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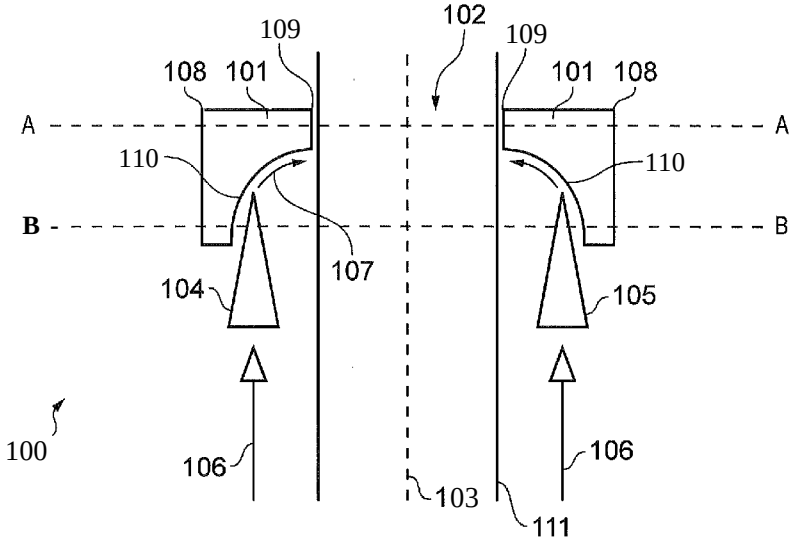

FIG. 1A

(57) Abstract: An apparatus, a module, a device and a method for shearing objects are disclosed. The apparatus is configured for insertion into a borehole. The apparatus comprises: a primary axis;a movable shearing means; and a deflecting means. The deflecting means and the movable shearing means are mutually configured such that, when the movable shearing means is driven by a driving force in a direction parallel to the primary axis, the movable shearing means slides along the deflecting means and at least a portion of the movable shearing means is deflected in a direction towards to the primary axis.

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AN APPARATUS, MODULE, DEVICE AND METHOD FOR SHEARING OBJECTS

FIELD OF THE INVENTION

Embodiments of the present invention relate to an apparatus, module and device for shearing. In particular, though without prejudice to the foregoing, certain embodiments relate to an apparatus, module, device and method suitable for use down boreholes or wellbores of oil, gas or geothermal wells, wherein the apparatus configured to be inserted therein to remotely shear objects passing through the apparatus such as tubing and/or wirelines.

BACKGROUND TO THE INVENTION

Surface Pressure Control Equipment (PCE) and surface Blow Out Preventers (BOP) can include multiple surface shear rams to cut coil tubing or wireline passing therethrough. Such shearing devices use shear rams which are driven by horizontally aligned hydraulic pistons. Such shearing devices are physically too large to operate down hole below a rotary table and are designed for surface use only.

Subsea safety tools, such as a Sub Sea Test Tree (SSTT) are either unable to cut/shear larger size coil tubing passing therethrough (for example coil tubing whose external diameter is greater than 2 inches / 50.8 mm) or are prone to sustaining damage to their sealing faces when attempting to cut coil tubing of such a diameter. If the subsea safety tool is unable to sever the coil tubing, there is no ability to pull the coil tubing out of the landing string before master valves, e.g. in the PCE or BOP are closed. If damaged is sustained due to forces applied to the

SSTT during a shearing process, this might compromises the sealing integrity of the SSTT which is one of its primary functions.

The listing or discussion of a prior-published document or any background in this specification should not necessarily be taken as an acknowledgement that the document or background is part of the state of the art or is common general knowledge. One or more aspects/embodiments of the present disclosure may or may not address one or more of the background issues.

BRIEF DESCRIPTION OF VARIOUS EMBODIMENTS OF THE INVENTION

The invention is as set out in the independent claims.

According to one example, there is provided an apparatus for shearing, wherein the apparatus is configured for insertion into a borehole, the apparatus comprising: a primary axis; a movable shearing means; and a deflecting means; and wherein the deflecting means and the movable shearing means are mutually configured such that, when the movable shearing means is driven by a driving force in a direction parallel to the primary axis, the movable shearing means slides along the deflecting means and at least a portion of the movable shearing means is deflected in a direction towards to the primary axis.

According to another example, there is provided a method comprising: inserting into a borehole an apparatus for shearing, the apparatus comprising: a primary axis; a movable shearing means; and deflecting means; driving the movable shearing means by a driving force in a direction parallel to the primary axis; sliding the driven movable shearing means along the deflecting means; and deflecting

at least a portion of the driven movable shearing means from the deflecting means in a direction towards the primary axis.

According to one aspect of the disclosure, there is provided an apparatus comprising:

a first member comprising an aperture therethrough defining a primary axis through the first member; and

at least one movable shearing member;

wherein the first member is configured such that, when the at least one movable shearing member is driven by a driving force in a direction parallel to the primary axis, the at least one movable shearing member is guided by the first member in a direction towards the aperture.

In various but not necessarily all embodiments of the invention the shearing members are driven by a linear actuator which is aligned parallel to the primary axis, i.e. in use in a typical well bore, aligned vertically and parallel to the well bore. The vertical motion of the shearing members is at least partly transferred to motion in a perpendicular direction, e.g. horizontal motion towards a centre of the apparatus, by a deflection means/guiding member which re-directs at least part of the vertical motion to sideways motion such that the shearing members shear objects, such as coil tubing or wireline, located within the centre of the apparatus.

Embodiments of the invention enable the use of a driving means aligned with the primary axis of the apparatus, i.e. the linear stroke of the driving means is aligned with the primary axis. Advantageously this enables the apparatus to have reduced dimensions in a plane perpendicular to the primary axis, i.e. the horizontal plane, such that embodiments can have a substantially cylindrical form factor with an

inside diameter of up to 9" (22.86 cm) that enables the apparatus to fit below Pressure Control Equipment (PCE), down hole below the rotary table, below a Subsea Test Tree (SSTT) and within a Blowout Preventer (BOP) stack. For example, an apparatus according to embodiments of the invention may comprise a module of a subsea landing string. An apparatus positioned at the lower end/bottom of such a landing string would enable cutting of objects passing within the landing string such as coil tubing and the disconnecting of the landing string allowing removal of the upper sections of the landing string and riser. Advantageously, allowing the removal of the objects within the landing string protects the integrity of safety valves located above the apparatus which do not have to, themselves, close around and sever the objects within the landing string.

