

(19)



(11)

EP 4 826 465 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(51) International Patent Classification (IPC):
G04B 13/02 (2006.01) **G04B 17/06** (2006.01)
G04B 43/00 (2006.01) **C22F 1/18** (2006.01)

(21) Application number: **25170820.2**

(52) Cooperative Patent Classification (CPC):
G04B 13/02; C22F 1/183; C22F 1/186;
G04B 17/063; G04B 43/007

(22) Date of filing: **15.04.2025**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH LA MA MD TN

(71) Applicant: **Richemont International S.A.**
1752 Villars-sur-Glâne (CH)

(72) Inventor: **BRUNNER, Lorenz**
8215 Hallau (CH)

(74) Representative: **Patentsmith SA**
Bahnhofstrasse 87
3232 Ins (CH)

(54) **TIMEPIECE MOVEMENT COMPONENT AND ITS METHOD OF MANUFACTURE**

(57) Timepiece movement component (1) intended to cooperate with a further timepiece movement component in dynamic friction, said timepiece movement component (1) comprising a titanium alloy core (3) and an outer layer (5) provided upon at least a part of said core (1) in an area intended to cooperate with said

further horological component.

According to the invention, said titanium alloy is a binary titanium-zirconium alloy comprising at least 10 wt%, preferably at least 20 wt%, further preferably at least 30 wt% zirconium, and in that said outer layer (5) is a thermal oxide layer.

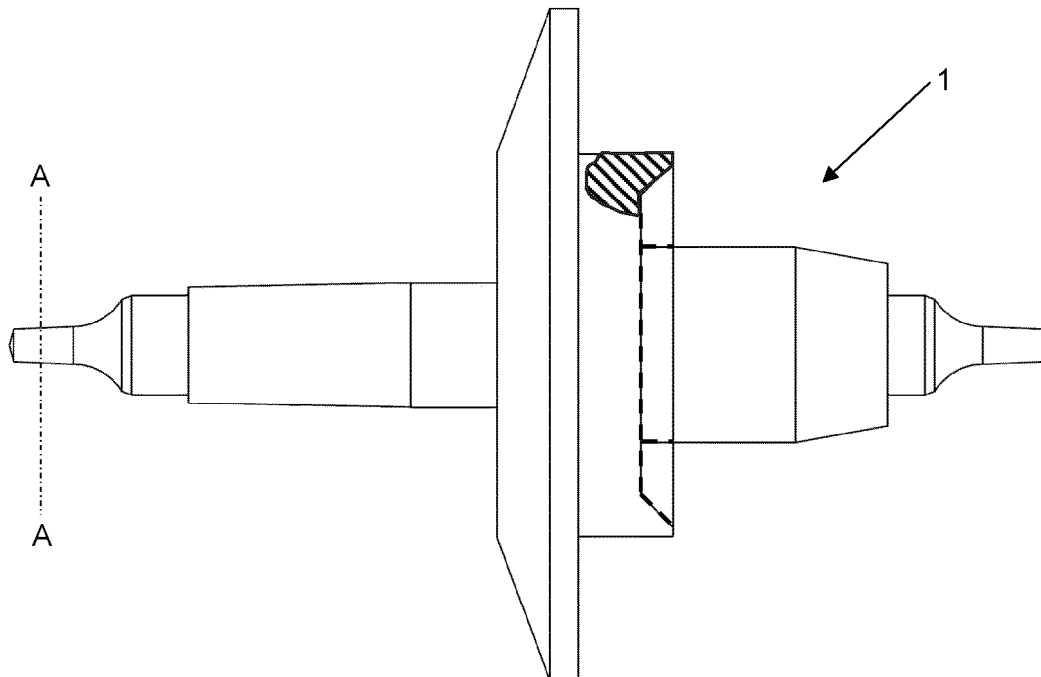


Figure 1

Description

Technical Field

[0001] The present invention relates to the field of horology. More particularly, it relates to a timepiece movement component intended to cooperate with a further timepiece movement component in dynamic friction, and hence be subject to frictional wear. The invention also relates to a method of manufacture of such a timepiece movement component. Examples of such timepiece movement components are axles, arbours, staffs (particularly balance staffs), gear wheels, pinions, racks, pallet stones, impulse pins, bearings and so on.

State of the Art

[0002] Modern watchmaking has a strong preference for using amagnetic or paramagnetic materials for movement components, in order to minimise or eliminate the effect of external magnetic fields on the running of the movement. This effect is most pronounced on the regulating system, which is typically of the conventional balance-hairspring type, is affected by external magnetic fields, since very small variations can, cumulatively, give significant deviations in the running of the movement. Indeed, resistance to magnetic fields of 15,000 Gauss is one of the conditions tested by Omega's "Master Chronometer" certification, and Rolex's "Superlative Chronometer" certification tests resistance to magnetic fields of 10,000 Gauss.

