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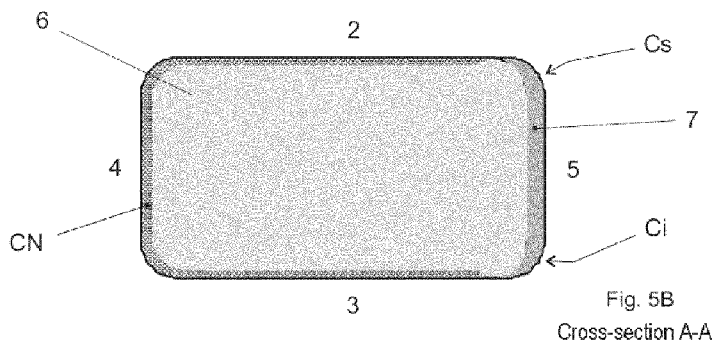
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(54) Title: PISTON RING AND PROCESS FOR THE MANUFACTURE THEREOF



(57) Abstract: The present invention relates to a piston ring, for utilization in the piston groove of a piston of an internal combustion engine, provided with a body (6) composed of a ferrous material defining an upper portion (2) facing towards the piston head, a lower portion (3), opposed, facing towards the piston skirt, an internal portion (4) facing towards the piston groove, and an external portion (5), opposed, to slide against the cylinder wall or liner, the upper and external portions (2, 5) being essentially mutually orthogonal and defining an upper chamfer (Cs) and the lower and external portions (3, 5) being essentially mutually orthogonal and defining a lower chamfer (Ci), wherein (i) the upper, lower and internal portions (2, 3, 4) are nitrided (CN), and (ii) the external portion (5) and the upper and lower chamfers (Cs, Ci) are not nitrided and coated by at least one coating layer (7) deposited by the process of ion plating.

Descriptive Memorandum of the Patent of Invention for
"PISTON RING AND PROCESS FOR THE MANUFACTURE THEREOF".

The present invention relates to a piston ring,
5 designed particularly for use in internal combustion
engines, based on martensitic stainless steel, having
the upper, lower and internal faces nitrided and the
external face, which comes into contact with the wall
of the cylinder/liner, not nitrided and provided with
10 at least one layer of coating applied by the process of
ion plating.

Through this new and improved coating of chromium
nitride there is achieved an increase in the working
15 life of the piston ring in diesel engines having a high
combustion pressure and high rotational speed (known
commercially as HSD (high-speed diesel) engines),
particularly when compared with the piston rings
currently utilised in this type of engine, whereof the
20 totality is nitrided and, following nitriding, receives
on the external face and upper and lower chamfers
thereof a layer of coating applied by the process of
physical vapour deposition (PVD). These advantages are
obtained without any corresponding disadvantageous
25 technical counterpart being encountered whilst
maintaining the manufacturing costs at a competitive
level.

The present invention relates furthermore to the
30 process for the manufacture of the ring.

DESCRIPTION OF THE STATE OF THE ART

In internal combustion piston engines the rings are
35 formed, in general, of a metal base to which there is
applied at least one layer of coating which comes into
contact with the wall of the cylinder. As an example,
there may be cited a base of cast iron or of stainless

steel, utilised as a function of the cost and/or of the type of stress to which the ring will be subjected.

5 The role of the layer of coating is very important because of the fact that it seeks to confer properties on the ring of low sliding friction and high spalling resistance, hardness and toughness. Nevertheless, it must be noted that some of these properties conflict and an increase in one thereof means a loss of
10 performance in another, because whereof the type of coating to be utilised will be selected as a function of the operational profile of the engine and of the stresses whereto the rings will be submitted during their working life.

15 In an internal combustion engine the compression ring, or first groove ring, is that which experiences most stresses by virtue of being in direct contact with the superheated gases of the burning compressed air
20 mixture. Consequently, by virtue of the very location thereof, they are continually exposed to high temperatures and to aggressive byproducts of the combustion.

25 A series of coatings has been proposed by those skilled in the art, each thereof seeking to improve the properties desired, increasing the strength of the piston rings. Several prior art refers to the ceramic coatings of chromium nitride in the form of CrN and/or
30 Cr₂N, very efficient and technically interesting because of the fact that they balance in a very competent manner the properties of absorption of internal stress, high hardness and low thickness, greatly reducing the occurrence of spalling.

