. Orientation systems of present disclosure may employ means other than the lug and lug channel, such as magnets in both plug and plug seat for establishing the desired orientation. Further, while certain embodiments may be characterized as a dart, other configurations of plugs are within the scope hereof.

[0034] Modifications or additions to the present system will become apparent. For example, the incorporation of composite or degradable materials in plug 300 may be desirable to facilitate drill out or other removal of plug 300 from plug seat 230. In other embodiments, orienting lugs 332 may be shearable when plug 300 encounters the lower side of a plug seat 230 rather than orienting lugs engaging lower guide 232. Further, orienting lugs 332 may be spring loaded, permitting the plug seat to have an inner diameter that matches the tubing to which the plug seat is attached. In such a plug seat 230, the orientation channel 233 may be recessed relative to (e.g. have a larger diameter than) the inner diameter of such tubing. Spring loading the orienting lugs 332 may permit the lugs to compress as it passes through the tubing and permit expansion of the lugs 332 into the lug channel 233 when the plug enters the plug seat 230.

[0035] In some applications, it may be desirable to include a degradable sleeve or other cover in the plug seat to prevent the intrusion of cement or other solids into the lug channels 233 and orientation slots 236. Such covering would be designed to degrade away or otherwise expose the channel and slots prior to plug engaging the plug seat. Further, some embodiment plugs may be made, in whole or in part, of materials that degrade at a rate that is reasonably predictable depending on the fluid environment. Such materials are known in the art and their use in plugs according to the present disclosure would eliminate or reduce the need for drill out. It will be appreciated that certain embodiment plugs may experience only, or substantially only, compressive loads when pressure is applied to the joined plug and plug seat—facilitating the use of these materials in such embodiment plugs.

[0036] The present disclosure includes preferred or illustrative embodiments in which specific tools are described. Alternative embodiments of such tools can be used in carrying out the invention as claimed and such alternative embodiments are limited only by the claims themselves. Other aspects and advantages of the present invention may be obtained from a study of this disclosure and the drawings, along with the appended claims.

We claim:

1. A valve for use in a well, the valve comprising:

a plug having an exterior surface and an alignment guide, the plug having a plurality of selectively engageable shoulders; and

a plug seat having a steering track and at least one receiving surface for engaging the plurality of selectively engageable shoulders;

wherein, the valve is actuatable by introduction of the plug from the top of the well or wellbore; and

communication of the alignment guide with the steering track causes the plurality of selectively engageable shoulders to engage the at least one receiving surface.

2. The valve of claim 1 wherein the plurality of selectively engageable shoulders are positioned on at least one retractable bar.

3. The valve of claim 2 having at least one slot comprising the at least one receiving surface.

4. The valve of claim 1 wherein the steering track comprises at least one groove and the alignment guide comprises at least one protrusion extending radially outward from the exterior surface of the plug, the valve further comprising an entry section for guiding the at least protrusion into the at least one groove.

5. The valve of claim 4 having at least one slot comprising the at least one receiving surface wherein the plurality of selectively engageable shoulders are positioned on at least one retractable bar.

6. The valve of claim 5 further comprising a circumferential seal, the seal configured to prevent fluid communication across the length of the plug when the plug is engaged on the plug seat.

7. The valve of claim 6 further comprising a sliding sleeve and a ported housing, the plug seat in communication with the sliding sleeve; wherein, a pressure differential applied to the plug moves the sliding sleeve from a closed position to an open position, thereby permitting fluid to exit the valve through the ported housing.

8. A dart for use in connection with a selectively operable valve, the selectively operable valve comprising an interior surface with a steering track and a plurality of slots arranged thereon, the plug comprising:

an alignment guide for engaging the steering track;

a plurality of expandable bars; and

a seal;

wherein, the plurality of expandable bars is complementary to the plurality of slots;

the alignment guide is arranged circumferentially with respect to the plurality of expandable bars such that engagement of the alignment guide with the steering track permits expansion of the plurality of expandable bar into the plurality of slots.

9. The dart of claim 8 further comprising an interior passage with a passage plug therein preventing fluid flow through the interior passage in at least one direction.

10. The dart of claim 9, the interior passage further comprising a grooved seat for engaging the passage plug, the grooved seat permitting fluid flow through the interior passage in at least one direction.

11. The dart of claim 9 wherein the passage plug is configured to degrade in the wellbore fluids.

12. The dart of claim 8 further comprising an orientation adjustment for changing the circumferential arrangement of the bars with respect to the alignment guide.

13. The dart of claim 8 wherein the bars in the plurality of bars and the slots in the plurality of slots are rectangular.

14. A method for preparing a well for treatment in at least one petroleum production zone formation in which a production tubing is inserted into the well, the method comprising:

as the production tubing is inserted into the well, providing a first sliding sleeve valve, a second sliding valve and a third sliding sleeve valve to be positioned at predetermined locations along said production tubing, said sliding valves each having a steering track and a plurality of receiving surfaces, being shiftable from a closed position to an open position and having one or more openings that enable communication of fluid flow from within the sliding sleeve valve to an outside of the sliding sleeve valve when shifted open;

recording the location along said production where the first sliding valve, the second sliding valve and the third sliding valve are positioned along said production tubing;

identifying a plug with an alignment guide and expandable bars complementary to the steering track and the plurality of receiving surfaces the first sliding valve.

15. The method of claim 14 wherein at least one slot comprises the plurality of receiving surfaces.

16. The method of claim 14 further comprising introducing the plug into the production tubing and engaging the alignment guide with the steering track of the third sliding valve, thereby

preventing engagement of the plurality of expandable bars with the plurality of receiving surfaces of the third sliding valve.

