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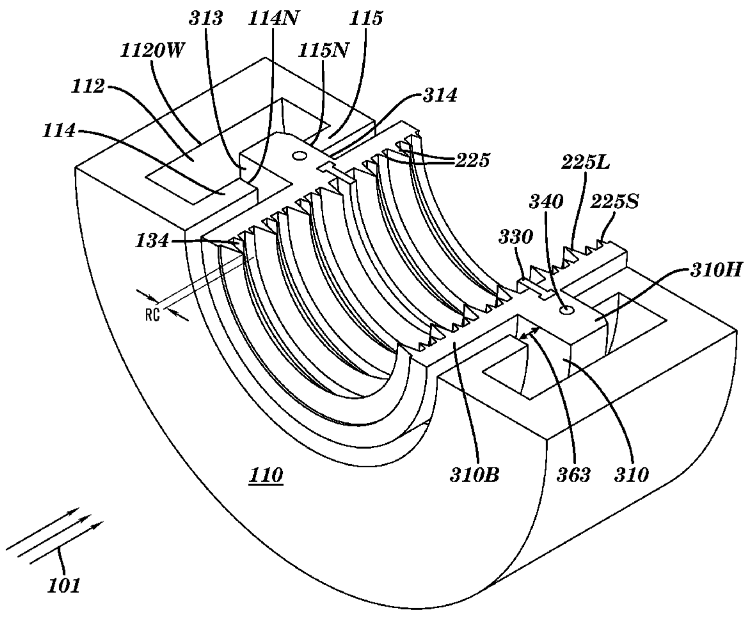

FIG. 8

(57) Abstract: An apparatus for sealing a turbine against leakage of a working fluid comprising at least one radially displaceable sealing ring, coaxially disposed about a rotating member of the turbine from a stationary member of the turbine, which sealing ring undergoes radial displacements that are coupled to radial displacements of the rotating member, such that a design radial clearance is substantially maintained without damage to the apparatus.

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FLOATING SEALING RING

1. Background of the Invention

1.1 Technical Field

[0001] The invention pertains to devices that seal against leakage of a working fluid between a stationary member and a rotating member of a turbine.

2. Related Art

2.1 Turbine Efficiency

[0002] A turbine is a machine for which the present invention provides a seal. The efficiency of a turbine depends upon its ability to maximize the conversion of thermal and kinetic energy carried by a working fluid, such as, for example, steam, into rotational energy of a rotating member that is housed in a stationary member. In steam turbines, a major loss in the efficiency of energy conversion occurs, for example, where leakage of steam bypasses (escapes) blades of the rotating member, and therefore imparts no energy to them. Leakage losses have been of concern for many years. However, with increasing fossil fuel costs and shrinking fossil fuel reserves, this concern is becoming paramount.

2.2 Sealing Devices

[0003] To address this concern, sealing devices, comprising non-contacting sealing rings that are deployed serially and coaxially along the length of a turbine's rotating member, provide sealing against excessive leakage of working fluid (e.g., steam) out of, or air into, the turbine, at all loads and under all steam conditions.

[0004] The sealing devices used in a turbine are designed to remain stationary while operating in close proximity to a rotating member. Typically such sealing devices are secured within complementary slots for their receipt ("slots"), fabricated into the stationary member of the turbine, to prevent their displacement relative to the rotating member. The efficiency of such sealing devices is directly related to their ability to prevent or reduce leakage of the working fluid.

[0005] Depending on their features, the sealing devices used, for example, in turbines, may be known as pressure packings, diaphragm packings, steam packings, steam seals, labyrinth seals, dummy rings, and gland seals.

[0006] 2.3 Sealing Rings

[0007] As indicated, *supra*, a component of such sealing devices is a non-contacting sealing ring. As its name implies, a sealing ring is a ring-shaped structure that may be comprised of several circumferentially linked arcuate ring segments.

[0008] These sealing rings extend radially inward from the slots in the turbine's stationary member (into which they are fixed) in close proximity to the outermost rotating surface of the turbine's rotating member, leaving only a small radial clearance between the innermost aspect of each sealing ring and the outermost rotating surface of the rotating member.

[0009] The efficiency of these sealing rings is directly related to their ability to seal various sections of the rotating member by preventing or reducing leakage of the working fluid. For example, in a turbine, these sealing rings maintain the turbine's efficiency by preventing steam from escaping from the turbine and also preventing air from leaking into the turbine.

[0010] The related art of sealing rings in the setting of turbines is best understood by reference to FIG. 1A, which shows a partial longitudinal sectional view of an exemplary prior art "labyrinth" sealing ring **210** coaxially disposed about a rotating member **122** of an exemplary turbine; and by reference to FIG. 1B, which shows a corresponding axial cross-sectional view of the exemplary prior art "labyrinth" sealing ring **210** coaxially disposed about a rotating member **122** of an exemplary turbine. A prior art sealing device may be comprised of a plurality of such sealing rings, serially disposed along the longitudinal **Z** axis of rotating member **122**. Exemplary prior art sealing ring **210** may be comprised of two or more sealing ring segments, as shown in FIG. 1B. When linked circumferentially, as shown in FIG. 1B, the sealing ring segments form a complete sealing ring.

[0011] Exemplary prior art sealing ring **210** circumscribes rotating member **122**, occupying a space between rotating member **122** and stationary member **110** of the turbine (FIG. 1A), to minimize fluid leakage between different regions through which rotating member **122** passes. While the full extent and full features of rotating member **122** are not illustrated, it will be understood that rotating member **122** is a portion of a complete rotating member inclusive of all means for extracting rotary energy from the thermal and kinetic energy of a working fluid, represented by arrows **101** in FIG. 1A.

[0012] As shown in FIG. 1A, exemplary prior art sealing ring **210** has a cross-sectional shape generally in the form of an "H," and may conveniently be divided into a radially inner ring portion ("body") **210B**, a radially outer ring portion ("dove tail") **210D**, and a middle portion ("neck") **210N**.

[0013] Dove tail **210D** is received by slot **112** in stationery member **110**. One or more radially-oriented springs **113**, housed within the outermost aspect of slot **112** above dove tail **210D** push exemplary prior art sealing ring **210** radially inward toward rotating member **122**, and also allows for some radial expansion or displacement of exemplary prior art sealing ring **210** away from rotating member **122**.

[0014] By convention in the art, the term "upstream" refers to a relatively higher pressure region of the working fluid; and, the term "downstream" refers to a relatively lower pressure region working fluid flow. In FIG. 1A and other figures showing longitudinal sections, upstream is generally to the left, and downstream is generally to the right.

[0015] Upstream shoulder **114** and opposing downstream shoulder **115** of slot **112** limit the inward radial travel of dove tail **210D** to a fixed radial clearance

RC. Upstream shoulder **114** has upstream lateral surface **114n** and downstream shoulder **115** has opposing downstream lateral surface **115n**. Upstream lateral surface **114n** and downstream lateral surface **115n** limit the axial travel of neck **210N**.

[0016] Operationally, exemplary prior art sealing ring **210** serves to contain most of the working fluid that would otherwise escape through the spaces between rotating member **122** and surrounding stationery member **110** of the turbine.

[0017] In FIG. 1A, body **210B** of prior art sealing ring **210** has a throttling portion comprising a plurality of exemplary throttling elements **225** such as, for example, teeth, knife-edged teeth, strips, or sealing strips, known in the art. Throttling elements **225** may be etched in, extruded from, affixed to, or otherwise established on body **210B** and are coextensive with body **210B**. Throttling elements **225** extend radially inward from body **210B** toward an outer surface **126** of rotating member **122**. Throttling elements **225** may have different lengths, ranging between a shortest throttling element, such as throttling element **225S** and a longest throttling element, such as throttling element **225L**.

[0018] The radial clearance **RC** between throttling elements **225** and outer surface **126** of rotating member **122** is defined as the linear distance between the tip of the longest throttling element, such as, for example, throttling element **225L** and the outer surface **126** of rotating member **122**.

[0019] As shown in FIG. 1A, some throttling elements **225** of exemplary prior art sealing ring **210** are correspondingly mounted opposite exemplary raised lands **130** and **132** on outer surface **126** of rotating member 1**22** to improve the sealing effectiveness of exemplary prior art sealing ring **210**. Exemplary throttling elements **225** are not in contact with surface **126** of rotating member **122** but extend to within very close proximity thereof, providing a seal against steam flow.

[0020] Annular chambers **134** may be defined between individual throttling elements. In operation, throttling elements **225** serve to contain most of the working fluid that would otherwise escape through the space between rotating member **122** and the stationary member **110** of the turbine which surrounds it. The channel formed by each throttling element against the outer surface **126** of the rotating member **122** results in a constriction through which the working fluid must pass.

[0021] Working fluid **101** passing through such a constriction undergoes a throttling effect that creates a fluid motion having both axial and radial components, and is accompanied by a reduction in the pressure of the working fluid. In the majority of prior art sealing devices, multiple constrictions are produced by arraying sealing rings, such as exemplary prior art sealing ring **210**, against one another in series to form sets of sealing rings. This arrangement causes successive throttling of the working fluid **101**, each of which is accompanied by a reduction in the pressure of the working fluid.

[0022] However, each successive constriction produces successively less pressure reduction. Consequently, multi-throttled sealing devices cannot completely eliminate leakage of the working fluid. Moreover, the number of throttling elements which are feasible in a particular design may be limited by factors, such as the amount of available axial space along which teeth may be arrayed.

[0023] All rotating members of turbines operate with some radial amplitude displacement, i.e., vibration. This means that the rotating member is vibrating with an amplitude on each side of its central longitudinal axis at a given phase angle. Conventional sealing rings cannot adjust their radial position during operation. Any contact between the rotating member and the sealing ring's throttling elements eventuates in elevated levels of vibration in the sealing ring, permanent damage to the throttling elements, and possible damage to the rotating member. In order to prevent contact, conventional sealing rings must rely on a relatively large radial clearance and having a correct internal alignment, which is very difficult to achieve.

[0024] One of the main problems with current seal designs is that their effectiveness is dependent on maintaining precise radial alignments with the rotating member throughout the operation of a turbine. If the radial alignment is off by a small amount, contacts ("rubs") between the throttling elements **225** and the rotating member **122** can occur, resulting in damage to the seals and loss of energy conversion efficiency. The only way to correct the loss in efficiency is to replace the damaged seals. However, power providers are operating turbines for 7 to 12 years between replacement overhauls, which means efficiency losses could be severe and very costly for the power providers.

[0025] Because maximum sealing efficiency is achieved with a minimum radial clearance, the precise maintenance of a sealing ring's radial alignment requires the maintenance of a minimum feasible radial clearance **RC**. Rubs will wear the throttling elements, decreasing the sealing efficiency of prior art exemplary sealing ring **210** by creating an unwanted increase in RC. A rub is most likely to occur as a result of transient conditions in a turbine's operation, during which rotating member **122** may be displaced from its normal position relative to prior art sealing ring **210**. Displacement often coincides with the starting or stopping of the turbine, load rejections, or overspeeds. It is therefore desirable to prevent rubs.

[0026] Various attempts have been made to minimize or eliminate contact between throttling elements **225** and rotating member **122** to avoid wearing down of the throttling elements and decreasing the efficiency of a sealing ring. For example, U.S. Pat. No. 5,599,026 to Sanders, et al., discloses the use of rubbing strips in conjunction with the throttling elements of a sealing ring to prevent contact between the throttling elements and a rotating member with respect to which the throttling elements form a seal.