[0003] To this end, various alloys of titanium have gained favour, although a compromise always must be reached in respect of the machinability of the alloy, and the surface hardness of the finished part. In essence, an alloy with a sufficient surface hardness for surfaces which cooperate with other parts in dynamic friction, that is to say which comprise bearing surfaces which are in moving contact with other components and which are hence subject to wear, is difficult or impossible to machine. An alloy which has good machinability typically has a native surface hardness which is very much insufficient for wear resistance. This leads to unacceptably rapid wear, and hence the component will require frequent replacement: it should be borne in mind that certain components of a timepiece movement, in particular the balance staff, pallet stones and escapement wheel, are subject to potentially billions of frictional cycles during the expected lifetime of the timepiece in which the component is integrated.

[0004] The typical solution is to provide a surface hardening treatment to a machinable alloy, and to this end document EP3339968 discloses a horological axle in a non-magnetic alloy of aluminium, titanium or magnesium, which is surface-hardened by anodisation in an aqueous bath. Particular alloys mentioned are aluminium alloys in the 6000 series (Al, Mg, Si) and 7000

series (Al, Zn, Cu), titanium grade 5 (5.5-6.75 wt% Al, 3.5-4.5 wt% V, balance Ti), and Mg-Zr alloys. This surface anodising exhibits a hardness of at least 300 HV, most preferably greater than 500 HV.

[0005] While the resulting axles do exhibit good performance, improvement is still desirable, particularly in respect of wear resistance when used with industry-standard lubricants such as Moebius 9010.

[0006] Document CH707504 describes a different solution, namely surface hardening of a titanium alloy balance staff by ion implantation, in order to obtain a surface hardness of at least 900 HV.

[0007] Although this potentially results in a much higher surface hardness than the anodisation of EP3339968, ion implantation is a complex process requiring specialised equipment, and is hence expensive and time-consuming to carry out.

[0008] The aim of the invention is hence to at least partially overcome the above-mentioned limitations of the prior art.

Disclosure of the Invention

[0009] More precisely, the invention relates to a timepiece movement component intended to cooperate with a further movement component in dynamic friction, said timepiece movement component comprising a titanium alloy core and an outer layer provided upon at least a part of said core in an area intended to cooperate with said further horological component, or even over the entire core.

[0010] According to the invention, said titanium alloy is a binary titanium-zirconium alloy comprising at least 10 wt%, preferably at least 20 wt%, further preferably at least 30 wt% zirconium, and said outer layer is a thermal oxide layer, which is distinguishable from an anodic oxide layer by analysis of its surface morphology and thickness, which is typically significantly larger than the at most several hundred nanometres of thickness of an anodic oxide layer.

[0011] Preferably, said alloy comprises between 20 wt% and 78.4 wt% zirconium, preferably between 30 wt% and 70 wt%, further preferably between 40 wt% and 60 wt% zirconium, the balance being titanium and up to 1 wt% impurities.

[0012] Surprisingly, the use of such a binary titanium-zirconium alloy, provided with a thermal oxide layer, provides unexpectedly excellent wear resistance and tribological properties, with the thermal oxide layer being producible with conventional, simple heat treating equipment and ambient air. Furthermore, the native alloy hardness of around 270 HV (+/- 30 HV) provides good machinability for producing the core. As a result, no specialised equipment or industrial gases are required, rendering production of the timepiece movement component extremely economical, despite its excellent surface hardness of at least 1000 HV, preferably between 1100 HV and 1400 HV.

[0013] The invention relates to all timepiece movement components which cooperate with other movement components in dynamic friction, such as axles, arbours and staffs generally, gear wheels, pinions, racks, metallic pallet stones, impulse pins, components of bearings, and so on, and these preferably have a principle dimension (i.e. a longest dimension) less than 10mm, preferably less than 5mm. However, it should be noted that the invention is particularly suited for horological axles, and more particularly balance staffs, which typically have pivots with a diameter between 0.04 and 0.08 mm which cooperate with antishock bearings. Such balance staffs can be incorporated in a timepiece oscillator comprising at least one further oscillator component, such as a hairspring and/or a balance wheel.

[0014] Although the entirety of the timepiece movement component may be provided with the outer layer of thermal oxide, this latter may be provided only on the contact surfaces, such as the pivots of an axle or balance staff, on the teeth of a gear wheel or pinion, or similar as appropriate for the type of component concerned.

[0015] Typically, said outer layer of thermal oxide has a thickness of between 0.5 μm and 20 μm , preferably between 1 μm and 15 μm , further preferably between 3 μm and 13 μm , further preferably between 5 μm and 10 μm .

[0016] The invention likewise to a method of manufacturing a timepiece movement component as defined above. This method comprises steps of:

- machining a piece of said titanium alloy to form said core;
- heat treating said as-machined core in the presence of oxygen to form said outer layer on said core.

[0017] This method hence provides the advantages mentioned above in the context of the timepiece movement component itself.

[0018] It should be noted that when the outer layer of thermal oxide is formed on the core, this leads to a slight increase in the dimensions of the part. If the dimensions and tolerances justify taking into account this increase, said core is, in its as-machined form, typically slightly smaller than the desired dimensions of the timepiece movement component in order that the formation of the thermal oxide layer brings the overall component to its desired final dimensions. If this is not an issue, this compensation can be omitted.

