



- (51) International Patent Classification:
F16J 9/14 (2006.01) *F16J 9/26* (2006.01)
- (21) International Application Number:
PCT/BR2014/000156
- (22) International Filing Date:
15 May 2014 (15.05.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
BR 10 20130121339 15 May 2013 (15.05.2013) BR
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(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, BN, 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, IR, IS, JP, KE, KG, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: A PISTON RING

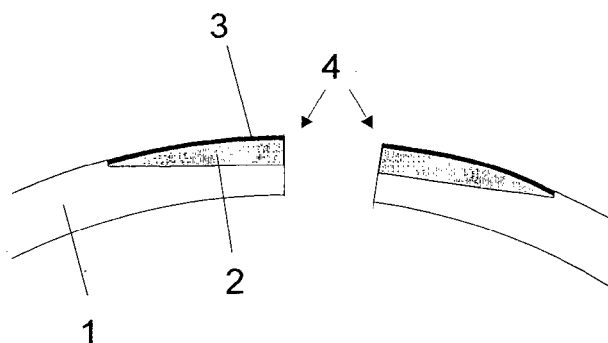


FIG. 3

(57) Abstract: The present invention relate to a piston ring (10) for use on internal combustion engines, more particularly, a ring (10) having a metallic base (1), where the outer portion of its ends receives two layers applied subsequently to provide greater resistance to wear, an intermediate layer (2) preferably comprising chrome nitride (CrN), applied by hypersonic thermal spray (HVOF) and an outer layer (3) comprising chrome nitride (CrN), applied by physical vapor deposition (PVD).

Specification of the Patent of Invention for: **"A PISTON RING"**

The present invention relates to a piston ring for use on internal combustion engines, more particularly to a ring provided with a metallic base wherein the external portion of it ends receive two layers applied subsequently to provide greater resistance to wear.

Description of the Prior Art

As a general rule, every internal combustion engine, whether it operates in Diesel cycle or in Otto cycle, on 2 strokes or 4 strokes, comprises at least one piston with its respective rings.

The piston ring is the part that performs the function of sealing the space between the engine sleeve and the piston, isolating the combustion chamber from the other internal engine components. This element is arranged radially at the piston top, preventing the combustion gases from escaping out of the combustion chamber toward the crankcase and preventing the engine oil from penetrating the combustion chamber on a reverse direction. There may be more than one piston ring surrounding a single piston, and it is very common to use three rings arranged parallelly at the piston top.

Generally, prior-art piston rings 10' comprise an opening between two ends 4', even when they are mounted on the piston and confined by the cylinder, as shown in figure 1 of this document. Among other functions, the opening is useful during the installation of the prior-art piston ring 10' around the piston (not shown in the figures). The opening provides access to a tool configured to open the ring 10', enlarging its inner diameter beyond the external radial limits of the piston, thus enabling access thereof to the ring groove, that is, the recess in the outer face of the piston where the ring is housed.

In summary, a piston ring should have good sealing capability, and in order to guarantee this characteristic along the useful life of the engine a piston ring should exhibit adequate mechanical stability, breaking strength, and also adequate resistance to wear with respect to its tribological pairs: the cylinder for its contact face and the piston groove for its side contact faces.

Excessive wear of the side faces and of the contact face ends up causing degradation of the sealing main function of the combustion chamber and results in abrupt degradation of the functioning conditions of the engine.

Many of the efforts to provide a solution to wear of piston rings have been directed to the development of coatings and surface treatments that impart better resistance to wear, with a direct impact on the durability of the engine.

Moreover, it is also known that the design of a piston ring (that is, its three-dimensional geometric form) can contribute to a longer useful life of the engine by controlling the wear of the piston rings and providing appropriate pressure distribution, thus providing greater homogeneity of the wear along the peripheral surface, or functional surface of the piston ring.

In terms of wear of piston rings, particularly a compression ring (or first-groove ring), the most affected part of the component is the region of ring surface that is in contact with the cylinder. Throughout this contact surface – hereinafter called outer radial face – there is a specific portion that undergoes even greater wear than the average wear which this outer radial face undergoes: the regions close to the ring ends (called critical zones 11 – see figure 4). This increase in wear is due, above all, to three main factors: the process of manufacturing the ring, the mechanical loading of the engine and the thermal conditions imposed to the ring during the operation of the engine.