[0027] FIG. 2 is a partial longitudinal sectional view of a labyrinth sealing device having rubbing strips disposed about a rotating member of a turbine. As shown in FIG. 2, rubbing strips **232** comprises strips of material oriented in parallel with the throttling elements **225** of sealing ring **210**, and which have a clearance **RCR** with respect to the rotating member **122** that is less than the radial clearance **RC**. Consequently, rubbing strips **232** are the first component of sealing ring **210** to make contact with rotating member **122** if conditions cause rotating member **122** to be displaced from its normal position relative to the sealing ring **210**.

[0028] Accordingly, rubbing strips protect throttling elements **225** and maintain the radial clearance **RC** until they are worn down, at which point any additional rubs will wear down the throttling elements, with an undesirable increase in the radial clearance **RC**.

[0029] Another structural modification that may decrease the leakage of working fluid is to variably angle throttling elements in the form of teeth that oppose the general direction of leakage flow. Such angled throttling elements are non-perpendicular (i.e., angled) with respect to the central longitudinal axis **Z** of rotating member **122**. This is sometimes referred to as a "herringbone" structure, and has been adapted for use at the periphery of a blade row or its encircling band, as illustrated in U.S. Pat. No. 3,897,169 to Fowler.

[0030] Yet another structural modification that may decrease the leakage of working fluid is to incorporate one or more vortex producing and shedding structures in a sealing ring. A vortex shedding tip seal lowers the pressure drop across throttling elements and reduces the quantity of steam which leaks past them, as exemplified in U.S. Pat. No. 5,735,667 to Sanders, et al.

3.1 Summary of the Problem in the Prior Art

[0031] As indicated, *supra*, the radial clearance **RC** that separates the outer surface of a turbine's rotating member from the innermost edges of the longest throttling elements of a conventional sealing ring is provided to prevent contact between them.

[0032] The control of the leakage losses in a turbine represents a considerable financial saving that can be achieved by the maintenance of the actual radial clearance of a sealing ring at, or close to, its original, factory-specified, design or otherwise specified value ("design radial clearance").

[0033] Maintaining the radial clearance at, or close to, the design radial clearance requires minimizing any increases of the radial clearance arising from rubs. In the case of a steam turbine, the efficiency of known sealing rings depends significantly on maintaining a narrowest radial clearance between their throttling elements and the turbine's rotating member. The radial clearance provides a space into which working fluid leaks. Over time, as the throttling elements undergo operational wear, the leakage rate into the radial clearance space increases with an attendant decrease in the energy conversion efficiency of the turbine. If an operational excursion should occur and the rotating member comes into contact with the throttling elements, they will be damaged and the working fluid's leakage rate will undergo an undesirable increase.

[0034] Presently, the efficiency of known sealing rings has reached an undesirable plateau. Heretofore, modifications to known sealing rings have delivered only incremental improvements in sealing efficiency, which improvements endure only for small amounts of time relative to the operational life of a steam turbine. In effect, sealing rings employing a rubbing strip temporarily transfer the risk and effect of contact with the rotating member from the throttling elements to the rubbing strip. Once the rubbing strip has been worn down by successive contacts with the rotating member, further contacts involve the throttling elements, completely effacing the gain in efficiency provided by the rubbing strip.

[0035] Accordingly, there is a need for a sealing ring whose sealing efficiency is not degraded by its very operation and whose sealing efficiency is substantially co-extensive with the operational life of a steam turbine.

3.0 Summary of the Invention

3.1 Solution of the Problem by the Present Invention

[0036] The present invention satisfies the foregoing need by providing a floating sealing ring that effectively hovers at its design radial clearance, no matter what radial displacements may transiently arise in the rotating member. That is, the present invention provides a sealing ring whose actual radial displacements are coupled to the radial displacements of the rotating member it circumscribes, such that, co-extensively with the operational life of a steam turbine, the actual radial clearance is maintained at the design radial clearance of the floating sealing ring.

[0037] If the rotating member of a turbine, changes its radial position relative to the floating sealing ring of the present invention, at least one sensing device contacts the rotating member and transmits the radial component of the force of contact through the floating sealing ring to a set of suspension devices, which, co-extensively with the operational life of a steam turbine, maintain the floating sealing ring at its design radial clearance, without damage to the floating sealing ring's throttling elements.

[0038] A much narrower radial clearance can be maintained with the floating sealing ring of the present invention and, unlike conventional sealing rings, its internal alignment in the turbine is not critical to assure proper sealing of the steam path.

[0039] Accordingly, it is an objective of the present invention:

1) to provide a floating sealing ring, a floating sealing ring segment, and an apparatus comprising more than one floating sealing ring, whose radial clearance is substantially maintained at its design radial clearance during any radial displacement of the rotating member for which it provides a seal;

2) to provide a floating sealing ring, a floating sealing ring segment, and an apparatus comprising more than one floating sealing ring, that eliminates the need for the dove tail found on a conventional sealing ring. Eliminating the dovetail **210D** (FIGS. 1A, 1B & 2) that overrides the shoulders **114**, **115** (FIGS. 1A & 2) of slot **112** (FIGS. 1A & 2) allows the sealing ring **210** to freely seek any radial position. By contrast, the dovetail on conventional sealing rings acts as a fixed radial positioning device, establishing a fixed radial clearance between the rotating member and the sealing ring for which no adjustment is possible after the turbine is closed for operation. If the radial alignment between the rotating member and the stationary sealing device deviates by only a small

amount (e.g., .010 inch) the rotating member and the stationary sealing device will rub against each other causing a permanent loss of efficiency and possible damage to the rotating member, depending on the intensity and duration of the rub.

3) to provide a floating sealing ring, a floating sealing ring segment, and an apparatus comprising more than one floating sealing, for sealing a turbine against leakage of a working fluid, the floating sealing ring or segment being coaxially disposed about a rotating member of the turbine from a stationary member of the turbine, which sealing ring or segment undergoes radial displacements that are coupled to radial displacements of the rotating member, such that a design radial clearance is substantially maintained without damage to the apparatus;

4) to provide a floating sealing ring, a floating sealing ring segment, and an apparatus comprising more than one floating sealing ring, for sealing a turbine against leakage of a working fluid, the sealing ring or segment being slideably disposed in a slot of a stationary member of the turbine, the sealing ring or segment comprising a body having throttling elements, a head, and at least one sensing device coupled to at least one set of suspension devices, wherein, co-extensively with the operational life of a steam turbine, the set of suspension devices suspends the sealing ring or segment coaxially about the rotatable member of the turbine at a design radial clearance and maintains the sealing ring or segment at the design radial clearance without damage to the throttling elements, whenever the sensing device contacts the rotating member;

5) to provide a method for producing a floating sealing ring or segment comprising:

a) providing a sealing ring or segment comprising a head and a body having throttling elements extending radially therefrom;

b) providing at least one set of suspension devices that suspend the sealing ring or segment at a design radial clearance;

c) disposing the sensing device among the throttling elements;

d) coupling the sensing device to the set of suspension devices such that the set of suspension devices maintains the sealing ring or segment at the design radial clearance without damage to the throttling elements, whenever the sensing device contacts the rotating member;

6) to provide method for sealing a turbine having a rotating member and a stationary member against leakage of a working fluid comprising:

a) defining a central longitudinal axis about which the rotating member rotates;

b) defining a design radial clearance between a longest throttling element of a sealing ring and an outer surface of the rotating member;

c) coaxially suspending the floating sealing ring from the stationary member at the design radial clearance by means of at least one set of suspension devices of the sealing ring, which set of suspension devices is coupled to at least one sensing device of the sealing ring;

d) substantially maintaining the sealing ring at the design radial clearance without damage to any of its throttling elements, whenever the sensing device contacts the rotating member.

4.0 Brief Description of the Drawings

[0040] FIG. 1A is a partial longitudinal sectional view of a known labyrinth sealing device disposed about a rotating member of an exemplary turbine.

[0041] FIG. 1B is an axial cross-sectional view of a known labyrinth sealing device disposed about a rotating member of an exemplary turbine.

[0042] FIG. 2 is a partial longitudinal sectional view of a known labyrinth sealing device, disposed about a rotating member of an exemplary turbine that uses rubbing strips.

[0043] FIG. 3 is a perspective schematic drawing of an exemplary rotating member of a machine, such as, for example, a turbine.

[0044] FIG. 4 is a perspective schematic drawing of the exemplary rotating member of FIG. 3 circumscribed by the floating sealing ring of the present invention.

[0045] FIG. 5 is an axial cross-sectional view of the floating sealing ring of the present invention showing an exemplary embodiment of a suspension device.

[0046] FIG. 6A is an elevated longitudinal view of an exemplary leaf spring forming a suspension device of the floating sealing ring of the present invention.

[0047] FIG. 6B is top plan view of an exemplary leaf spring forming a suspension device of the floating sealing ring of the present invention.

[0048] FIG. 7 is a perspective schematic drawing of a semicircular portion of the stationary member of a turbine, having a slot for the receipt of the floating sealing ring of the present invention.

[0049] FIG. 8 is a perspective schematic drawing of a semicircular portion of the stationary member of a turbine, showing the disposition of a semicircular portion of the floating sealing ring of the present invention in a slot for its receipt.

[0050] FIG. 9 is a partial longitudinal sectional view of the floating sealing ring of the present invention disposed about a rotating member of an exemplary turbine.

5.0 Detailed Description of the Invention

[0001] Before the present invention is described, it is to be understood that this invention is not limited to the particular embodiments described, as these may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, because the scope of the present invention will be limited only by the appended claims.

[0002] As used herein:

a) the term "radial clearance" is defined as the distance between the outer surface of a turbine's rotating member and the innermost edge of the longest throttling element of a sealing ring;

b) the term “actual radial clearance” means the instantaneous, moment-to-moment or operational distance between the outer surface of a turbine’s rotating member and the innermost edge of the longest throttling element of a sealing ring;

c) the term “design radial clearance” means an original, factory-specified, design, preferred or otherwise specified value of the radial clearance;

d) The term “coupled” when referring to the relationship between a suspension device and a sensing device means that the suspension device is in communication with and responsive to forces or signals generated, transmitted or relayed by the sensing device;

e) The term “coupled” when referring to the relationship between a floating sealing ring or a segment or array thereof and a rotating member means that the floating sealing ring or a segment or array thereof undergoes a radial displacement substantially concomitant with and substantially in response to a radial displacement of the rotating member.

f) As used herein and in the appended claims, the singular forms "a", "an", and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a rubbing strip" includes a plurality of such rubbing strips, and so forth.

[0051] FIG. 3 is a perspective schematic drawing of an exemplary rotating member of a turbine. In FIG. 3, rotating member **122**, having outer surface **126** and raised lands **130**, **132**, is disposed along central longitudinal axis **Z**, which is generally parallel to working fluid flow vectors, represented by arrows **101**.

[0052] FIG. 4 is a perspective schematic drawing of the exemplary rotating member **122** of FIG. 3 circumscribed by a floating sealing ring **310** of the present invention. In FIG. 4 body (inner ring portion) **310B** and upstream aspect of head (outer ring portion) **310H** of floating sealing ring **310** are visible.

[0053] FIG. 4 shows one exemplary suspension device in the form of a leaf spring **360S**. Leaf spring **360S** is a member of a set of one or more exemplary suspension devices, in the form of leaf springs, circumferentially secured about upstream lateral wall **313** of head **310H** by exemplary paired retainer bolts **364** passing through exemplary suspension spring maintenance slots **365**.

[0054] FIG. 5 is an axial cross-sectional view of the floating sealing ring **310** of the present invention showing another view of an exemplary embodiment of a suspension device in the form of a leaf spring **360S**.