According to another aspect of the disclosure there is provided an apparatus comprising:

guiding means comprising a passage therethrough defining a primary axis through the apparatus; and

at least one movable shearing means;

wherein the guiding means is configured such that, when the at least one movable shearing means is driven by a driving force in a direction parallel to the primary axis, the at least one movable shearing means is guided by the guiding means in a direction towards the passage.

The apparatus may be implemented in a module, such as a component of a landing string.

The apparatus may be configured for use in a borehole or wellbore.

The apparatus may be implemented in a device, such as a shear ram tool, a pressure control equipment (PCE), a surface test tree (STT), a

subsea test tree (SSTT), a blow out preventer (BOP), a string run into an oil / gas / geothermal well or a sub-sea landing string component.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of various examples of embodiments of the present invention reference will now be made by way of example only to the accompanying drawings in which:

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS OF THE INVENTION

The Figures illustrate an apparatus 100 comprising:

a deflecting means/first member 101 comprising an aperture 102 therethrough defining a primary axis 103 through the first member; and

at least one movable shearing member 104, 105;

wherein the first member is configured such that, when the at least one movable shearing member is driven by a driving force 106 in a direction parallel to the primary axis, the at least one movable shearing member slides along the first member and at least a part of the movable shearing member is deflected by/glanced from the first member in a direction 107 towards the aperture.

Fig 1A schematically illustrates a side on view of an embodiment of the invention in a first state;

Fig 1B schematically illustrates a side on view of the embodiment of Fig 1A in a second state;

Fig 2A schematically illustrates a cross sectional view of the embodiment of Fig 1A along the line A-A;

Fig 2B schematically illustrates a cross sectional view of the embodiment of Fig 1B along the line B-B;

Figs 3A to 3C schematically illustrate side on views of further embodiments of the invention;

Fig 4A schematically illustrates a side on view of a further embodiment of the invention;

Fig 4B schematically illustrates a cross sectional view of the embodiment of Fig 4A along the line A-A;

Fig 5A schematically illustrates a side on view of a further embodiment of the invention;

Fig 5B schematically illustrates a cross sectional view of the embodiment of Fig 5A along the line A-A; and

Fig 6 schematically illustrates a side on view of a further embodiment of the invention.

The first member 101 may correspond to a deflecting means or guiding means which comprises a passage 102 therethrough that defines a primary axis through the apparatus 100. The at least one movable shearing member 104 105 may correspond to at least one movable shearing means. The deflecting means 101 may be configured such that, when the at least one movable shearing means is driven by a driving force in a direction parallel to the primary axis, the at least one movable shearing means slides along and is deflected by the deflecting means in a direction towards the passage.

The first member 101 is annular and has an outer diameter 108 and an inner diameter 109. The inner diameter defines the central aperture of the first member. The apparatus is configured such that, in a first state, a passage is provided through the apparatus parallel to the primary axis through which objects, such as coil tubing 111, wireline and/or

fluids may pass. An inner surface 110 of the first member, located between the outer and inner diameters, is shaped so as to be able to receive a first movable shearing member 104. The inner surface is shaped such that when the first movable shearing member is driven in a direction parallel to the primary axis towards the inner surface, the first moveable shearing member glances from the inner surface towards the centre of the aperture in the direction 107 substantially perpendicular to the primary axis.

Likewise, on an opposite side the apparatus, a further inner surface of the first member is shaped so as to receive a second movable shearing member 105 and to deflect/glance the movable shearing member along the inner surface in a direction towards the centre of the aperture when driven in a direction parallel to the primary axis.

A driving force 10ó in a direction parallel to the primary axis is provided to each of the shearing members. This driving force is provided by driving means (not shown in Figs 1A and 1B but is described below and shown in Fig 4A and 5A).

Fig 1A shows the apparatus in a first operational state in which the shearing members are located outside of the aperture and outside of the passage through the apparatus, such that the apparatus 100 is hollow with the passage therethrough enabling objects and fluids to pass through the apparatus.

Fig I B shows the apparatus in a second operational state in which the shearing members have been provided with a force in a (vertical) direction parallel to the primary axis which causes the shearing members to move in the vertical direction. When the shearing

members come into contact with the inner surface of the first member, the shape of the inner surface causes the shearing members to glance therefrom and to rotate and move inwards in a direction towards the centre of the aperture and passage. The opposingly located shearing members are thereby moved towards one another until their shearing edges abut one another (alternatively, the shearing members may be configured such that they overlap one another) so that an object located within the aperture/passage is sheared by the shearing members.

In use, an object, such as coil tubing 111 or wireline may be located within the aperture. According to various but not necessarily all embodiments, a tube 111 within the passage having an outer diameter greater than 2", 50.8 mm and a wall thickness of greater than 0.157" 3.99 mm could be cut. For example a tube with an outer diameter of 3 ½", 88.9 mm and a wall thickness of 0.2" 5.08 mm could be cut with embodiments of the present invention. Embodiments of the invention could be configured to shear tubing having a wall thickness of less than: 3 mm, 4 mm, 5 mm, 6 mm or 7 mm.

Once sheared, the object may be extracted. For example, where the apparatus is used down hole in an oil or gas well and coil tubing is passed through the apparatus. Following a shearing process, the coil tubing above the shearing point can be extracted and removed. Advantageously, where the apparatus is used in a landing string located below an SSTT within a BOP, i.e. such that the apparatus is located below safety valves of the SSTT and BOP, the apparatus enables the coil tubing to be severed and pulled upwards through the safety valves before their closure which preserves the integrity of the safety valves.

In the embodiments show in Fig 1A, the apparatus consists of only two movable shearing members. The first movable shearing member is located at one side of the aperture and passage through the apparatus and a second movable shearing member located substantially at an opposite side of the aperture and passage. The apparatus is configured such that at least a part of the two movable shearing members are moved towards each other.

