United States Patent [19]

Kurio

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[45] **Mar. 4, 1975**

[54] **SEALING DEVICE FOR USE IN ROTARY PISTON ENGINE**

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[52] **U.S. Cl.** **418/142**

[51] **Int. Cl.** **F01c 19/00**

[58] **Field of Search** 418/142

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Primary Examiner—C. J. Husar

Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

[57] **ABSTRACT**

A sealing device for use in a rotary piston engine having a rotor eccentrically rotatably accommodated in a rotor cavity formed in a center housing and a pair of end walls secured to the center housing, which comprises an annular groove formed on each side surface of the rotor, the annular groove accommodating therein a pair of sealing strips curled into a substantially circular configuration. The sealing strips are respectively held flat against groove faces of the groove by a supporter and are collapsibly biased by a spring patch member with one side edge of each of the sealing strips tightly, but slidably, contacting the end wall.

9 Claims, 15 Drawing Figures

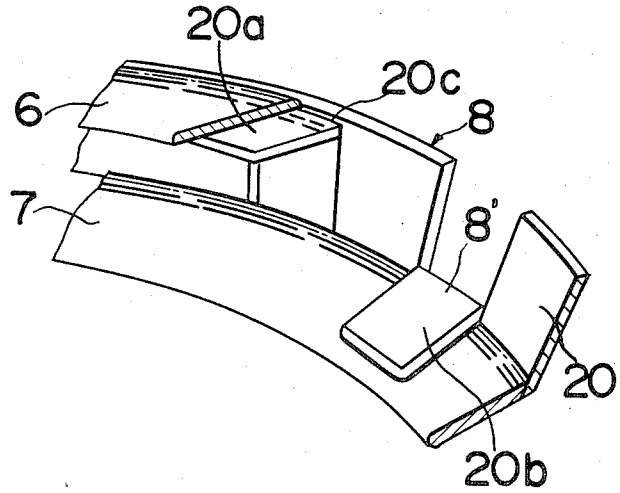


FIG. 1

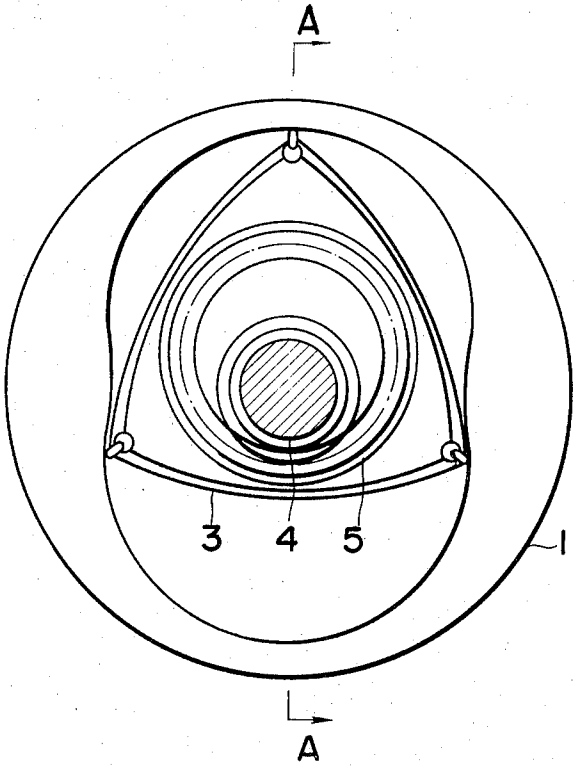


FIG. 2

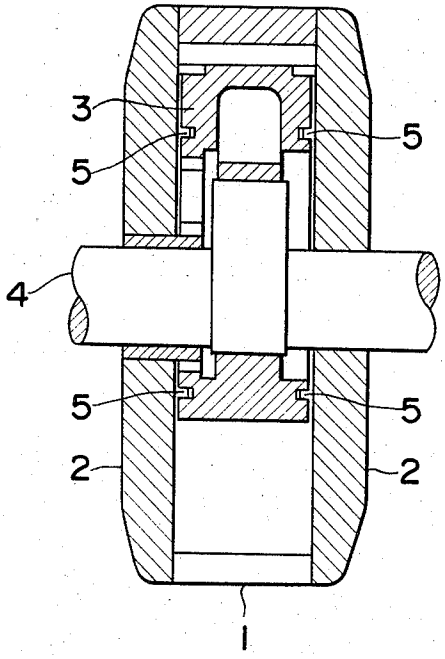


FIG. 3

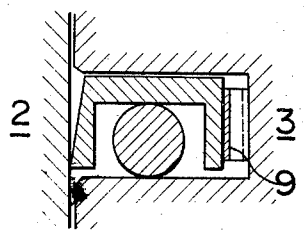


FIG. 4

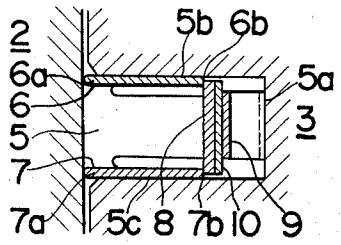


FIG. 5

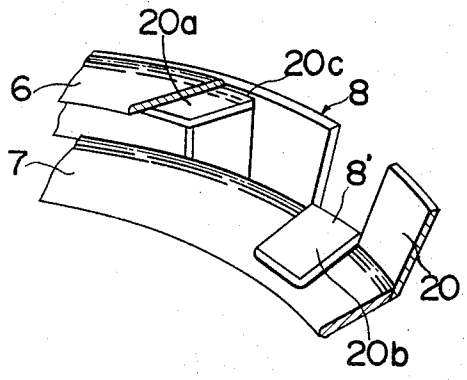


FIG. 6

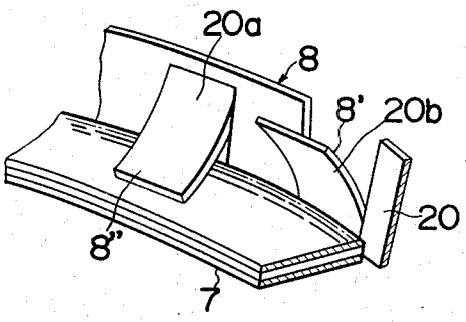


FIG. 7

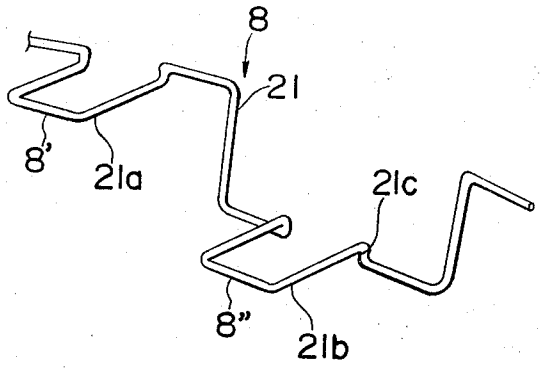


FIG. 8 (a)

FIG. 9 (a)

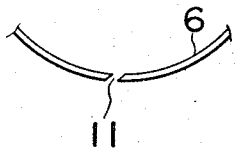
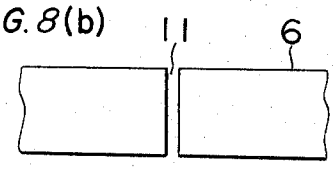


FIG. 8(b)



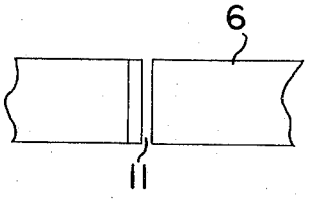
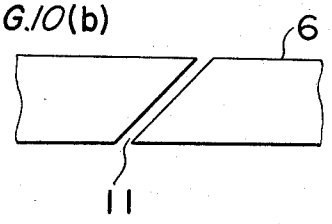


FIG. 9 (b)

FIG. 10(b)



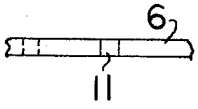
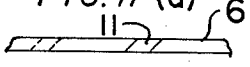


FIG. 10(a)

FIG. 11 (a)



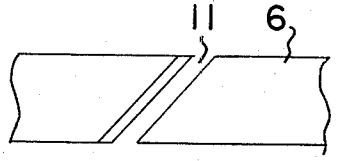


FIG. 11 (b)

SEALING DEVICE FOR USE IN ROTARY PISTON ENGINE

The present invention relates to an oil seal device and, more particularly, to an improved oil seal device for use in a rotary piston internal combustion engine.