[0055] In FIG. 5, exemplary floating sealing ring is comprised of two exemplary semicircular floating sealing ring segments, aligned by means of fastening devices, such as, for example, suitable pins or bolts (not shown in FIG. 5) disposed in one or more sets of paired alignment holes **340** drilled into complementary positions on the apposing faces of the sealing ring segments. The rigid attachment of the floating sealing ring segments to one another assures that the resultant floating sealing ring behaves mechanically as a continuous uninterrupted unit. A floating sealing ring may be comprised of more than two floating sealing ring segments.

[0056] Leaf spring **360S** is a member of a set of one or more leaf springs, circumferentially secured about head **310H** by exemplary paired retainer bolts **364** passing through exemplary suspension spring maintenance slots **365**. Two such leaf springs **360S** are shown mounted on the upstream lateral wall **313** of head **310H** (FIG 4).

[0057] FIG. 6A is an elevated longitudinal view of an exemplary leaf spring forming a suspension device of the floating sealing ring of the present invention. FIG. 6B is top plan view of an exemplary leaf spring forming a suspension device of the floating sealing ring of the present invention.

[0058] In FIG. 6A, leaf spring **360S** is seen to have a first force-transmitting surface **362A** and an opposing parallel second force-transmitting surface **362B**. First force-transmitting surface **362A** and opposing parallel second force-transmitting surface **362B** may be physical or virtual. First force-transmitting surface **362A** and opposing parallel second force-transmitting surface **362B** transmit opposing antiparallel forces generated by leaf spring **360S** or an alternative suspension device, as more fully discussed, *infra*.

[0059] In FIG. 6A, first force-transmitting surface **362A** and second force-transmitting surface **362B** are parallel surfaces on opposing aspects of leaf spring **360S**, which is representative of a suspension device and is a member of a set of suspension devices. Accordingly, it is to be understood that first force-transmitting surface **362A** and second force-transmitting surface **362B** are also representative of physical or virtual parallel surfaces on opposing aspects of a *set* of suspension devices.

[0060] As indicated *supra*, floating sealing ring **310** may be comprised of a single unit that circumscribes rotating member **122** or it may be comprised of a plurality of arcuate segments, such as, for example, four arcuate segments, each spanning 90 degrees, such that when the segments are mechanically joined end-to-end, the segments form a complete floating sealing ring spanning 360 degrees about rotating member **122.**

[0061] FIG. 7 is a perspective schematic drawing of a semicircular portion of stationary member **110** of a turbine, having a slot **112** for the receipt of the floating sealing ring (not shown in FIG. 7) of the present invention. Slot **112** in stationery member **110** has upstream shoulder **114** and opposing downstream shoulder **115**. Upstream shoulder **114** has upstream lateral surface **114n** and downstream shoulder **115** has opposing downstream lateral surface **115n.**

[0062] FIG. 8 is a perspective schematic drawing of a semicircular portion of the stationary member **110** of a turbine, showing an inferior semicircular segment of floating sealing ring **310** of the present invention in greater detail. Floating sealing ring **310** is seen to be disposed in slot **112.**

[0063] In FIG. 8, body **310B** of floating sealing ring **310** has a throttling portion comprising a plurality of exemplary throttling elements **225** such as, for example, teeth, knife-edged teeth, strips, or sealing strips, known in the art. Throttling elements **225** may be etched in, extruded from, affixed to, or otherwise established on body **310B** and are circumferentially coextensive with body **310B**. Annular chambers **134** may be defined between individual throttling elements.

[0064] In FIG. 8, sensing device **330** is disposed among throttling elements **225**, and will be discussed in greater detail, *infra*. In FIG. 8, exemplary alignment hole **340** (representative of a set comprising at least one alignment hole) provides alignment among arcuate segments, discussed, *supra*, in those cases where floating sealing ring **310** is comprised of such segments. For example, in FIG. 8, floating sealing ring **310** would be comprised of two 180 degree arcuate segments. A fastening device, such as a bolt or pin, is placed in exemplary alignment hole **340** to physically join one floating ring segment to another in forming a complete, substantially rigid sealing ring. An advantage to using a sealing ring that is mechanically joined is the elimination of leakage between segment interfaces that may arise in conventional sealing rings.

[0065] The radial clearance **RC** between throttling elements **225** and outer surface **126** of rotating member **122** is defined as the linear distance between the longest throttling element, such as, for example, throttling element **225L** and the outer surface **126** (FIG. 3) of rotating member **122** (FIG. 3). Floating sealing ring **310 is** installed at a design radial clearance appropriate to the turbine for which is being deployed.

[0066] Exemplary throttling elements **225** are not in contact with surface **126** (FIG. 3) of rotating member **122** (FIG. 3) but extend to within very close thereof, to maintain the clearance **RC** between the surface of rotating member

122 and the longest throttling elements **225L**, providing an effective seal against steam flow.

[0067] In FIG. 8, head **310H** of floating sealing ring **310** has upstream lateral wall **313** and downstream lateral wall **314**. For purposes of clarity, suspension device **360S** of the set of suspension devices shown in FIG. 4 is not shown in FIG. 8. However, double-headed arrow **363** shows the antiparallel force vectors that are transmitted by any member of the set of suspension devices (FIG. 4) to upstream lateral surface **114n** of upstream shoulder **114** and downstream lateral surface **115n** of downstream shoulder **114** of slot **112.**

[0068] FIG. 9 is a partial longitudinal sectional view of the floating sealing ring **310** of the present invention disposed about a rotating member **122** of a turbine. Floating sealing device **310** may be comprised of a plurality of such floating sealing rings, disposed axially along rotating member **122.**

[0069] Floating sealing ring **310** circumscribes rotating member **122**, occupying a space between rotating member **122** and stationary member **110** of a turbine (not shown in FIG. 9), to minimize fluid leakage between different regions through which rotating member **122** passes. While the full extent and full features of rotating member **122** are not illustrated, it will be understood that rotating member **122** is a portion of a complete rotating member of a turbine, inclusive all means for extracting rotary energy from the thermal and kinetic energy of working fluid **101.**

[0070] As shown in FIG. 9, floating sealing ring **310** has a cross-sectional shape generally in the form of an inverted "T," and may conveniently be divided into radially inner ring portion (“body”) **310B** and head portion (“head”) **310H**. While this shape may be preferred for strength, ease of installation, and removal, it will be understood by those skilled in the art that other shapes may be equally employed.

[0071] Unlike the conventional sealing rings described *supra*, floating sealing ring **310** is devoid of a dove tail, such as dove tail **210D** appearing in FIGS. 1A and 2. The elimination of the dovetail from floating sealing ring **310** removes the means by which inward radial travel of a conventional sealing ring is arrested when it is disposed into a slot, such as slot **112**, thereby allowing floating sealing ring **310** to freely seek a radial position relative to the outer surface **126** of rotating member **122**, as more fully explained *infra*.

[0072] As shown in FIG. 9, head **310H** is disposed in slot **112** of stationery member **110** so that its upstream lateral wall **313** and opposing downstream lateral wall **314** are respectively parallel to and oppose upstream lateral surface **114n** of shoulder **114** of slot **112** and opposing downstream lateral surface **115n** of opposing shoulder **115** of slot **112**.

[0073] FIG. 9 shows a suspension device **360**, which is representative of a *set* of suspension devices comprising at least one suspension device (“suspension device set”). In FIG. 9, suspension device set **360** is shown as disposed between upstream lateral surface **114n** of slot **112** and upstream lateral wall **313** of body **310B**.

[0074] In this disposition:

a) first force-transmitting surface **362A** of set of suspension devices **360** makes slideable contact with upstream lateral surface of **114n** of shoulder **114** of slot **112**;
b) second force-transmitting surface **362B** of suspension device set **360** is attached to upstream lateral wall **313** of head **310H**; and,
c) downstream lateral wall **314** of head **310H** makes slideable contact with downstream lateral surface **115n** of shoulder **115** of slot **112**.

[0075] Unlike the conventional sealing rings described *supra*, in FIG. 9, slot **112** is devoid of an outer radially-oriented spring, such as spring **113** appearing in FIG. 1A and FIG. 1B.

[0076] The longitudinal cross sectional widths of head **310H** are narrower than the longitudinal cross sectional widths at which necks **210N** of conventional sealing rings **210** shown in FIG. 1A are manufactured, so that floating sealing ring **310** (or a segment thereof) with suspension device **360** in place (as shown in FIG.9), may conveniently be inserted into the slot **112** (without the presence of a spring **113** shown in FIG. 1A) pre-existing in, for example, stationary turbine members that are adapted to receive conventional sealing rings, such as exemplary prior art sealing ring **210**, shown in FIG. 1A.

[0077] In FIG. 9, body **310B** of floating sealing ring **310** projects a throttling portion comprising a plurality of exemplary throttling elements **225**, such as, for example, teeth, knife-edged teeth, strips, or sealing strips, known in the art. Throttling elements **225** may be etched in, extruded from, affixed to, or otherwise established on body **310B** and are circumferentially coextensive with body **310B**. Throttling elements **225** extend radially inward from body **310B**

toward outer surface **126** of rotating member **122**. Throttling elements **225** may have different lengths, ranging between a shortest throttling element, such as throttling element **225S** and a longest throttling element, such as throttling element **225L**.

[0078] The radial clearance **RC** between longest throttling elements **225** and outer surface **126** of rotating member **122** has been defined as the radial linear distance between the longest throttling element, such as, for example, throttling element **225L** and the outer surface **126** of rotating member **122**. An annular solid of revolution ("clearance annular solid") corresponding to the radial clearance may be defined by rotating the radial line segment corresponding to the distance **RC** around central longitudinal axis **Z**.

[0079] As shown in FIG. 9, some throttling elements **225** of floating sealing ring **310** are correspondingly mounted opposite exemplary raised lands **130** and **132** on outer surface **126** of rotating member **122** to improve the sealing effectiveness of floating sealing ring **310**. Throttling elements **225** are not in contact with surface **126** of rotating member **122** but extend to within very close proximity thereof, to maintain the clearance **RC** between the surface of rotating member **122** and throttling elements **225**, providing an effective seal against steam flow.

[0080] Annular chambers **134** may be defined between individual throttling elements. In operation, throttling elements **225** serve to contain most of the working fluid that would otherwise escape through the space between rotating member **122** and stationary portion **110** of the turbine which surrounds it. The channel formed by each throttling element against an outer surface of the rotating member **122** results in a constriction through which the working fluid must pass.

[0081] Operationally, exemplary floating sealing ring **310** serves to contain most of the working fluid that would otherwise escape through the spaces between rotating member **122** and stationery surrounding structure **110** of a turbine. Additional floating sealing rings **310** may be provided in series along rotating member **122.**

[0082] Floating sealing ring **310** is further comprised of at least one set of suspension devices, such as exemplary suspension device **360.** Suspension device **360** is operationally coupled to a sensing device **330** by means of the ability of floating sealing ring **310** to mechanically transmit forces impacting upon sensing device **330.**

[0083] Operationally, suspension device **360** generates antiparallel force vectors (represented by double-headed opaque arrow **363**) respectively directed to upstream lateral surface **114n** and downstream lateral surface **115n** of slot **112**, which force vectors are substantially parallel to central longitudinal axis **Z** of rotating member **122** and substantially maintain floating sealing ring **310** at radial clearance **RC**.

[0084] Suspension device **360** may be any device(s) that generates antiparallel forces (double-headed opaque arrow **363**) that directly or indirectly maintains downstream lateral wall **314** in slideable contact with downstream lateral surface **115n.**

[0085] Antiparallel forces may, for example, be physical, mechanical, electrical, magnetic, hydraulic or fluidic in nature. Mechanical antiparallel forces, may, for example, be exerted by a suitable spring, such as, for example, the leaf spring **360S** shown in FIG. 4

[0086] The antiparallel forces generated by suspension device **360** also serve to maintain floating sealing ring **310** in an axial alignment with respect to rotating member **122**.