Advantageously, by providing the first and second shearing members in such diametrically opposing positions with respect to one another, opposing forces in a (horizontal) direction perpendicular to the primary axis on either side of the first member generated during the shearing process cancel one another out. For example, the resultant force in a left direction on the first member due to the force in a right direction on the first movable shearing member is cancelled out by the opposing resultant force in a right direction on the first member due to the force in a left direction on the second movable shearing member. Such an arrangement means that no extraneous horizontal forces, i.e. forces perpendicular to the primary axis are present or transmitted to other parts of the apparatus, such as an external pressure bearing housing (not shown).

Certain embodiments of the invention include a housing and means for coupling the apparatus to other devices, such as modules in a landing string. The above mentioned configuration avoids horizontal forces being transmitted to the housing during a shearing operation, which might otherwise compromise the coupling and sealing integrity between the apparatus and a device to which is it attached. Accordingly, certain embodiments of the invention seek to maintain a

reliable and secure coupling between devices and the apparatus's housing.

Fig 2A schematically illustrates a cross sectional view of the apparatus 100 of Fig 1A, i.e. in the first operational state prior to a shearing process, along the line A-A. The first member 101 is annular having an outer diameter 108 and an inner diameter 109 defining an aperture 102 and passage through the apparatus centered on the primary axis 103. In use, an object, such as coil tubing 111 or wireline may be located within the aperture.

Fig 2B schematically illustrates a cross sectional view of the apparatus 100 of Fig 1A, i.e. again in the first operational state prior to a shearing process, along the line B-B. Here, the outer diameter 108 of the annular first member 101 and a point along the inner surface 110 are shown. Also, a cross sectional cut through of each wedge shaped shearing members shown. The shearing members are configured, i.e. shaped, dimensioned and made of a suitably hard material so as to prove a shearing edge for shearing objects within the aperture/passage of the apparatus.

Figs 3A to 3C schematically illustrate side on views of further embodiments with differing shaped inner surfaces 110 of the first member and differing shaped shearing members 104, 105. The shearing members 104 105 drawn in solid lines represent the sharing members in the first operational state / pre-shearing configuration and the shearing members 104' 105' drawn in dashed lines represent the sharing members in the second operational state / post-shearing configuration.

In Fig 3A, instead of having a gradually curving inner surface, the cross sectional shape of each side of the annular first member is substantially "L" shaped. The shearing members are shaped so that their outer surface/abutment surface 301 which contacts the inner surface/ abutment surface 110 is curved so as to cause the shearing members to rotate and move in an inward direction towards the aperture when driven towards the first member.

In Fig 3B, the inner abutment surface 110 is shaped as in Fig 1A. However, instead of wedged shaped shearing members, the outer abutment surface 301 of the shearing members which are incident on and contact the inner abutment surface is curved.

In Fig 3C, instead of having a gradually curving inner abutment surface, the inner abutment surface's cross sectional shape on each side is triangular, i.e. the such that the radius of the aperture gradually reduces in a linear manner.

It is to be appreciated that any shape of first member's inner abutment surface and shearing members' outer abutment surface (i.e. the surface of the shearing member which in incident to and contacts with the first member's inner surface) may be utilized which causes the shearing members, when driven by a force parallel to the primary axis, to move in a direction inwards towards the aperture/passage of the apparatus. The shapes and / or angles of the first member and the shearing members may be adjusted to change the operational stroke, i.e. the extent of movement of the shearing members inwards towards the aperture/passage. Thus, in various embodiments of the invention, the respective abutment surfaces are mutually configured and shaped to as to cause at least a part of the shearing members to be deflected

and glanced from the deflecting means towards the central passage way 102.

The shearing members may comprise rams shears and may be hardened steel shears.

Fig 4A schematically illustrates a side on view of an apparatus 400 of a further embodiment of the invention wherein the apparatus 400 includes a means 401 for providing a force in a direction parallel to the primary axis. Furthermore, a housing 40ó is provided to surround the various members and the driving means.

The driving means 401, may correspond to a linear actuator for providing linear motion in a direction parallel to the primary axis. This linear motion is transferred to sideways motion via the interaction of the sharing members with the first members as discussed above.

In one embodiment, the driving means comprises a hydraulic mechanism. The driving means could be a remotely operable piston 405 that is actuated via hydraulic pressure provided to the piston via a control line 402 which provides the pressurized hydraulic fluid. The piston is biased such that the apparatus remains in its first (open) state (as shown in Fig 1A) negating the necessity for a holding spring. Other forms of linear actuators would also be usable with embodiments of the present invention.

The linear actuator is aligned such that the linear movement is provides, i.e. its stroke, is in a direction parallel to the primary axis, for example, in use in a well bore, the driving means is vertically aligned as opposed to being horizontally aligned.

Fig 4B schematically illustrates a cross sectional view of the apparatus of Fig 4A along the line A-A. This shows that a single linear actuator 405 provides both the driving force for the first movable shearing member 104 as well as the driving force for the second movable shearing member 105. Moreover, the linear actuator itself comprises an aperture 403 therethrough parallel to the primary axis so as to maintain a passageway through the apparatus enabling objects to freely pass through the apparatus prior to a shearing process.

Coupling means or a linking mechanism 403 is provided to link the shearing members to the driving means to enable the shearing members to be rotatably coupled to the driving means. Advantageously, such a rotatable coupling allows the linear force parallel to the primary axis from the driving means to be transmitted to the shearing members causing movement of the same, whilst still allowing the shearing members to move towards the aperture by rotating towards the aperture due to the guiding action of the guiding means 101. Furthermore, a rotatable coupling could allow reciprocal movement, i.e. to revert back to the first state of Figl A from the second state of Fig lB, by vertical motion of the driving means in an opposite direction to its initial driving stroke direction.

Fig 5A schematically illustrates a side on view of an apparatus 500 of a further embodiment. Fig 5B schematically illustrates a cross sectional view of the apparatus 500 along the line A-A. The apparatus 500 of Figs 5A and 5B is similar to the apparatus 400 of Figs 4A and 4B, except that instead of a single hollow linear actuator, two linear actuators 501 502 are provided each with their own control line 503 504 via which the actuators can be individually controlled. The two linear actuators are

provided on opposing sides of the aperture and passage 50ó through the apparatus to enable objects to pass therethrough.