35 In the great majority of the applications the ceramic coating of chromium nitride is applied by the PVD process, according whereby the material to be deposited

as a coating is vaporised from a solid source in the form of atoms or molecules by means of low-pressure gases (or plasma) in the direction of the piston ring, whereon it condenses. The formation of the coating on the substrate depends on the materials vaporised and on the material of the substrate, on the conditions of the surface, on the energy available (temperature and ion bombardment), and on the atmosphere (chemical reactions, reactive deposition, etc).

10

The PVD process presents some interesting advantages for the production of tribological coatings such as, for example, (i) the possibility of operating at very low working pressures thereby rendering possible the synthesis of materials of high purity; (ii) improvement in the adhesion of the coating to the substrate because of the possibility of "cleaning" the surface of the substrates by means of the ion bombardment; (iii) uniform thickness of the coating; (iv) control over the crystalline structure of the coating; and (v) relatively low deposition temperatures. As additional advantages ion bombardment promotes epitaxial growth and improves the atomic mobility, and normally no effluents or pollutants are utilised because of the fact that in the majority of cases toxic products or solutions are not involved.

In the specific case of engines of the high-speed diesel type, because of the high combustion pressures and the high rotational speeds which they reach, the rings are very stressed, in particular the compression rings. For that reason, compression rings are in general specified having a base constituted of stainless steel the totality thereof being nitrided, having a wear-resistant coating applied to the external face, a posteriori, by the PVD process.

30
35

This type of ring is known for its high mechanical strength and by the high price thereof, nevertheless in some applications even they do not manage to prevent the emergence and propagation of cracks, not only in
5 the coating but in the entire ring, which may lead to a catastrophic failure entailing the disassembly of the engine.

In these situations, cracks are initiated at the upper
10 and lower chamfers, being respectively the edges joining the lateral face to the upper face and to the lower face. In some cases the cracks ends up by propagating throughout the cross-section of the ring, rupturing the part and requiring the complete
15 disassembly of the engine.

With the objective of solving this difficulty, the United States patent US 6 508 473 reveals a piston ring based on stainless steel nitrided on the upper and
20 lower faces thereof. The nitrided faces have a hardness of 700 HV. The ring comprises furthermore a film of hard coating on the external face thereof in contact with the wall of the liner/cylinder, spaced from 0.0001 mm to 0.3 mm from the upper and lower faces. According
25 to the patent, this spacing, although minimal, prevents the propagation of cracks up to a reasonable limit of utilisation, however in regimes of severe utilisation this technique does not guarantee the strength of the ring.

30 Up to the present time a piston ring, especially a compression or first groove ring, has not been developed which manages to attain the standards of durability demanded in severe applications, such as
35 those demanded by the diesel engines operating at high feed pressures and at high rotational speeds.

OBJECTS OF THE INVENTION

5 The present invention has as object thereof a piston ring, particularly a compression or first groove ring for use in internal combustion engines not presenting the occurrence of potentially catastrophic cracks even when functioning under the critical operating conditions of diesel engines which operate with high feed pressures and at high rotational speeds.

10

The present invention also has as object thereof a piston ring, particularly a compression or first groove ring, for use in internal combustion engines, based on martensitic stainless steel, having the upper, lower and internal faces nitrided and the external face, which comes into contact with the wall of the cylinder/liner, not nitrided and provided with at least one layer of coating applied by the process of ion plating.

20

Furthermore, the present invention has as object thereof a piston ring, particularly a compression or first groove ring for use in internal combustion engines, for use in diesel engines operating at high feed pressures and at high rotational speeds, satisfying the design and durability objectives and maintaining a competitive manufacturing cost in relation to the rings presently utilised.

30 Finally, the present invention has as object thereof a manufacturing process objectified in the three foregoing paragraphs.

