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(71) Applicants: **MAHLE METAL LEVE S/A** [BR/BR]; Rodovia Anhanguera, sentido interior, - capital, Km 49,7, 13210-877 Jundiaí, Sao Paulo (BR). **MAHLE INTERNATIONAL GMBH** [DE/DE]; Pragstraße 26-46, 70376 Stuttgart (DE).

(72) Inventor: **ABLAS MARQUES, Gisela**; Rua Professor Luiz Rivelli 131, 13208-611 Jundiaí, Sao Paulo (BR).

(74) Agent: **BRP RENAUD UND PARTNER MBB**; Königstraße 28, 70173 Stuttgart (DE).

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(54) Title: PISTON RING

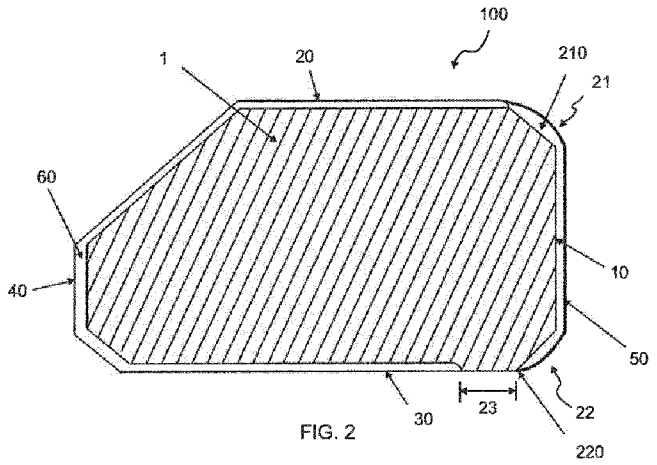


FIG. 2

(57) Abstract: A piston ring is described comprising at least a metal base (1), a sliding face (10), a superior face (20) and an inferior face (30), the interceptions between the sliding face (10) and the superior and inferior faces (20, 30) defining, each thereof, a region of superior intersection (21) and a region of inferior intersection (22), the region of superior intersection defining a sliding chamfer (210), the inferior face (30) in the region extending from the region of inferior intersection (22) by up to a length of 100 to 300 micrometres defining a partial region (23), the perimetric region of the piston ring (100) being nitrided, the sliding chamfer (210), the sliding face (10), the region of inferior intersection (22) and the partial region (23) being devoid of nitridation such that the fragility is reduced of the ring (100) caused by the nitridation of the said regions wherein the recurrence and propagation of cracks is common, in addition permitting the maintenance of nitrided regions having great wear resistance.

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"PISTON RING"

[0001] The present invention relates to a piston ring, more specifically to application in a first groove of a piston for use in an internal combustion engine, provided with a particular distribution of the layer of nitridation, resulting in an increase in resistance to rupture arising from the propagation of cracks.

Description of the state of the art

[0002] In the field of the technology available for piston rings of internal combustion engines, particularly that directed towards the rings of the first groove of a piston responsible for sealing the combustion chamber, preventing the leakage of combustion gases into the crankcase, it is known that, in general, when a failure through rupture of the ring is observed, the initial crack leading to the rupture of the said ring is initiated in the region of the inferior edge of the surface of the external diameter (also known as sliding face), that is to say the edge (generally chamfered) responsible for the sealing of the piston chamber and for the scraping of oil when the assembly is functioning.

[0003] Whilst one of the reasons for the crack being initiated in this specific region may be due to the high level of stresses present in this edge when the assembly is working, the propensity to the rupture of this region is aggravated by the fact that one of the technical practices of surface treatment of the piston rings is the application of a nitrided layer around the entire body of the ring.

[0004] The nitridation of the body (or base) of the ring permits increasing the face hardness thereof and, consequently, the wear resistance thereof, this characteristic being desirable by virtue of the propensity to continuous work of the piston. However, the nitridation of the steel forming the base of the ring renders the nitrided region fragile at diverse points due to the formation of phases of carbonitrides acting as points of initiation of cracks, consequently rendering them less ductile and more fragile. This favours the appearance of the aforementioned initial cracks and leads to the inevitable failure through rupture of the ring.

