The rolling bearing comprises an inner ring (1), an outer ring (2), at least one row of rolling elements and at least one seal (7) provided between said outer and inner rings. The seal (7) has, in cross section, the overall shape of a H.
Seal for rolling bearing, in particular for rolling bearing used in a wind turbine.

The present invention relates to the field of seals used in the rolling bearings, and more particularly in the rolling bearings operating in an aggressive outdoor environment due to the presence of various kinds of pollution, such as splashing water, dust and other foreign matter, to the exposition of the ultraviolet radiation emitted by the sun, and to the variations of temperature.

This is notably the case of the rolling bearings used in a wind turbine in order to angularly orient the rotor of said turbine according to the direction of the wind.

Otherwise, in the case of rolling bearings, and more specifically in the case of large-sized rolling bearings used for instance in such wind turbine, each time the bearing is lubricated, there is a high increase in the pressure inside the bearing. During this operation, said pressure may raise to 0.4 MPa. Thus, there is a risk that the surplus grease will be ejected from the bearing at the location of the seals. In the case of large-sized rolling bearings, pressure relief valves are provided to allow this surplus grease to be ejected. Nonetheless, the surplus grease does sometimes escape from the bearing via the seals rather than through these valves.

However, there are numerous applications in which an escape of grease through the bearing seals must be reliably avoided, both during the lubricating of the bearings, i.e. while the interior of the bearings is being pressurized, and during normal running of the bearings, even in the case of relative movements that the two rings may do in addition to the rotational movements, under the action of the loads on the bearing. Such relative movements of the rings are
relatively important more especially as the rolling bearing has a large diameter.

With the aim of avoiding this drawback, document FR-A-2 778954 discloses a sealing arrangement for a rolling bearing comprising at least one row of rolling elements between first and second rings which are concentric and radially separated from one another by an annular space. This arrangement comprises at least an elastic seal fixed to the first ring and exhibiting a lip pressing against a bearing surface situated on the second ring inside the annular space. The lip of the seal is shaped in such a way that the force with which it presses against the bearing surface increases with the pressure inside the bearing.

With such a sealing arrangement, the lip opposes effectively any escape of grease, not only during lubrication but also during normal running of the bearing.

However, the sealing arrangement disclosed in this document has the drawback of being force fitted into a groove formed on the inner ring of the rolling bearing in order to obtain its retaining on said ring. This is detrimental in terms of mounting time and of cost.

One aim of the present invention is to overcome the aforementioned drawback.

It is a particular object of the present invention to provide a seal which is easy to install into a bearing, which prevents grease from escaping from the bearing, even under the effect of a raised pressure inside said bearing, and which also prevents the ingress of moisture, dust and other bodies into the bearing.

A further object to the present invention is to provide a seal having good wear and aging resistances.
Another object to the present invention is to provide a seal adapted to a large-sized rolling bearing, such as a bearing for a wind turbine.

In one embodiment, the seal is adapted to a rolling bearing comprising an inner ring, an outer ring, and at least one row of rolling elements between said outer and inner rings. The seal has, in cross section, the overall shape of a H.

Preferably, the seal comprises internal lips and external lips of the seal forming the two substantially parallel branches of said H, said lips being adapted to cooperate with opposite radial ribs of the inner and outer rings located axially between said lips in order to axially retain the seal between said rings.

Advantageously, the seal is formed from thermoplastic urethane liner. Preferably, the seal has hardness equal to or greater than 90 Shore A.

The invention also relates to a rolling bearing comprising an inner ring, an outer ring, at least one row of rolling elements and at least one seal provided between said outer and inner rings. The seal has, in cross section, the overall shape of a H. Preferably, the seal comprises internal lips and external lips of the seal forming the two substantially parallel branches of said H. The inner and outer rings comprise opposite radial ribs located axially between the internal and external lips to axially retain the seal.

Preferably, the internal and external lips of the seal are resiliently coupled in the axial direction with the radial ribs.

In one embodiment, the thickness of the radial ribs is larger than the axial gap between the internal lips and the external lips in a free state of the joint in order to keep in a permanent contact the seal and said ribs by elasticity.
Advantageously, the seal is freely moveable in the circumferential direction relative to the inner ring and/or the outer ring.

The internal lips can exhibit an outwardly curved profile so that only the free ends of said lips press against retaining surfaces of the ribs. The retaining surfaces of the ribs are substantially perpendicular to the rotational axis of the bearing.

In one embodiment, the radial ribs define an annular passage narrowing inwardly in direction of the rolling elements.