The shearing members are located, on their respective side, between the outer and inner diameters of the first member. One linear actuator 501 provides the driving force to the first shearing member 104 and the another linear actuator 502 provides the driving force to the second shearing member 105.

Fig 5B schematically illustrates a cross sectional view of the embodiment of Fig 5A along the line A-A, and clearly shows the two distinct driving means 501 502 located on opposing sides of the aperture and passage 50ó through the apparatus.

Fig ó schematically illustrates a side on view of a further embodiment of the invention. This embodiment comprises the apparatus 400 of Fig 4A and 4B with its inner housing 40ó. However, the apparatus 000 further comprises an outer housing 601. This outer housing is separate from and distinct to the first member 101.

The outer housing is provided with coupling means / joining mechanism 602 and 003 via which the apparatus 600 can be attached to other devices, such as modules of a landing string, a wear bushing or casing hanger below a rig's BOP stack and SSTT.

As previously discussed, the configuration of the first member and the shearing members ensures that any forces perpendicular to the primary axis that might arise during the shearing process are cancelled out due to the symmetry and opposing locations of the shearing members. Advantageously, this ensures that no horizontal forces due

to the shearing process are transmitted to the outer housing 601 which might otherwise affect the tensile stress of the housing and the integrity of the coupling means 602 and the seal provided thereby to an assembly of connected devices.

The apparatus of may be generally of a cylindrical shape, having a diameter configured so as to enable passage through a circular passage or aperture, such as a borehole, wellbore, tube or pipe.

In certain embodiments designed for oil, gas and geothermal drilling, it is to be appreciated that the selection of materials for various components, such as external components, would be governed by: American Petroleum Institute (API), American Society of Mechanical Engineers (ASME) and National Association of Corrosion Engineers (NACE) standards. However, the certain internal components could be substituted for other materials having properties required for their intended function, e.g. appropriate hardness for the shearing members.

The apparatus, in particular the operation of the driving means, may be remotely operable, e.g. at the surface. The apparatus may be incorporated in a standalone device or module. As used here 'module' refers to a unit or apparatus that excludes certain parts/components that would be added by an end manufacturer or a user. The apparatus may comprise a module in a landing string that is located between a Retainer valve and a lubricator valve.

The apparatus may be incorporated or integrated in a shear ram tool, a pressure control equipment (PCE), a surface test tree (STT), a sub-sea

test tree (SST), a blow out preventer (BOP), a string run into an oil/gas well or a sub-sea landing string.

In the above description, the wording 'connect' and 'couple' and their derivatives mean operationally connected/coupled. It should be appreciated that any number or combination of intervening components can exist (including no intervening components).

Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not. The components of the figs are functional and the functions described may or may not be performed by a single physical entity as shown.

Although features have been described with reference to certain embodiments, those features may also be present in other embodiments whether described or not. Features described in the preceding description may be used in combinations other than the combinations explicitly described.

Although various embodiments of the present invention have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the invention as claimed.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore

referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

We claim:

1. An apparatus for shearing, wherein the apparatus is configured for insertion into a borehole, the apparatus comprising:

a primary axis;

a movable shearing means; and

a deflecting means;

wherein the deflecting means and the movable shearing means are mutually configured such that, when the movable shearing means is driven by a driving force in a direction parallel to the primary axis, the movable shearing means slides along the deflecting means and at least a portion of the movable shearing means is deflected in a direction towards to the primary axis.

2. An apparatus as claimed in claim 1, wherein the deflecting means and the movable shearing member comprise respective abutment surfaces, wherein the abutment surfaces are mutually configured such that, in use, the at least a portion of the driven movable shearing member glances off the deflecting member towards the primary axis.

3. An apparatus as claimed in any one of the previous claims, wherein the shape of the deflecting means and the shape of the movable shearing member are mutually configured such that, when the movable shearing member is driven by the driving force in the direction parallel to the primary axis, the at least a

portion of the movable shearing member glances from the deflecting means in a direction towards the primary axis.

4. An apparatus as claimed in any one of the previous claims, wherein the direction towards the primary axis comprises at least one of: a direction towards a centre of the apparatus and a direction substantially perpendicular to the primary axis.

5. An apparatus as claimed in any one of the previous claims, wherein the apparatus is configured to have an aperture therethrough defining the primary axis and wherein the apparatus is configured to shear an object located within the aperture.

ó. An apparatus as claimed in any one of the previous claims, wherein the apparatus has only two movable shearing members.

7. An apparatus as claimed in any one of the previous claims, further comprising means for providing the driving force to the movable shearing member.

8. An apparatus as claimed in claim 7, wherein the means for providing the driving force to the movable shearing member comprises either:

an aperture therethrough parallel to the primary axis, or

a plurality of means each configured to provide a driving force to plurality of movable shearing members.

9. An apparatus as claimed in any one of the previous claims, wherein the driving force is provided via a hydraulic mechanism.

10. An apparatus as claimed in any one of the previous claims, wherein the apparatus is configured for movement within a borehole and/or within a pipe.

11. An apparatus as claimed in any one of the previous claims, wherein the apparatus is configured for operation within a borehole and/or within a pipe.

12. A module comprising the apparatus of any one of the previous claims.

13. A device comprising the apparatus of any one of previous claims 1 to 11.

14. A shear ram tool, a pressure control equipment (PCE), a surface test tree (STT), a sub-sea test tree (SST), a string run into an well or a landing string comprising an apparatus as claimed in any one of previous claims 1 to 11.

15. A method comprising:

inserting into a borehole an apparatus for shearing, the apparatus comprising:

a primary axis;

a movable shearing means; and

deflecting means;

driving the movable shearing means by a driving force in a direction parallel to the primary axis;

sliding the driven movable shearing means along the deflecting means; and

deflecting at least a portion of the driven movable shearing means from the deflecting means in a direction towards the primary axis.