[0005] Another problem caused by the nitridation on piston rings is the necessity to create chamfers on the edges of the ring, principally on the inferior edge of the external diameter, by virtue of the fact that a pointed edge, or 'sharp corner', would lead to the concentrations of stresses being increased even further. However, the utilisation of sharp corners in this region, if possible, would be desirable for a first groove ring by virtue of the fact that it would improve the sealing and the oil scraping on the face of the piston chamber.

[0006] The state of the art comprises attempts to reduce the fragility and the propensity of cracks arising in this specific region, however they are not shown to be entirely effective. The document US 6698763 reveals a piston ring provided with four faces surface treated with a nitrided layer. The nitrided layer is, in turn, eliminated from the chamfers of the sliding face of the ring by mechanical means, and a layer of ceramic is superimposed.

[0007] The solution proposed by US 6698763 is not effective in terms of significantly reducing the fragility of the ring by virtue of the fact that the region immediately adjacent to the inferior chamfer and the face of the external diameter of the ring still retain the nitrided layer, that is to say that they still present points of high hardness resulting in the great propensity of the appearance of cracks.

[0008] The document JPH05172248 in turn reveals a solution wherein the face of the external diameter of the piston ring does not receive the nitridation treatment and, on the contrary thereto, receives a layer of hardened ceramic.

[0009] The solution proposed by JPH05172248 is also shown not to be effective in reducing the fragility of the ring by virtue of the fact that the region immediately adjacent to the inferior chamfer of the external diameter of the ring remains subject to cracks due to the occurrence of the nitrided layer.

[0010] In this sense, the state of the art does not comprise a solution permitting the elimination of the fragility from the region of intersection of the sliding face with the inferior face of the said ring, caused by the application of the nitrided layer, including from the region immediately adjacent to the chamfers/edges, whilst permitting the retention of the said nitrided layer in other regions in order to profit from the beneficial properties thereof against wear.

[0011] Furthermore, the state of the art does not demonstrate concern to present a solution permitting selecting between the employment or the elimination of the chamfer of the region of inferior intersection of

the sliding face of the ring, which would permit greater sealing and oil scraping capacity.

Objects of the Invention

[0012] In view of the difficulties presented and not resolved by the prior art, the present invention has as object the provision of a piston ring presenting high wear resistance on the entire body thereof, whilst eliminating the fragility typical of the application of the nitrided layer in the region of the sliding face of the ring, especially of the regions adjacent to the intersection of the said face with the inferior face.

[0013] Another object of the present invention is the provision of a piston ring permitting the elimination of the chamfer from the inferior region of the sliding face thereof, permitting the utilisation of pointed edges or 'sharp corners' for more efficient oil scraping and sealing.

Brief description of the invention

[0014] Piston ring comprising at least a metal base composed fundamentally of iron and substantially annular defining a perimetric region, a sliding face capable of being installed adjacently to the wall of a cylinder, a superior face and an inferior face disposed in opposition to the superior face, the superior and inferior faces being adjacent to the sliding face, and the interceptions between the sliding face and the superior and inferior faces defining, each thereof, a region of superior intersection and a region of inferior intersection.

[0015] The region of superior intersection defines a sliding chamfer, and the inferior face of the region extending from the region of inferior intersection having a length in micrometres defines a partial region, whilst the perimetric region of the piston ring is nitrided, there being devoid of nitridation the sliding chamfer, the sliding face, the region of inferior intersection and the partial region.

[0016] Furthermore, the region of inferior intersection is a vertex or a chamfer, and the sliding chamfer, the sliding face, the region of inferior intersection and the partial region are provided with a surface wear layer.

Summary description of the drawings

[0017] The present invention will be described below in greater detail based on an example of embodiment represented in the drawings. The figures show:

Figure 1: a photograph of a piston ring (cross-section) subjected to failure through rupture.

Figure 2: a view of a cross-section of the piston ring of the present invention.

Figure 3: a cross-sectional detail of the region of the chamfer of the piston ring of the present invention.

Detailed description of the figures

[0018] The present invention relates to a piston ring 100, particularly for use in a groove of a piston of an internal combustion engine or of a compressor.

[0019] Firstly, it is clarified again that the process of failure through cross-sectional rupture is typically initiated by a crack, that is to say a fissure, or structural discontinuity of the worked material. This crack is, naturally, a reduction in area of distribution of forces and, consequently, a region of concentration of stresses.