[0087] As shown schematically in FIG. 9, suspension device **360** may transmit its antiparallel forces to opposing parallel force transmitting surfaces **362A** and **362B**. Force transmitting surface **362A** makes slideable contact with upstream lateral wall **114n** of shoulder **114** and force transmitting surface **362B** is attached to upstream lateral wall **313** of head **310H**.

[0088] In FIG. 9, sensing device **330** comprises one of more proximity strips, each having the general shape of an upright "T" when radially disposed with respect to rotating member **122**, with an exposed length that exceeds the length of a longest throttling element. Each proximity strip is affixed to floating sealing ring **310** so as to be disposed within the clearance annular solid. A proximity strip may, for example, be comprised of Stelite® alloy, Nimonic® alloy, carbon or combinations thereof.

[0089] Sensing device **330** may either be provided as an integral extension of body **310B** of floating sealing ring **310** or may be removeably attached as a replacement to any throttling element **225**.

[0090] The material of sensing device **330** may be chosen to suit the particular needs of the application. The material of sensing device **330** should preferably:

a) have a low coefficient of friction; and,

b) demonstrate superior wear characteristics; and,

c) minimize damage to the rotating member during instances of contact.

[0091] Examples of possible material that could be used for the radial positioning device **330** include, without limitation, Stelite® alloy, Nimonic® alloy, carbon or combinations thereof. For example, sensing device **330** may be comprised of a Nimonic® alloy having an innermost surface comprising a layer of carbon.

[0092] Sensing device **330** is disposed with respect to rotating member **122** at a proximity radial clearance **PRC** that is smaller than the radial clearance **RC**. Consequently **PRC** defines an inner annular solid of revolution ("proximity solid annulus") that is contained within the clearance solid annulus defined by **RC**. If rotating member **122** intrudes upon the proximity solid annulus defined by **PRC** and threatens to encroach upon the clearance solid annulus defined by **RC**, its surface **126** comes into contact with the innermost surface of sensing device **330** and avoids contacting any throttlings **225**.

[0093] Upon contact with sensing device **330**, the radial component of the force imparted by this contact is transmitted through body **310B** and head **310H** of floating sealing ring **310**, momentarily overcoming the antiparallel forces **363** exerted by the set of suspension devices **360** and slideably moving floating sealing ring **310** relative to lateral surfaces **114n** and **115n**, to a new position, such that the actual radial clearance is substantially maintained at the design radial clearance, without any damage to throttling elements **225** as a result of the transient changes in position.

[0094] When contact with proximity sensing device **330** ceases, the sealing ring is established at a new radial position relative to rotating member **122** at which rotating member **122** either no longer makes contact with proximity sensing device **330** or makes contact that is so "light" that the magnitude of any radial components of the force of contact is too low to move the floating sealing ring **310**. Accordingly, floating sealing ring **310** either moves out of the way or is spared a "hard" rub.

[0095] While the invention has been disclosed in connection with the embodiments depicted herein, it will be apparent to one of ordinary skill in the art that various modifications and substitutions may be made to these embodiments without departing in any way from the scope of the invention as defined in the following claims.

I claim:

1. An apparatus for sealing a turbine against leakage of a working fluid comprising at least one radially displaceable sealing ring, coaxially disposed about a rotating member of the turbine from a stationary member of the turbine, which sealing ring undergoes radial displacements that are coupled to radial displacements of the rotating member, such that a design radial clearance is substantially maintained without damage to the apparatus or the turbine.

2. The apparatus of claim 1, wherein the design radial clearance is substantially maintained without damage to the apparatus co-extensively with the operational life of the turbine.

3. An apparatus for sealing a turbine against leakage of a working fluid comprising at least one floating sealing ring, slideably disposed in at least one slot of a stationary member of the turbine, which slot has an upstream lateral surface and a downstream lateral surface, the floating sealing ring comprising a body having throttling elements, a head, and at least one sensing device coupled to at least one set of suspension devices, wherein the set of suspension devices suspends the floating sealing ring coaxially about a rotatable member of the turbine at a design radial clearance; and, substantially maintains the floating sealing at the design radial clearance without damage to the throttling elements, whenever the sensing device contacts the rotating member.

4. The apparatus of claim 3, wherein the design radial clearance is substantially maintained without damage to the throttling elements co-extensively with the operational life of the turbine.

5. The apparatus of claim 3, wherein a cross section of the floating sealing ring generally has the shape of an inverted T, when the floating sealing ring is radially oriented with respect to a central longitudinal axis of the rotating member of the turbine.

6. The apparatus of claim 3, wherein the floating sealing ring is devoid of a dovetail.

7. The apparatus of claim 3, wherein the set of suspension devices comprises a set of springs.

8. The apparatus of claim 7, wherein the springs comprise leaf springs.

9. The apparatus of claim 3, wherein the set of suspension devices comprises any devices that generate opposing antiparallel forces substantially parallel to a longitudinal axis of the rotating member.

10. The apparatus of claim 9, wherein the opposing antiparallel forces are respectively transmitted through a first force-transmitting surface and a second force-transmitting surface.

11. The apparatus of claim 10 wherein the antiparallel forces, directly or indirectly, maintain an upstream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

12. The apparatus of claim 10 wherein the antiparallel forces directly or indirectly maintain a downstream lateral wall of the head in slideable contact with the downstream lateral surface of the slot.

13. The apparatus of claim 10, wherein the antiparallel forces, directly or indirectly, maintain a downstream lateral wall of the head in slideable contact with the downstream lateral surface of the slot and maintain an upstream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

14. The apparatus of claim 9, wherein the opposing antiparallel forces comprise physical, mechanical, electrical, magnetic, gravitational, hydraulic, or fluidic forces.

15. The apparatus of claim 9, wherein the opposing antiparallel forces suspend the floating sealing ring at the design radial clearance.

16. The apparatus of claim 15, wherein, upon contacting the rotating member, the sensing device transmits a radial component of the force of the contact through the floating sealing ring, momentarily overcoming the antiparallel forces exerted by the set of suspension devices and slideably moving the floating sealing ring to a new position, such that its actual radial

clearance is substantially maintained at the design radial clearance, without any damage to throttling elements.

17. The apparatus of claim 3, wherein the sensing device is disposed among the throttling elements.

18. The apparatus of claim 3, wherein the sensing device comprises an integral extension of the body arising among the throttling elements.

19. The apparatus of claim 3, wherein the sensing device is removeably attachable among the throttling elements.

20. The apparatus of claim 3, wherein the sensing device comprises a removeable replacement of a throttling element.

21. The apparatus of claim 3, wherein the sensing device is comprised of a proximity strip in the general shape of an upright "T" when radially disposed with respect to the rotating member having an exposed length that exceeds the length of a longest throttling element.

22. The apparatus of claim 21, wherein the proximity strip is disposed among the throttling elements.

23. The apparatus of claim 21, wherein the proximity strip comprises an integral extension of the body arising among the throttling elements.

24. The apparatus of claim 21, wherein the proximity strip is removeably attachable among the throttling elements.

25. The apparatus of claim 21, wherein the proximity strip comprises a removeable replacement of a throttling element.

26. The apparatus of claim 21, wherein the proximity strip is comprised of Stelite® alloy, Nimonic® alloy, carbon or combinations thereof.

27. The apparatus of claim 3, wherein the floating sealing ring

comprises at least two floating ring segments, the floating ring segments being fixedly fastened to one another so as to form a mechanically unitary and continuous floating sealing ring, each floating ring segment comprising a body segment having means for fixedly joining it to another floating ring segment, and throttling elements, a head segment, and at least one sensing device coupled to at least one set of suspension devices, wherein the set of suspension devices suspends each floating sealing ring segment coaxially about the rotatable member of the turbine at a design radial clearance and substantially maintains each floating sealing segment at the design radial clearance without damage to the throttling elements, whenever the sensing device contacts the rotating member.

28. The apparatus of claim 27, wherein the design radial clearance is substantially maintained without damage to the throttling elements, co-extensively with the operational life of the turbine.

29. The apparatus of claim 27, wherein a cross section of the floating sealing ring segment generally has the shape of an inverted T, when the floating sealing ring segment is radially oriented respect to a central longitudinal axis of the rotating member of the turbine.

30. The apparatus of claim 27, wherein the means for fixedly fastening one floating ring segment to another floating ring segment comprises disposing a fastening device in one or more sets of paired alignment holes drilled into complementary positions on matched apposing faces of the sealing ring segments.

31. The apparatus of claim 27, wherein the floating ring segment is devoid of a dovetail.

32. The apparatus of claim 27, wherein the set of suspension devices comprises a set of springs.

33. The apparatus of claim 32, wherein the springs comprise leaf springs.

34. The apparatus of claim 27, wherein the set of suspension devices comprises any devices that generate opposing antiparallel forces substantially parallel to a longitudinal axis of the rotating member.

35. The apparatus of claim 34, wherein the opposing antiparallel forces are respectively transmitted through a first force-transmitting surface and a second force-transmitting surface.

36. The apparatus of claim 35 wherein the antiparallel forces, directly or indirectly, maintain an upstream lateral wall of the head segment in slideable contact with the upstream lateral surface of the slot.

37. The apparatus of claim 35 wherein the antiparallel forces directly or indirectly maintain a downstream lateral wall of the head segment in slideable contact with the downstream lateral surface of the slot.

38. The apparatus of claim 35, wherein the antiparallel forces, directly or indirectly, maintain a downstream lateral wall of the head segment in slideable contact with the downstream lateral surface of the slot and maintain an upstream lateral wall of the head segment in slideable contact with the upstream lateral surface of the slot.

39. The apparatus of claim 34, wherein the opposing antiparallel forces comprise physical, mechanical, electrical, magnetic, gravitational, hydraulic, or fluidic forces.

40. The apparatus of claim 34, wherein the opposing antiparallel forces suspend the floating sealing ring segment at the design radial clearance.

41. The apparatus of claim 34, wherein, upon contacting the rotating member, the sensing device transmits a radial component of the force of the contact through the floating sealing ring segment, momentarily overcoming the antiparallel forces exerted by the set of suspension devices and slideably moving the floating sealing ring segment to a new position, such that its actual radial clearance is maintained at the design radial clearance, without any damage to throttling elements.

42. The apparatus of claim 27, wherein the sensing device is disposed among the throttling elements.

43. The apparatus of claim 27, wherein the sensing device comprises an integral extension of the body segment arising among the throttling elements.

44. The apparatus of claim 27, wherein the sensing device is removeably attachable among the throttling elements.

45. The apparatus of claim 27, wherein the sensing devices comprises a removeable replacement of a throttling element.

46. The apparatus of claim 27, wherein the sensing device is comprised of a proximity strip in the general shape of an upright “T” when radially disposed with respect to the rotating member having an exposed length that exceeds the length of a longest throttling element.

47. The apparatus of claim 46, wherein the proximity strip is disposed among the throttling elements.

48. The apparatus of claim 46, wherein the proximity strip comprises an integral extension of the body arising among the throttling elements.

49. The apparatus of claim 46, wherein the proximity strip is removeably attachable among the throttling elements.

50. The apparatus of claim 46, wherein the proximity strip comprises a removeable replacement of a throttling element.

51. The apparatus of claim 46, wherein the proximity strip is comprised of Stelite® alloy, Nimonic® alloy, carbon or combinations thereof.