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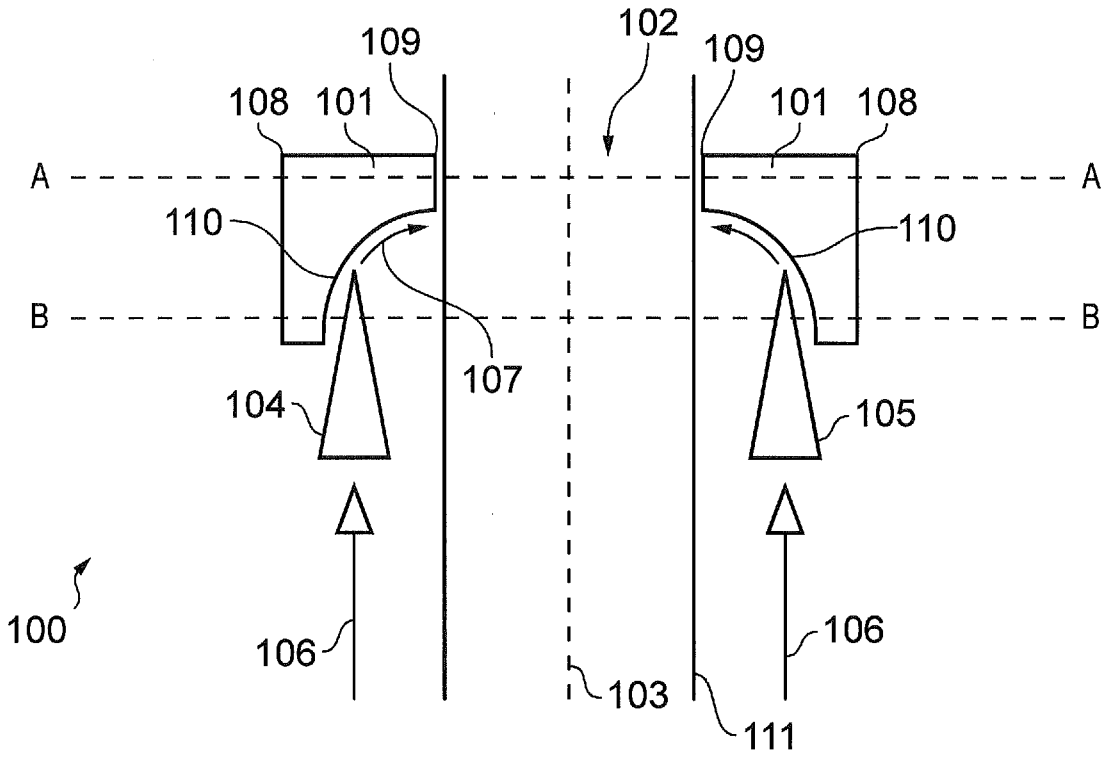
109
102
109
108
101
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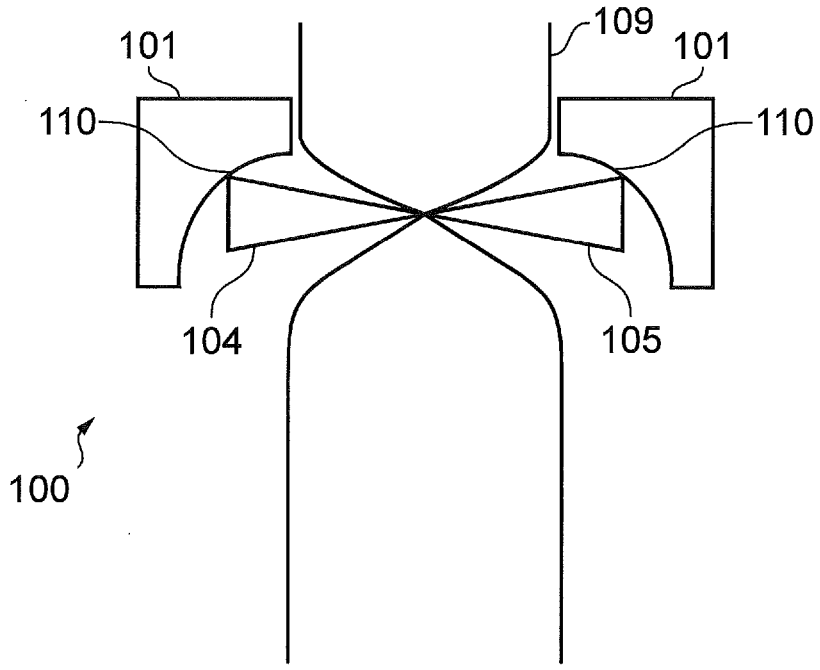
108
A
A
110
110
B
B
107
104
105
100
106
106
103
111