[0020] In this manner, the concentrated stresses act upon the crack, deforming it and, more specifically, propagating it through the structure of the material. Finally, such propagation becomes significant or sufficient to lead to the rupture of the material. Figure 1 shows a piston ring 100A subjected to failure through rupture while working. It may be perceived that the propagation of the crack occurs from the inferior region 110A of the external diameter of the ring, indicating that the crack originated proximate to the inferior chamfer of the external diameter of the ring.

[0021] This behaviour is repeated in the great majority of the piston rings subjected to failure through rupture, including those described by the aforecited documents of the state of the art (US 6698763 and JPH05172248), the technologies whereof revealed have as object the resolution of this very problem, however without presenting appreciable improvements. The failure generally commences from the inferior region of the external diameter of the rings, by virtue of the fact that this region is subjected to constant cyclic traction-compression forces which, when added to the work of oil scraping and sealing, render the same extremely conducive to the propagation of faults through fatigue.

[0022] The present invention resolves this problem by means of the particular distribution of the layer of nitridation upon the piston ring 100, preventing the formation of fragile faces of carbonitrides in regions of interest and, consequently, reducing the propensity of occurrence and propagation of cracks, as will be elucidated below.

[0023] Figure 2 illustrates the cross-section of the piston ring 100 of the present invention. Said ring 100 is formed by a substantially annular metal base 10 formed of a metallic material of ferrous composition such as steel.

[0024] The base 10 comprises a sliding face 10 and a contact face 40, mutually opposed, together with a superior face 20 and an inferior face 30, mutually opposed and adjacent to the sliding and contact faces 10, 40, defining a substantially rectangular cross-sectional profile. The sliding face 10 is capable of being installed adjacently to the wall of a cylinder and the contact face 40 is maintained housed in the groove of the piston. The superior face 20 is oriented towards the face of the piston.

[0025] The intersections between the sliding face 10 and the superior and inferior faces 20, 30 each define a region of superior intersection 21 and a region of inferior intersection 22. All the intersections of the faces 10, 20, 30, 40 each define a chamfer, with the exception of the region of inferior intersection 22 which may define a chamfer or a plain edge, this characteristic being a particular advantage of the present invention as will be elucidated in further detail below. The region of superior intersection 21 defines, specifically, a sliding chamfer 210.

[0026] The upper face 20 and the contact face 40 are provided with a nitrided layer 60 covering the faces thereof completely, including the chamfers thereof. The sliding face 10 and the sliding chamfer 210 do not receive the nitrided layer.

[0027] As figure 3 shows, the inferior face 30 in the region extending from the region of inferior intersection 22 defines a partial region 23 devoid of nitridation. In other words, commencing from the region of inferior intersection 22, there is a region 23 of the inferior face 30 devoid of nitrided layer 200, this region 23 possessing a cross-sectional thickness (in relation to the ring 100) of between 100 and 300 micrometres, and more preferentially of 200 micrometres. It must be further noted that should the region of inferior intersection 22 be a chamfer, the chamfer also does not receive the nitrided layer and the partial region 23 commences from the end of the chamfer (the end of the chamfer being indicated by 220, as illustrated in figure 3).

[0028] In this manner, the regions adjacent to the region of inferior intersection 22 remain devoid of nitrided layer 200. This prevents such region becoming fragile through the formation of phases of carbonitrides, reducing the possibilities of occurrence of cracks leading to the failures through rupture typical of this region. In this manner, the present invention achieves a truly significant efficacy in the reduction of the failures in piston rings, differing from the technologies comprised by the state of the art wherein the failure may still occur in the regions immediately adjacent to the inferior chamfer of the external diameter of the ring.

[0029] Furthermore, the present invention, on the basis of the reduction in the risk of rupture, permits the possibility for the region of inferior intersection 22 of not defining a chamfer, but of defining a plain edge, differing from the piston rings of the state of the art being obligatorily provided with a chamfered edge in the inferior region of the external diameters thereof for elimination of the 'sharp corner' thereof.

[0030] The utilisation of the region of inferior intersection 22 as an edge (instead of chamfer) permits greater efficiency in the sealing and scraping of oil, improving the performance of the equipment as a whole. However, the presence of a 'sharp corner' or pointed edge creates a point of concentration of stresses rendering this region fragile, this being balanced by the fact that the region of inferior intersection 22 of the ring 100 of the present invention is devoid of nitrided layer, reducing the concentration of non-metallic inclusions and, consequently, the occurrence of failures through the initiation and propagation of cracks and in this manner permitting the non-utilisation of the chamfer with an acceptable structural equilibrium. The utilisation of an edge in an equivalent region of a piston ring of the state of the art would not be possible by virtue of the fact of the presence of the nitrided layer and of the 'sharp corner' taken together would significantly increase the propensity of occurrence of cracks and rupture of the ring.