17. The method of claim 16 further comprising engaging the alignment guide with the second sliding valve steering track, thereby preventing engagement of the plurality of expandable bars with the second sliding valve plurality of receiving surfaces.

18. The method of claim 14 further comprising introducing the plug into the production tubing and engaging the alignment guide with the steering track of the third sliding valve, wherein the the plurality of expandable bars are too large in at least one dimension to allow engagement of the plurality of expandable bars with the receiving surfaces of the third sliding valve.

19. The method of claim 18 further comprising engaging the alignment guide with the second sliding valve steering track, thereby preventing engagement of the plurality of expandable bars with the second sliding valve plurality of receiving surfaces.

20. The method of claim 14 wherein the first sliding valve, the second sliding valve, and the third sliding valve each have a smallest inner diameter that is substantially the same.

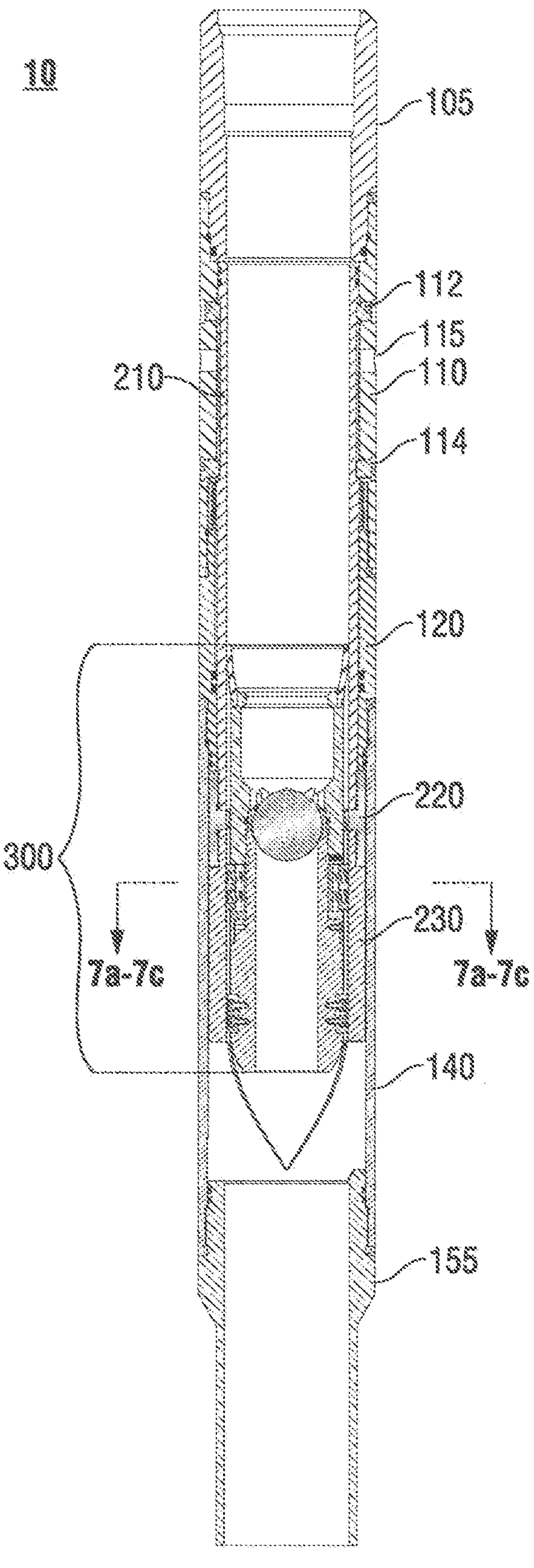

FIG. 1

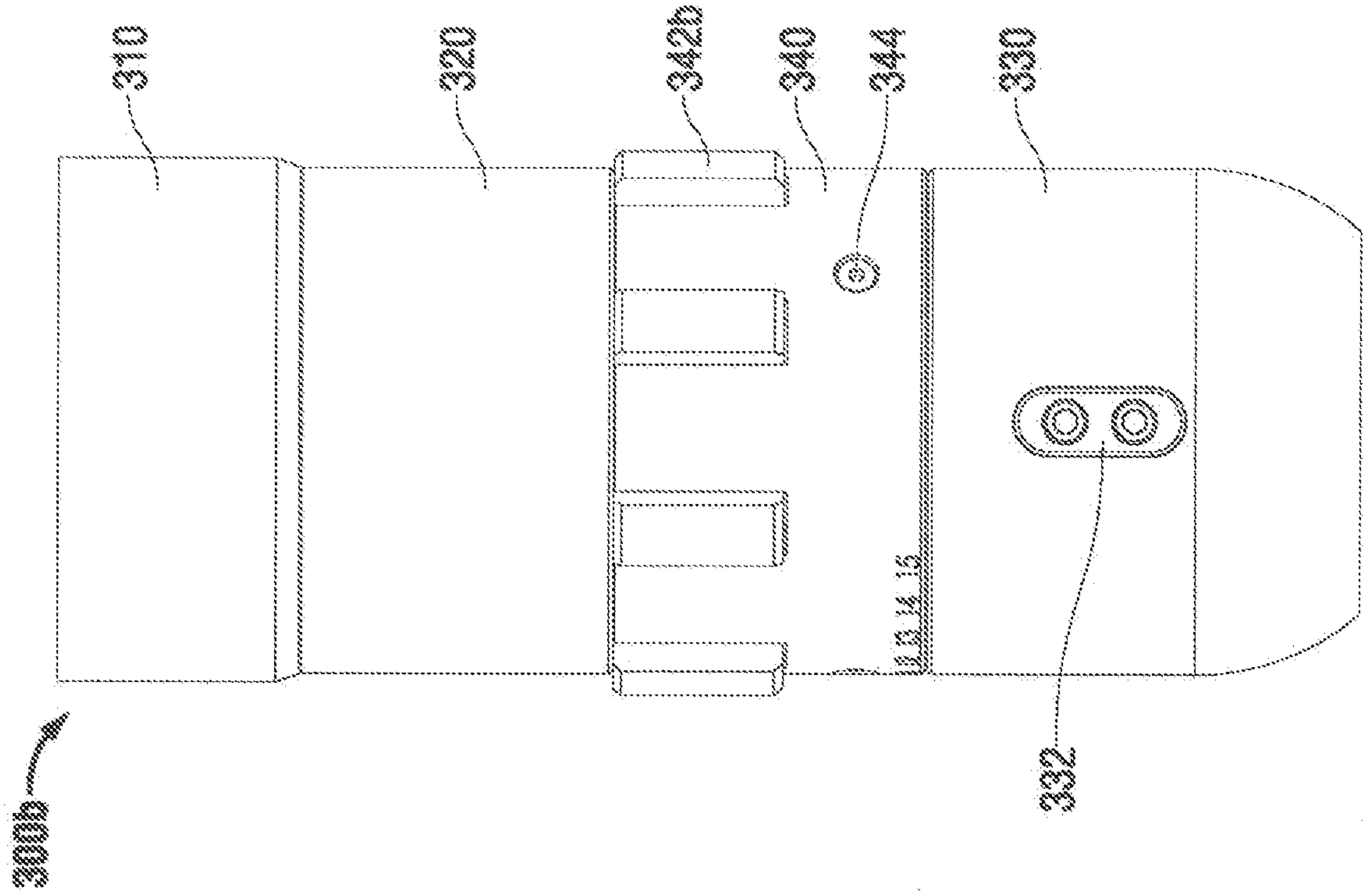
310
320
342b
340
344
330
332
300b

FIG. 3

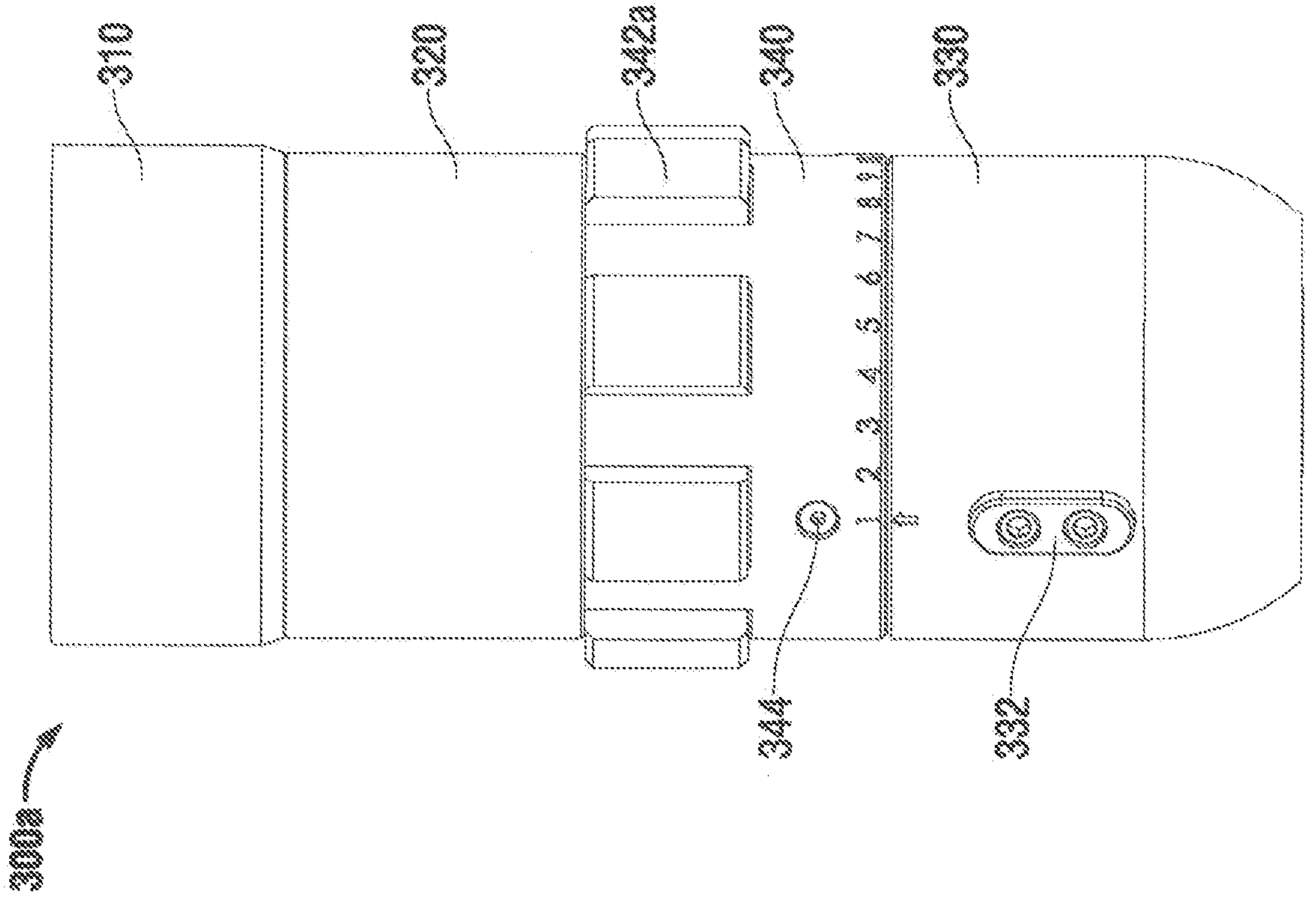