FIG. 1A


101
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104
105
100

FIG. 1B

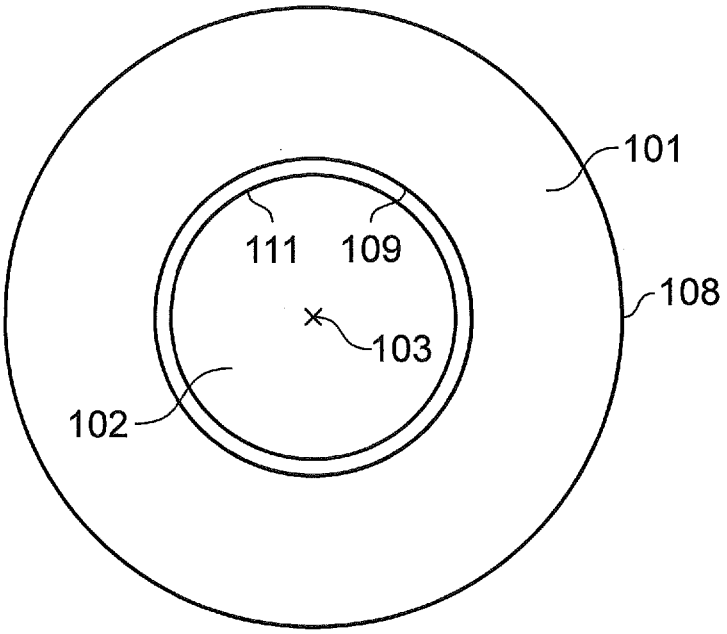


FIG. 2A

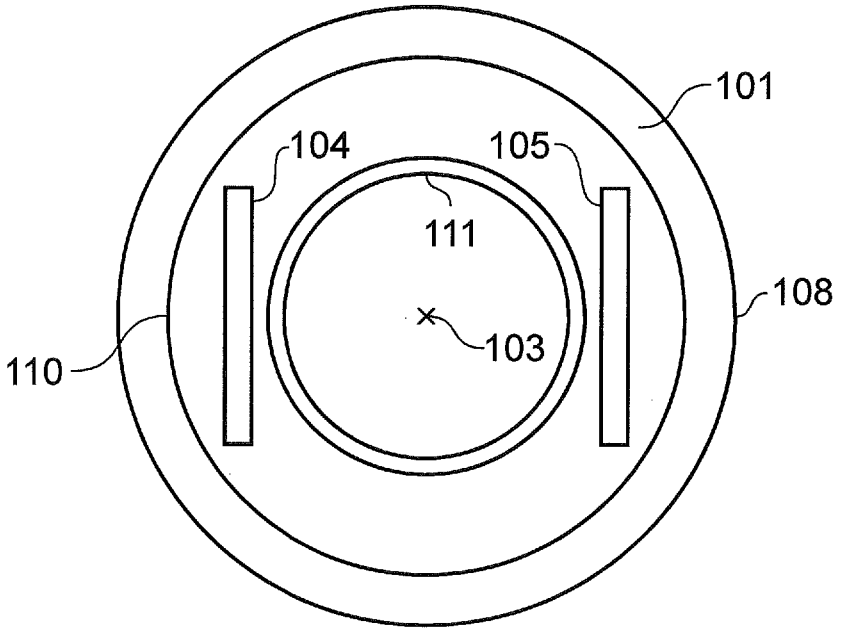


FIG. 2B

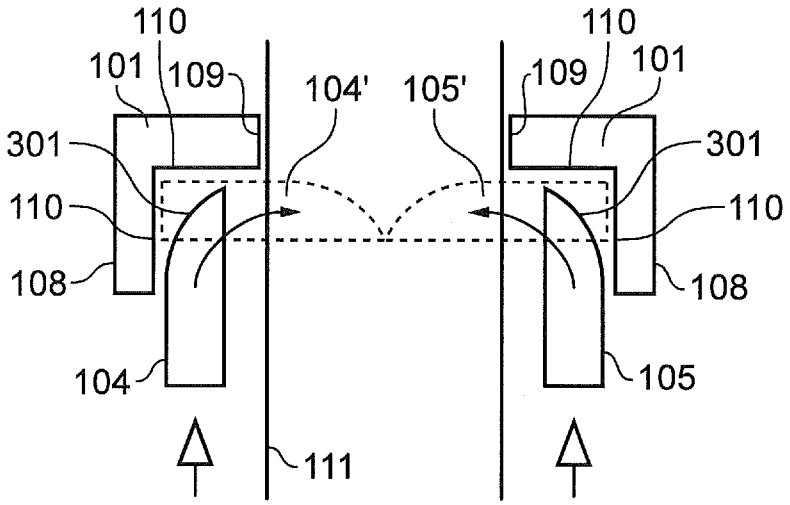


FIG. 3A