[0031] Finally, the continuance of the nitrided layer on the remaining superior and inferior lateral faces 20 and 30 of the ring 100 permits the maintenance of the resistance to wear between the ring and the

groove of the piston, brought about by the process of nitridation.

[0032] As illustrated in figures 2 and 3, particularly in respect of this preferential constructive configuration, the sliding chamfer 210, the sliding face 10 and the region of inferior intersection 22 are subsequently coated with a layer of material resistant to wear 50, such as chromium, by a deposition process such as PVD (physical vapour deposition).

[0033] In respect of the process of obtainment of a piston ring 100 such as that aforedescribed, this presents the following stages:

Stage I) Obtainment of a piston ring 100 comprising a substantially annular base 10 provided with superior, inferior and contact sliding faces 10, 20, 30, 40.

Stage II) Coating of the sliding chamfer 210, the sliding face 10, the region of inferior intersection 22 and the partial region 23 by material preventing the diffusion of the nitrogen.

Stage III) Surface treatment of the piston ring 100 by gas nitridation.

Stage IV) Removal of the layer of protective material from the sliding face 10 and from the partial region 23.

Stage V) Coating of the sliding chamfer 210, the sliding face 10, the region of inferior intersection 22

and the partial region 23 by a material having great resistance to wear 50.

[0034] Each of the stages are detailed below:

Stage I)

[0035] The obtainment of a piston ring 100 having the characteristics determined may be realised by any of the methods known in the state of the art, such as extrusion followed by cutting.

[0036] The chamfers of the faces 10, 20, 30, 40 may be obtained directly in stage I provided this is concluded by means of lamination. Alternatively, it is possible to obtain the chamfers through processes of machining. As has already been elucidated, the present invention also permits the non-utilisation of the chamfer in the region of inferior intersection 23, should this be desirable.

Stage II)

[0037] In this stage the faces and the regions referred to are coated with a material preventing the diffusion of the nitrogen into the base 10.

Stage III)

[0038] Utilisation of gas nitridation to confer hardness on the areas not coated by the material preventing the nitridation. The procedure utilised is such as that of the accepted technical practice involved, immersing the part in a sealed environment fed with ammonia. An appropriate temperature and time are applied to diffuse nitrogen at the velocity and in

the depth desired, which may vary according to application.

Stage IV)

[0039] Removal of the layer of protective material (nitrogen diffusion inhibitor) from the regions whereupon it had been applied.

Stage V)

[0040] To improve the performance of the sliding chamfer 210, the sliding face 10, and the region of inferior intersection 22 in respect of the high level of wear by virtue of their being devoid of the nitrided layer, recoating of the said regions with a material 50 promoting this resistance by a process such as physical vapour deposition (PVD) and a material such as chromium nitride.

[0041] An example of preferred embodiment having been described, it shall be understood that the scope of the present invention covers other possible variations, being limited solely by the content of the appended claims, the possible equivalents being included therewithin.

CLAIMS

1. Piston ring comprising at least a metal base (1) fundamentally composed of iron and substantially annular defining a perimetric region, a sliding face (10) capable of being installed adjacently to the wall of a cylinder, a superior face (20) and an inferior face (30) disposed in opposition to the superior face (20), the superior and inferior faces (20, 30) being adjacent to the sliding face (10), the interceptions between the sliding face (10) and the superior and inferior faces (20, 30) defining, each thereof, a region of superior intersection (21) and a region of inferior intersection (22), the region of superior intersection defining a sliding chamfer (210), the inferior face (30) in the region extending from the region of inferior intersection (22) for a length of from 100 to 300 micrometres microns defining a partial region (23), the piston ring (100) being characterised in that the perimetric region of the piston ring (100) is nitrided, the sliding chamfer (210), the sliding face (10), the region of inferior intersection (22) and the partial region (23) being devoid of nitridation.

2. Piston ring (100), according to claim 1, characterised in that the region of inferior intersection (22) is an edge.

3. Piston ring (100), according to claim 1, characterised in that the region of inferior intersection (22) is a chamfer.

4. Piston ring (100), according to claim 1, characterised in that the partial region (23) possesses a length of 200 micrometres.

