

(19) World Intellectual Property Organization
International Bureau



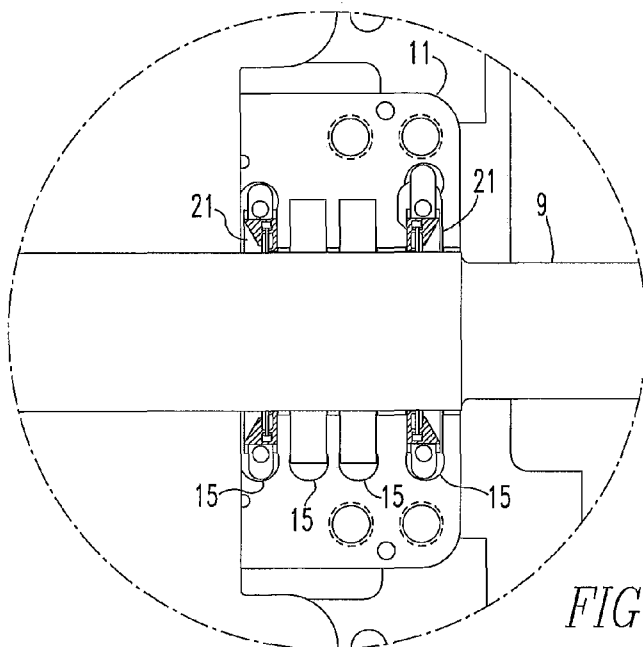
(43) International Publication Date
10 November 2011 (10.11.2011)

(10) International Publication Number
WO 2011/139741 A2

- (51) International Patent Classification:
F01D 11/00 (2006.01) *F02C 7/28* (2006.01)
F01D 25/24 (2006.01) *F16J 15/02* (2006.01)
- (21) International Application Number:
PCT/US2011/034075
- (22) International Filing Date:
27 April 2011 (27.04.2011)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/330,623 3 May 2010 (03.05.2010) US
- (71) Applicant (for all designated States except US): **ELLIOTT COMPANY** [US/US]; 901 North Fourth Street, Jeannette, Pennsylvania 15644 (US).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **MINDOCK, III, Michael, Arthen** [US/US]; 687 Arrow Road, New Ringgold, Pennsylvania 19760 (US).
- (74) Agents: **BYRNE, Richard, L.** et al.; The Webb Law Firm, One Gateway Center, 420 Fort Duquesne Boulevard, Suite 1200, Pittsburgh, Pennsylvania 15222 (US).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,

[Continued on next page]

(54) Title: BRUSH RING SEAL



(57) Abstract: A brush ring seal device for installation within a packing case of a turbine includes: a brush seal carrier having a substantially ring-shaped body portion having a front face, a rear face, an inner circumferential groove, and an outer circumferential groove; a brush seal mounted within the inner circumferential groove of the brush seal carrier; and a ring-shaped spring mounted within the outer circumferential groove of the brush seal carrier. The rear face of the brush seal carrier is coated with an anti-friction coating, thereby allowing movement of the brush ring seal device within the packing case.

WO 2011/139741 A2

SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG). **Published:**

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

BRUSH RING SEAL

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention, in general, is related to steam turbines, gas expanders, and industrial gas turbines and, more particularly, to a seal for sealing the radial gap between the rotor and the casing of the turbine.

Description of Related Art

[0002] With reference to **FIGS. 1** and **2**, a typical steam turbine **1** includes a casing **3** having an inlet end **5** and an exhaust end **7** and a rotor **9** extending through inlet end **5** and exhaust end **7** of casing **3**. Packing boxes **11** are provided at inlet end **5** and exhaust end **7** of casing **3** around rotor **9**. Packing boxes **11** are employed to seal an annular gap formed by rotor **9** penetrating through inlet end **5** and exhaust end **7** of casing **3**.

[0003] Traditionally, carbon ring seals **13** have been installed in packing boxes **11** to limit the leakage of gases from casing **3** to the atmosphere. A plurality of carbon rings **13** are positioned within grooves **15** in each of packing boxes **11**. Typically, multiple carbon ring seals **13** are positioned within each of packing boxes **11**.

[0004] Carbon is used in the manufacture of the ring seals **13** because it provides a low friction surface to interact with the rotor **9** and packing boxes **11**. However, carbon is a very brittle material and may fracture if too great of a load is applied thereto. Therefore, industry standards require a limitation of the differential pressure across a carbon ring to 35 psi. As a result, with carbon ring seals it is typically necessary to provide multiple seals along the shaft.

[0005] Accordingly, a need exists for a ring seal for use in a packing box that ensures low leakage through the rotor shaft-casing gap while also accommodating radial motion of the seal for shaft excursions. A further need exists for a ring seal that is manufactured from a durable material to prevent fracture when encountering a large differential pressure load. Provided according to this invention is a brush seal that can be used with existing packing boxes to replace most or all of the carbon ring seals.