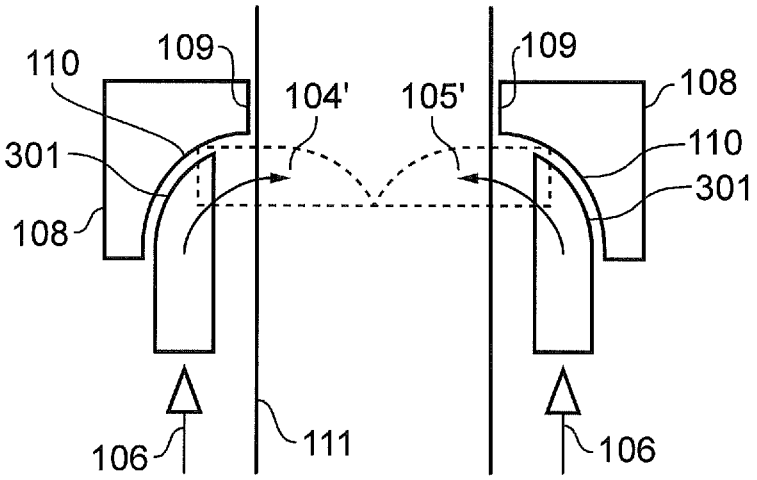


FIG. 3B

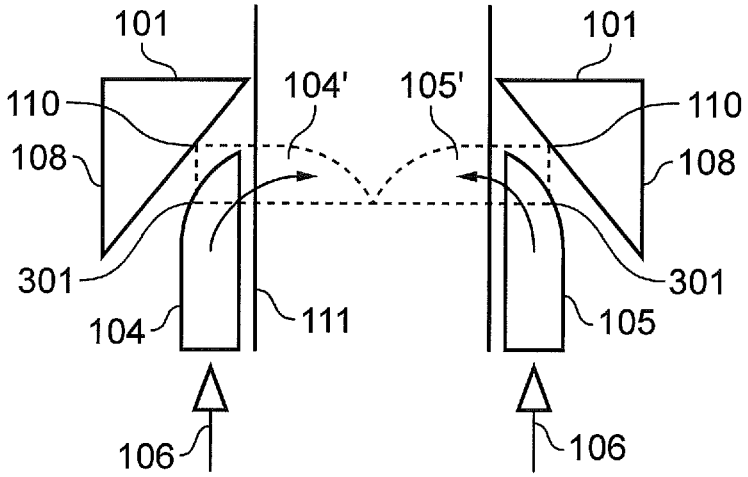


FIG. 3C

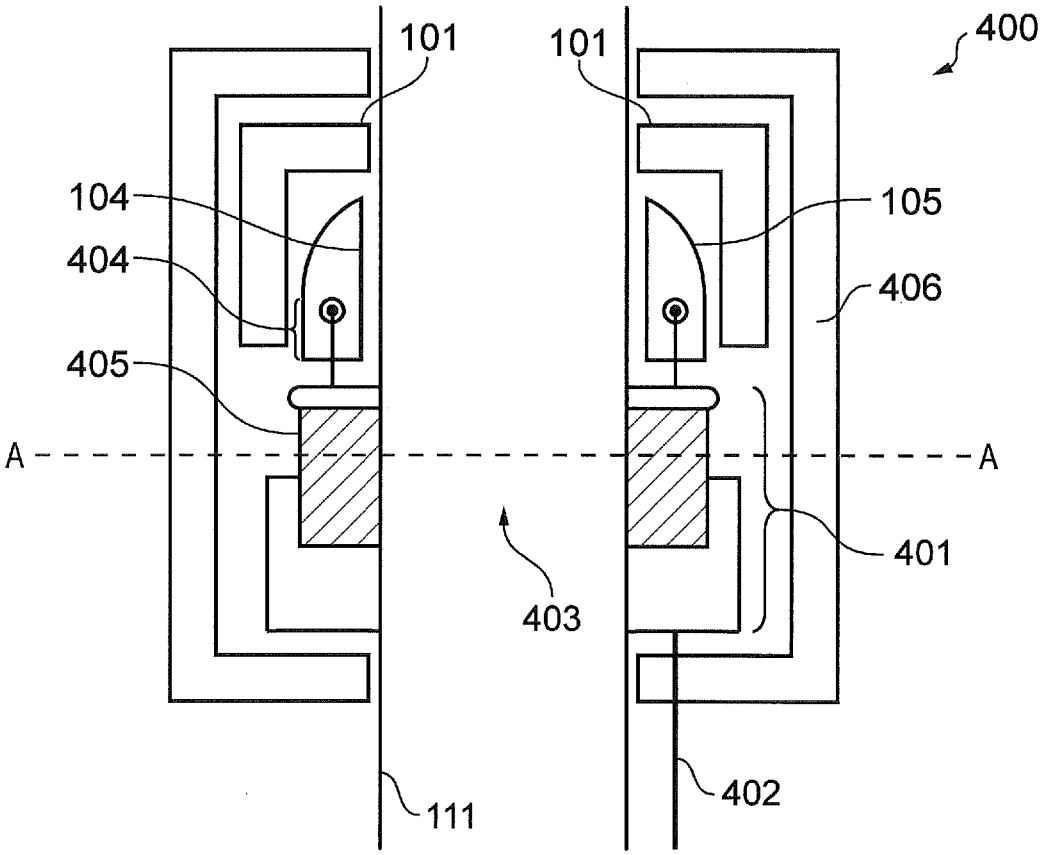


FIG. 4A

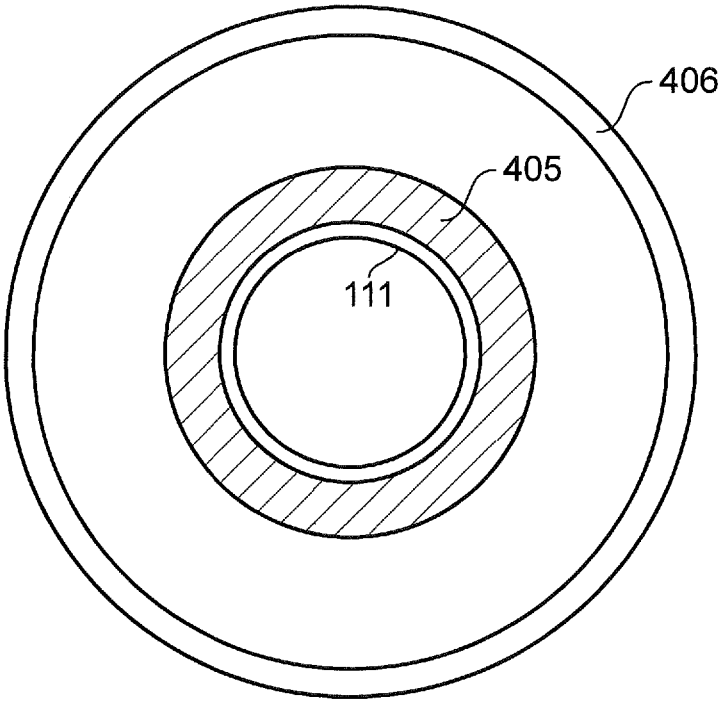
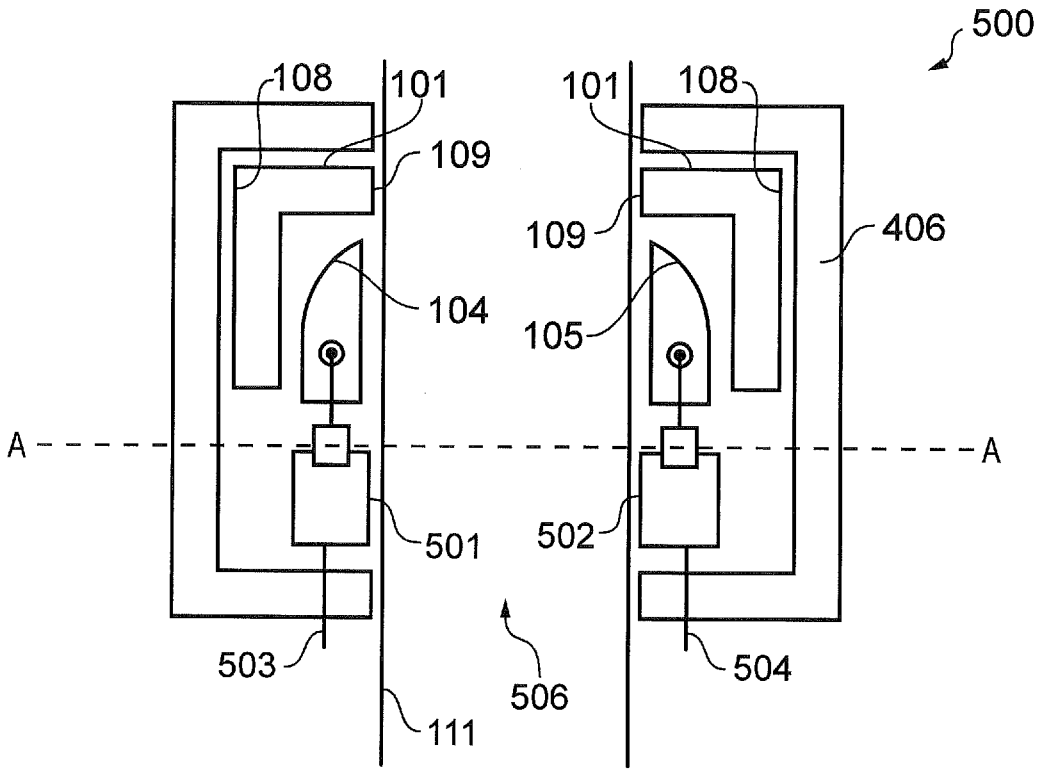