52. An apparatus for sealing a turbine against leakage of a working fluid comprising a plurality of coaxial and linearly arrayed floating sealing rings, each floating sealing ring comprising a body having throttling elements, a head, and at least one sensing device coupled to at least one set of suspension devices, wherein the set of suspension devices suspends each floating sealing ring coaxially about the rotatable member of the turbine at a design radial clearance and substantially maintains the sealing ring at the design radial clearance without damage to the throttling elements, whenever the sensing device contacts the rotating member.

53. The apparatus of claim 52, wherein the design radial clearance is substantially maintained without damage to the throttling elements, co-extensively with the operational life of the turbine.

54. The apparatus of claim 52, wherein a cross section of the floating sealing rings generally has the shape of an inverted T, when the floating sealing rings are radially oriented respect to a central longitudinal axis of the rotating member of the turbine.

55. The apparatus of claim 52, wherein the floating sealing ring is devoid of a dovetail.

56. The apparatus of claim 52, wherein the set of suspension devices comprises a set of springs.

57. The apparatus of claim 56, wherein the springs comprise leaf springs.

58. The apparatus of claim 52, wherein the set of suspension devices comprises any devices that generate opposing antiparallel forces substantially parallel to a longitudinal axis of the rotating member.

59. The apparatus of claim 58, wherein the opposing antiparallel forces are respectively transmitted through a first force-transmitting surface and a second force-transmitting surface.

60. The apparatus of claim 59, wherein the antiparallel forces, directly or indirectly, maintain an upstream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

61. The apparatus of claim 59, wherein the antiparallel forces directly or indirectly maintain a downstream lateral wall of the head in slideable contact with the downstream lateral surface of the slot.

62. The apparatus of claim 59, wherein the antiparallel forces, directly or indirectly, maintain a downstream lateral wall of the head in slideable contact with the downstream lateral surface of the slot and maintain an upstream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

63. The apparatus of claim 58 wherein the opposing antiparallel forces comprise physical, mechanical, electrical, magnetic, gravitational, hydraulic, or fluidic forces.

64. The apparatus of claim 58, wherein the opposing antiparallel forces suspend the floating sealing ring at the design radial clearance.

65. The apparatus of claim 58, wherein, upon contacting the rotating member, the sensing device transmits a radial component of the force of the contact through the floating sealing ring, momentarily overcoming the antiparallel forces exerted by the set of suspension devices and slideably moving the floating sealing ring to a new position, such that its actual radial

clearance is substantially maintained at the design radial clearance, without any damage to throttling elements.

66. The apparatus of claim 52, wherein the sensing device is disposed among the throttling elements.

67. The apparatus of claim 52, wherein the sensing device comprises an integral extension of the body arising among the throttling elements.

68. The apparatus of claim 52, wherein the sensing device is removeably attachable among the throttling elements.

69. The apparatus of claim 52, wherein the sensing device comprises a removeable replacement of a throttling element.

70. The apparatus of claim 52, wherein the sensing device is comprised of a proximity strip in the general shape of an upright "T" when radially disposed with respect to the rotating member having an exposed length that exceeds the length of a longest throttling element.

71. The apparatus of claim 70, wherein the proximity strip is disposed among the throttling elements.

72. The apparatus of claim 70, wherein the proximity strip comprises an integral extension of the body arising among the throttling elements.

73. The apparatus of claim 70, wherein the proximity strip is removeably attachable among the throttling elements.

74. The apparatus of claim 70, wherein the proximity strip comprises a removeable replacement of a throttling element.

75. The apparatus of claim 70, wherein the proximity strip is comprised of Stelite® alloy, Nimonic® alloy, carbon or combinations thereof.

76. A combination comprising a turbine, including a rotatable member and a stationary member, and at least one apparatus for sealing the turbine as claimed in claim 1.

77. A combination comprising a turbine, including a rotatable member and a stationary member having at least one slot, and at least one floating sealing ring as claimed in claim 3.

78. The combination of claim 77, wherein the floating sealing ring is comprised of ring segments as claimed in claim 27.

79. A combination comprising a turbine, including a rotatable member and a stationary member having at least one slot, and at least apparatus for sealing a turbine as claimed in claim 52.

80. A method for producing a floating sealing ring against leakage of a working fluid from a turbine having a stationary member and a rotating member, the sealing ring being slideably disposable in at least one slot of the

stationary member, which slot has an upstream lateral surface and a downstream lateral surface, the method comprising:

a) providing a sealing ring comprising a head and a body having throttling elements extending radially therefrom;

b) providing at least one set of suspension devices that suspend the sealing ring at a design radial clearance;

c) disposing a sensing device among the throttling elements;

d) coupling the sensing device to the set of suspension devices such that the set of suspension devices maintains the sealing ring at the design radial clearance without damage to the throttling elements, whenever the sensing device contacts the rotating member;

81. The method of claim 80, wherein the set of suspension devices comprises a set of springs.

82. The method of claim 81 wherein the springs comprises leaf springs.

83. The method of claim 80, wherein the set of suspension devices comprises any device that generates opposing antiparallel forces that are substantially parallel to a longitudinal axis of the rotating member.

84. The method of claim 83, wherein the opposing antiparallel forces are respectively transmitted through a first force-transmitting surface and a second force-transmitting surface of the set of suspending devices.

85. The method of claim 84, wherein the antiparallel forces, directly or indirectly, maintain an upstream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

86. The method of claim 84, wherein the antiparallel forces directly or indirectly maintain a downstream lateral wall of the head in slideable contact with the downstream lateral surface of the slot.

87. The method of claim 84, wherein the antiparallel forces, directly or indirectly, maintain a downstream lateral wall of the head in slideable contact with the downstream lateral surface of the slot and maintain an upstream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

88. The method of claim 83, wherein the opposing antiparallel forces comprise physical, mechanical, electrical, magnetic, gravitational, hydraulic, or fluidic forces.

89. The method of claim 83, wherein the opposing antiparallel forces suspend the sealing ring at the design radial clearance.

90. The method of claim 83, wherein, upon contacting the rotating member, the sensing device transmits a radial component of the force of the contact through the floating sealing ring, momentarily overcoming the antiparallel forces exerted by the set of suspension devices and slideably moving the floating sealing ring to a new position, such that its actual radial clearance is substantially maintained at the design radial clearance, without any damage to throttling elements.

91. The method of claim 80, wherein the sensing device comprises an integral extension of the body arising among the throttling elements.

92. The method of claim 80, wherein the sensing device is removeably attachable among the throttling elements.

93. The method of claim 80, wherein the sensing device comprises a removeable replacement of a throttling element.

94. The method of claim 80, wherein the sensing device is comprised of a proximity strip in the general shape of an upright "T" when radially disposed with respect to the rotating member having an exposed length that exceeds the length of a longest throttling element.

95. The method of claim 94, wherein the proximity strip is disposed among the throttling elements.

96. The method of claim 94, wherein the proximity strip comprises an integral extension of the body arising among the throttling elements.

97. The method of claim 94, wherein the proximity strip is removeably attachable among the throttling elements.

98. The method of claim 94, wherein the proximity strip comprises a removeable replacement of a throttling element.

99. The method of claim 94, wherein the proximity strip is comprised of Stelite® alloy, Nimonic® alloy, carbon or combinations thereof.

100. A method for sealing a turbine against leakage of a working fluid, the turbine having a rotating member and a stationary member having at least one slot with an upstream lateral surface and a downstream lateral surface, the method comprising:

a) defining a central longitudinal axis about which the rotating member rotates;

b) defining a design radial clearance between a longest throttling element of a floating sealing ring and an outer surface of the rotating member;

c) slideably disposing a floating sealing ring comprising a body having throttling elements, a head, and at least one sensing device coupled to at least one set of suspension devices, in the slot of the stationary member thereby coaxially suspending the floating sealing ring at the design radial clearance by means of the set of suspension devices;

d) maintaining the floating sealing ring at the design radial clearance;

e) substantially restoring the floating sealing ring to the design radial clearance without damage to any of its throttling elements, whenever the sensing device contacts the rotating member;

101. The method of claim 100, wherein the set of suspension devices comprises a set of springs.

102. The method of claim 101 wherein the springs comprises leaf springs.

103. The method of claim 100, wherein the set of suspension devices comprises any device that generates opposing antiparallel forces that are substantially parallel to a longitudinal axis of the rotating member.

104. The method of claim 103, wherein the opposing antiparallel forces are respectively transmitted through a first force-transmitting surface and a second force-transmitting surface of the set of suspending devices.

105. The method of claim 104, wherein the antiparallel forces, directly or indirectly, maintain an upstream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

106. The method of claim 104, wherein the antiparallel forces, directly or indirectly, maintain a downstream stream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

107. The method of claim 104, wherein the antiparallel forces, directly or indirectly, maintain the downstream lateral wall of the head in slideable contact with the downstream lateral surface of the slot and maintain the upstream lateral wall of the head in slideable contact with the upstream lateral surface of the slot.

108. The method of claim 103, wherein the opposing antiparallel forces comprise physical, mechanical, electrical, magnetic, gravitational, hydraulic, or fluidic forces.

109. The method of claim 103, wherein the opposing antiparallel forces suspend the sealing ring at the design radial clearance.

110. The method of claim 103, wherein upon contacting the rotating member, the sensing device transmits a radial component of the force of the contact through the sealing ring, momentarily overcoming the antiparallel forces exerted by the set of suspension devices and slideably moving the floating sealing ring to a new position, such that its actual radial clearance is substantially maintained at the design radial clearance, without any damage to throttling elements.

111. The method of claim 100, wherein the sensing device comprises an integral extension of the body arising among the throttling elements.

112. The method of claim 100, wherein the sensing device is removeably attachable among the throttling elements.

113. The method of claim 100, wherein the sensing device comprises a removeable replacement of a throttling element.

114. The method of claim 100, wherein the sensing device is comprised of a proximity strip in the general shape of an upright "T" when radially disposed with respect to the rotating member having an exposed length that exceeds the length of a longest throttling element.

115. The method of claim 114, wherein the proximity strip is disposed among the throttling elements.

116. The method of claim 114, wherein the proximity strip comprises an integral extension of the body arising among the throttling elements.

117. The method of claim 114, wherein the proximity strip is removeably attachable among the throttling elements.

118. The method of claim 114, wherein the proximity strip comprises a removeable replacement of a throttling element.

119. The method of claim 114, wherein the proximity strip is comprised of Stelite® alloy, Nimonic® alloy, carbon or combinations thereof.

120. The method of claim 100, wherein the head is disposed within the slot, such that an upstream lateral wall of the head opposes the upstream lateral surface of the slot and a downstream lateral wall of the head opposes the downstream lateral surface of the slot.

121. The method of claim 104, wherein the set of suspension devices is disposed between the upstream lateral surface of the slot and the upstream lateral wall of the head, such that the first force-transmitting surface of the set of suspension devices makes slideable contact with the upstream lateral surface of the slot; the second force-transmitting surface of the set of suspension devices is coincident with the upstream lateral wall of the head; and, the downstream lateral wall of the head makes slideable contact with downstream lateral surface of the slot.