SUMMARY OF THE INVENTION

[0006] An object of the present invention is to provide a ring seal for use in a packing box of a steam turbine that ensures low leakage through the rotor shaft-casing gap of the turbine to allow radial motion of the seal for shaft excursions. It is also an object of the present invention to provide a ring seal that is manufactured from a durable material to prevent fracture when encountering a large differential pressure load and/or high temperature differential.

[0007] Accordingly, the present invention is directed to a brush ring seal device for installation within a packing case of a turbine. The brush ring seal includes: a brush seal carrier having a substantially ring-shaped body portion having a front face, a rear face, an inner circumferential groove, and an outer circumferential groove; a brush seal mounted within the inner circumferential groove of the brush seal carrier; and a ring-shaped spring mounted within the outer circumferential groove of the brush seal carrier. The rear face of the brush seal carrier is coated with an anti-friction coating, thereby allowing movement of the brush ring seal within the packing case.

[0008] The brush seal carrier and brush seal may be each manufactured as two half segments or as rings then split, for example by EDM. The ring-shaped spring may be configured to retain the two half segments of the brush seal carrier together. The two half segments of the brush seal carrier may form a pair of axial slots at a joint thereof when coupled together. The brush seal carrier device may further comprise support tabs positioned within the axial slots at the joint of the two half segments. The anti-friction coating may include one of tungsten disulfide, molybdenum disulfide, Jet-Hot Pistonclad™, or Molybdenum and Nickel/Chrome. The brush seal carrier may be manufactured from metal.

[0009] The present invention is also directed to a turbine that includes: a casing having an inlet end and an exhaust end; a rotor extending through the casing between the inlet end and the exhaust end; a packing case surrounding the rotor at the inlet end and the exhaust end of the casing to provide sealing of an annular gap formed by the rotor extending through the inlet end and the exhaust end of the casing; and at least one brush ring seal device installed within the packing case. The brush ring seal device includes: a brush seal carrier having a substantially ring-shaped body portion having a front face, a rear face, an inner circumferential groove, and an outer circumferential groove; a brush seal mounted within the inner circumferential groove of the brush seal carrier; and a ring-shaped spring mounted within the outer circumferential groove of

the brush seal carrier. The rear face of the brush seal carrier is coated with an anti-friction coating, thereby allowing movement of the brush ring seal within the packing case.

[0010] The brush seal carrier and brush seal may be each manufactured as two half segments or as rings then split, for example by EDM. The ring-shaped spring may be configured to retain the two half segments of the brush seal carrier together. The two half segments of the brush seal carrier may form a pair of axial slots at a joint thereof when coupled together. The brush seal carrier device may further comprise support tabs positioned within the axial slots at the joint of the two half segments. The anti-friction coating may include one of tungsten disulfide, molybdenum disulfide, Jet-Hot Pistonclad™, or Molybdenum and Nickel/Chrome. The brush seal carrier may be manufactured from metal.

[0011] The present invention is also directed to a method of sealing an annular gap formed by a rotor extending through a casing of a turbine between an inlet end of the casing and an exhaust end of the casing. The method includes the steps of: positioning a packing case to surround the rotor at the inlet end and the exhaust end of the casing; providing at least one brush ring seal device; and installing the brush ring seal device within the packing case to seal the annular gap. The brush ring seal device includes: a brush seal carrier having a substantially ring-shaped body portion having a front face, a rear face, an inner circumferential groove, and an outer circumferential groove; a brush seal mounted within the inner circumferential groove of the brush seal carrier; and a ring-shaped spring mounted within the outer circumferential groove of the brush seal carrier. The rear face of the brush seal carrier is coated with an anti-friction coating, thereby allowing movement of the brush ring seal within the packing case.

[0012] These and other features and characteristics of the present invention, as well as the methods of operation and functions of the related elements of structures and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims with reference to the accompanying drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limits of the invention. As used in the specification and the claims, the singular form of “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0013] FIG. 1 is a top plan view of a steam turbine in partial cross-section that includes conventional carbon ring seals installed in packing boxes;
- [0014] FIG. 2 is a portion of the top plan view of FIG. 1 enlarged for magnification purposes of the packing box;
- [0015] FIG. 3A is an exploded, front perspective view of a brush ring seal in accordance with the present invention;
- [0016] FIG. 3B is a partially assembled, exploded, front perspective view of the brush ring seal in accordance with the present invention;
- [0017] FIG. 4 is an assembled, front perspective view of the brush ring seal in accordance with the present invention;
- [0018] FIG. 5 is an assembled, rear perspective view of the brush ring seal in accordance with the present invention;
- [0019] FIG. 6 is a cross-sectional view of the brush ring seal taken along line 6-6 in FIG. 4;
- [0020] FIG. 7 is a top plan view of a steam turbine in partial cross-section that includes brush ring seals installed in the packing boxes in accordance with the present invention; and
- [0021] FIG. 8 is a portion of the top plan view of FIG. 7 enlarged for magnification purposes.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