The invention also relates to a manufacturing method of a seal for a rolling bearing in which the seal is manufactured in the form of a band and is then cut to the desired length, and in which the ends of the seal are heated in order to weld them, the seal being rolled on itself with the ends placed end-to-end to obtain an annular seal.

The invention also relates to an assembly method of a seal inside a rolling bearing comprising an inner ring, an outer ring, at least one row of rolling elements between said outer an inner rings, and opposite radial ribs provided on said ribs, wherein the seal having in cross section the overall shape of a H is axially pushed between the inner and outer rings in order that a first branch of said H bears against the ribs, said branch being then radially deformed inwards and passing through an annular passage defined by said ribs. The seal is still axially pushed until a second branch of the seal bears against the ribs, the first branch recovering by elasticity its initial shape.

An illustrative and non-limiting embodiment of the present invention will be described below in detail with reference to the appended drawings, in which:

- Figure 1 is a half section of a rolling bearing comprising two seals in accordance with the invention,
- Figure 2 is a part section on a larger scale of the rolling bearing of Figure 1,
- Figure 3 is a part section showing the mounting of one of the seals into the rolling bearing of Figure 1, and
- Figures 4a to 4c represent the steps for manufacturing the seal shown on Figure 3.

The rolling bearing as illustrated by Figure 1 is a large-diameter rolling bearing comprising an inner ring 1 and an outer ring 2 between which are housed two rows of rolling elements 3 and 4, which in this case are balls, two annular cages 5, 6 for respectively maintaining the circumferential spacing of rolling elements 3 and 4, and two annular seals 7 and 8.

The inner and outer rings 1, 2 are concentric and symmetric with respect to a transverse radial plane passing through the centre of the rolling bearing. The inner ring 1 is of the solid type. A "solid ring" is to be understood as a ring obtained by machining with removal of material (by machining, grinding) from tube stock, bar stock, rough forgings and/or rolled blanks.

The inner ring 1 has a bore 1a of cylindrical shape designed to be fixed to a chassis or to a structure of a machine (not shown) and delimited by opposite radial lateral surfaces 1b, 1c. The inner ring 1 also includes a stepped exterior cylindrical surface 1d onto which first and second toroidal circular races 9, 10 are formed. The races 9 and 10 are mutually symmetric with respect to the transverse radial plane passing through the centre of the rolling bearing. Each race 9, 10 is subdivided by an annular groove 11, 12 into two raceways having in cross section a concave internal profile adapted to the rolling elements 3, 4. The raceways of the races 9, 10 are directed outwards.
The outer ring 2, also of the solid type, includes an outer cylindrical surface 2a delimited by opposite radial lateral surfaces 2b, 2c. The radial lateral surfaces 2b and 1b, 2c and 1c of the inner and outer rings 1, 2 are respectively coplanar. The outer ring 2 also includes a stepped bore 2d of cylindrical shape into which first and second toroidal circular races 13, 14 are formed. The races 13, 14 are mutually symmetric with respect to the radial plane passing through the centre of the rolling bearing. Similarly to races 9 and 10, each race 13, 14 is subdivided by an annular groove 15, 16 into two raceways having in cross section a concave internal profile adapted to the rolling elements 3, 4. The raceways of the races 13, 14 are directed radially inwards. Each rolling element 3, 4 respectively arranged between the raceways of the races 9, 13 and 10, 14, while at the same time being kept spaced apart by the cages 5 and 6, have four points of contact with the rings 1, 2.

The rings 1, 2 comprise, in a way known per se, holes 17 and 18 for fixing the two rings to two parts of a machine, which can rotate one with respect to the other by virtue of the rolling bearing.

The two rings 1, 2 are separated radially from one another by an annular space 19 in which the cages 5 and 6 rotate. The seals 7, 8 are positioned radially between the inner and outer rings 1, 2 inside the annular space 19. The seal 7 is mounted axially between the rolling elements 3 and the radial surfaces 1b, 2b of the rings 1, 2. The seal 7 is entirely housed into the rings 1 and 2. In other words, the seal 7 is axially offset relative to the radial surfaces 1b, 2b towards the interior of the rolling bearing.

The seal 8 is positioned axially between the rolling elements 4 and the radial surfaces 1c, 2c of the rings 1 and 2, remaining distant from said surfaces. The seal 8 is identical to the seal 7 and is
positioned symmetrically with respect to the latter with regard to the radial plane passing through the centre of the rolling bearing. A closed space is defined between the rings 1, 2 and the seals 7, 8 in which the rolling members 3, 4 are housed so as to be protected against polluting elements.