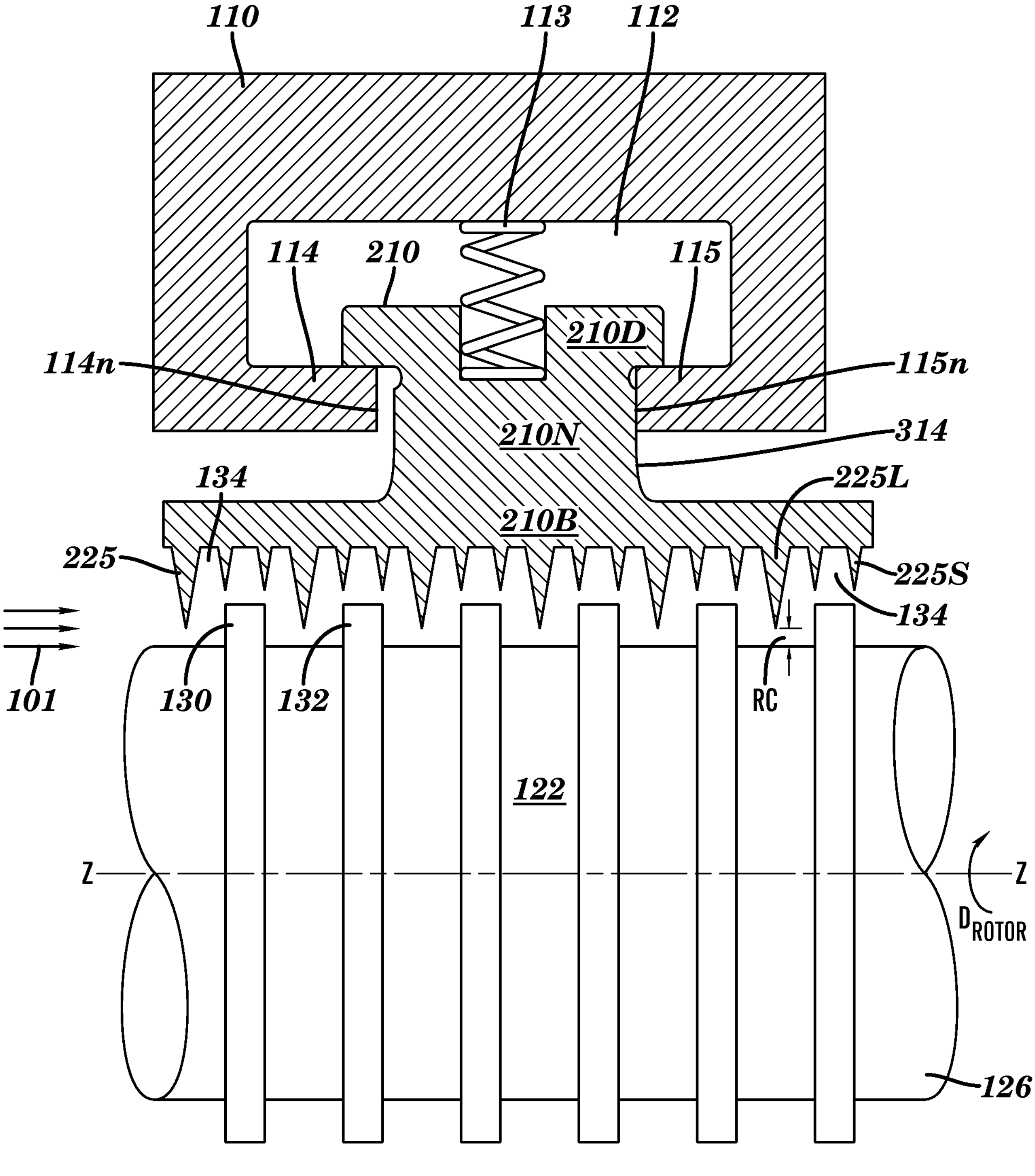

110
113
112
114
210
115
210D
114n
115n
210N
314
134
225L
210B
225
225S
134
101
130
132
RC
122
Z
Z
DROTOR
126

FIG. 1A

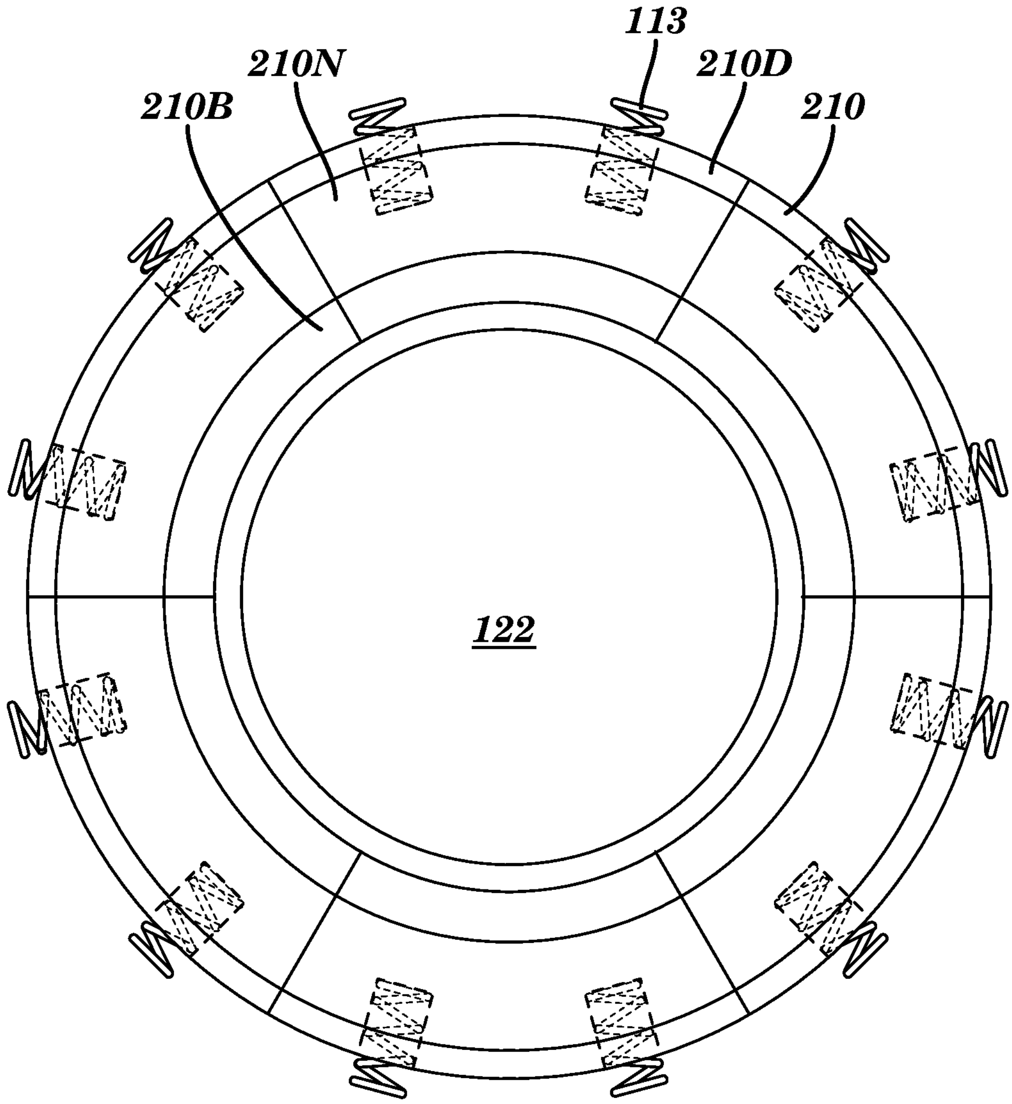


FIG. 1B

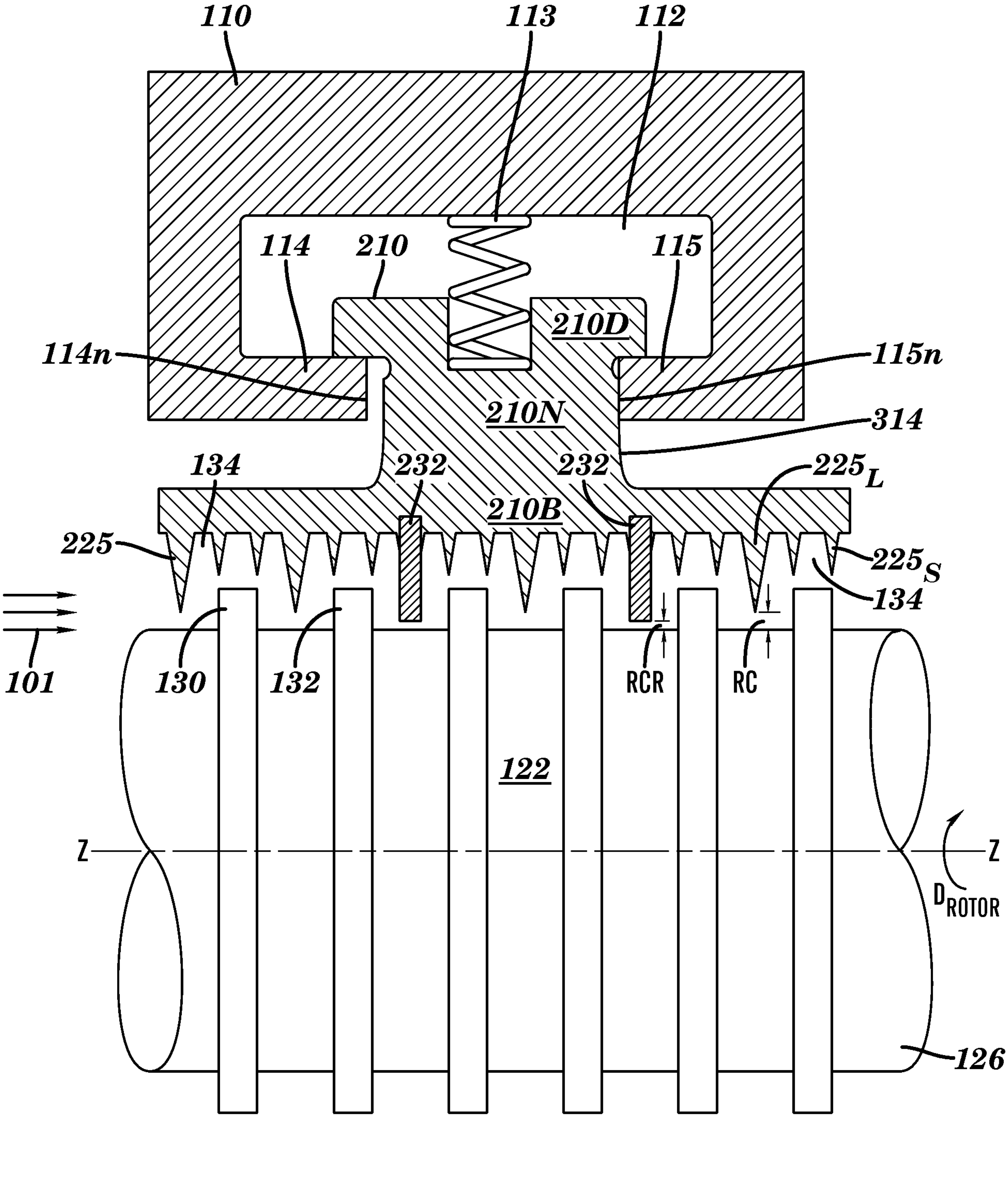

110
113
112
114
210
115
210D
114n
115n
210N
314
134
232
232
225L
210B
225
225S
134
101