A type of internal combustion engine to which the present invention is applied is a rotary piston engine also known as a Wankel engine, which makes use of a three-lobed rotor that rotates eccentrically within a substantially epitrochoidally shaped cavity. In the rotary piston engine, there is a problem of preventing lubrication oil from entering any of the working chambers, defined by the rotor within the epitrochoidally shaped cavity, and being burnt. The rotor lobes fit closely against the sides of the cavity in which they rotate, but, since it is not practical to fit the rotor closely enough to the sides of the cavity to completely prevent undesired movement of oil, it is the usual practice to provide an oil seal means, in the form of oil-control rings, inserted in circular grooves formed in both sides of the rotor.

Conventionally, such rings, as shown in FIG. 3 of the accompanying drawings, are bracket-like in cross-section, and, when a ring is positioned in a groove, the top of the bracket is placed in contact with the side of the groove, one leg of the bracket is placed in contact with the base of the groove or in contact with a spring which contacts the base of the groove, and the end of the other leg projects slightly from the groove to come into contact with the walls of the cavity within which the rotor rotates. To secure an oil-control ring within a groove in the rotor, there is conventionally provided packing in the form of an O-ring which is fitted underneath the oil-control ring and between the oil-control ring and one side of the groove. However, such conventional oil seal means have disadvantages in that the O-ring employed is generally made of rubber and therefore there are basic limits to the precision with which the ring can be made and also the ring is subject to deformation and dimensional change due to the effects of heat and to the chemical nature of the burned gases with which the ring comes into contact. Also, gasoline or oil may be absorbed by the ring, thus leading to further changes in the spring loading capacity of the ring.

Because of such disadvantages, the effectiveness of the conventional oil seal means is lessened and the service life is also short.

It is accordingly an essential object of the present invention to provide an improved rotary piston engine oil seal means that overcomes the disadvantages inherent in the conventional oil seal means.

It is another object of the present invention to provide an improved rotary piston engine oil seal means that is simple in construction and easy to mount.

In accomplishing these and other objects, there is provided according to the present invention, an oil seal means for use in a rotary piston engine which comprises a pair of equidistantly spaced and substantially circular strips of different diameters which are inserted into a circular groove formed in each side surface of a rotor or rotary piston; the substantially larger diameter strip lying flat against the outer side of the groove, that is the groove face remote from the rotatory center of the rotor, and the substantially smaller diameter strip lying flat against the inner side of the groove, that is the groove face close to the rotatory center of the rotor,

and one rim of each strip projecting slightly outwardly from the groove in substantially parallel relation to the axial direction of the rotor.

For keeping the strips of each pair in tight contact with the respective corresponding groove faces in the circular groove, a substantially ring-shaped supporter having a plurality of elastic tongues, each extending therefrom in substantially the axial direction of the rotor towards the opening of the groove, is provided for each groove for pressing said strips in the opposite directions within the groove by means of said elastic tongues. While the strips of each pair are pressed against the respective groove faces in the grooves by the supporter, these strips are collapsibly accommodated within said grooves backed up by a spring patch member, with or without the intervention of a back-up ring member, so that each side edge of the strips adjacent to the opening of the groove tends to project toward the corresponding side wall of the rotor housing for slidable engagement therewith.

A better understanding of the present invention may be had from the following full description when read in reference to the accompanying drawings, in which;

FIG. 1 is a front sectional view of a rotary piston engine embodying the present invention;

FIG. 2 is a longitudinal cross-sectional view taken along the line A-A in FIG. 1;

FIG. 3 is a longitudinal cross-sectional view of a portion of a conventional rotary piston engine having oil seal means employed in the form of an O-ring;

FIG. 4 is a similar view to FIG. 3, showing a corresponding portion of the engine having oil seal means according to the present invention;

FIG. 5 is a perspective view of a portion of the oil seal device according to one embodiment of the present invention;

FIG. 6 is a similar view to FIG. 5, showing another embodiment of the present invention;

FIG. 7 is a perspective view of a patch element made of wire according to a still further embodiment of the present invention;

FIG. 8 *a* and *b* are end edge and plan views respectively of each strip employed, showing one manner of end-to-end connection, and

FIG. 9*a* and *b*, 10*a* and 10*b*, and 11*a* and 11*b* are end edge and plan views respectively of various strips; employed, showing different alternative manners of end-to-end connection.