BRIEF DESCRIPTION OF THE INVENTION

35

The objects of the present invention are achieved by a piston ring, for utilization in the piston groove of a piston of an internal combustion engine, provided with

a body composed of a ferrous material defining an upper portion facing towards the piston head, a lower portion, opposed, facing towards the piston skirt, an internal portion facing towards the piston groove and
5 an external portion, opposed, to slide against the cylinder wall or liner, the upper and external portions being essentially mutually orthogonal and defining an upper chamfer and the lower and external portions being essentially mutually orthogonal and defining a lower
10 chamfer, wherein (i) the upper, lower and internal portions are nitrided, and (ii) the internal portion and the upper and lower chamfers are not nitrided and coated by at least one layer of coating deposited by the process of ion plating.

15 Additionally, the objects of the present invention are achieved by a process for the manufacture of a piston ring as defined in the above paragraph, comprising the following stages:

20 Stage (i): nitriding the upper, lower and internal portions, and

Stage (ii): deposition of at least one layer of coating
25 on the internal portion and on the upper and lower chamfers by the process of ion plating.

SUMMARY DESCRIPTION OF THE DRAWINGS

30 The present invention shall be described below in greater detail, based on an example of embodiment represented in the drawings. The figures show:

Figure 1 is a schematic perspective view of any
35 compression ring.

Figure 2 is a magnified cross-sectional view of a compression ring of the prior art, after fracture/breakage in its cross-section.

5 Figure 3 is a microscopic cross-sectional view of a compression ring of the prior art in the region of the upper chamfer thereof.

10 Figure 4 is a microscopic cross-sectional view of a compression ring of the prior art in the region of the lower chamfer thereof.

15 Figure 5 is a schematic plan view of a non-limiting embodiment of the piston ring object of the present invention.

Figure 5A is a schematic view of cross-section A-A of the piston ring illustrated in figure 5.

20 Figure 5B is a magnified schematic view of cross-section A-A of the piston ring illustrated in figures 5 and 5A.

25 Figure 6 is a microscopic cross-sectional view of a non-limiting embodiment of the piston ring, object of the present invention, in the region of the upper chamfer thereof.

30 Figure 7 is a view of test equipment with six rings object of the present invention for a fatigue test.

Figure 8 is a schematic view of the stresses to which the rings are subjected in the equipment illustrated in figure 7.

35

Figure 9 is a graph representing the stress experienced by a ring during the cycles of the fatigue test realised by the equipment illustrated in figure 7.

DETAILED DESCRIPTION OF THE FIGURES

Figure 1 represents in schematic form any piston ring
5 for utilisation in an internal combustion engine. The
present invention relates to a piston ring for use in
the piston groove of the piston of an internal
combustion engine. The preferable embodiment of the
ring 1 object of the present invention is the
10 compression ring of an engine operating according to
the high rotational speed diesel cycle wherein there is
high combustion pressure (high-speed diesel type),
however it is evident that it may assume any other
required or desirable embodiment, such as a second
15 groove ring, an oil ring, or even any other embodiment.

Figure 2 reveals a ring of the prior art utilised in an
engine of the high-speed diesel type. There may be seen
therein a magnified cross-sectional view of a
20 compression ring of the prior art after
fracture/breakage of its cross-section. The figure
permits it to be seen that the initiation of the crack
occurred at the lower chamfer and, with the passage of
time, propagated across the cross-section of the ring
25 until the catastrophic failure, entailing the total
disassembly of the engine.

The applicant has executed exhaustive tests with this
type of ring of the prior art, a compression ring
30 having a base constituted by stainless steel, the
totality thereof being nitrided, with a wear-resistant
coating being applied to the external face, a
posteriori, by the PVD process.

35 From that study, the applicant has concluded that:

(i) That type of catastrophic failure is related to the
fact of the coating layer being applied by PVD and onto

a nitrided surface → when the layer was applied directly onto the ferrous base material, the crack resistance was greater, although there were concerns in respect of the wear through friction;

5

(ii) The crack/fissure initiates at approximately 180° from the region of the opening of the ring and at the lower chamfer.

10 (iii) The occurrence of cracks/fissures was greater as greater the thickness of the nitrided layer in the region of the chamfer.

Figures 3 and 4 illustrate microscopic cross-sectional views of a compression ring of the prior art, respectively in the region of the upper and lower chamfers thereof. In these two figures there may be clearly seen the greater thickness of the nitrided layer 11 on the chamfers, over which the coating layer 12 is applied by PVD.