Considering that at present the engines undergo higher demands in terms of environmental impact and of output, all the engine components should perform their functions, but in a more demanding manner due to either a more severe working condition or a lower level of final damage accumulated on the components after operation, in this context the piston rings are no exception. In this regard, it is necessary to prolong the useful life of the piston ring, more particularly in the end regions. This wear is particularly more marked on heavy duty Diesel engines (HDD).

One of the surface treatment operations used in the prior art to impart greater surface resistance to these parts is the physical vapor

deposition process, capable of depositing, for instance, a chrome nitride layer of about 30 microns throughout the peripheral surface that contacts the cylinder, including the end regions 4' of the ring 10'.

One of the prior-art proposals that try to solve the problem of wear of piston-ring ends is presented in document US 2004056425, which describes a low-cost ring-manufacture method and which provides a countermeasure for the wear of the ends. In this technology, a film is deposited onto the outer surface or slide surface, where the film thickness in the end region (vertex) is larger than in the adjacent region (see figure 1). The coating can be applied either by physical vapor deposition (PVD/DFV) or by chemical vapor deposition (CVP/DQV), wherein the end region is exposed longer than the rest of the ring in order to guarantee a larger coating thickness at the ends.

However, it should be noted that the PVD / CVD processes exhibit a great limitation with respect to the final thickness of the coating. Usually, the thickness is not larger than 30 microns, although there are a few cases that make reference to coatings with larger thickness. Anyway, thicker coatings will have a poor performance, since the coating undergoes an increase in tension as a result of the thickness and also loses properties of the material of the layer, which impairs the resistance to wear when one obtains layers with thickness larger than 30cm. Moreover, although the document mentions a low cost of the process employed, it is known that PVD/CVD processes are quite expensive, and it is natural that the larger the thickness the greater the impact on the final price.

Other attempts were also made to solve the problem of excessive wear in the end region of piston rings. Such solutions can be found in documents JP2000120866, DE102008035148, US2010090416 and US200204107, which mention geometric relations implemented with a view to diminish the contact pressure area in the end portion of the piston ring during the working conditions, these solutions being considered capable of decreasing wear in said end regions of piston rings.

Although this theory seems to have a reasonable technical basis, it is known that such an approach does not solve the problem of high wear at the ring ends. In other words, the solution of exposing the base material of the ring with a PVD/CVD coating is the solution that makes use of the geometric approach.

Thus, the present invention indicates a new direction toward coating the end regions with a layer of a determined thickness deposited onto another.

Objectives of the Invention

Therefore, an objective of the present invention is to provide a compression ring that will resist wear in the slide region of the ring ends so as to prevent exposure of the base material that exposes the piston ring.

It is also an objective of the present invention to provide a piston ring with a metallic steel base comprising a layer having high resistance to wear, which is generated by a thermal spray method in the end regions of a ring, while another layer of chrome nitride generated by PVC is deposited subsequently.

It is a further objective of the present invention to provide a ring as set forth above at a competitive cost.

Brief Description of the Invention

The objectives of the present invention are achieved by providing a piston ring having a metallic base to which an outer slide layer is associated, an intermediate layer being positioned between the base and the outer layer, the outer layer and the intermediate layer being exclusively present on the outer radial face of each end region of the ring.

Brief Description of the Drawings

The present invention will now be described in greater detail with reference to embodiments represented in the drawings. The figures show:

- Figure 1 is a prior-art piston ring;
- Figure 2 is a piston ring of the present invention;
- Figure 3 is a detail of a piston ring of the present invention; and

- Figure 4 is an example of the wear of prior-art piston rings in the end region of the rings.

Detailed Description of the Figures

The present invention proposes a piston ring 10 for internal combustion engine, more particularly a compression ring for heavy duty Diesel engines.

As it is known, such engines are quite demanding, which causes premature failure of their compression rings, due to the high wear in the rind-end regions. The present invention proposes a novel compression ring 10 that is capable of resisting wear in the end regions 4, without exposing the base material of the ring, thus maintaining high shapability at a reduced cost.