130
132
RCR
RC
122
Z
Z
DROTOR
126

FIG. 2

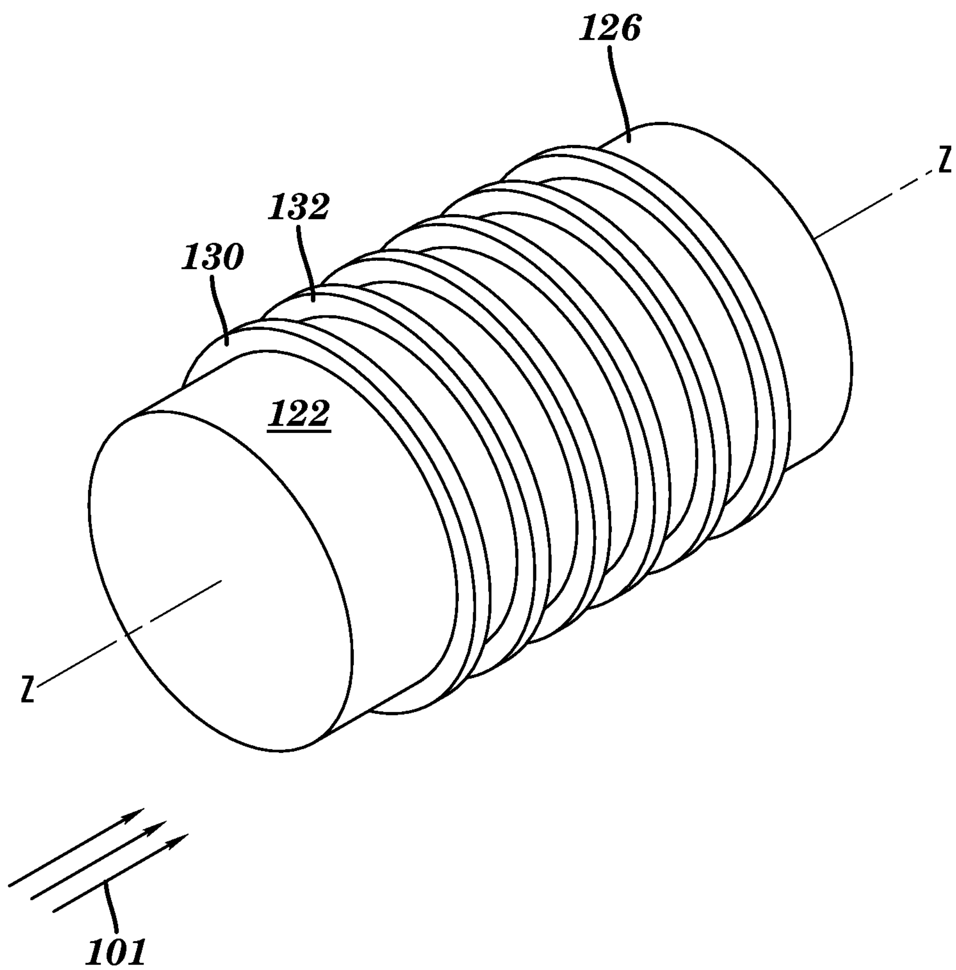


FIG. 3

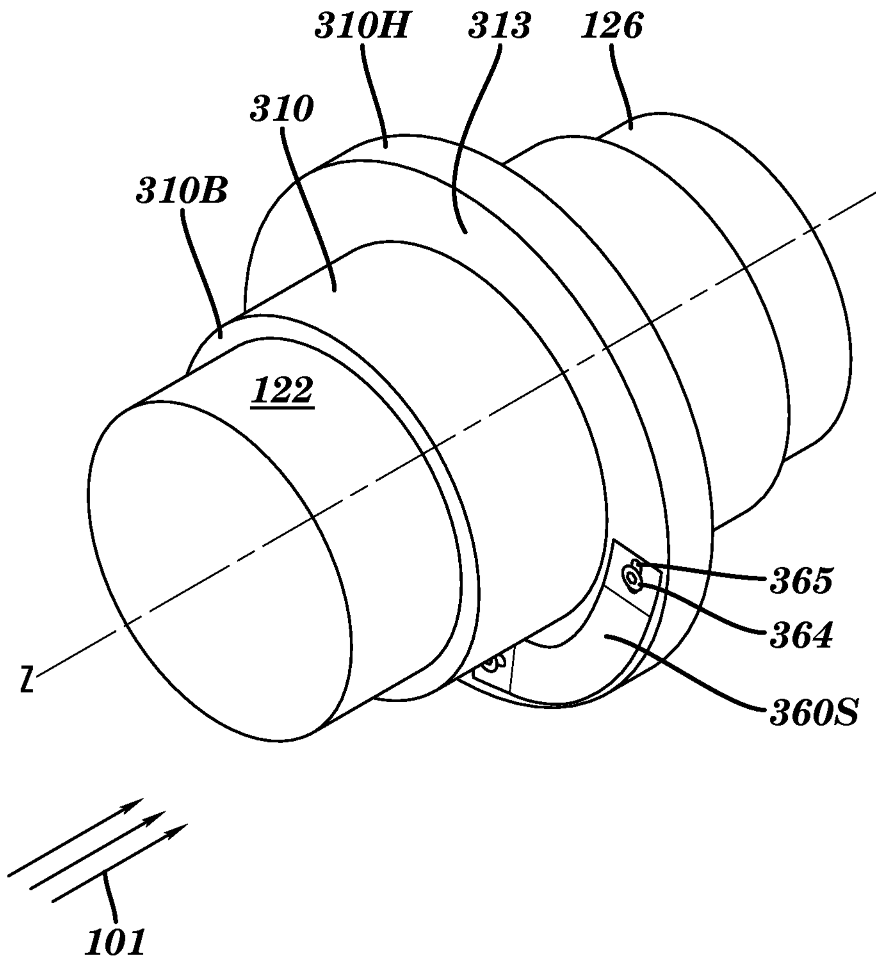


FIG. 4

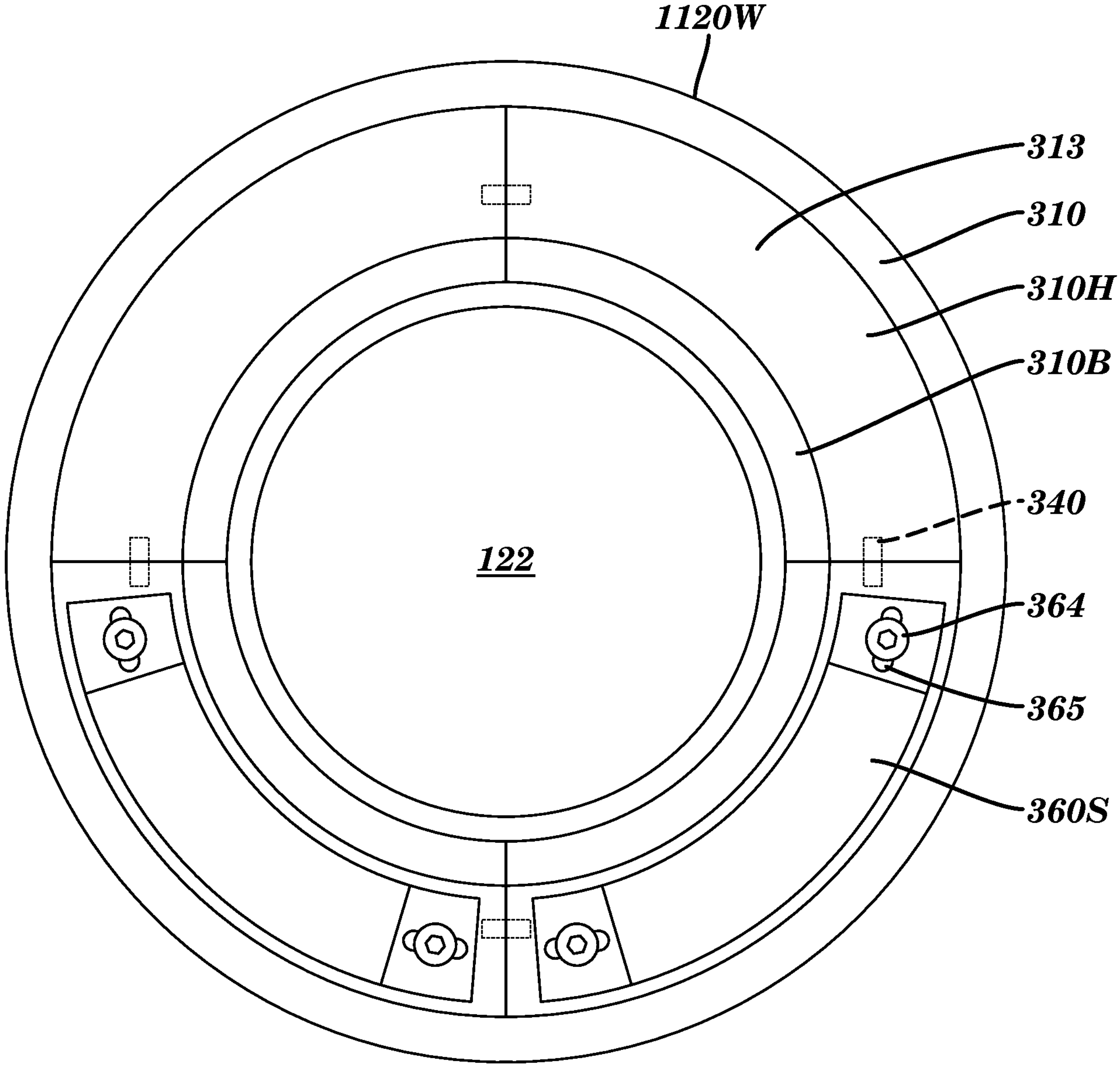


FIG. 5

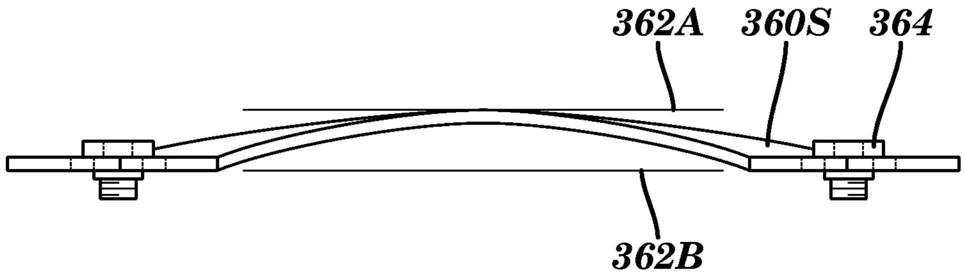


FIG. 6A

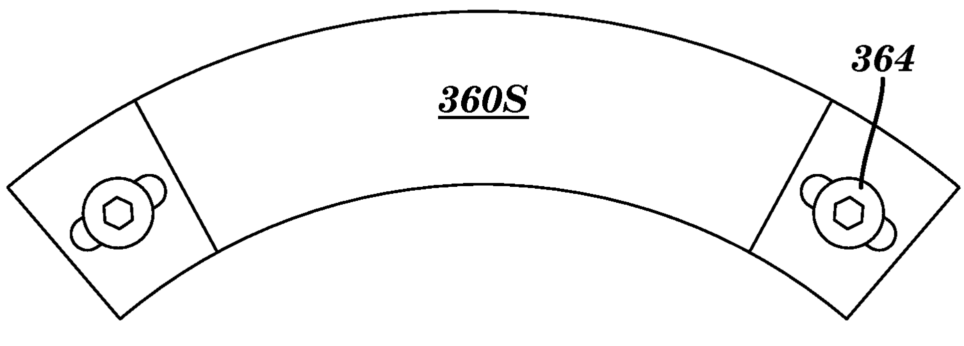


FIG. 6B

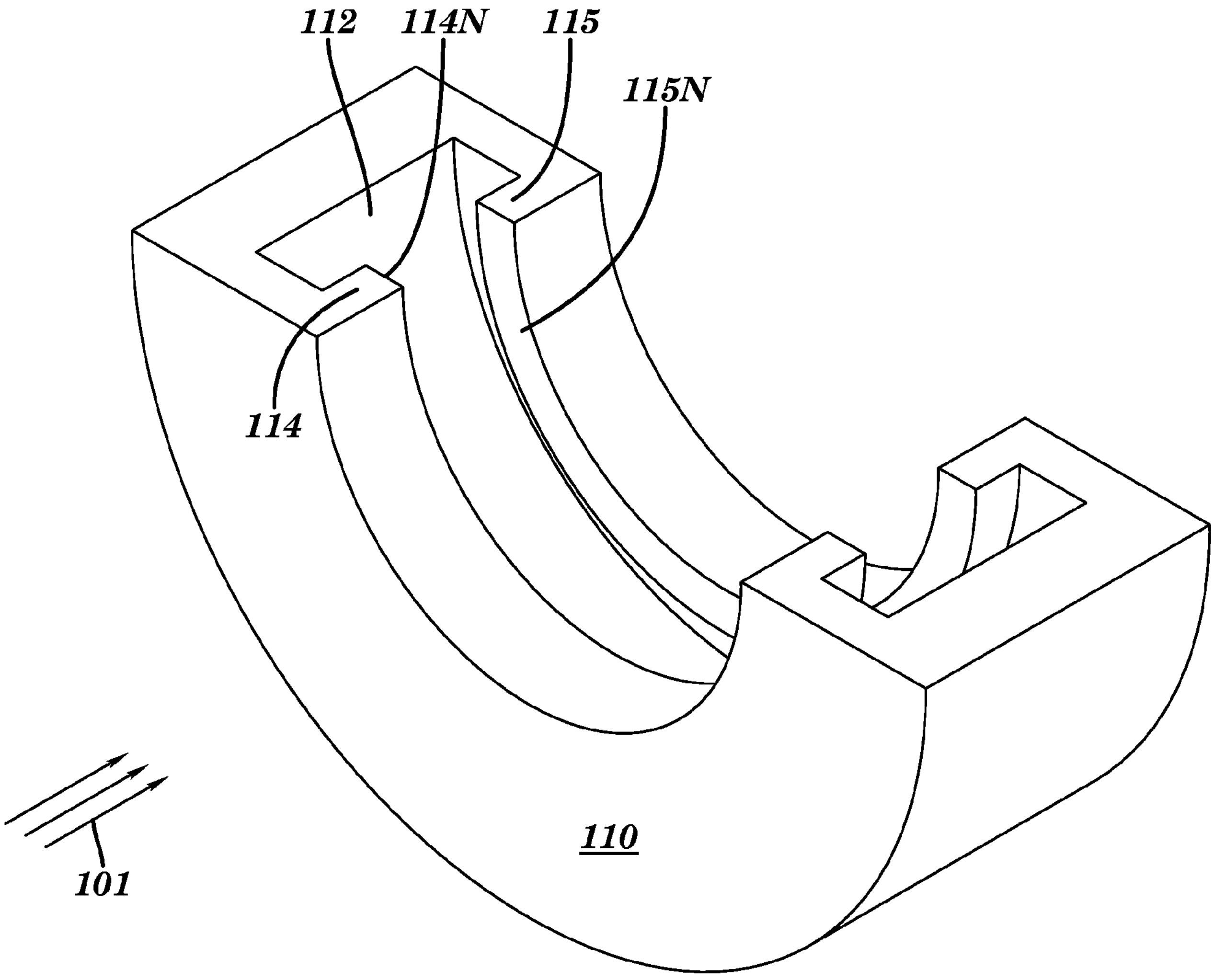