- [0022] For purposes of the description hereinafter, the terms “upper”, “lower”, “right”, “left”, “vertical”, “horizontal”, “top”, “bottom”, “lateral”, “longitudinal”, and derivatives thereof shall relate to the invention as it is oriented in the drawing figures. However, it is to be understood that the invention may assume various alternative variations, except where expressly specified to the contrary. It is also to be understood that the specific devices illustrated in the attached drawings, and described in the following specification, are simply exemplary embodiments of the invention. Hence, specific dimensions and other physical characteristics related to the embodiments disclosed herein are not to be considered as limiting.
- [0023] With reference to FIGS. 3A, 3B, and 4-6, a brush ring seal device, denoted generally as reference numeral 21, includes a brush seal carrier that is split into a first half 25 and a second half 27. The components of the brush ring seal device 21 including the brush ring seal carrier, brush seal (described hereafter) and garter spring (also described hereafter) are split in two half

segments to enable placement of the brush ring seal device into the packing box and around the shaft being sealed. When assembled, first half **25** and second half **27** form a substantially ring-shaped body portion that has a front face **29**, a rear face **31**, an inner circumferential groove **33**, and an outer circumferential groove **35**. Front face **29** tapers toward the center of the ring shaped body portion, while the rear face **31** is substantially flat.

[0024] When installed within a packing box **11** of a steam turbine **1**, rear face **31** faces toward the low pressure side and is in contact with packing case **11**, and front face **29** faces the high pressure side. The packing box provides axial restraint of the brush ring seal device by providing a substantially flat radial face against which the rear face **31** of the brush ring seal device is pressed during pressurized use. The packing box provides no radial restraint on the brush seal ring while the ring is being emplaced. The bristles of the brush surrounding the shaft naturally align the brush ring seal device on the shaft. During pressurized use, friction between the rear face of the brush ring seal and the flat face against which it abuts tends to fix the radial position of the brush ring seal device. Small excursions of the shaft are accommodated by flexing of the bristles. Accordingly, rear face **31** has applied thereto a low-coefficient of friction coating to facilitate limited radial movement of brush ring seal device **21** should the rotor **9** contact brush ring seal device **21** during a more extensive shaft excursion. The anti-friction coating may be any one of the following: tungsten disulfide, molybdenum disulfide, Jet-Hot Pistonclad™, or Molybdenum and Nickel/Chrome. However, this is not to be construed as limiting the present invention as it has been envisioned that any suitable anti-friction coating may be utilized depending on the sealed fluid parameters (*e.g.*, temperature, pressure, corrosiveness). The coating permitting limited radial movement of the contact brush ring seal device protects the bristles from being permanently damaged during more extensive shaft excursions, and thus extends the life of the brush ring seal device and improves sealing. In addition, brush seal carrier **25, 27** may be manufactured from a metal material such as, but not limited to, grade 304 stainless steel, grade 410 stainless steel, or 17-14 ph stainless steel.

[0025] Brush ring seal device **21** further includes a brush seal that is split into a first half **39** and a second half **41**. When assembled, first half **39** and second half **41** form a substantially ring-shaped body portion that is sized and shaped to fit within inner circumferential groove **33** of brush seal carrier **25, 27**. More specifically, first half **39** and second half **41** of brush seal each include a bristle strip **40** coupled to a retainer **42**. Bristle strip **40** is manufactured from a plurality

of bristles that are welded or clamped together. The bristles may be manufactured from Haynes 25, which is an alloy of cobalt, nickel, chromium, and tungsten. However, this is not to be construed as limiting the present invention as any suitable material may be used to manufacture the bristles. Retainer 42 is configured to slide within inner circumferential groove 33 of brush seal carrier 25, 27 during assembly as shown in FIGS. 3A and 3B. Brush seal 39, 41 functions to seal the radial gap between rotor 9 and brush seal carrier 25, 27, and brush seal carrier 25, 27 supports brush seal 39, 41 and acts as a face seal against packing box 11. As is well known in the art, the bristles of the brush seal approach the shaft at a slight angle to the radial extending toward the circumferential direction in which the shaft normally rotates. Ideally there is a slight clearance between the ends of the bristles and the surface of the shaft while the seal is not pressurized. Under pressure the bristles move into contact with the surface of the shaft.

[0026] Brush ring seal device 21 also includes a ring-shaped garter spring 43. Garter spring 43 is mounted within outer circumferential groove 35 of the brush seal carrier to retain first and second halves 25, 27, 39, and 41 of brush seal carrier and brush seal together once assembled around rotor 9 in packing box 11. When first half 25 and second half 27 of brush seal carrier are coupled together, a pair of axial slots 45 are formed at a joint thereof. While the figures show these axial slots 45 being formed in second half 27 of the brush seal carrier, this is not to be construed as limiting the present invention as axial slots 45 may also be formed in first half 25 of the brush seal carrier or formed in both first half 25 and second half 27 of brush seal carrier.