[0019] The heat treating can be carried out in a conventional oven, by induction heating or similar, preferably in one or more cycles at at least one temperature between 250°C and 880°C, for a duration of between 10 and 110 minutes. More specifically, this may be carried out in a single cycle at a temperature of between 15 and 80 minutes at a temperature of between 600°C

and 850°C.

[0020] Advantageously, said heat treating may be carried out in ambient air at ambient pressure, which avoids using any industrial gases, keeping the cost of the method as low as possible.

[0021] An optional step of burnishing may also be carried out after said machining and before said heat treating, and/or a step of tribological finishing may be carried out after said heat treating.

[0022] As before, this method results in particularly economical production of timepiece movement components with unexpectedly excellent wear resistance and tribological properties, and is compatible with conventional heat treating equipment and can be carried out with ambient air rather than industrial gases.

Brief description of the drawings

[0023] Further details of the invention will become apparent upon reading the detailed description, in reference to the appended figures which illustrate:

- Figure 1: a schematic representation of a balance staff;
- Figure 2: a schematic, not-to-scale representation of a cross-section of the pivot of the balance staff of figure 1, along the line A-A;
- Figure 3: optical micrographs of a comparison test piece and an invention test piece after a tribological test;
- Figure 4a: a wear graph of the comparison test piece illustrated in figure 3;
- Figure 4b: a wear graph of the invention test piece illustrated in figure 3;
- Figure 5: graphs of coefficients of friction measured during the tribological tests resulting in the optical micrographs of figure 3;
- Figure 6: a graph of coefficients of friction plotted against wear volume for the results of said tribological tests.

Embodiments of the Invention

[0024] Figures 1 and 2 illustrate a timepiece movement component 1 according to the invention. Although this component 1 is illustrated in the form of a balance staff, it should be understood that the invention likewise applies to all timepiece movement components which cooperate with other movement components in dynamic friction, such as axles, arbours and staffs generally, gear wheels, pinions, racks, metallic pallet stones, impulse pins, components of bearings, components of

chronographs, components of calendars and so on.

[0025] The term "dynamic friction" relates to a cooperation between two components wherein a relative movement is produced therebetween, such that the contact surfaces are subjected to friction as a result of this relative movement. This is opposed to a static friction, which is the case for instance when a first part is force-fitted onto a second part, such as where e.g. a gear wheel is force fitted onto its axle, and hence no relative movement between the two components occurs in use.

[0026] Such components 1 typically have a principal dimension less than 10 mm, preferably less than 5 mm. The principal dimension is the longest dimension, i.e. the length for elongate components such as arbours, axles and shafts, the diameter for wheels, and either the diameter or the length for pinions, depending on the aspect ratio. In the specific case of a balance staff, the length is typically of the order of 2 mm, with a diameter of less than 2 mm, and pivots with a diameter of the order of 0.06 mm.

[0027] The component 1 is based on a particular family of binary titanium-zirconium alloys, which form the core 3 of the component 1. These titanium-zirconium alloys contain at least 10 wt% (5.5 at%) zirconium, preferably at least 20 wt% (11.6 at%) zirconium, further preferably at least 30 wt% (18.4 at%) zirconium, further preferably between 20 wt% (11.6 at%) and 78.4 wt% (65.6 at %) zirconium, further preferably between 20 wt% (11.6 at%) and 70 wt% (55.1 at%) zirconium, further preferably between 40 wt% (25.9 at%) and 60 wt% (44.1 at%) zirconium, the balance being titanium and the industry standard allowance for impurities (typically up to 1 wt%). Typical alloys are Ti51Zr49 (wt%) and Ti50Zr50 (wt%).

[0028] This family of alloys presents a significantly increased hardness compared to both titanium and zirconium alone, while still retaining sufficiently-good machinability, typical as-supplied hardness being 270 HV +/- 30 HV.

[0029] Furthermore, and surprisingly, when simply heat treated in an oxygen-containing atmosphere, oxidation of the surface of the alloy results in the growth of a Ti-Zr oxide ceramic outer layer with remarkable and unexpected tribological properties in the context of timepiece movement components.

[0030] As a result, the component 1 is provided with an outer layer 5, which is a thermal oxide layer of this type, at least in areas which will be subject to dynamic friction when in use, e.g. on the pivots of a balance staff, on the contact surfaces of teeth of gear wheels, of pallet stones or similar.

[0031] In order to manufacture the component 1 according to the invention, a billet, bar, rod or semi-finished blank of said alloy is provided, and the core 3 is machined conventionally, e.g. by high-precision profile turning ("décolletage") in the case of an axle or staff, conventional teeth cutting for a gear wheel or pinion,

etc. Alternatively, the core 3 can be machined by laser turning. An optional burnishing or other surface finishing step may be carried out prior to thermal oxide layer 5 growth.