Taking as a basis the research and development thereof, the applicant has developed the present piston ring 1 which bravely satisfies the technical requirements of the high-speed diesel engines.

Geometrically, the ring 1 object of the present invention is like any ring, that is to say a piston ring for utilisation in the groove of a piston of an internal combustion engine provided with a body 6 composed of a ferrous material defining an upper portion 2 facing towards the piston head, a lower portion 3, opposed, facing towards the piston skirt, an internal portion 4 facing towards the groove of the piston, and an external portion 5, opposed, to slide against the cylinder wall or liner (these latter not illustrated).

The upper and external portions 2, 5 are essentially mutually orthogonal and define an upper chamfer Cs, whereas the lower and external portions 3, 5, also essentially mutually orthogonal, define a lower chamfer
5 Ci.

In a preferable manner, the body 6 is constituted by stainless steel containing essentially 13 to 18% chromium, this material being the most appropriate for
10 the stresses of the high rotational speed diesel engines, however it is evident that it may vary if necessary or desirable. In an even more preferable, but not obligatory, manner the stainless steel utilized has the composition shown in the following table.

15

Chemical element	Percentage
Carbon (C)	0.80 - 0.95
Silicon (Si)	0.35 - 0.50
Manganese (Mn)	0.25 - 0.40
Phosphorous (P)	0.040 maximum
Sulphur (S)	0.040 maximum
Chromium (Cr)	17.0 - 18.0
Molybdenum (Mo)	1.00 - 1.25
Vanadium (V)	0.08 - 0.15

The great innovation of the ring 1 object of the present invention resides in the fact that the upper, lower and internal portions 2, 3, 4 are nitrided (see
20 the CN layer visible in figures 5B and 6), together with the internal portion 5 and the upper and lower chamfers Cs, Ci not being nitrided and coated with at least one layer of coating 7 deposited by the process of ion plating.

25

In a preferable, but not obligatory, manner the layer of coating applied is composed of chromium nitride the greater part whereof being formed by the CrN phase, however it is evident that other alternatives may be

utilised, such as the greater part of the chromium nitride having a phase of Cr_2N , a coating of niobium nitride, a multilayer coating of chromium nitride, or of chromium nitride and niobium nitride, or even any
5 other necessary or desirable layer. In the preferable embodiment of the invention, the layer of coating 7 has a thickness of essentially 20 microns.

A further innovative characteristic of the ring 1
10 object of the present invention resides in the fact that the nitrided portions (the upper, lower and internal portions 2, 3 and 4) are subjected to a treatment creating a nitrided layer of lower hardness, having a reduced hardness of approximately 700 HV. A
15 conventional process of gas nitriding can be described, being the process utilized in this product. That which ensures that the hardness is lower are the treatment parameters, adjusted such as to ensure a maximum hardness in the nitrided layer to prevent the formation
20 of cracks/fissures and consequent breakage/rupture of the ring.

Figure 7 is a view of a test apparatus with six rings object of the present invention for a fatigue test. As
25 may be seen, the machine comprises two heads with means to clasp/faasten six piston rings, such that each head secures the ring adjacently to the opening thereof. During the test, the machine moves open extremities of the rings closer together and separates them such that
30 the rings are forced between a position of maximum opening A_{max} and of minimum opening A_{min} , as may be seen in figure 8.

Figure 9, in its turn, shows a graph representing the
35 stress experienced by the ring during the cycles of the fatigue test carried out by the equipment illustrated in figure 7. With the ring of the state of the art, after a certain number of cycles the breakage/rupture

of the part occurred, while the ring 1 object of the present invention endured this test without breaking/rupturing.

- 5 The process for the manufacture of the piston ring herein revealed is also a new invention, comprising the following stages:

10 Stage (i): deposition of at least one coating layer 7 on the external portion 5 and on the upper and lower chamfers Cs, Ci, by the process of ion plating.

15 Stage (ii): nitriding of the upper, lower and internal portions 2, 3, 4.

As mentioned above, the coating layer 7 applied in stage (i) is a layer of chromium nitride formed in a preferential manner by CrN and having a preferential thickness of essentially 20 microns.

20 Finally, the process additionally comprises a stage of treatment creating a nitrided layer having lower hardness in the nitrided portions.