[0027] A pair of support tabs 47 is positioned within axial slots 45. Support tabs 47 support brush ring seal device 21 in packing case 11 during assembly and prevent rotation thereof until pressure is applied. In addition, each of support tabs 47 includes a hole 49. Garter spring 43 includes a first end 51 and a second end 53. First end 51 and second end 53 each include a hook as shown in FIG. 3A. During assembly, first end 51 is passed through a hole 49 in one of support tabs 47 and second end 53 is passed through a hole 49 of the other support tab 47 and then the first end 51 and second end 53 of garter spring 43 are coupled together using the hooks to form a ring-shaped garter spring 43 positioned within outer circumferential groove 35 as shown in FIGS. 4 and 5.

[0028] With reference to FIGS. 7 and 8 and with continuing reference to FIGS. 3A, 3B, and 4-6, in operation, brush ring seal device 21 is designed to seal an annular gap formed by rotor 9 extending through casing 3 of steam turbine 1 between inlet end 5 of casing 3 and exhaust end 7

of casing 3. Initially, first and second halves 25, 27, 39, and 41 of the brush seal carrier and brush seal are positioned around rotor 9 within packing box 11. Garter spring 43 is thereafter mounted within outer circumferential groove 35 of brush seal carrier 25, 27 to retain first and second halves 25, 27, 39, and 41 of the brush seal carrier and brush seal together. In addition, support tabs 47 are positioned within axial slots 45 to support brush ring seal device 21 in packing case 11 during assembly until pressure is applied.

[0029] When fluid begins to flow in the casing 3, a differential pressure is created across brush ring seal device 21, which creates an axial force pushing brush ring seal device 21 from the high pressure region toward the low pressure region. Without the anti-friction coating applied to rear face 31 of brush seal carrier 25, 27, brush ring seal device 21 would require a large force to move radially should rotor 9 contact brush seal carrier 25, 27. The use of an anti-friction coating on rear face 31 of brush seal carrier 25, 27 significantly reduces the force rotor 9 must exert on brush ring seal device 21 to move brush ring seal device 21, and hence less damage will occur to brush ring seal device 21 and rotor 9 during an impact.

[0030] In addition, a major advantage of brush ring seal device 21 is that it is not made from brittle carbon. Accordingly, brush ring seal device 21 can reliably withstand differential pressures as high as 500 psi. Consequently, fewer brush ring seal devices 21 are required to seal against high casing internal pressure. As shown in FIGS. 7 and 8, only two brush ring seal devices 21 may be required in each packing box 11 rather than multiple carbon seals. However, this is not to be construed as limiting the present invention as one brush ring seal device 21 may be utilized.

[0031] Although the invention has been described in detail for the purpose of illustration based on what is currently considered to be the most practical and preferred embodiments, it is to be understood that such detail is solely for that purpose and that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover modifications and equivalent arrangements. For example, it is to be understood that the present invention contemplates that, to the extent possible, one or more features of any embodiment can be combined with one or more features of any other embodiment.

THE INVENTION CLAIMED IS

1. A brush ring seal device for installation within a packing case of a turbine, the brush ring seal device comprising:

a brush seal carrier having a substantially ring-shaped body portion having a front face, a rear face, an inner circumferential groove, and an outer circumferential groove;

a brush seal mounted within the inner circumferential groove of the brush seal carrier; and

a ring-shaped spring mounted within the outer circumferential groove of the brush seal carrier,

wherein the rear face of the brush seal carrier is coated with an anti-friction coating, thereby allowing movement of the brush ring seal device within the packing case.

2. The brush ring seal device of claim 1, wherein the brush seal carrier and brush seal are each manufactured as two half segments.

3. The brush ring seal device of claim 2, wherein the ring-shaped spring retains the two half segments of the brush seal carrier together.

4. The brush ring seal device of claim 2, wherein the two half segments of the brush seal carrier form a pair of axial slots at a joint thereof when coupled together.

5. The brush ring seal device of claim 4, further comprising support tabs positioned within the axial slots at the joint of the two half segments.

6. The brush ring seal device of claim 1, wherein the anti-friction coating comprises one of tungsten disulfide, molybdenum disulfide, Jet-Hot Pistonclad™, and Molybdenum and Nickel/Chrome.

7. The brush ring seal device of claim 1, wherein the brush seal carrier is manufactured from metal.

8. A turbine comprising:
 - a casing having an inlet end and an exhaust end;
 - a rotor extending through the casing between the inlet end and the exhaust end;
 - a packing case surrounding the rotor at the inlet end and the exhaust end of the casing to provide sealing of an annular gap formed by the rotor extending through the inlet end and the exhaust end of the casing; and
 - at least one brush ring seal device installed within the packing case, the brush ring seal device comprising:
 - a brush seal carrier having a substantially ring-shaped body portion having a front face, a rear face, an inner circumferential groove, and an outer circumferential groove;
 - a brush seal mounted within the inner circumferential groove of the brush seal carrier; and
 - a ring-shaped spring mounted within the outer circumferential groove of the brush seal carrier,
- wherein the rear face of the brush seal carrier is coated with an anti-friction coating, thereby allowing movement of the brush ring seal device within the packing case.
9. The turbine of claim 8, wherein the brush seal carrier and brush seal are each manufactured as two half segments.
10. The turbine of claim 9, wherein the ring-shaped spring retains the two half segments of the brush seal carrier together.
11. The turbine of claim 9, wherein the two half segments of the brush seal carrier form a pair of axial slots at a joint thereof when coupled together.
12. The turbine of claim 11, further comprising support tabs positioned within the axial slots at the joint of the two half segments.