[0032] The thermal oxide layer 5 is not an added coating applied on to the surface of the core 3, but is grown by thermal oxidation and is hence intimately integrated with the material of the core, giving excellent resistance to chipping. Since the growth of the thermal oxide layer 5 occurs approximately half inside the alloy and half on its surface, the dimensions of the core 3 as-machined, i.e. prior to heat treatment, may take into account this subsequent change if the dimensions and tolerances justify such compensation, and the core 3 as-machined is hence typically of slightly smaller dimensions than the finished component 1. If this change in dimensions is not critical, it can be ignored, however.

[0033] Typically, the final thickness of the thermal oxide layer is between 0.5 μm and 20 μm , preferably between 1 μm and 15 μm , further preferably between 3 μm and 13 μm , and the finished component 1 may be considered as being a metal/ceramic composite.

[0034] Typical process conditions for growing the thermal oxide layer 5 are a temperature of 250°C to 880 °C, in ambient air, for a duration of between 10 and 110 minutes, in one or more cycles, and with optional quenching steps in the case of multiple cycles. Good results have been obtained with a single cycle of between 15 and 80 minutes at a temperature of between 600°C and 850°C.

[0035] Although ambient air at ambient pressure shows good results, and is particularly economic to carry out since it does not require the provision of industrial gases, the use of a controlled atmosphere at a different pressure than ambient pressure is not excluded.

[0036] The entire core 3 as machined can be heated in an oven, as is generally known, but it is also possible to carry out local heating e.g. by induction heating, for instance if it is desired to provide the thermal oxide layer 5 only on the pivots of an axle, balance staff or similar.

[0037] After heat treatment and cooling, the thermal oxide layer 5 is typically subjected to a tribological finishing step such as a polishing step.

[0038] Tribological tests were carried out using standardised invention test pieces, with a 6 mm +/- 1 mm radius contact surface which was polished to a mirror finish (<20 nm roughness, as per ISO 25178). The invention test pieces were prepared according to the process as described above, with an approximately 10 μm thick thermal oxide layer 5, and as a comparison, comparison test pieces conventionally manufactured from AISI 1095 carbon steel and thermally-hardened were also produced. This steel is commonly used for balance staffs in applications not requiring resistance to magnetic fields, and is hence a relevant point of comparison.

[0039] The test was carried out by pressing the test pieces, lubricated with Moebius 9010, against a ruby block with a force of 6.4 N, giving an average Hertz pressure of 600 MPa over a contact width of 58.3 μm . The ruby block was displaced in translation back and forth at a speed of 2.38 $\text{mm}\cdot\text{s}^{-1}$, at a frequency of 4 Hz, giving a total distance travelled between each test piece and the ruby block of 200 m. This test hence simulates the conditions between a balance staff pivot and a ruby endstone of an anti-shock bearing.

[0040] The results of these tests for the invention test pieces and the comparison test pieces are illustrated in figures 3-6.

[0041] Figure 3 illustrates optical micrographs of the contact surfaces of the test pieces, the comparison test piece being illustrated on the left and the invention test piece on the right, and figures 4a (comparison test piece) and 4b (invention test piece) illustrate surface wear topologies of the contact surface, with the original surface as reference. As can be clearly seen, significant visible wear has occurred on the comparison test piece, whereas the invention test piece has in fact picked up material and has not been subject to any visible wear. The worn volume of the comparison test piece was measured via Keyence surface measurements as 5142 μm^3 , whereas for the invention test piece this was so small as to not be quantifiable.

[0042] Figure 5 is a graph illustrating the variation in coefficient of friction (COF) measured during the test, with values at the start, the average, and at the end. As can be clearly seen, the coefficient of friction increases significantly for the comparison test piece as it wears, whereas it decreases slightly for the invention test piece.

[0043] Figure 6 is a graph of worn volume (horizontal-axis) vs coefficient of friction (vertical-axis), which again illustrates the large increase in performance of the invention over the conventional AISI 1095 carbon steel.

[0044] As can be seen from the foregoing, the use of binary titanium-zirconium alloy as described above for the core 3, with a thermal oxide layer 5 thereupon, provides significant improvements for wear resistance and tribological properties, when lubricated with Moebius 9010, which is a generally-available industry-standard lubricant with proprietary formulation. Furthermore, the thermal oxide outer layer can be formed using conventional heat treating equipment, and with ambient air, with a relatively short processing time, which makes the method of the invention particularly economical to carry out. This combination of extremely high wear resistance, excellent tribological performance and simplicity of the formation of the thermal oxide layer 5 is highly advantageous and highly unexpected, particularly in view of prior art solutions.