310
320
342a
340
330
344
332
300a

FIG. 2

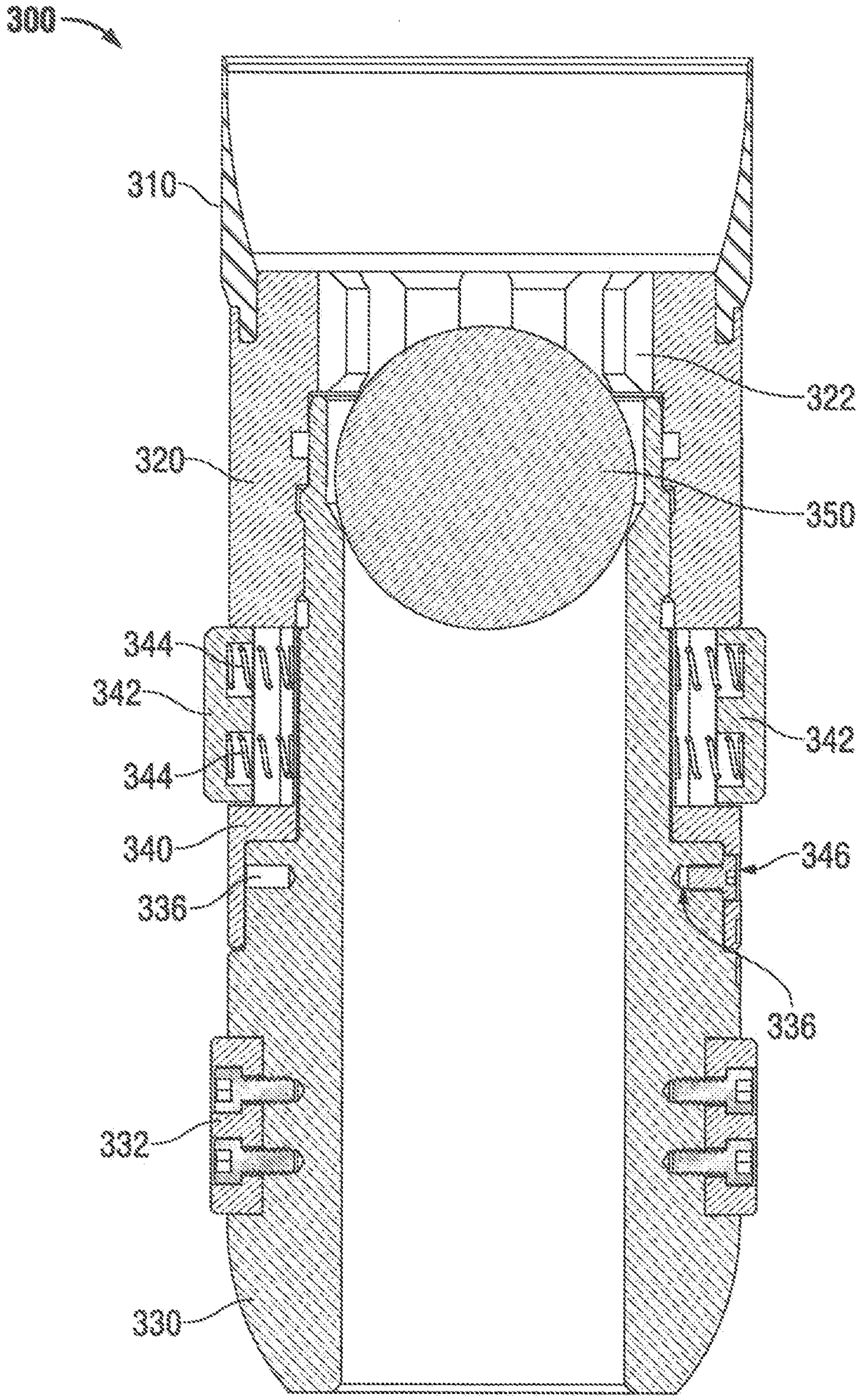

FIG. 4

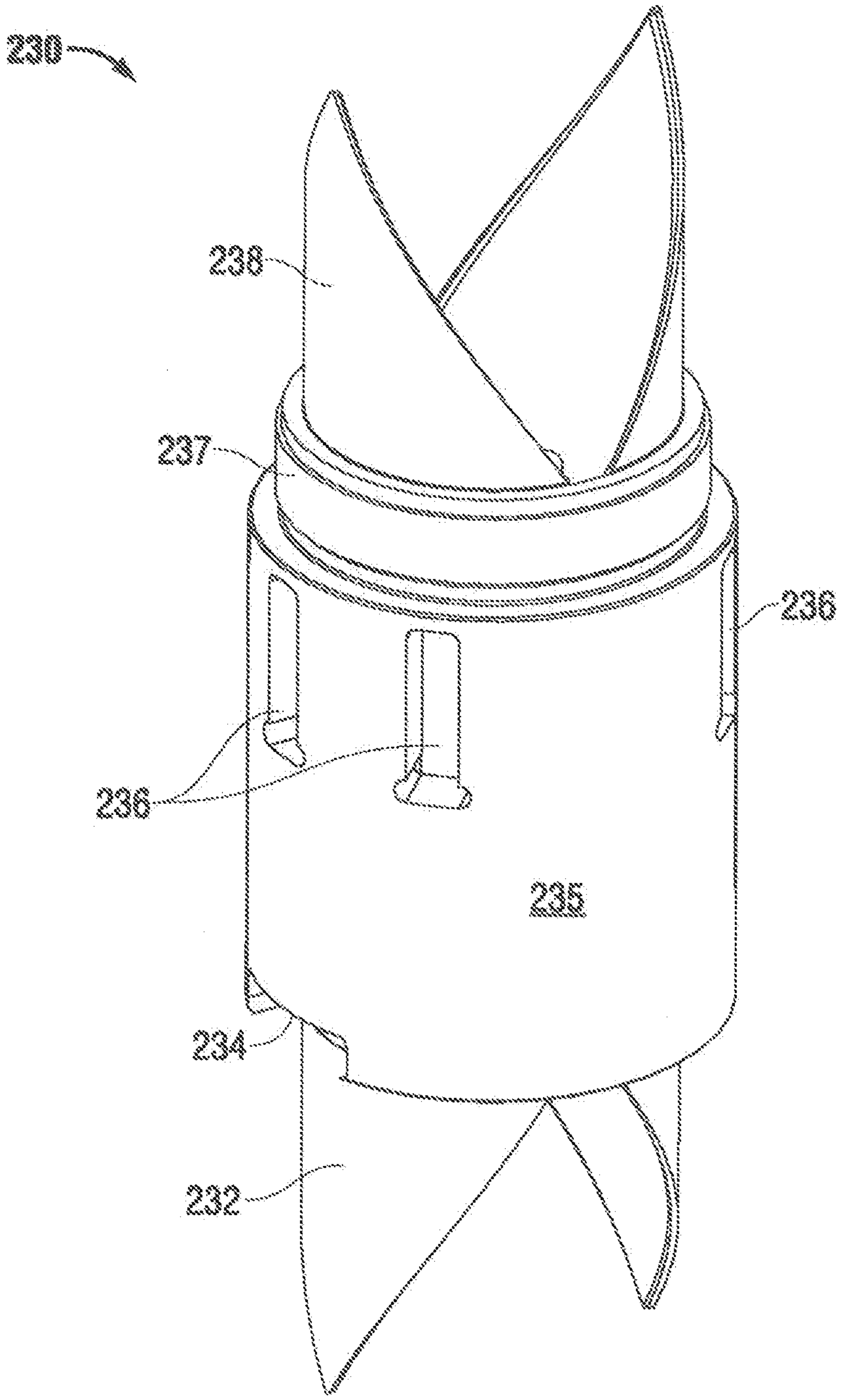

FIG. 5

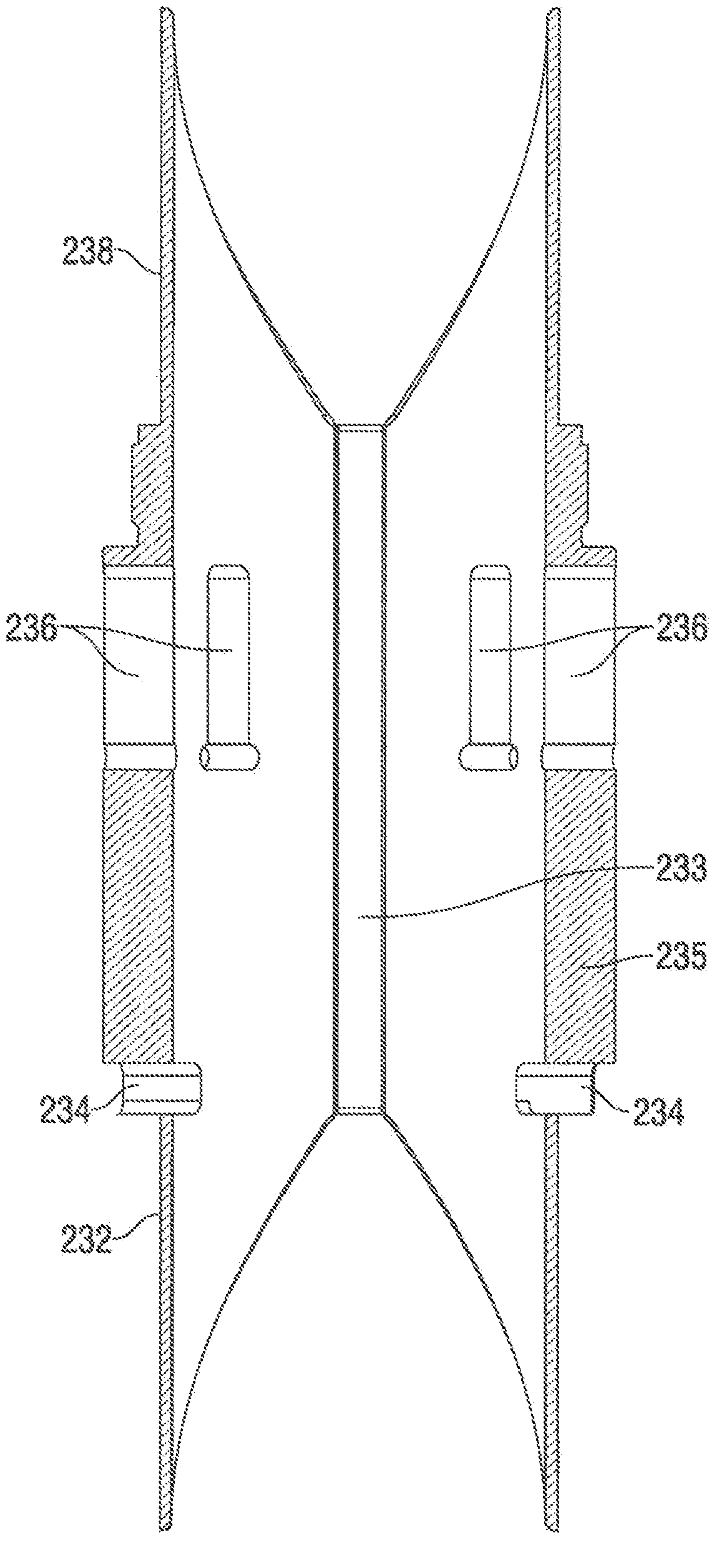

FIG. 6

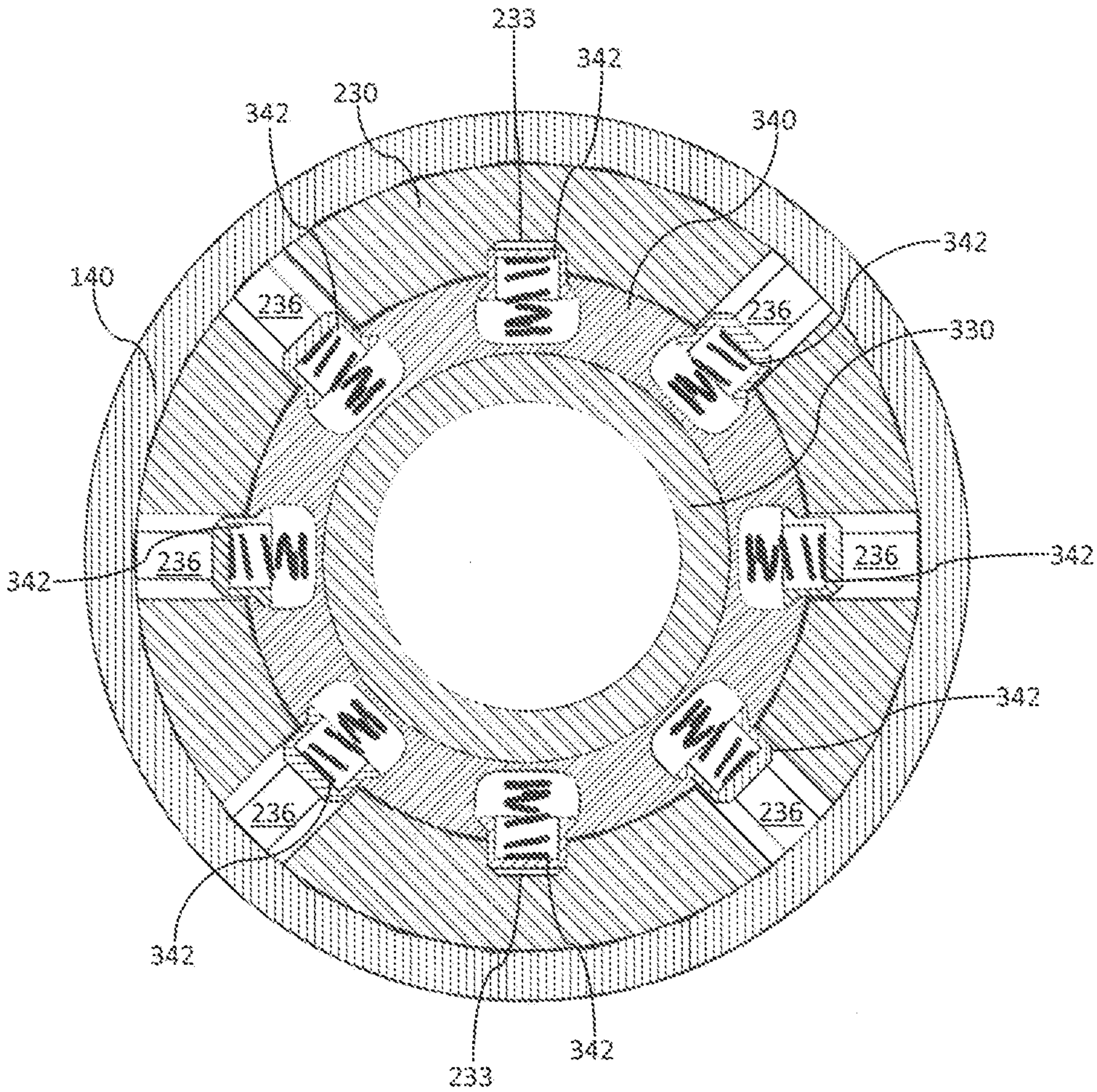
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FIG. 7a