25 Having being described an example of preferred embodiment, it shall be understood that the scope of the present invention encompasses other possible variations, being limited solely by the content of the appended claims, included therein the possible
30 equivalents.

CLAIMS

1. Piston ring, for utilization in the piston groove of a piston of an internal combustion engine, provided with a body (6) composed of a ferrous material defining an upper portion (2) facing towards the piston head, a lower portion (3), opposed, facing towards the piston skirt, an internal portion (4) facing towards the piston groove, and an external portion (5), opposed, to slide against the cylinder wall or liner, the upper and external portions (2, 5) being essentially mutually orthogonal and defining an upper chamfer (Cs) and the lower and external portions (3, 5) being essentially mutually orthogonal and defining a lower chamfer (Ci), the ring being characterised in that (i) the upper, lower and internal portions (2, 3, 4) are nitrided (CN), and (ii) the external portion (5) and the upper and lower chamfers (Cs, Ci) are not nitrided and coated by at least one coating layer (7) deposited by the process of ion plating and the hardness of the nitrided portions is superficial and max. 700 HV.
2. Piston ring according to claim 1, characterised in that it is a compression or first groove ring.
3. Piston ring according to claim 1 or 2, characterised in that the body (6) is composed of stainless steel containing 13% to 18% chromium.
4. Piston ring according to claim 1, 2 or 3, characterised in that the coating layer (7) is a layer of chromium nitride the greater part whereof is formed of CrN.
5. Piston ring according to claim 4, characterised in that the coating layer (7) has a thickness of essentially 20 microns.

6. Piston ring according to any of the foregoing claims, characterised in that the nitrided portions are subjected to a treatment creating a nitrided layer
5 having lower hardness.

7. Process for the manufacture of a piston ring as defined in claims 1 to 6, characterised in that it comprises the following stages:
10

Stage (i): nitriding the upper, lower and internal portions (2, 3, 4), and

Stage (ii): deposition of at least one coating layer
15 (7) on the external portion (5) and on the upper and lower chamfers (Cs, Ci) by the process of ion plating.

8. Process according to claim 7, characterised in that the coating layer (7) applied in stage (ii) is a
20 layer of chromium nitride formed principally of CrN.

9. Process according to claim 7 or 8, characterised in that the coating layer (7) applied in stage (ii) has a thickness of essentially 20 microns.
25

10. Process according to claim 7, 8 or 9, characterised in that it furthermore comprises a stage of treatment creating a nitrided layer having lower hardness in the nitrided portions.