[0045] Preferably, the timepiece movement component 1 of the invention is a balance staff, which is part of a timepiece oscillator, in combination with at least

one additional oscillator component such as a balance wheel and/or a hairspring. The said at least one additional oscillator component is advantageously non-magnetic, for example a hairspring made of non-magnetic material. The hairspring can thus be provided in the form of a non-magnetic spiral, such as a silicon spiral or a non-magnetic metal alloy spiral (FeMn, NbZr, NbTi base, etc.) with its ferrule, also advantageously made of a non-magnetic metal alloy. Even more advantageously, the timepiece oscillator is made up solely of non-magnetic parts. For example, a brass balance, a brass or nickel silver (an alloy of copper, nickel and zinc) plateau, a corundum ellipse and a silicon spiral can be provided. In addition, a skilled person may choose to combine the oscillator with an axis according to the invention with a non-magnetic escapement. For example, the pallet and/or escape wheel may be made of non-magnetic NiP alloy or silicon. It should also be pointed out that in the context of the above mentioned non-magnetic metal alloy hairspring, the index assembly (raquetterie in French) which is mounted friction-tight on the balance cock or bridge consists of an index where the hairspring passes between the curb pins or between the boot and the pin. To minimize wear caused by the hairspring blade, the boot and pin are advantageously constructed from a non-magnetic material and treated according to the invention.

[0046] Although the invention has been described in reference to specific embodiments, further variations are possible without departing from the scope of the invention as defined in the appended claims.

Claims

1. Timepiece movement component (1) intended to cooperate with a further timepiece movement component in dynamic friction, said timepiece movement component (1) comprising a titanium alloy core (3) and an outer layer (5) provided upon at least a part of said core (1) in an area intended to cooperate with said further horological component, **characterised in that** said titanium alloy is a binary titanium-zirconium alloy comprising at least 10 wt%, preferably at least 20 wt%, further preferably at least 30 wt% zirconium, and **in that** said outer layer (5) is a thermal oxide layer.
2. Timepiece movement component (1) according to claim 1, wherein said alloy comprises between 20 wt% and 78.4 wt%, preferably between 20 wt% and 70 wt%, further preferably between 40 wt% and 60 wt% zirconium, the balance being titanium and up to 1 wt% impurities.
3. Timepiece movement component (1) according to any preceding claim, wherein said timepiece movement component (1) has a principle dimension less

than 10mm, preferably less than 5mm.

4. Timepiece movement component (1) according to any preceding claim, wherein said outer layer (5) has a thickness of between 0.5 μm and 20 μm , preferably between 1 μm and 15 μm , further preferably between 3 μm and 13 μm . 5
5. Timepiece movement component (1) according to any preceding claim, wherein said timepiece movement component (1) is a horological axle. 10
6. Timepiece movement component (1) according to any preceding claim, wherein said horological axle is a balance staff. 15
7. Timepiece movement component (1) according to any preceding claim, wherein said balance staff has pivots with a diameter between 0.04 and 0.08 mm, said outer layer (5) being provided at least on said pivots. 20
8. Timepiece oscillator comprising a timepiece movement component (1) according to claim 6 and at least one other oscillator component. 25
9. Timepiece movement comprising at least one timepiece movement component (1) according to any of claims 1-7. 30
10. Timepiece comprising a timepiece movement according to the preceding claim.
11. Method of manufacturing a timepiece movement component (1) according to any of claims 1-7, comprising steps of: 35
 - machining a piece of said titanium alloy to form said core (3);
 - heat treating said as-machined core (3) in the presence of oxygen to form said outer layer (5) on said core (3). 40
12. Method according to the preceding claim, wherein a step of burnishing is carried out after said machining and before said heat treating. 45
13. Method according to any of claims 11-12, further comprising a step of tribological finishing carried out after said heat treating. 50
14. Method according to any of claims 11-13, wherein said heat treating is carried out in one or more cycles at at least one temperature between 250°C and 880°C, for a duration of between 10 and 110 minutes. 55
15. Method according to claim 14, wherein said heat

treating is carried out in a single cycle at a temperature of between 15 and 80 minutes at a temperature of between 600°C and 850°C.