To this end, the ring 10 of the present invention makes use of a metallic base (of steel, cast iron or aluminum) provided with a chemical composition particularly developed for application of an intermediate layer 2, layer of wear-resistant material, preferably chrome nitride, but not limited to this material, this intermediate layer being applied by the thermal spray process, preferably by a high-velocity spray containing, as carburant, oxygen (HVOF), wherein an outer layer 3 is applied onto this intermediate layer 2 by physical vapor deposition (PVD), preferably of CrN, but not limited only to this material, alternatives of other nitrides, for example, Ti, W, or even carbides may be used as a final coating material of the contact surface of the rings. One may also use coatings with multi-layer concepts, either involving nanometric concepts or not.

For a better understanding, see figures 2 and 3. Such coatings are applied onto the outer radial face of each end regions 4 of the piston ring 10. For this purpose, the portion that will receive the coatings is chamfered or pared so that, after application of the coating, the ring size will not alter significantly.

After application of the layer located at the ends of the piston ring, one may apply a finish method, as for instance grinding, with a view to providing an adequate condition of the surface, be it because of the shape of

the ring ends or due to a criterion of surface roughness. Only after the end regions have been properly finished will the final coating be applied.

The great advantage of the present invention is that of not applying a very thick PVD layer, which would generate too high tensions in the coating and an excessive cost. So, one employs a process that enables deposition of material having good resistance to wear onto the end regions of the piston ring with thickness sufficient to prevent exposure of the base material, even for very severe working conditions, this intermediate layer being highly compatible (good adhesion) with the outer PVD layer. In this way, internal tensions are reduced, the thickness of the coating at the ends 4 of the ring 10 is enlarged, the cost of manufacturing the ring 10 is reduced, and better functioning condition for the component is achieved. It should be noted that, due to the high wear on the prior-art rings, the base material of the ring has low resistance to wear and, when it undergoes stress as a tribologic surface, it does not exhibit good compatibility, which leads to high wear and deterioration of the functionality of good gas sealing of the combustion chamber which the piston ring should have.

In this way, if the outer coating 3 is totally consumed, it maintains the intermediate coating 2, which also prevents wear of the piston ring 10. This constructive embodiment is of great advantage, since the market does not accept willingly the possibility of a base material 1 being directly exposed to the cylinder body when the PVD coating is consumed. In this way, one prevents the problems, besides the high wear mentioned before, and the prior-art component remains vulnerable to stoppage due to direct contact between the base 1 material and the slide surface of a cylinder.

The present invention has, as a particularity, the fact that it would not possible to achieve the results of the present invention without application of an intermediate layer by thermal spray. The thermal spray process including the HVOF has the advantage that, besides having resistance to wear similar to a coating deposited by PVD, it enables a localized deposition of material only in the region where greater resistance to wear is required (ends 4 of the ring 10), which cannot be achieved by other processes, such

as galvanic chroming. Moreover, the HVOF process enables one to deposit larger thicknesses without increasing the internal tensions of the coating.

Preferred examples of embodiments having been described, one should understand that the scope of the present invention embraces other possible variations, being limited only by the contents of the accompanying claims, which include the possible equivalents.

CLAIMS

1. A piston ring provided with a metallic base (1) to which an outer slide layer (3) is associated, wherein an intermediate layer (2) is positioned between the base (1) and the outer layer (3), the ring (1) being characterized in that the outer layer (3) and the intermediate layer (2) are exclusively present on the outer radial face of each end region (4) of the ring (10).
2. The piston ring according to claim 1, characterized in that the intermediate layer (2) comprises a wear-resistant material applied by the thermal spray technique.
3. The piston ring according to claim 2, characterized in that the intermediate layer (2) comprises chrome nitride (CrN), applied by hypersonic thermal spray (HVOF).
4. The piston ring according to claim 1, characterized in that the outer layer (3) comprises chrome nitride (CrN), applied by physical vapor deposition (PVD).
5. The piston ring according to claim 1, characterized in that it is a compression ring or oil-scraping ring (10).
6. The piston ring according to claim 1, characterized in that it is a compression ring applied to an internal combustion engine that operates in Diesel-cycle, Otto-cycle, of two or three strokes.