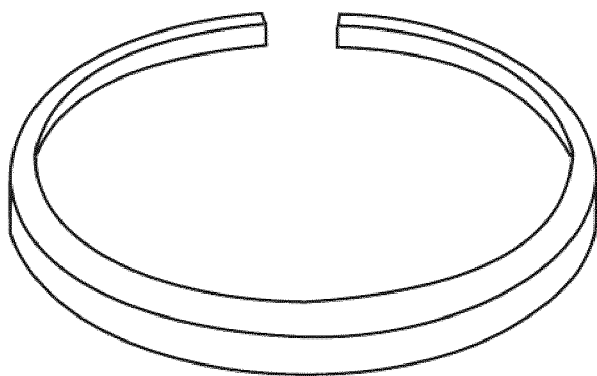


Fig. 1

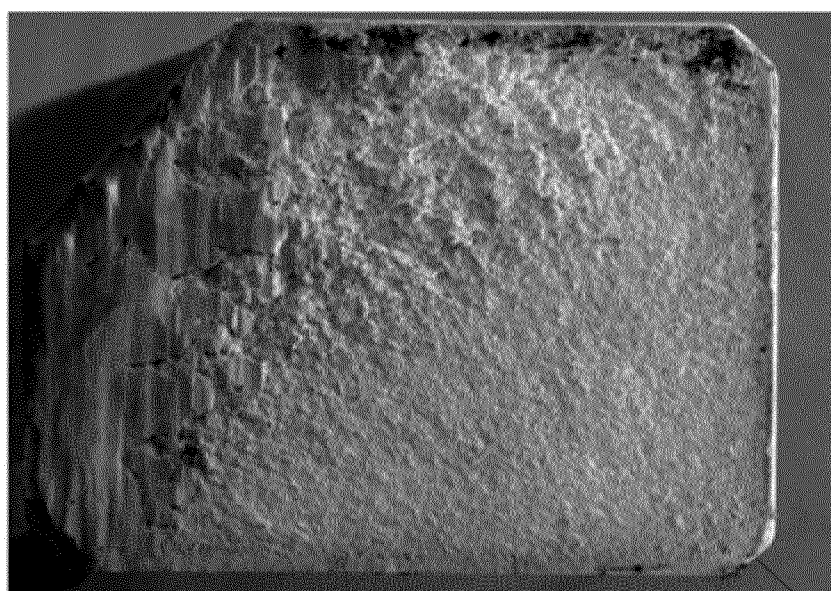


Fig. 2

Ci

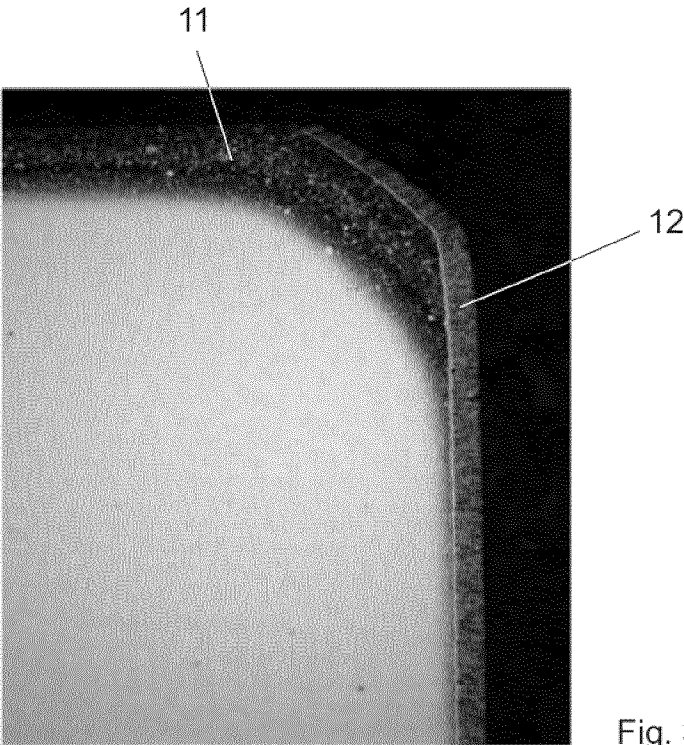


Fig. 3

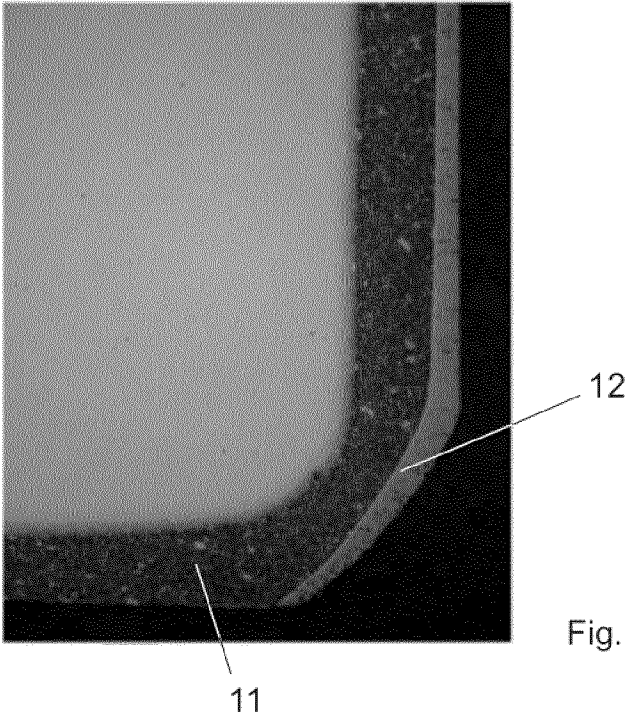