As shown more clearly on Figure 2, the seal 7 has, in cross section, the overall shape of a H. The seal 7 formed of an elastic material comprises an annular portion 20, two annular internal lips 21, 22 forming one of the branches of the H, and two annular external lips 23, 24 forming the other branch of said H. The lips 21, 22 and 23, 24 are symmetric with respect to a transverse radial plane passing through the centre of the seal 7, the lips 21, 23 and 22, 24 being also symmetric with respect to a transverse axial plane passing through the portion 20. The lips 21, 23 and 22, 24 respectively press against annular radial protrusions or ribs 25 and 26 provided on the inner and outer rings 1 and 2 and radially facing each other. The lips 21 to 24 have a certain degree of axial elasticity and join or attach directly the annular portion 20.

The annular rib 25 extends radially from the exterior cylindrical surface Id of the inner ring 1 in the direction of the rib 26 of the outer ring 2. The rib 25 is in the vicinity of the radial surface Ib. The rib 25 is delimited by opposite radial lateral surfaces 25a, 25b and by a frustoconical exterior surface 25c orientated in such a way that its upward extension is located towards the cage 5 and the rolling elements 3, i.e. on the internal side of the rolling bearing. Here, the frustoconical surface 25c makes an angle of approximately 45° with the axis of the rolling bearing.

Similarly, the annular rib 26 provided on the bore 2d of the outer ring 2 is delimited by opposite radial lateral surfaces 26a, 26b
and by a frustoconical bore 26c. The radial lateral surfaces 25a and 26a, 25b and 26b are respectively coplanar. By considering the frustoconical exterior surface 25c, the bore 26c has a slope in an opposite direction. Thus, the downward extension of the bore 25c is located towards the cage 5 and the rolling element 3. The ribs 25, 26 delimit an annular passage or a hole 27 radially delimited by the frustoconical surfaces 26c and 25e which narrows inwards in direction of the rolling elements 3.

The seal 7 is axially maintained into the space 19 defined between the inner and outer rings 1, 2 by the opposite radial ribs 25, 26. More precisely, the surfaces 25a, 26a, 25b, 26b respectively form retaining surfaces for the lips 21 to 24. The annular portion 20 of the seal 7 is radially disposed into the hole 27 in a non-contact state.

The lips 21, 22 exhibit an outwardly curved profile so that only their free ends press against the bearing surfaces 25a, 26a. Similarly, the lips 23, 24 exhibit an inwardly curved profile so that in absence of pressure, only their free ends respectively press against the retaining surfaces 25b, 26b. The free ends of branches of the seal 7 converge axially towards one another. In the embodiment depicted, the lips 21, 22 and 23, 24 are shaped and dimensioned in such a way that their lines of pressing against the rib 25 and 26 are perpendicular to the axis of the rolling bearing.

In order to keep in a permanent contact state the lips 21, 23 and 22, 24 with ribs 25 and 26, the thickness of the ribs is made larger than the axial gap between the lips in a free state. Thus, by the elasticity of the seal 7 in axial direction, the lips 21 to 24 are kept in permanent contact with the retaining surfaces 25a, 26a, 25b, 26b. The seal 7 and the ribs 25, 26 are thus resiliently coupled in the axial
direction which prevents relative axial displacement between the seal 7 and the rings 1, 2.

The annular ribs 25, 26 axially maintain the seal 7 into the space 19 defined between the inner and outer rings 1 and 2. The ribs 25, 26 constitute a means of axially retaining the seal 7 into the space 19 provided between the rings 1, 2. To this end, the internal diameter of the lips 21, 23 is smaller than the diameter of the downward extension of the frustoconical surface 25c, and the external diameter of the lips 22, 24 is larger than the diameter of the downward extension of the frustoconical bore 26c.

The seal 7 is radially maintained into the space 19 by the inner and outer rings 1 and 2. Radial gaps are provided between the lips 21, 23 and the exterior surface 1d, and between the lips 22, 24 and the bore 2d.

The internal lips 21, 22 axially located towards the cage 5 and the rolling element 3, i.e. on the internal side of the rolling bearing, which are in contact with the ribs 25, 26 prevent any escape of grease from the inside of the bearing to the outside.