13. The turbine of claim 8, wherein the anti-friction coating comprises one of tungsten disulfide, molybdenum disulfide, Jet-Hot Pistonclad™, and Molybdenum and Nickel/Chrome.

14. The turbine of claim 9, wherein the brush seal carrier is manufactured from metal.

15. A method of sealing an annular gap formed by a rotor extending through a casing of a turbine between an inlet end of the casing and an exhaust end of the casing, the method comprising:

positioning a packing case to surround the rotor at the inlet end and the exhaust end of the casing;

providing at least one brush ring seal device comprising:

a brush seal carrier having a substantially ring-shaped body portion having a front face, a rear face, an inner circumferential groove, and an outer circumferential groove;

a brush seal mounted within the inner circumferential groove of the brush seal carrier; and

a ring-shaped spring mounted within the outer circumferential groove of the brush seal carrier; and

installing the brush ring seal device within the packing case to seal the annular gap,

wherein the rear face of the brush seal carrier is coated with an anti-friction coating, thereby allowing movement of the brush ring seal device within the packing case.

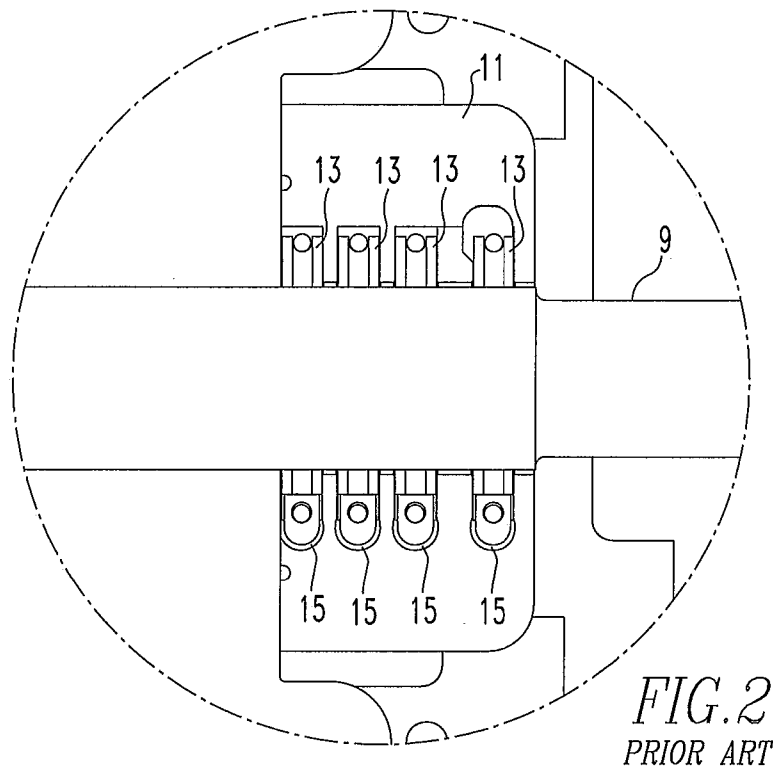
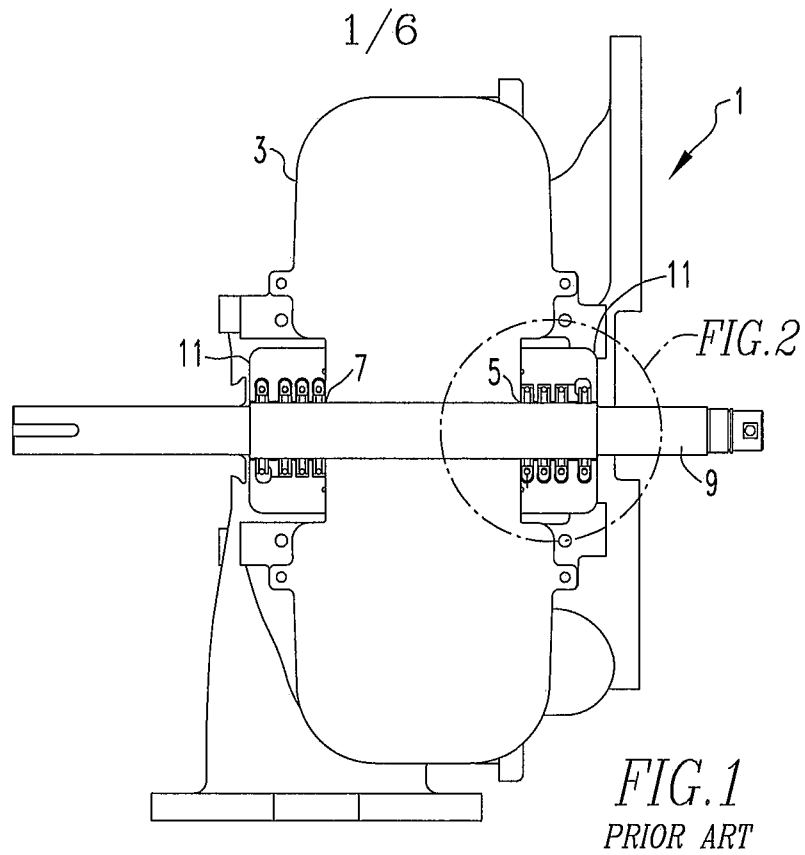
16. The method of claim 15, wherein the brush seal carrier and brush seal are each manufactured as two half segments.