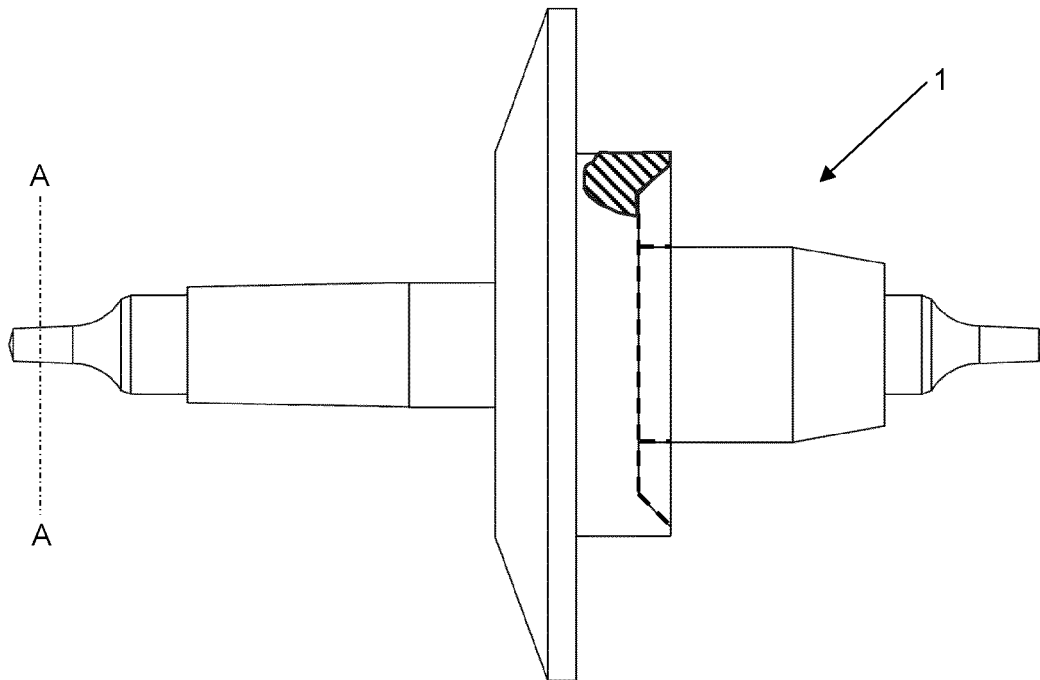


Figure 1

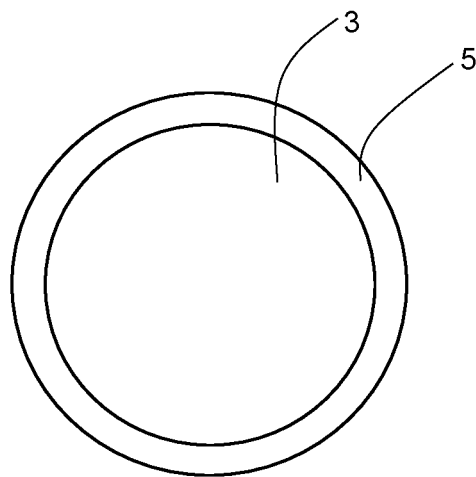


Figure 2

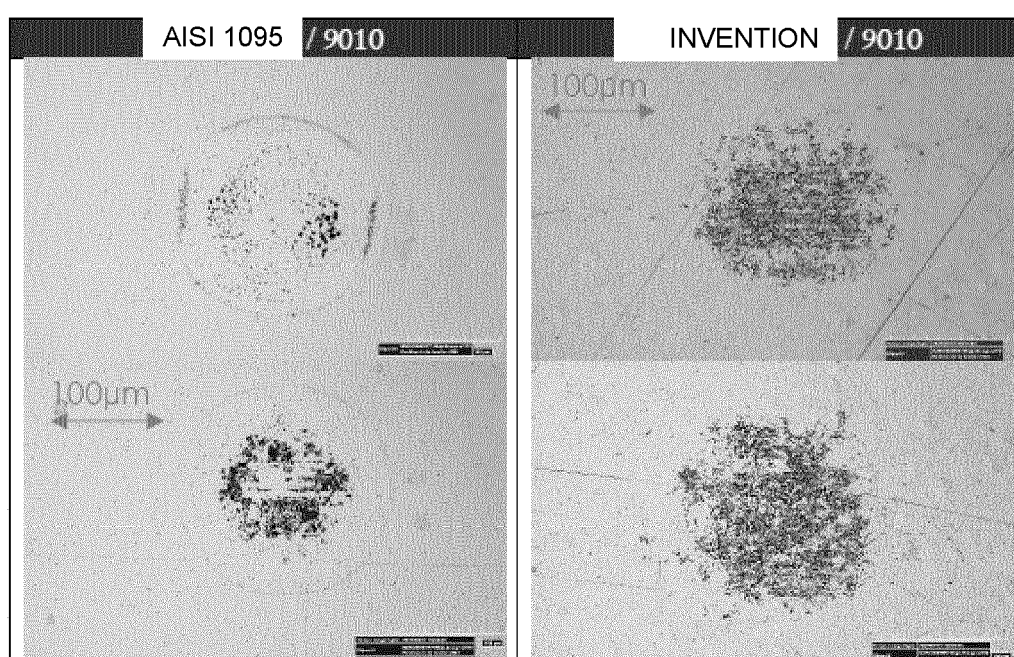


Figure 3

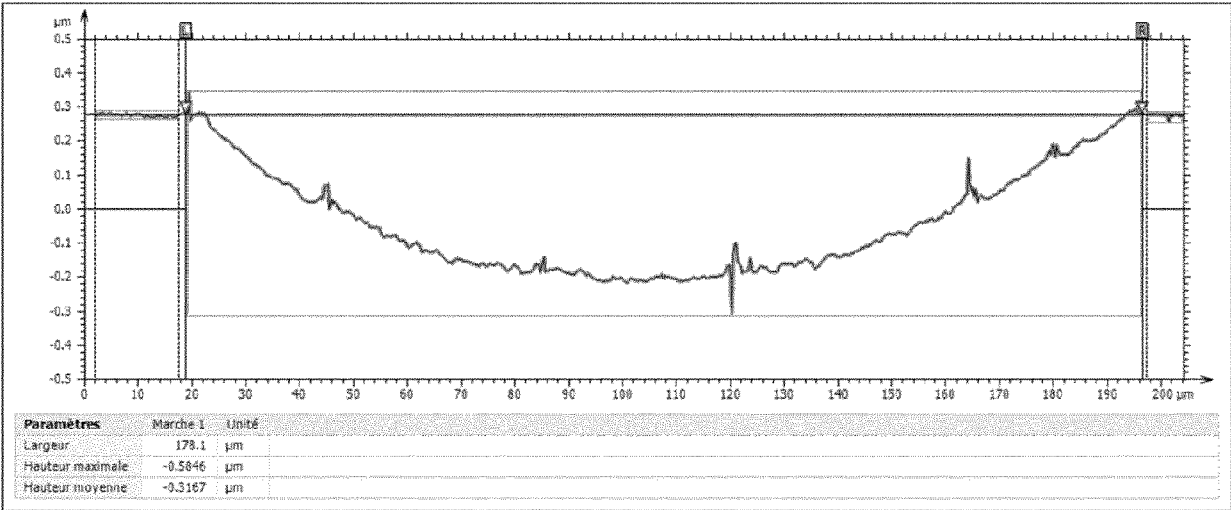


Figure 4a

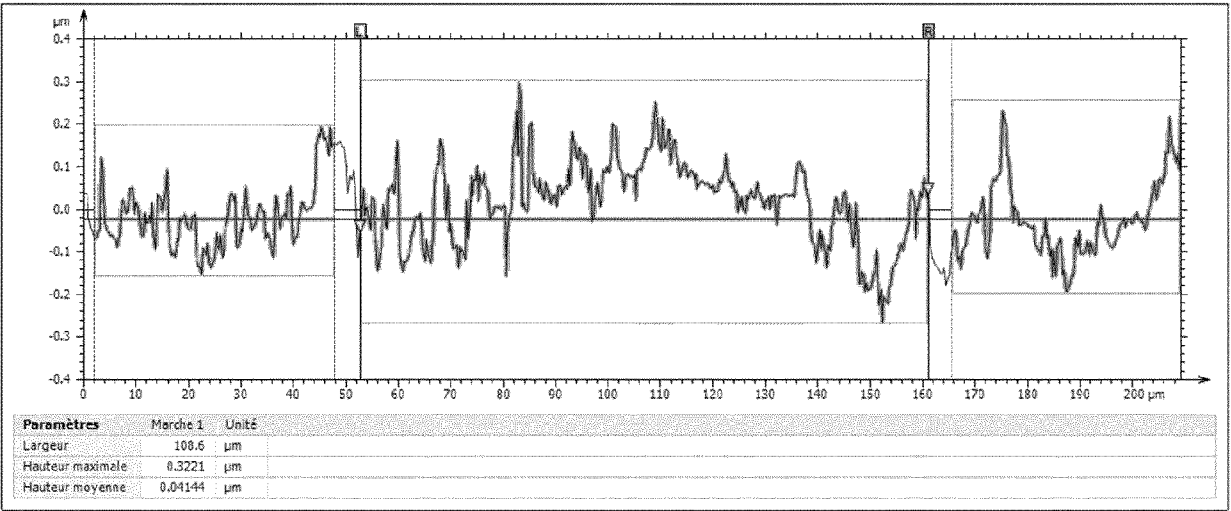


Figure 4b

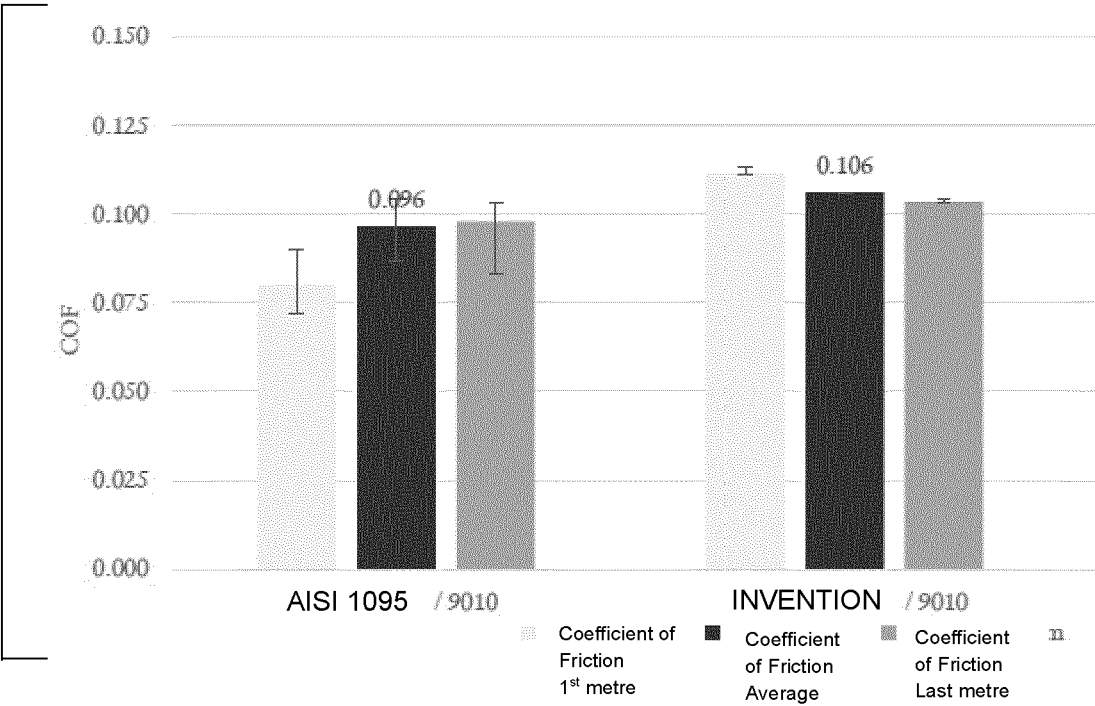


Figure 5

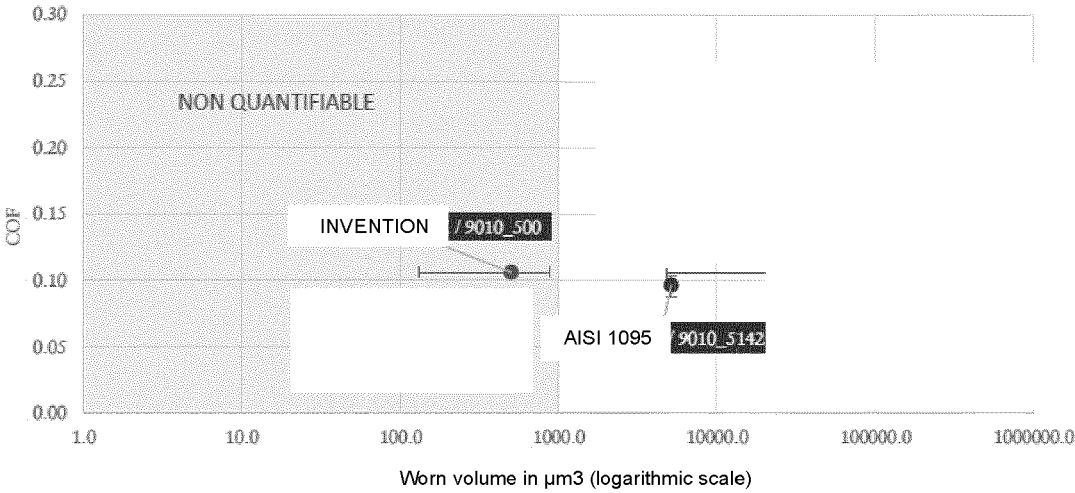


Figure 6



EUROPEAN SEARCH REPORT

Application Number

EP 25 17 0820

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	CH 707 504 A2 (OMEGA SA [CH]) 31 July 2014 (2014-07-31) * paragraphs [0012], [0026], [0021], [0019]; claim 1; figure 1 * -----	1-15	INV. G04B13/02 G04B17/06 G04B43/00 C22F1/18