Before proceeding with the description of the present invention, it is to be noted that, throughout the several accompanying drawings, like numerals refer to like parts.

Referring to the drawings in more detail, there is shown in FIG. 1 and 2, a rotor cavity of substantially epitrochoidal shape formed by a center housing 1 and a pair of end walls 2 secured thereto. Within the rotor cavity, there is a three-lobed rotor 3 which is mounted on a rotary shaft 4 through a sun and planet gear assembly. The cavity is divided into substantially three working chambers the volume of each of which varies in accordance with eccentric rotation of the rotor 3 effected by the combustion of fuel-air mixture in one of the working chambers and then conditioned in the power stroke.

The arrangement and function of the rotary piston engine so far described is well known to those skilled

in the art and, therefore, the details thereof are herein omitted for the sake of brevity.

Hereinafter, the oil seal device according to the present invention will be described in detail with reference to FIGS. 4 to 11.

In the surface of each side of the rotor 3, there is formed a circular groove 5 coaxial with the center of the rotor 3, said groove 5 being composed of an opening facing a corresponding end wall 2, a bottom face 5*a* remote from the end wall 2, and a pair of opposed groove faces 5*b* and 5*c*. The description will hereinafter continue with reference to the groove 5 and the oil seal device on one side only of the rotor 3, it being understood that the same description shall apply to both sides of the rotor.

In the groove 5, a pair of sealing strips 6 and 7 preferably 0.5 mm. thick, each of which is preferably made of steel and has the same width as that of the other, are collapsibly accommodated in such a manner that the one strip 6 is held flat against the groove face 5*b* and the other strip 7 is held flat against the other groove face 5*c*. This is achieved by a substantially ring-shaped supporter 8 having a construction which will be described later, which is held in position close to the bottom face 5*a* of the groove 5.

The circumferential lengths of the sealing strips 6 and 7 are slightly less than the outer and inner peripheries of the contours of the groove faces 5*b* and 5*c*, respectively, by a distance on the order of, for example, a fraction of millimeter, thereby to provide a space 11 between the ends of the sealing strips when said sealing strips 6 and 7 are curled to fit within the groove 5 in the manner as hereinbefore described, said space 11 in each of said strips 6 and 7 being defined by a pair of opposed ends thereof, as shown in FIGS. 8–11. The provision of this space 11 between the opposed ends of each of the sealing strips 6 and 7 ensures in cooperation with the supporter 8 that the sealing strips 6 and 7 fit flat against the corresponding groove face 5*b* and 5*c* with substantially no space left for fluid and/or gaseous matter such as exhaust gases, atomized fuel-air mixture and lubrication oil to pass therethrough. If metallic material which absolutely does not undergo thermal expansion and shrinkage is available, the use of this metallic material is preferable for the sealing strips 6 and 7 and/or other members susceptible to the elevated temperature. In any event, if each of these sealing strips 6 and 7 is made of such metallic material, it may be made in the form of a cylindrical body without the provision of the space 11.

Each of these sealing strips 6 and 7 has a pair of rims 6*a* and 6*b*, and 7*a* and 7*b* and these sealing strips 6 and 7 and the supporter 8, both within the groove 5, are backed up by a spring patch element 9 acting on a back-up member 10 and, therefore, are biased in one direction towards the opening of the groove 5 in parallel relation to the axial direction of the power output shaft 4 (FIG. 2) with the rims 6*a* and 7*a* tightly contacting the end wall 2 and the other rims 6*b* and 7*b* being pressed by the patch element 9 through the back-up member 10.

In view of the fact that the edge surface of each of the rims 6*a* and 7*a* of the sealing strips 6 and 7 facing the end wall 2 slides on the end wall 2 at a relatively high speed, these portions of the rims 6*a* and 7*a* are preferably surface-hardened thereby to impart a sufficient wear resistance thereto. For this purpose, these portions of the rims 6*a* and 7*a* of the sealing strips 6 and 7 may be nitrided, nickel-chromium plated or chilled. In the case where the portions of the rims 6*a* and 7*a* are to be chilled, the method disclosed in U.S. Pat., patented on Apr. 25, 1972 under U.S. Pat. No. 3,658,451 may be advantageously and effectively applicable.