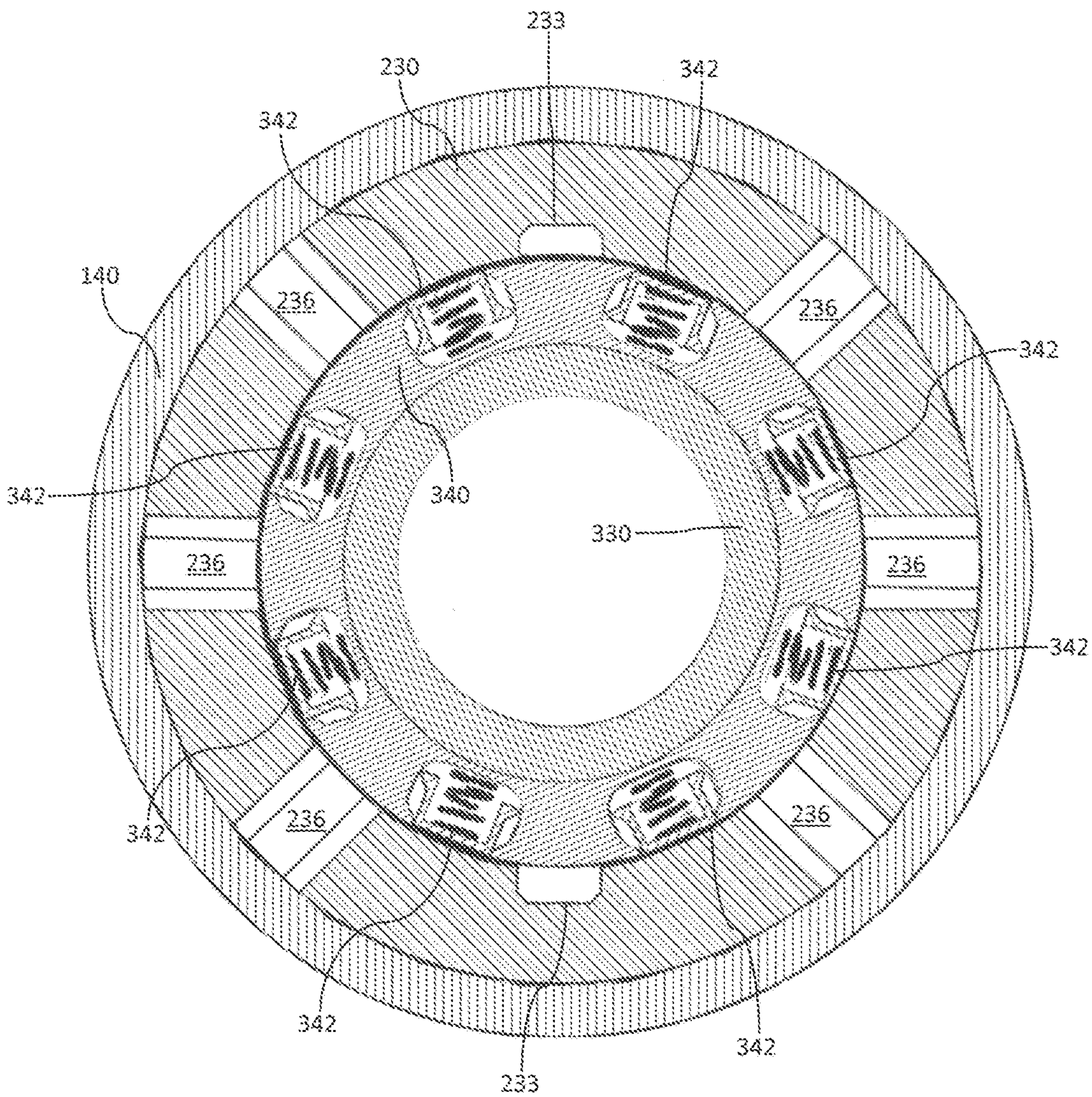
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FIG. 7b

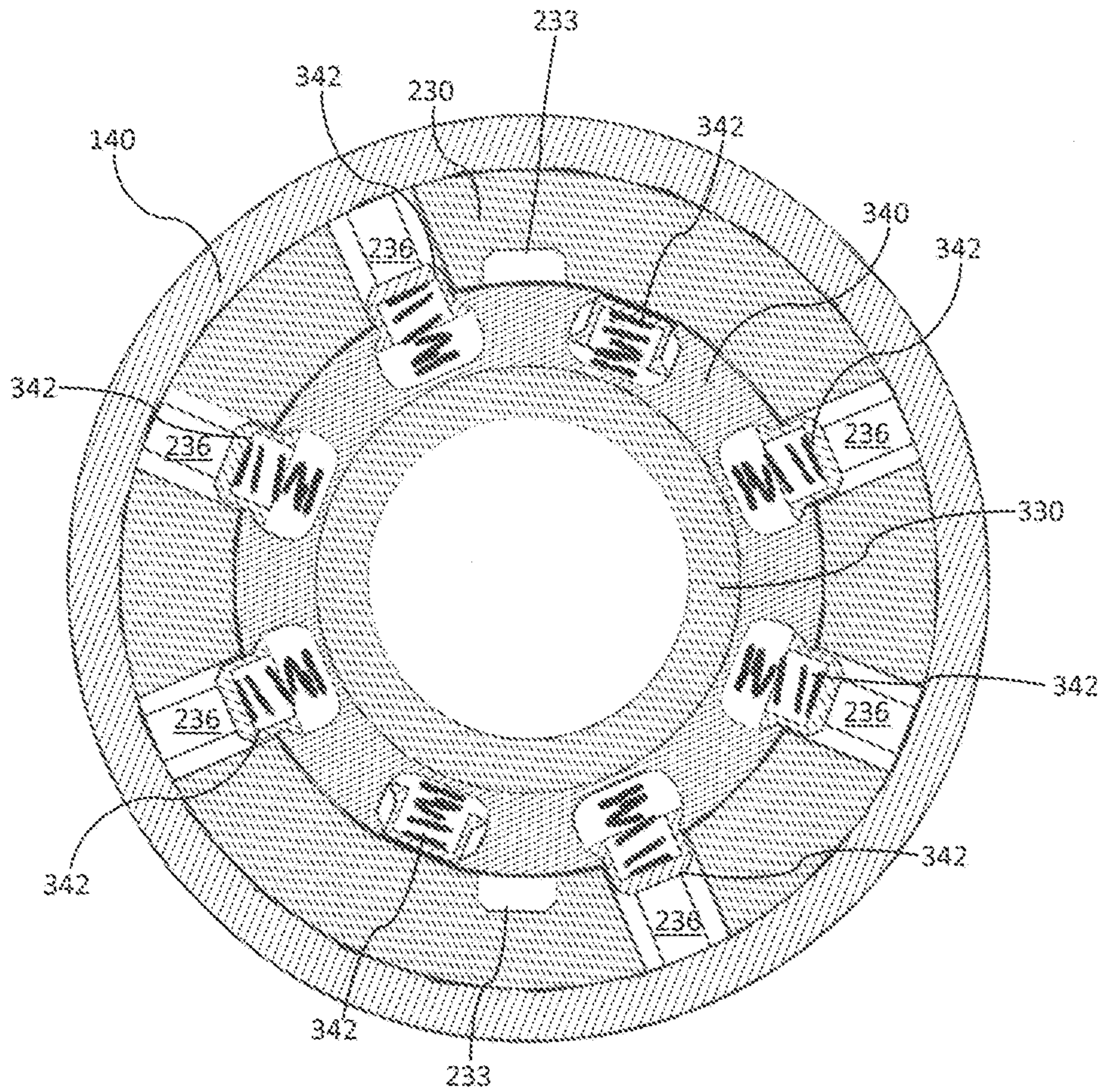
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FIG. 7c