Besides, by virtue of the outwardly curved profile of said lips 21, 22 and of their cooperation with the retaining surfaces 25a, 26a, any increase of pressure inside the bearing leads to an increase of the pressing force of the lips 21, 22 against the retaining surfaces 25a, 26a without the risk of said lips being expelled under the effect of the raised pressure likely to occur, for example, when lubricating the bearing through greasing holes (not shown). In this case, there may be a radial planar contact between the lip 21 and the retaining surface 25a, and between the lip 22 and the retaining surface 26a. The radial gaps between the lips 21 and the inner ring 1, and between the lips 22 and the outer ring 2 make these planar contacts easier.
The external lips 23, 24 axially located towards the external side of the rolling bearing which are in contact with the ribs 25, 26 prevent foreign matter from entering inside of the bearing, such as moisture, dust or muddy water. The internal lips 21, 22 supplement the action of the external lips 23, 24, and improve the protection against the ingress of moisture and other foreign bodies into the bearing from the outside.

The internal lips 21, 22 and the external lips 23, 24 of the seal 7 also maintain their functions in the event of relative movements of the two rings 1 and 2 under the action of loads (axial, radial, tipping moments) to which the bearing may be subjected during running, without the seal 7 losing its sealing function.

During running, the seal 7 can move in the circumferential direction relative to the inner ring 1 and/or outer ring 2. In this case, sliding occurs against the retaining surfaces 25a, 25b, 26a, 26b. With such a sliding, a little wear may occur on the lips 21 to 24 of the seal. However, with the elasticity of the seal 7 in axial direction, the lips 21 to 24 are kept in permanent contact with the retaining surfaces 25a, 26a, 25b, 26. By virtue of the radial gaps between the lips 21, 23 and the ring 1, and between the lips 22, 24 and the ring 2, a slight radial movement can also occur between the seal 7 and said rings.

The angular movement of the seal 7 relative to the rings 1, 2 remains possible since there is no fixing part between these elements. The seal 7 is namely not rigidly fixed to one of said rings 1, 2 in the circumferential direction. This makes the mounting of the seal 7 easier into the rings 1, 2 of the bearing. Specifically, the seal is mounted with a simple axial pushing movement without angular indexation. More precisely, with the axial pushing movement, the lips 21, 22 initially bear against the radial surfaces 25b, 26b. After, as shown on
Figure 3, by virtue of the frustoconical surface 25c and bore 26c, the lips 21, 22 are radially compressed or deformed towards the annular portion 20. After, passing through the hole 27, the lips 21, 22 recover by elasticity their initial shape. Finally, the lips 23, 24 press against the retaining surfaces 25b, 26b of the ribs 25, 26. In this mounted position of the seal 7, the ribs 25, 26 are axially clamped between the lips 21, 23 and 22, 24. The contact of said lips directed axially in direction of the ribs prevents any axial movement of the seal 7 with respect to the rings 1, 2.

Advantageously, the seal 7 is integrally formed from a thermoplastic urethane liner (TPU) offering a good resistance to low and high temperatures, to wear, to ozone, to ultraviolet radiations, and being an excellent fungal inhibitor. Besides, with such a material, the seal 7 can easily be manufactured by extrusion at the desired shape in cross section in the form of a band as shown on Figure 4a, and after cutting to the desired length, and then wound on itself as depicted on Figure 4b. To obtain the seal 7, a heating plate 31 is used to heat the ends of the band in order to weld them end to end (Figure 4c). With such a welding, the mechanical properties of the seal outperform those obtained with a seal wounding on itself and connected end to end by glue. Besides, with the use of a thermoplastic urethane liner, the seal 7 is flexible enough to allow an easy installation into the bearing but has also enough stiffness for its axial retaining on the ribs 25, 26.

Preferably, the seal material has a shore A hardness equal to or greater than 90, for a good compromise between stiffness and sealing effect.

As above-mentioned, the sealing of the bearing on the other side is provided by the seal 8 which is identical to the seal 7 and which cooperates with annular ribs 29, 30 of the inner and outer rings.
1, 2. Said ribs 29, 30 and 25, 26 are mutually symmetric with respect to the transverse radial plane passing through the center of the rolling bearing. In the embodiment depicted, the ribs 25, 29 and 26, 30 are integrally formed with the inner and outer rings 1 and 2. Alternatively, said ribs may be separate bodies.

It should be noted that the embodiment illustrated and described was given merely by way of a non-limiting indicative example and that modifications and variations are possible within the scope of the invention. Thus, the invention applies not only to double rows of balls with four-point contact but also to other types of rolling bearing, for example, bearings with a single row of balls, or with at least three rows of balls. It is easily understood that it could also be possible to use bearing with other types of rolling members such as rollers. The disclosed rolling bearing is particularly useful as bearing for wind turbines which are submitted to high internal pressures and exposed to UV light and rain water.
CLAIMS

1. Rolling bearing comprising an inner ring (1), an outer ring (2), at least one row of rolling elements (3) and at least one seal (7) provided between said outer and inner rings, characterized in that the seal (7) has, in cross section, the overall shape of an H.