Furthermore, the thickness of each of the sealing strips 6 and 7 at the respective surface thereof contacting the end wall 2 is preferably within the range of 0.2 to 0.3 mm. provided that each of said strips 6 and 7 has the abovementioned thickness. In practice, depending on the thickness of each of the sealing strips, the thickness thereof at the respective surface contacting the end wall 2 may be within the range of 0.2 to 0.5 mm. In any event, this is for the purpose of preventing the performance of each sealing strip as a seal device from deteriorating during the service life thereof which may otherwise occur when these portions of the rims 6*a* and 7*a* wear.

The spring patch element 9 employed in the arrangement as shown in FIG. 4 is in the form of a wave washer and the back-up member 10 interposed between the rims 6*b* and 7*b* of the respective strips 6 and 7 and the spring patch element 9 of the wave washer type is in the form of a flat washer having a width substantially equal to the distance between the groove faces 5*b* and 5*c* in the radially outward direction. Nevertheless, the element 9 and member 10 are not always limited to the particular types described, respectively, and may be integrally formed so far as the desired or expected purpose can be achieved.

The space 11 in each of the sealing strips 6 and 7 (hereinafter, reference is made only to the strip 6 for the sake of brevity.) may be in various forms as shown in FIGS. 9–12. Referring therefore to these drawings, it will be readily understood that the space 11 can be formed as in FIG. 8*a* and FIG. 8*b* in which each of the opposed ends of the sealing strip 6 is square-cornered and the space 11 defined thereby extends in parallel relation to the widthwise direction; of said sealing strip 6 as shown in FIG. 8*b*. On the other hand, FIGS. 9*a* and 9*b* illustrate that the opposed ends of the sealing strip 6 are respectively inclined in the opposite and lengthwise directions with respect to each other and the space 11 defined thereby extends in parallel relation to the widthwise direction of said sealing strip 6 as shown in FIG. 9*b*. As seen in FIGS. 10*a* and *b*, the space 11 can be inclined to the circumferential direction of the strip 6, and square-cornered. Finally, as shown in FIGS. 11*a* and *b*, the space 11 can be inclined to the circumferential direction of the strip 6, and the opposed ends can also be inclined.

As stated above, although the description has proceeded with reference to only sealing strip 6, the same shall be understood as equally applicable to the sealing strip 7.

Hereinafter, the details of the supporter 8 will be described with reference to FIGS. 5 to 7.

Referring first to FIG. 5, the supporter 8 comprises a ring having a large sized washer-like shape, preferably made of elastically deformable metallic material, and having a sufficient width substantially equal to the space between the sealing strips 6 and 7. The ring, indicated by 20 has a plurality of elastic tongues 20*a* and 20*b* formed by pressing portions of the ring 20 in the same direction at equal intervals alternately radially outwardly and inwardly from the plane of the ring 20.

The tongues formed by radially outwardly bending portions of the ring **20** are generally indicated by **20***a* while the tongues formed by radially inwardly bending portions of the ring **20** are generally indicated by **20***b*. Care must be taken that a space having a size corresponding to the thickness of any of the sealing strips **6** and **7**, only one spare being shown as indicated by **20***c* in association with the tongue **20***a*, be provided between the root of each tongue **20***a* and **20***b* and a corresponding inner or outer peripheral edge of the ring **20** for contact with the rim **6***b* and **7***b* of the sealing strip **6** and **7** as clearly shown.

The tongues **20***a* and **20***b* thus formed act in cooperation with each other to elastically press the sealing strips in the opposite directions and in the radially outwards and inwards directions with respect to the ring **20** thereby causing said strips **6** and **7** to be held flat against the groove faces **5***b* and **5***c* within the groove **5**.

In the embodiment shown in FIG. **6**, the tongues **20***a* and **20***b* are made to extend diagonally radially outwardly and inwardly. However, in this embodiment, unlike the embodiment of FIG. **5** wherein a set of tongues **20***a* are associated with the outer sealing strip **6** while a set of tongues **20***b* with the inner sealing strip **7**, the set of tongues **20***a* are associated with the inner sealing strip **7** and the set of tongues **20***b* with the outer sealing strip **6**. In addition, in case of practical employment of the supporter of the construction shown in FIG. **6**, a plurality of sealing strips **6** and **7** are respectively provided in a set, for example, three sealing strips such as shown in FIG. **6**, due to the fact that, if each tongue is made to extend diagonally from the plane of the ring **20**, there is in fact formed between the tip of said tongue and the level of one face of the ring **20** close to said tip a space having a relatively larger size than that of the space **20***c* in FIG. **5**, that is, the thickness of the corresponding strip.