FIG. 7

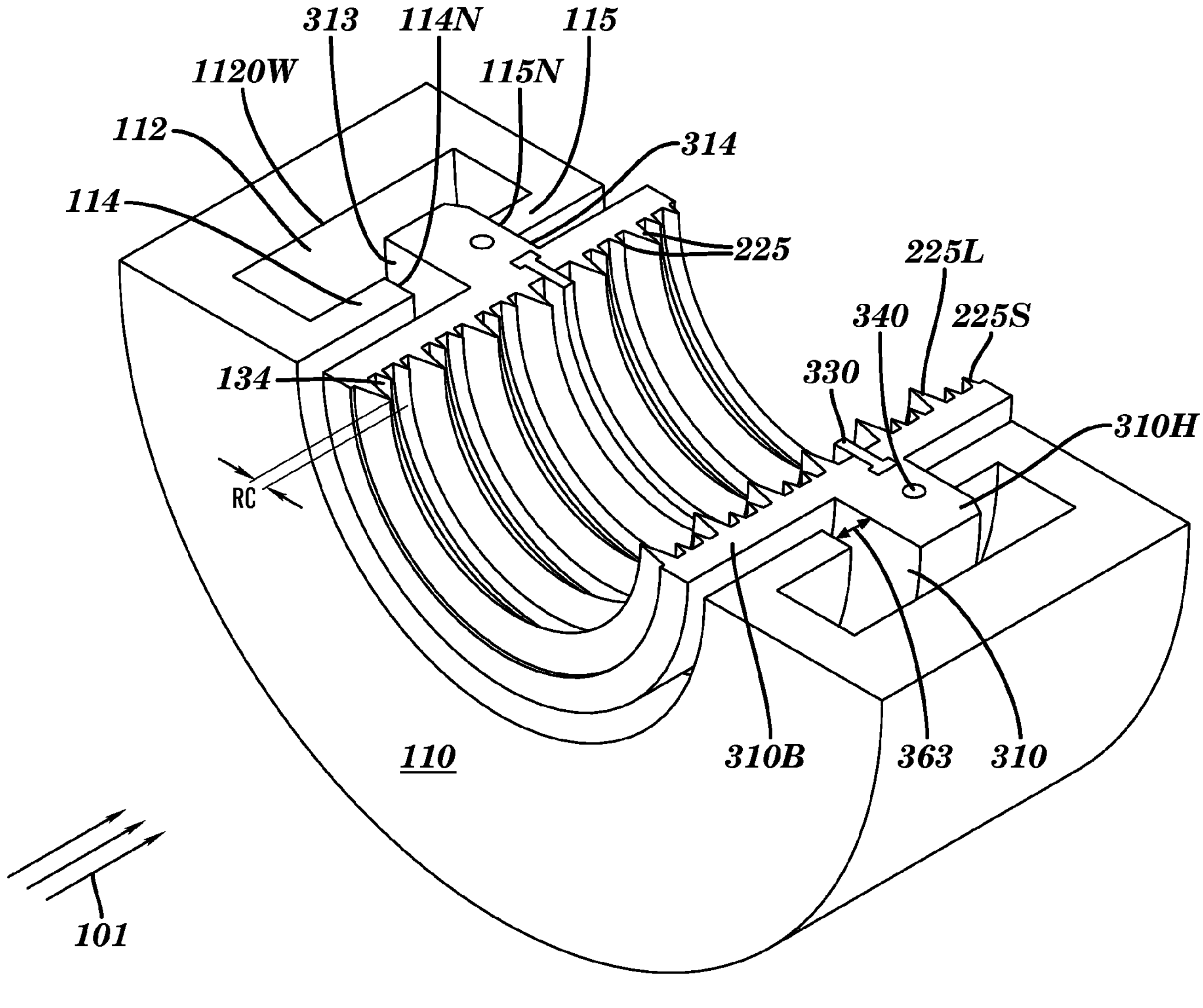
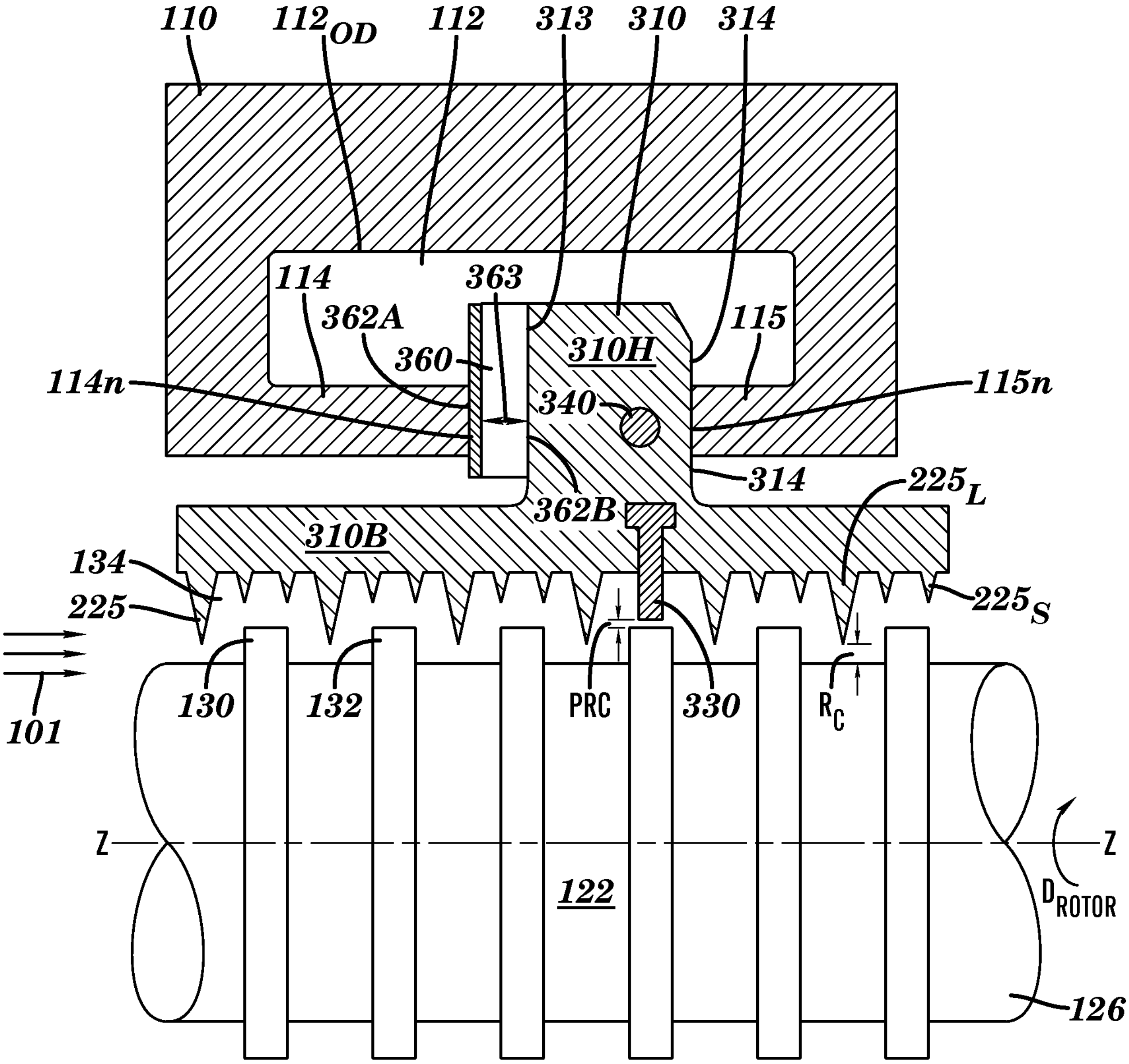

313
114N
115
1120W
115N
112
314
114
225
225L
340
225S
134
330
310H
RC
110
310B
363
310
101

FIG. 8



110
112OD
112
313
310
314
114
363
362A
115
360
310H
114n
340
115n
314
362B
225L
310B
134
225
225S
101
130
132
PRC
330
RC
Z
Z
122
DROTOR
126

FIG. 9