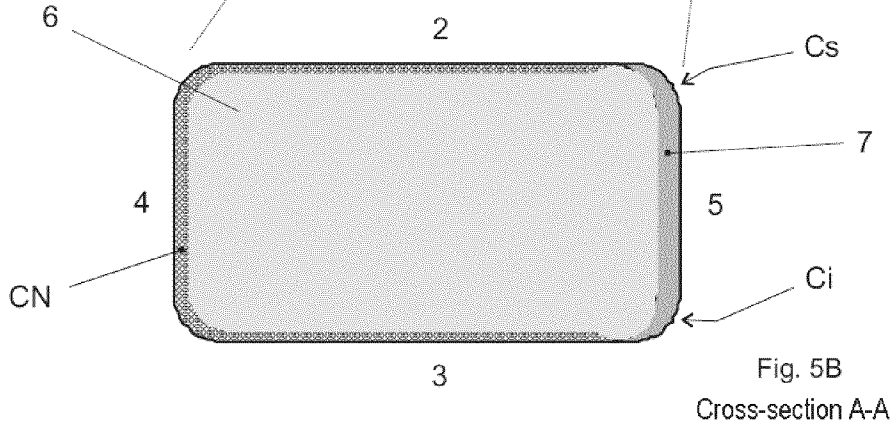
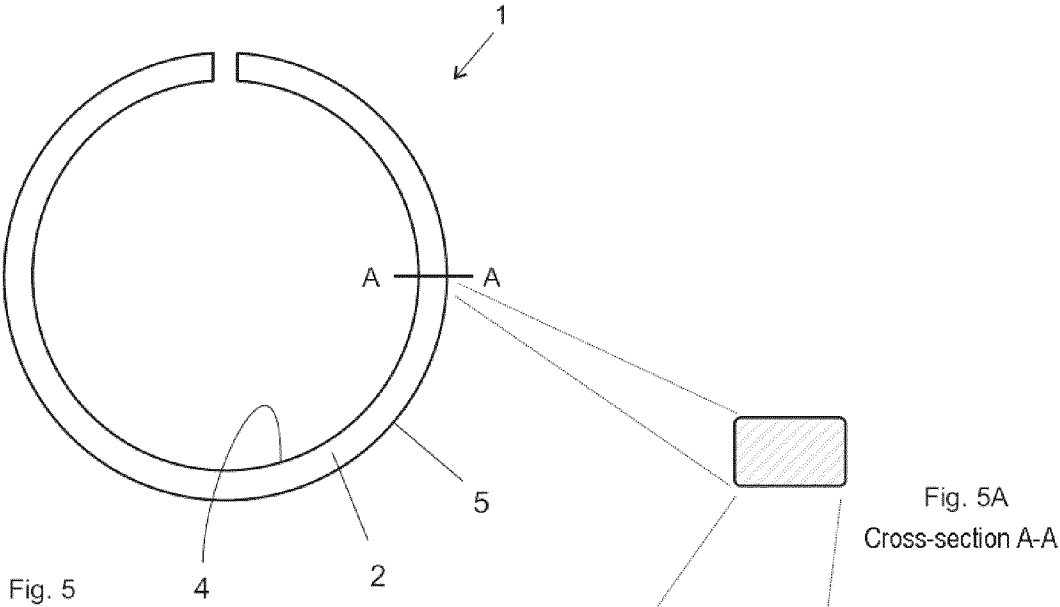


Fig. 4



1
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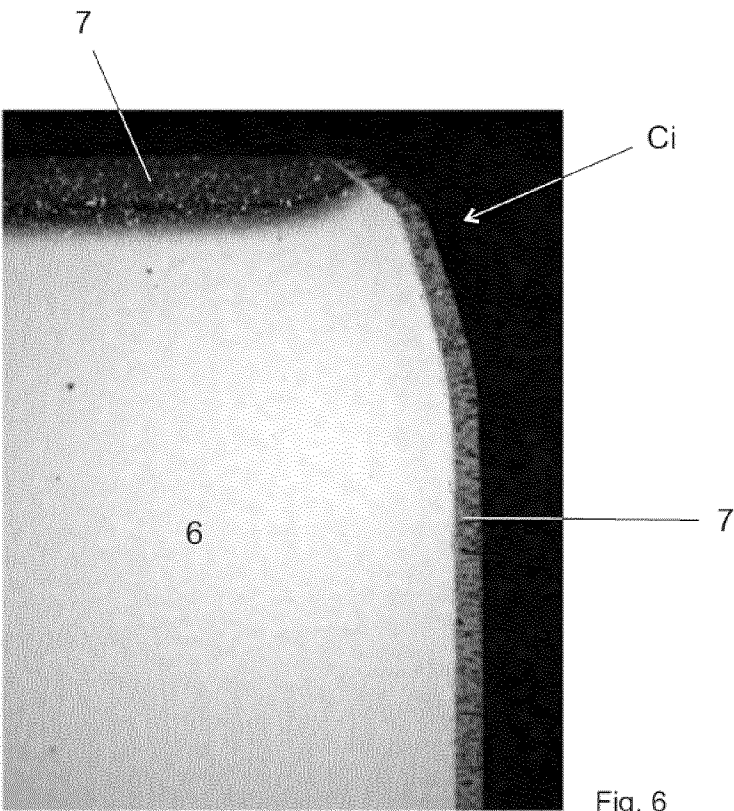