2. Rolling bearing according to claim 1, comprising internal lips (21, 22) and external lips (23, 24) of the seal forming the two substantially parallel branches of said H, the inner and outer rings (1, 2) comprising opposite radial ribs (24, 25) located axially between the internal and external lips (21 to 24) to axially retain the seal.

3. Rolling bearing according to claim 2, wherein the internal and external lips (21 to 24) of the seal (7) are resiliently coupled in the axial direction with the radial ribs (24, 25).

4. Rolling bearing according to claim 2 or 3, wherein the axial thickness of the radial ribs (24, 25) is larger than the axial gap between the internal lips (21, 22) and the external lips (23, 24) in a free state of the seal in order to keep in a permanent contact the seal (7) and said ribs by elasticity.

5. Rolling bearing according to any of the preceding claims, wherein the seal (7) is moveable in the circumferential direction relative to the inner ring (1) and/or the outer ring (2).

6. Rolling bearing according to any of the claims 2 to 5, wherein the internal lips (21, 22) exhibit an outwardly curved profile so that only the free ends of said lips press against retaining surfaces (25a, 26a) of the ribs (25, 26).

7. Rolling bearing according to claim 6, wherein the retaining surfaces (25a, 26a) of the ribs (25, 26) are substantially perpendicular to the rotational axis of the bearing.
8. Rolling bearing according to any of the claims 2 to 7, wherein the radial ribs (24, 25) define an annular passage narrowing inwardly in direction of the rolling elements (3).

9. Seal (7) for a rolling bearing comprising an inner ring (1), an outer ring (2), and at least one row of rolling elements (3) between said outer and inner rings, the seal being intended to be disposed between said rings characterized in that the seal (7) has, in cross section, the overall shape of a H.

10. Seal according to claim 9, comprising internal lips (21, 22) and external lips (23, 24) of the seal forming the two substantially parallel branches of said H, said lips being adapted to cooperate with opposite radial ribs (24, 25) of the inner and outer rings (1, 2) located axially between said lips in order to axially retain the seal between said rings.

11. Seal according to claim 9 or 10, forming from thermoplastic urethane liner.

12. Seal according to any of the claims 9 to 11, having hardness equal to or greater than 90 shore A.

13. Manufacturing method of a seal for a rolling bearing in which the seal is manufactured in the form of a band and is then cut to the desired length, characterized in that the ends of the seal are heated in order to weld them, the seal being rolled on itself with the ends placed end-to-end to obtain an annular seal.

14. Assembly method of a seal inside a rolling bearing comprising an inner ring, an outer ring, at least one row of rolling elements between said outer and inner rings, and opposite radial ribs provided on said ribs, characterized in that the seal having in cross section the overall shape of a H is axially pushed between the inner and outer rings in order that a first branch of said H bears against the ribs, said branch being then radially deformed inwards and passing
through an annular passage defined by said ribs, and in that the seal is still axially pushed until a second branch of the seal bears against the ribs, the first branch recovering by elasticity its initial shape.
INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2008/063793

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16J15/34 F16C33/78

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16J F16C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>DE 103 08 702 A1 (AUDI NSU AUTO UNION AG) paragraph [0028] figure</td>
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[Continuation in Box C]

See patent family annex

- Special categories of cited documents
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier document but published on or after the international filing date
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Date of the actual completion of the international search
25 June 2009

Date of mailing of the international search report
31/08/2009

Name and mailing address of the ISA/
European Patent Office, P B 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel (+31-70) 340-2040, Fax (+31-70) 340-3016

Authorized officer
Van WeI, Oscar
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<td>1.</td>
<td>☐ Claims Nos., because they relate to subject matter not required to be searched by this Authority, namely</td>
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<tr>
<td>2.</td>
<td>☐ Claims Nos, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically</td>
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<td>3.</td>
<td>☐ Claims Nos: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6(4)(a)</td>
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| 1. | ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims |
| 2. | ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of additional fees |
| 3. | ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers |

| 4. | ☐ NO required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims. It is covered by claims Nos. 1-12, 14 |

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees
This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-12, 14

   Rolling bearing comprising an inner ring and an outer ring having opposite radial ribs cooperating with a seal that has an overall shape of an H, the seal intended to be disposed in such a radial bearing and its assembly method in such a radial bearing.

2. claim: 13

   Manufacturing method of a seal suitable for a rolling bearing whereby a band is cut to a desired length, the ends of the bands being then heated and welded together to obtain an annular seal.
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Form PCT/ISA/21 (patent family annex) (April 2005)