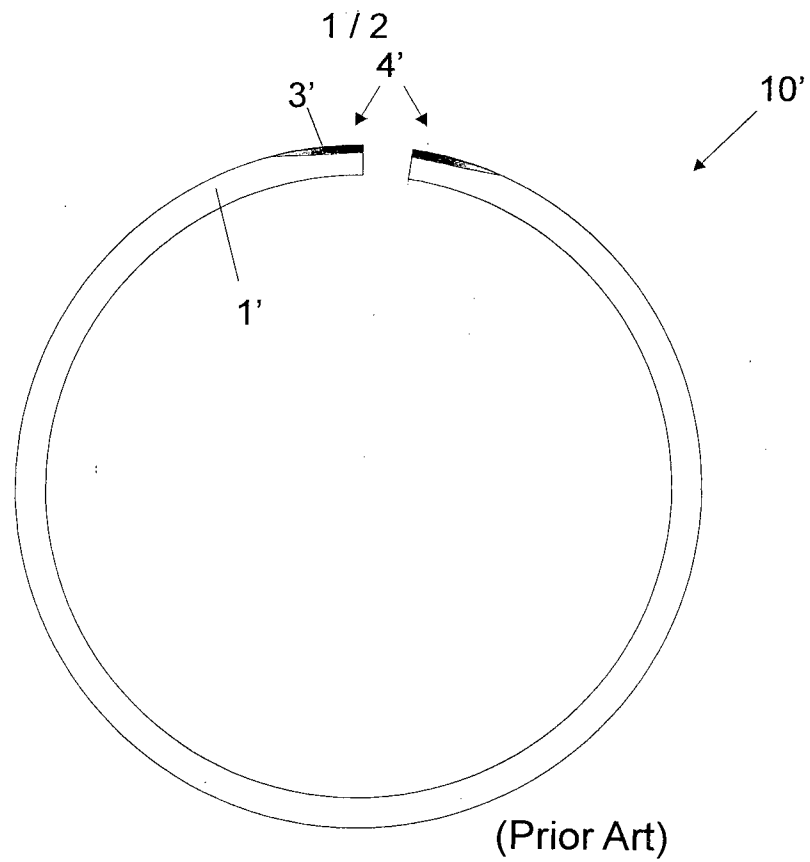


FIG. 1

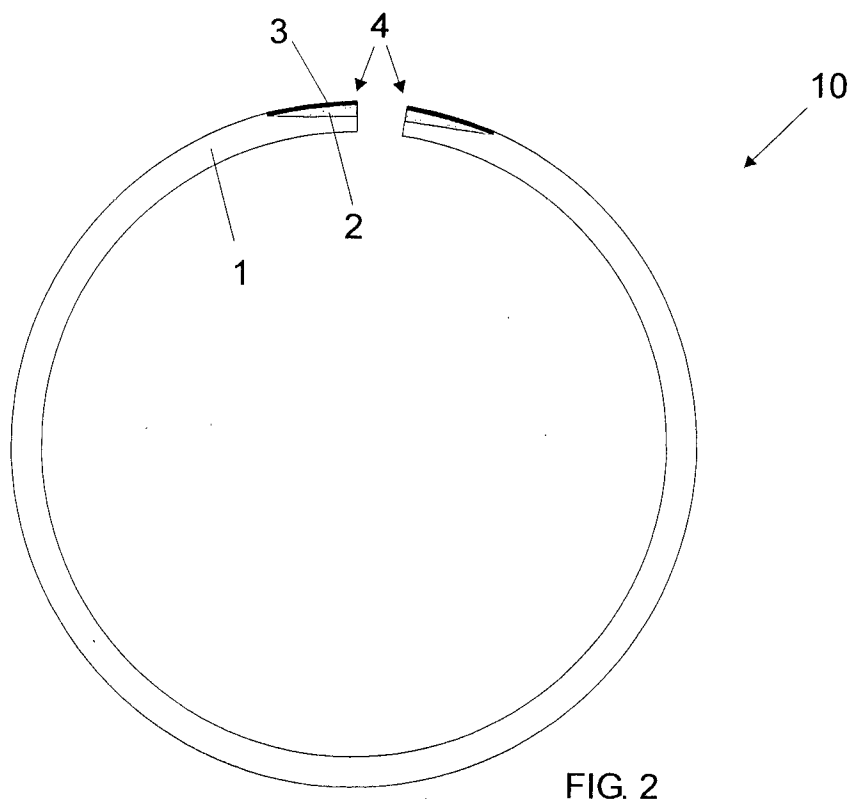
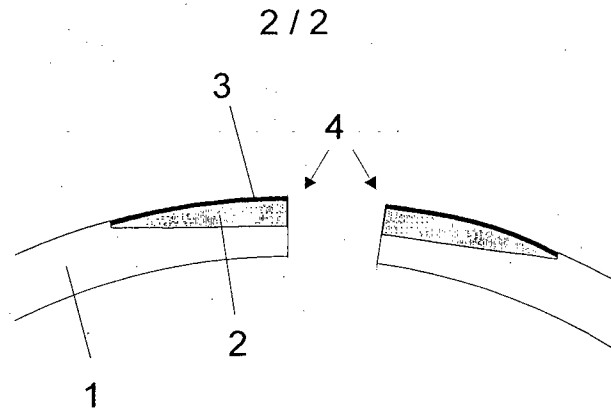
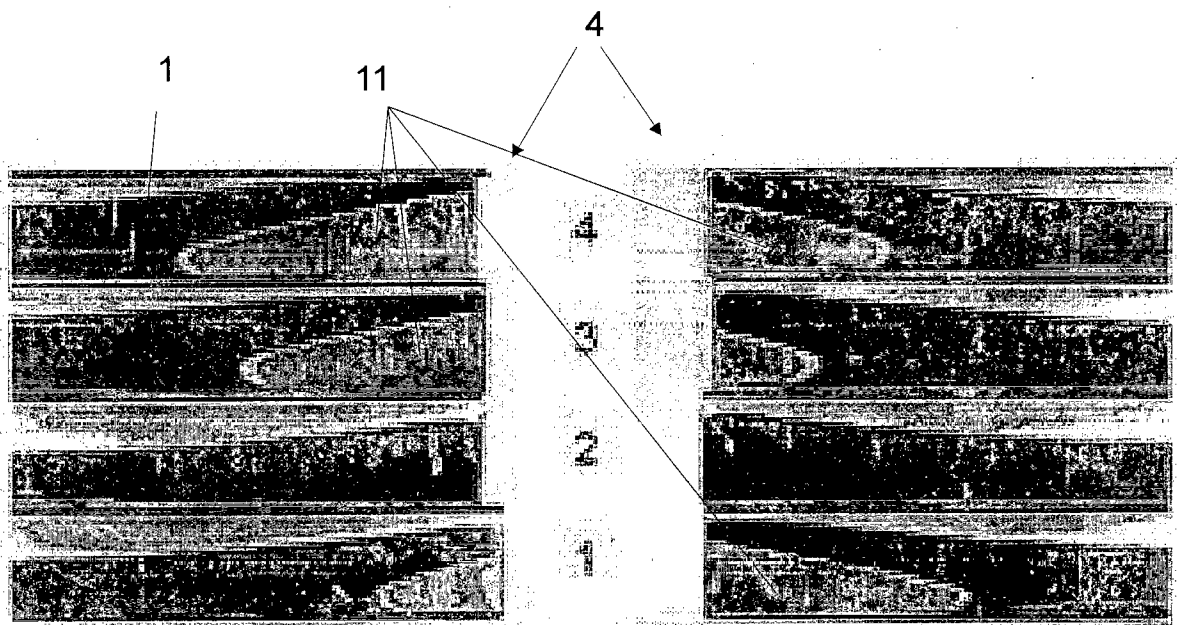


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No
PCT/BR2014/000156

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16J9/14 F16J9/26
ADD.

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

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 practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.



See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

2 October 2014

Date of mailing of the international search report

10/10/2014

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INTERNATIONAL SEARCH REPORT

International application No

PCT/BR2014/000156

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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