Fig. 6

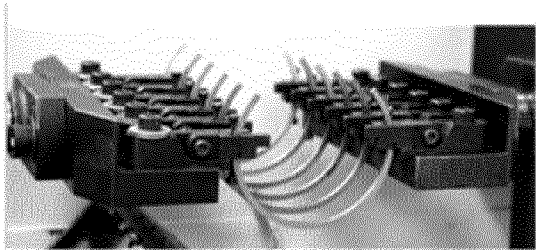


Fig. 7

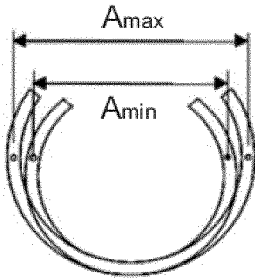


Fig. 8

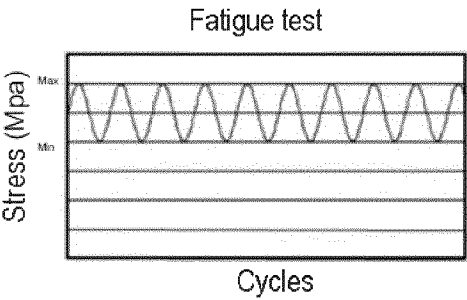


Fig. 9

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference P102C13024WO	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/EP2015/052622	International filing date (<i>day/month/year</i>) 9 February 2015 (09-02-2015)	(Earliest) Priority Date (<i>day/month/year</i>) 25 February 2014 (25-02-2014)
Applicant MAHLE METAL LEVE S/A		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of:

- ☒ the international application in the language in which it was filed
☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6**bis**(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (See Box No. II)

3. ☐ **Unity of invention is lacking** (see Box No III)

4. With regard to the **title**,

- ☒ the text is approved as submitted by the applicant
☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

- ☒ the text is approved as submitted by the applicant
☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,

- a. the figure of the **drawings** to be published with the abstract is Figure No. 5B
☐ as suggested by the applicant
☒ as selected by this Authority, because the applicant failed to suggest a figure
☐ as selected by this Authority, because this figure better characterizes the invention
b. ☐ none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/052622

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16J9/26 C23C14/06 C23C28/04
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 C23C

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2007 298103 A (NIPPON PISTON RING CO LTD) 15 November 2007 (2007-11-15) abstract; figures -----	1-10
Y	JP 2007 271072 A (NIPPON PISTON RING CO LTD) 18 October 2007 (2007-10-18) abstract; figures -----	1-10
Y	GB 2 367 304 A (TEIKOKU PISTON RING CO LTD [JP]) 3 April 2002 (2002-04-03) cited in the application the whole document -----	1-10



Further documents are listed in the continuation of 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

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

12 May 2015

Date of mailing of the international search report

26/05/2015

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2007298103 A	15-11-2007	JP 4761375 B2	31-08-2011
		JP 2007298103 A	15-11-2007

JP 2007271072 A	18-10-2007	JP 4761374 B2	31-08-2011
		JP 2007271072 A	18-10-2007

GB 2367304 A	03-04-2002	GB 2367304 A	03-04-2002
		JP 3295388 B2	24-06-2002
		JP 2000291800 A	20-10-2000
		US 6508473 B1	21-01-2003