5. Piston ring (100), according to claim 1, characterised in that the sliding chamfer (210), the sliding face (10), and the region of inferior intersection (22) are provided with a surface wear layer (50).

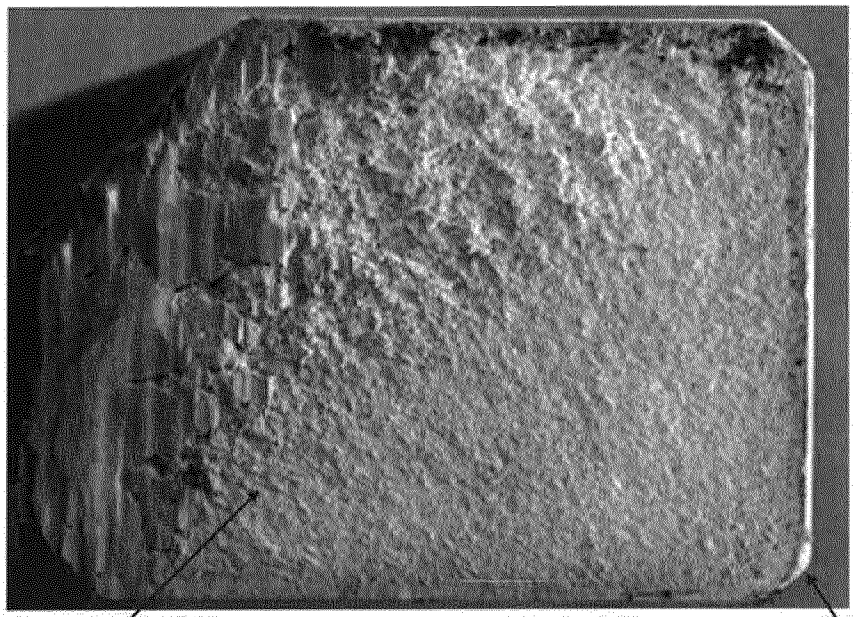


FIG. 1

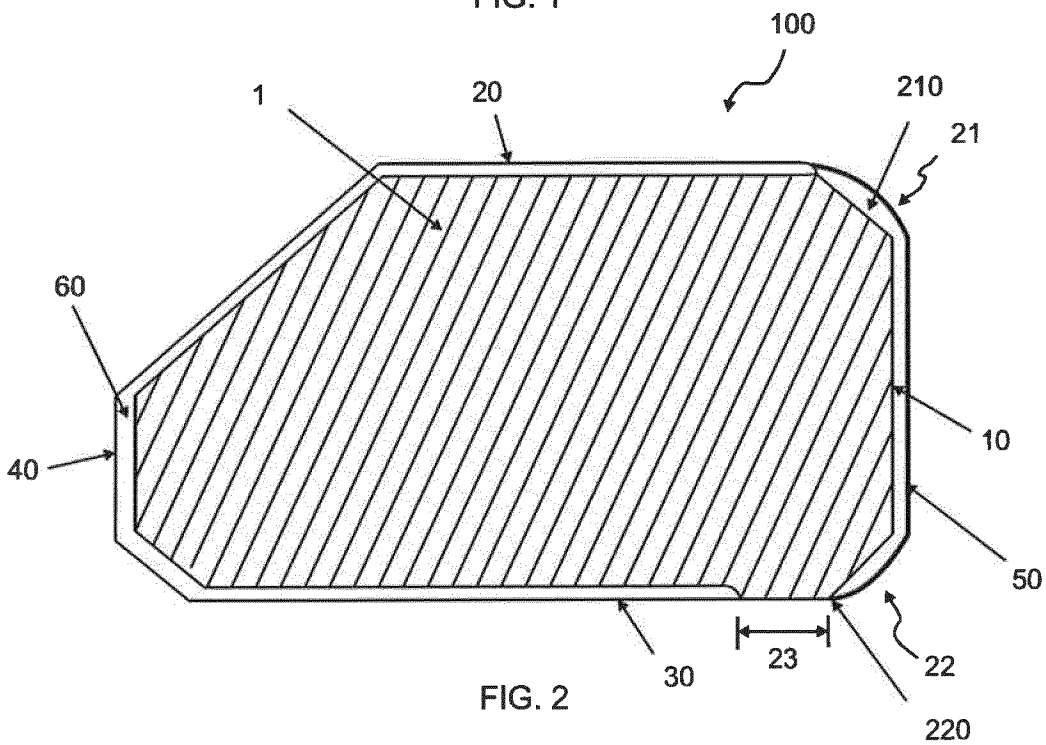


FIG. 2

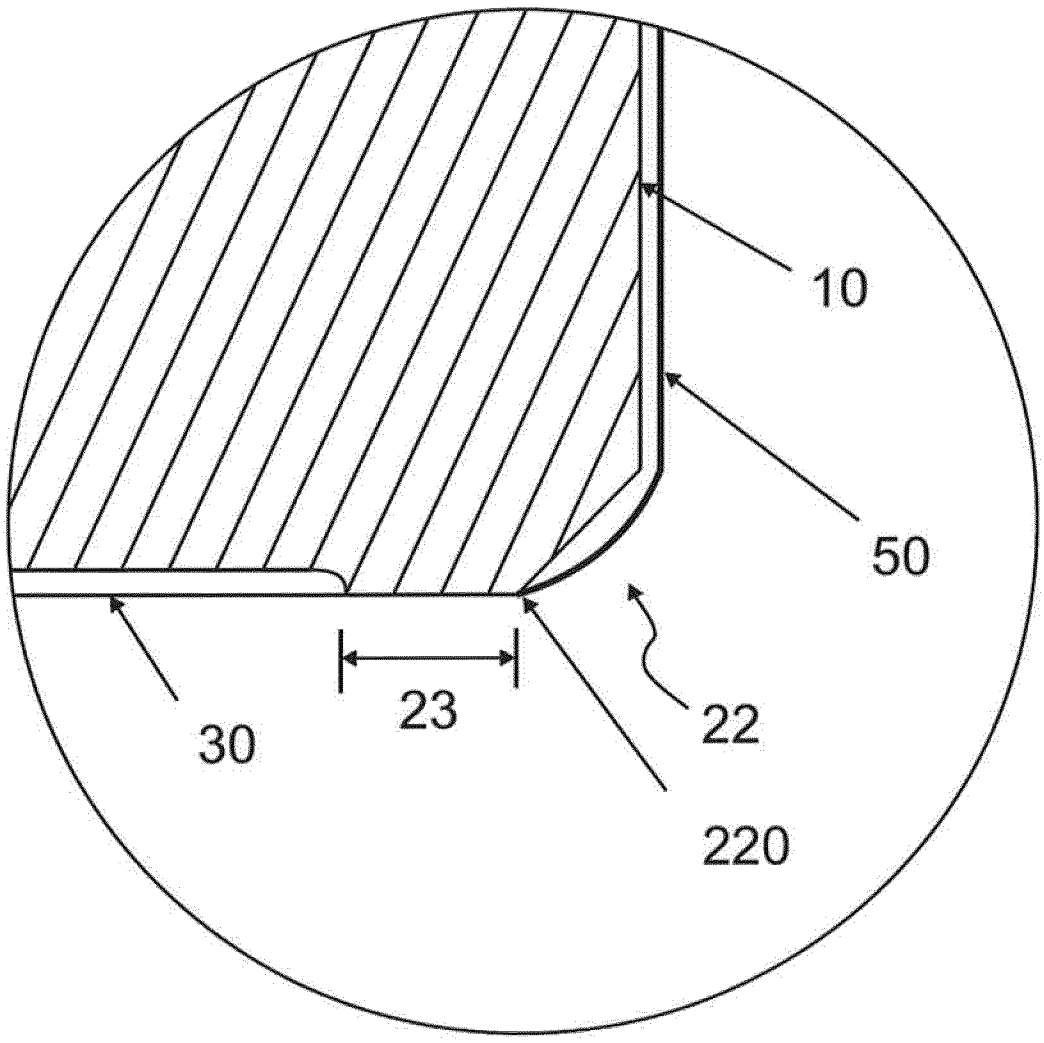


FIG.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/069428

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16J9/20 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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012/205876 A1 (FUJIMURA KAZUHIRO [JP] ET AL) 16 August 2012 (2012-08-16) paragraph [0049] - paragraph [0051]; figures -----	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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Date of the actual completion of the international search	Date of mailing of the international search report
10 November 2016	17/11/2016

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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/069428

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012205876 A1	16-08-2012	CN 102639851 A	15-08-2012
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