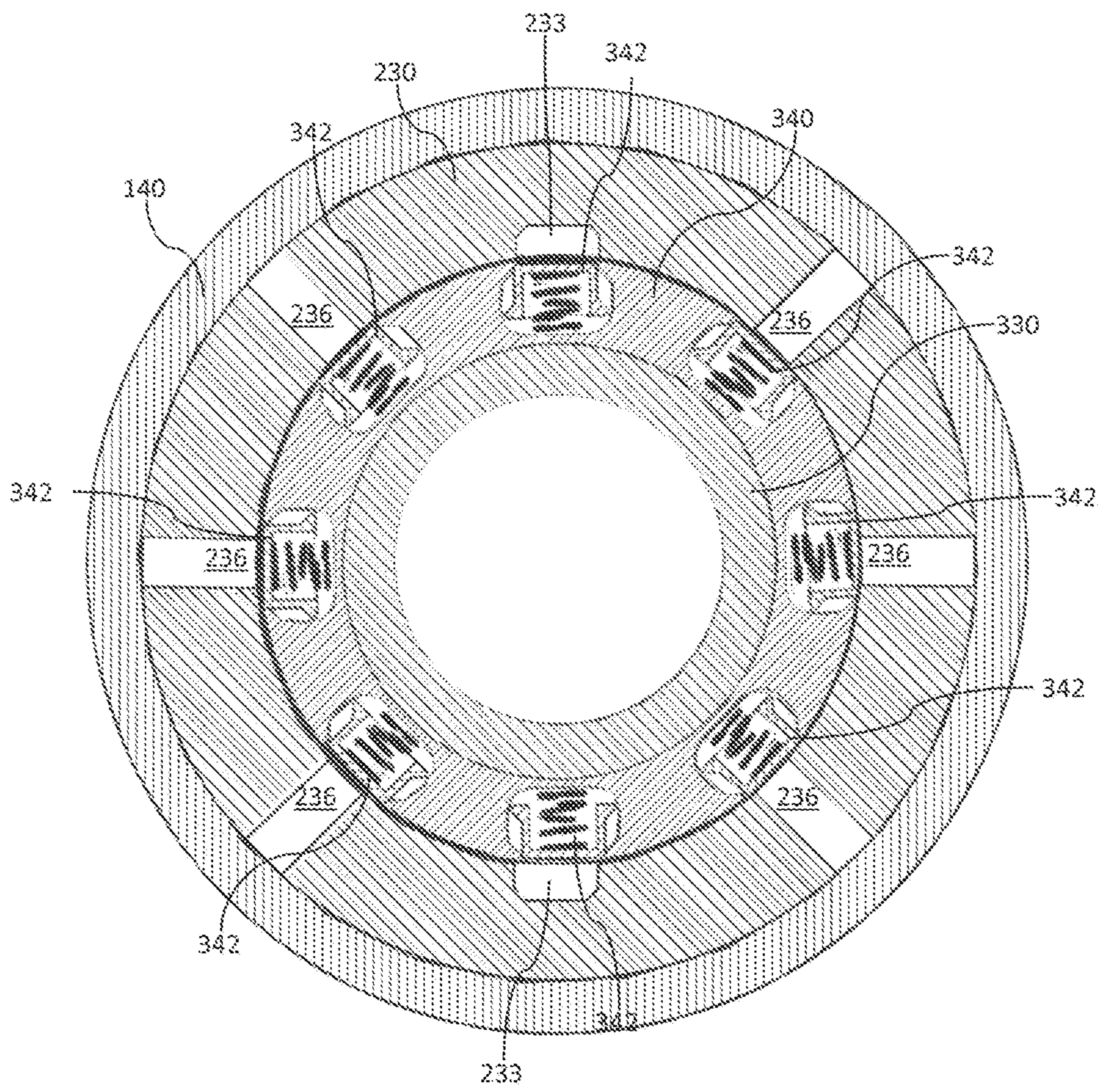
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FIG. 7d

FIG. 1