17. The method of claim 16, wherein the ring-shaped spring retains the two half segments of the brush seal carrier together.

18. The method of claim 16, wherein the two half segments of the brush seal carrier form a pair of axial slots at a joint thereof when coupled together.

19. The method of claim 18, wherein support tabs are positioned within the axial slots at the joint of the two half segments.

20. The method of claim 15, wherein the anti-friction coating comprises one of tungsten disulfide, molybdenum disulfide, Jet-Hot Pistonclad™, and Molybdenum and Nickel/Chrome.



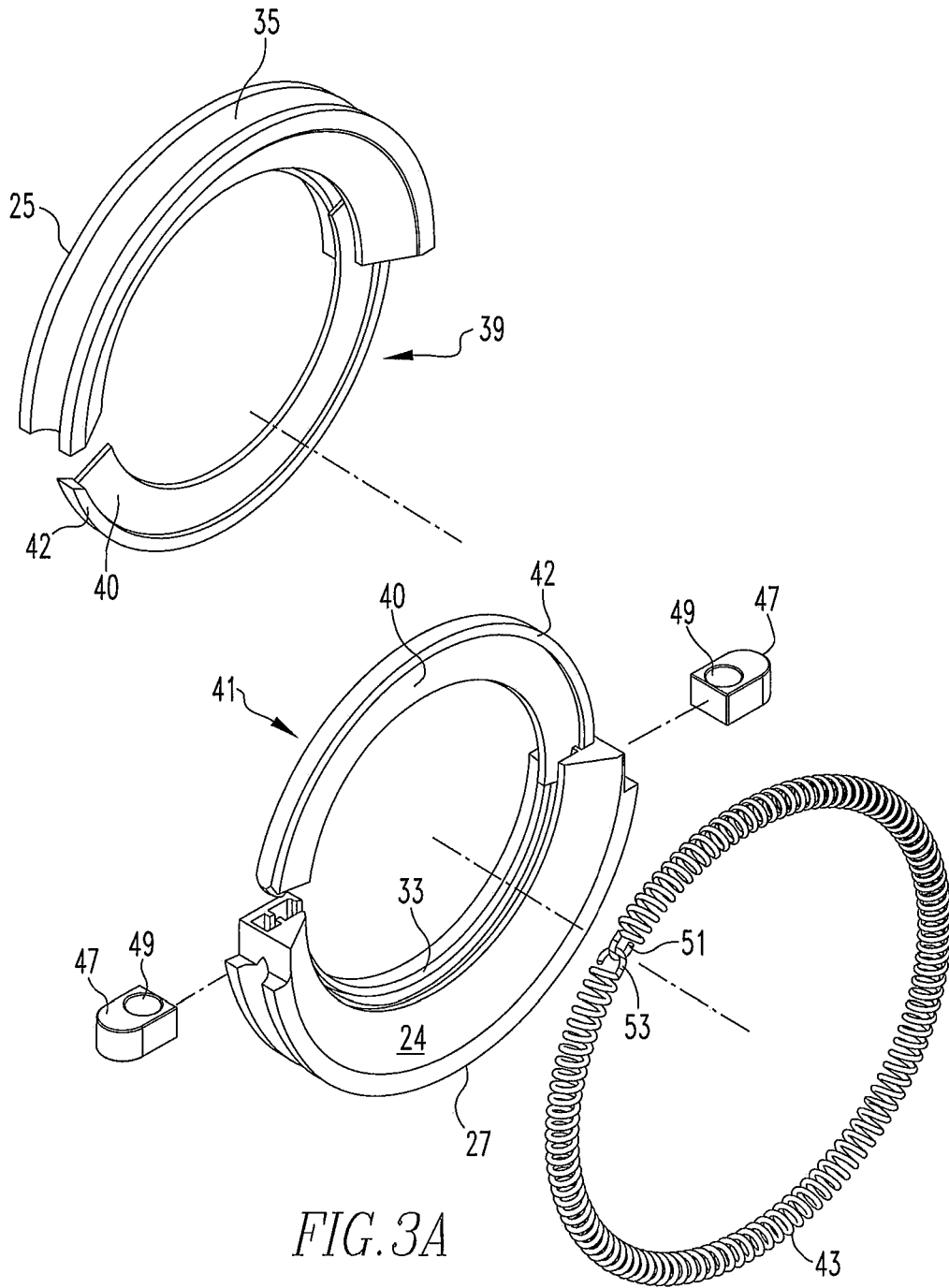
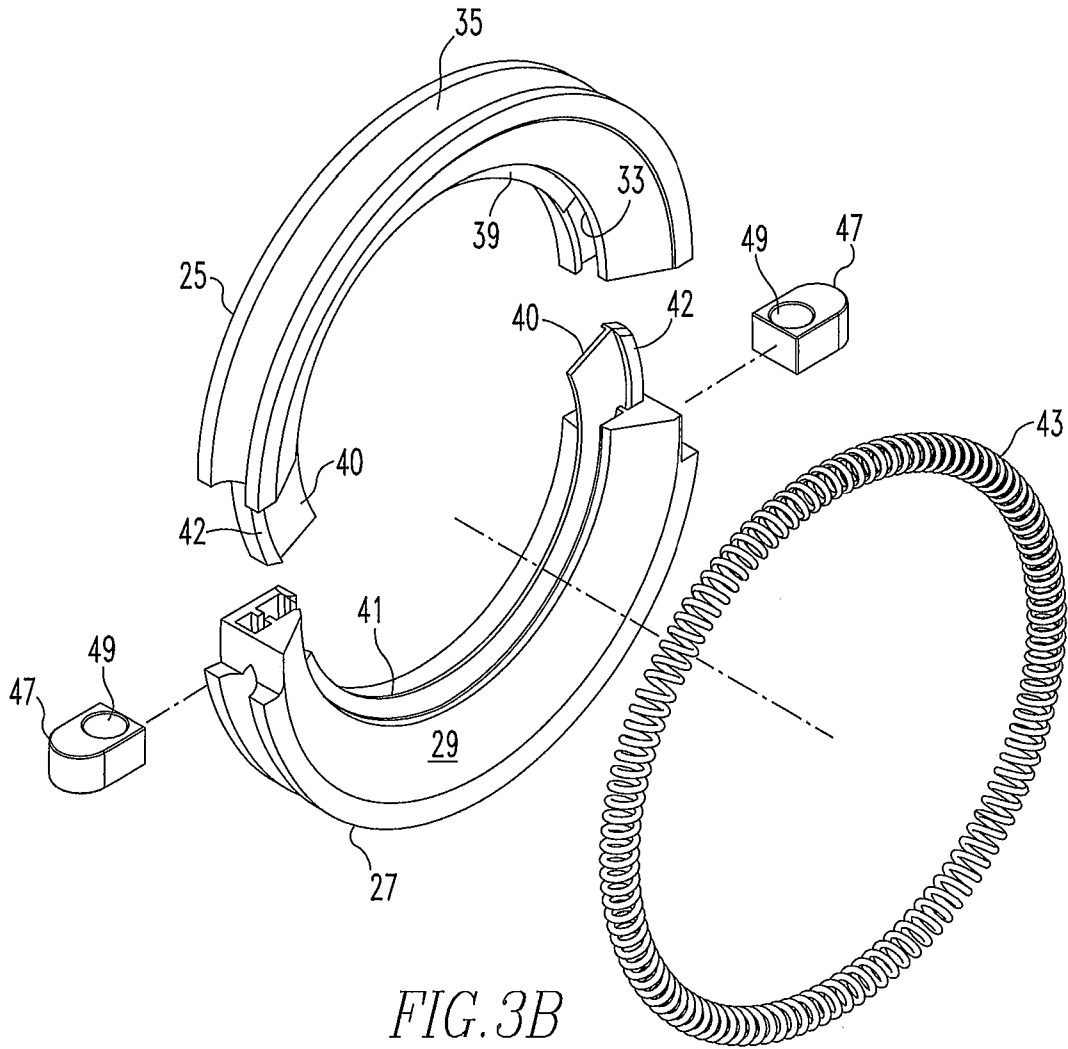
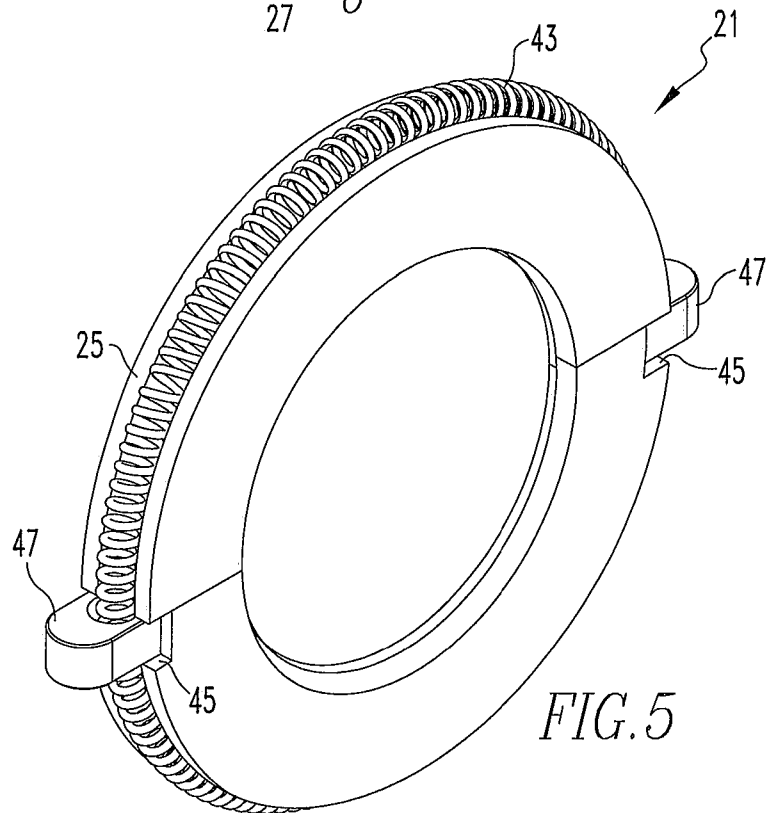
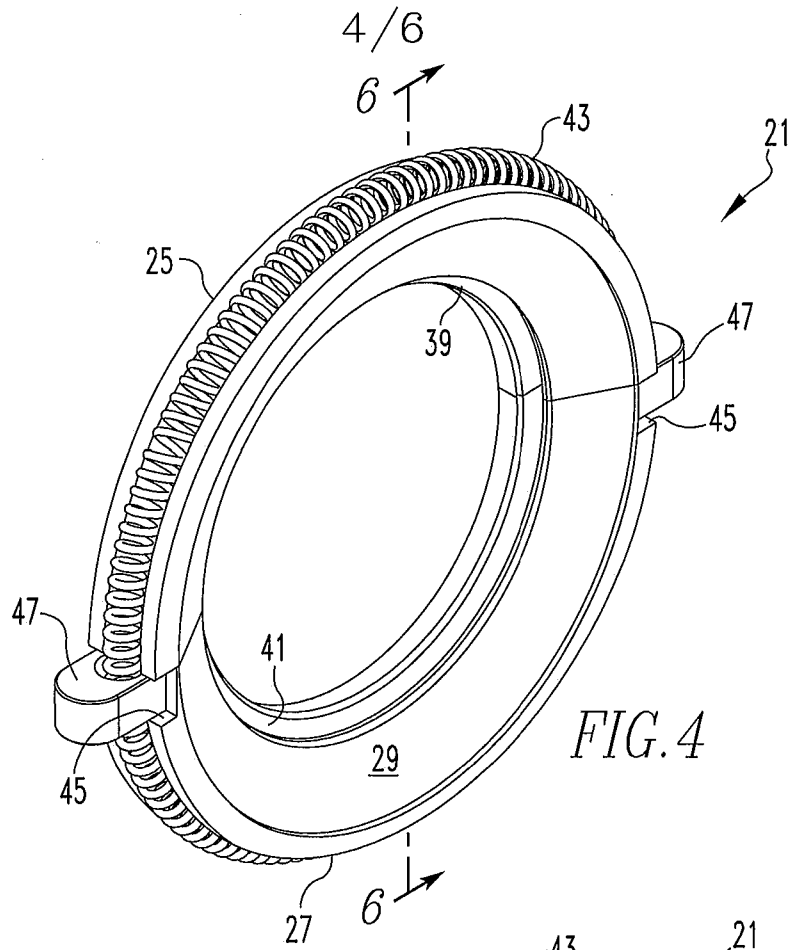