Referring now to FIG. **7**, the supporter **8** is shown as formed by an elastically deformable wire **21**, for example, piano wire, curved in a zigzag manner so as to follow substantially the contour of the supporter of FIG. **5**. Equivalents of the elements such as indicated by **20***a*, **20***b* and **20***c* in FIG. **5** are respectively indicated by **21***a*, **21***b* and **21***c*.

From the foregoing, it has now become clear that the seal device according to the present invention makes no use of an O-ring which has heretofore been largely employed. Furthermore, in view of the use of two sealing strips **6** and **7** each made substantially in the form of a ring, a double sealing effect can be advantageously achieved. The elimination of the use of the O-ring ensures an advantageous improvement of the durability of the sealing device.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art and, therefore, they should be construed as being included within the true scope of the present invention unless otherwise they depart therefrom.

What is claimed is:

1. A sealing device for use in a rotaty piston internal combustion engine having a rotor eccentrically rotatably accommodated in a rotor cavity formed by a center housing having a substantially epitrochoidally shaped bore for said rotor cavity and a pair of end walls secured to both ends of said center housing, said rotor having an annular groove on each of the opposite side surfaces of said rotor defined by a pair of outer and inner groove faces, the plane of each of which lies in parallel relation to the longitudinal axis of said rotor, and a bottom face facing towards a corresponding end wall; said sealing device comprising a first, substantially circularly curved sealing strip means and a second, substantially circularly curved sealing strip means, both slidably accommodated within said groove for sliding in a direction parallel to the longitudinal axis of the rotor; first biasing means for biasing said first and second sealing strip means flat against the respective groove faces in the radially outwards and inwards directions, respectively, comprising a circular member made of elastically deformable metallic material and having a plurality of elastic tongue members alternately radially outwardly and inwardly bent from the plane of said circular member in the same direction at intervals, a set of said tonuge members which are radially outwardly bent from said circular member acting to press one sealing strip means against the one groove face while another set of the tongue members, which are radially inwardly bent from said circular member act to press the other sealing strip means against the other groove face, and second biasing means within said groove for biasing said first and second sealing strip means outwardly of said groove, thereby causing one end face of each of said sealing strip means adjacent to the opening of said groove to tightly but slidably contact the corresponding end wall.

2. The sealing device as claimed in claim **1**, wherein said second biasing means comprises a wave washer acting to elastically bias said first and second sealing strip means so as to cause the corresponding end faces thereof to contact the end wall.

3. The sealing device as claimed in claim **1**, wherein said end face of each of said first and second sealing strip means contacting the end wall is surface-hardened to impart thereto a sufficient resistance to wear.

4. The sealing device as claimed in claim **1**, further comprising a back-up member interposed between said first and second mentioned biasing means for uniformly transmitting the resilient force of said second mentioned means to said first and second sealing strip therethrough.

5. The sealing device as claimed in claim **1**, wherein each of said first and second sealing strip means is a single sealing strip having a pair of spaced opposed ends defining a space therebetween.

6. The sealing device as claimed in claim **1** wherein said circular member comprises a wire made of elastically deformable metallic material, said wire being curved in a zigzag manner to form said tongue members.

7. The sealing device as claimed in claim **1** wherein said circular member is a ring made of elastically deformable metallic material having a plurality of elastic tongues alternately diagonally radially outwardly and radially inwardly bent from the plane of said ring at intervals, the set of said tongues which are radially inwardly bent from said ring acting to press said outer sealing strip means against the outer groove face while the other set of the tongues which are radially outwardly bent from said ring act to press said inner sealing strip means against the inner groove face.

8. The sealing device as claimed in claim 7, wherein said sealing strip means are a plurality of said first and second sealing strips against both said inner and outer groove faces.

9. The sealing device as claimed in claim 1 wherein said circular member is a ring made of elastically deformable metallic material having a plurality of elastic tongues alternately diagonally radially outwardly and radially inwardly bent from the plane of said ring at intervals, the set of said tongues which are radially inwardly bent from said ring acting to press said inner sealing strip means against the inner groove face while the other set of the tongues which are radially outwardly bent from said ring act to press said outer sealing strip means against the outer groove face.

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