Y	US 2009/199932 A1 (ZAK GAD [CA]) 13 August 2009 (2009-08-13) * paragraphs [0001], [0002], [0018] - [0020], [0036], [0038] * -----	1-15	
A	US 2014/198624 A1 (VON GRUENIGEN CEDRIC [CH] ET AL) 17 July 2014 (2014-07-17) * paragraph [0013]; figure 1 * -----	1-15	
A	WO 2024/227680 A2 (ROLEX SA [CH]) 7 November 2024 (2024-11-07) * page 3, line 16 - page 6, line 36 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			G04B C22F
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		4 September 2025	Reeb, Bertrand
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P24C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 25 17 0820

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-09-2025

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CH 707504 A2	31-07-2014	CH 707504 A2	31-07-2014
		CN 203965807 U	26-11-2014

US 2009199932 A1	13-08-2009	CA 2610634 A1	16-05-2009
		US 2009199932 A1	13-08-2009
		US 2012216921 A1	30-08-2012
		US 2012219736 A1	30-08-2012
		US 2012291929 A1	22-11-2012

US 2014198624 A1	17-07-2014	CH 707503 A2	31-07-2014
		CN 103941571 A	23-07-2014
		CN 110275418 A	24-09-2019
		EP 2757424 A1	23-07-2014
		HK 1200222 A1	31-07-2015
		JP 6223408 B2	01-11-2017
		JP 2014137377 A	28-07-2014
		JP 2016053589 A	14-04-2016
		RU 2014101335 A	27-07-2015
		US 2014198624 A1	17-07-2014

WO 2024227680 A2	07-11-2024	WO 2024227679 A1	07-11-2024
		WO 2024227680 A2	07-11-2024

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 3339968 A [0004] [0007]
- CH 707504 [0006]