FIG. 3A





5/6

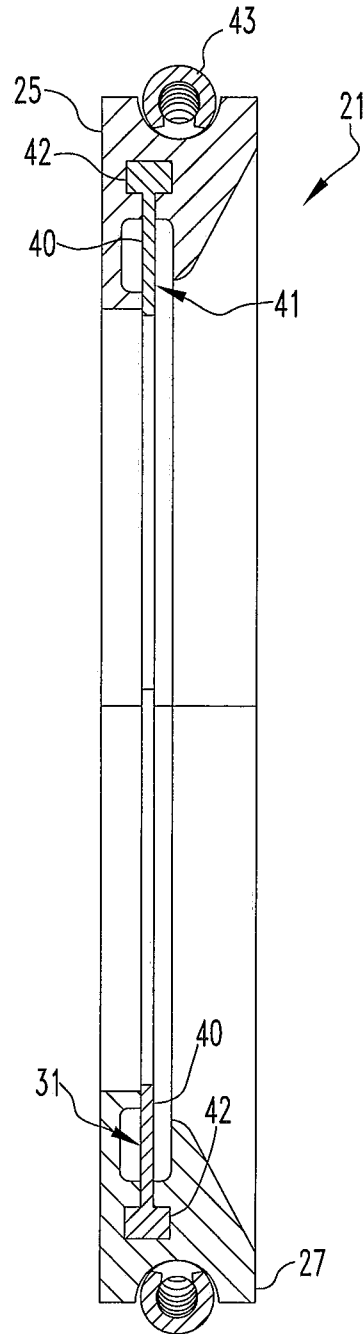


FIG. 6