FIG. 4B


500
108
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101
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109
109
406
104
105
A
A
501
502
503
504
506
111

FIG. 5A

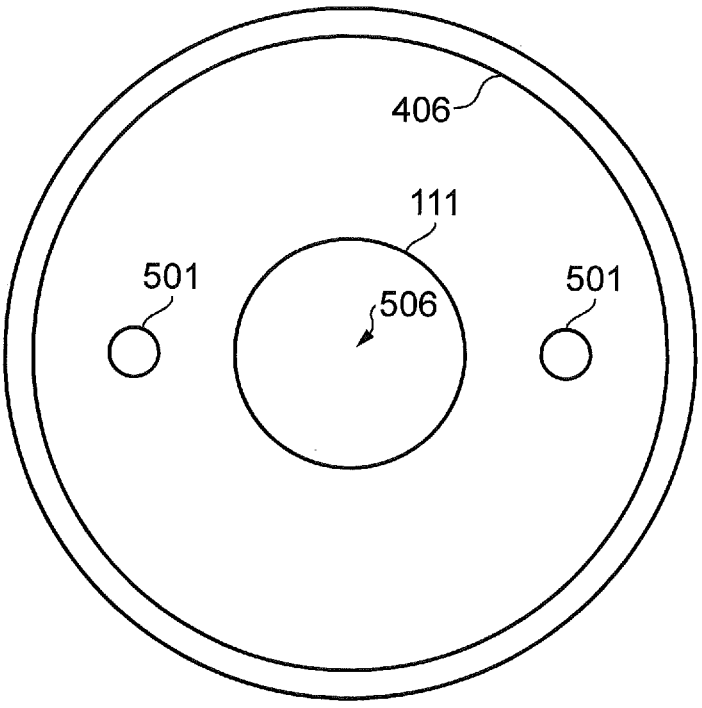
406
111
501
501
506

FIG. 5B

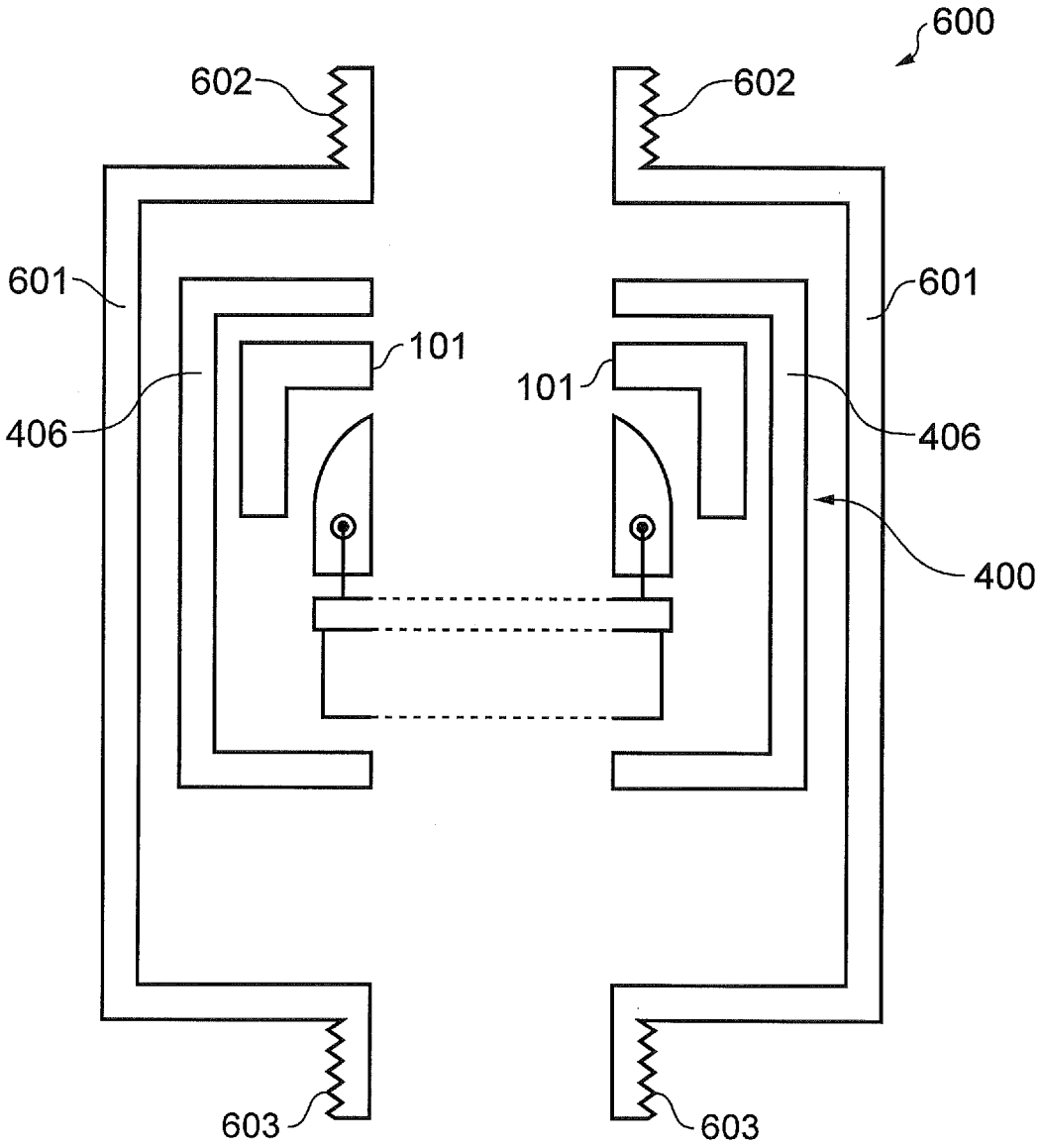

FIG. 6