(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 263 721 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
03.01.2018 Bulletin 2018/01

(21) Application number: **16755004.5**

(22) Date of filing: **24.02.2016**

(51) Int Cl.:
C22C 9/01 *(2006.01)* ***B22D 27/20*** *(2006.01)*
C22C 9/05 *(2006.01)*

(86) International application number:
PCT/JP2016/000987

(87) International publication number:
WO 2016/136254 (01.09.2016 Gazette 2016/35)

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **24.02.2015 JP 2015034357**

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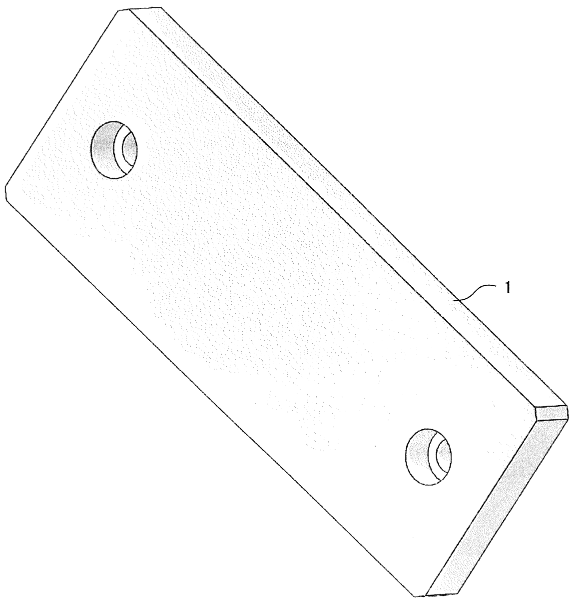
(54) HIGH TEMPERATURE WEAR-RESISTANT ALUMINUM-BRONZE-BASED MATERIAL

(57) Provided is a material endowed with high wear resistance in high-temperature environments. This high temperature wear-resistant aluminum-bronze-based material has an Al content of 9.0 mass% to 11.0 mass%, inclusive, an Ni content of 1.0 mass% to 3.0 mass%, inclusive, an Mn content of 8.5 mass% to 15.0 mass%, inclusive, an Si content of 2.0 mass% to 4.0 mass%, inclusive, an Fe content of 0.5 mass% to 5.0 mass%, inclusive, and a Co content of 0.01 mass% to 1.5 mass%, inclusive, with the remainder being substantially Cu.

[FIG. 1]



EP 3 263 721 A1

Printed by Jouve, 75001 PARIS (FR)

Description

Technical Field

[0001] The present invention relates to an aluminum-bronze-based material having high wear resistance in high-temperature environments.

Background Art

[0002] In high-temperature environments in industrial machines and facilities such as incinerators, copper alloys such as high-strength brass castings are generally used in sliding members such as exhaust valve bushes.

[0003] As an example of such a sliding member, Patent Literature 1 discloses a copper-based bearing sliding material which contains 3 to 15% by mass of Al, 1 to 8% by mass of Mn, 0.05 to 5% by mass of Si, 0.5 to 5% by mass of Ni, and 1 to 10% by mass of Fe, with the remainder being unavoidable impurities and Cu, in which an Fe-Mn-Si-based hard material is dispersed.

Citation List

Patent Literature

[0004] Patent Literature 1: JP3929288B

Summary of Invention

Technical Problem

[0005] However, the hardness of the matrix material of the known aluminum bronze-based sliding member as disclosed in Patent Literature 1 decreases in high-temperature environments (for example, a high-temperature environment at 150°C to 350°C). Accordingly, the allowable surface pressure value is lowered, and it cannot be said that wear resistance is sufficient. Thus, a further sophisticated material is demanded to be supplied in order to reduce the replacement frequency of sliding members in industrial machines which are used in adverse environments where the replacement is not easy.

[0006] The present invention has been made to solve such a known problem, and an object thereof is to provide a material which has both surface pressure resistance and wear resistance not only in normal temperature environments but also in high-temperature environments. Solution to Problem

[0007] The high temperature wear-resistant aluminum-bronze-based material according to the present invention is characterized in that an Al content is 9.0% by mass or more and 11.0% by mass or less, an Ni content is 1.0% by mass or more and 3.0% by mass or less, an Mn content is 8.5% by mass or more and 15.0% by mass or less, an Si content is 2.0% by mass or more and 4.0% by mass or less, an Fe content is 0.5% by mass or more and 5.0% by mass or less, and a Co content is 0.01% by mass or more and 1.5% by mass or less, with the remainder being substantially Cu. Advantageous Effects of Invention

[0008] According to the high temperature wear-resistant aluminum-bronze-based material according to the present invention, there can be provided a sliding member which has both surface pressure resistance and wear resistance even in high-temperature environments. The reduction of the wear amount due to sliding movements enables the replacement frequency of a component such as a sliding member to be drastically reduced in industrial machines and molds of which sliding members are not easy to replace.

Brief Description of Drawings

[0009]

FIG. 1 is a schematic diagram of a plate-like sliding member which adopts as a base material a high temperature wear-resistant aluminum-bronze-based material according to the present embodiment and which is the type having no solid lubricant.

FIG. 2 is a schematic diagram of a plate-like sliding member which adopts as a base material the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment and which is the type having a solid lubricant.

FIG. 3 is a schematic diagram of a hollow cylindrical sliding member which adopts as a base material a high temperature wear-resistant aluminum-bronze-based material according to the present embodiment and which is the type having no solid lubricant.

FIG. 4 is a schematic diagram of a hollow cylindrical sliding member which adopts as a base material a high temperature wear-resistant aluminum-bronze-based material according to the present embodiment and which is the type having a solid lubricant. Description of Embodiments

[0010] Hereinafter, a high temperature wear-resistant aluminum-bronze-based material according to an embodiment of the present invention will be described in detail.

[0011] The high temperature wear-resistant aluminum-bronze-based material according to the present embodiment is a material which contains Al, Ni, Mn, Si, Fe, and Co in respective predetermined amounts in terms of % by mass, with the remainder being Cu.

[0012] The high temperature wear-resistant aluminum-bronze-based material according to the present embodiment has an Al content of 9.0% by mass or more and 11.0% by mass or less, and preferably 9.0% by mass or more and 10.0% by mass or less. When the Al content is within the above-described value range, the matrix material can have an appropriate hardness of HV280 or more, thereby improving surface pressure resistance. It is noted that the hardness of the matrix material is measured by a method in accordance with JIS Z2243 2008.

[0013] When the Al content is less than the above-described value range, hardness becomes insufficient. On the other hand, when the Al content exceeds the above-described value range, hardness becomes high, but toughness becomes low. Therefore, heat resistance is reduced.

[0014] Also, the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment has an Ni content of 1.0% by mass or more and 3.0% by mass or less, and preferably 1.5% by mass or more and 2.5% by mass or less. The inclusion of Ni enables the solubility limit of Al in an α phase to be widened, and also the melting point of the matrix material to be increased thereby improving heat resistance. Furthermore, the inclusion of Ni contributes to deposition of a hard material, together with Fe-Si-Mn described later.

[0015] When the Ni content is less than the above-described value range, the heat resistance of the matrix material is not satisfied. On the other hand, when the Ni content exceeds the above-described value range, there is the drawback that the matrix material is embrittled, and a manufactured product becomes expensive because Ni is a rare metal.

[0016] Also, when the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment has a structure in which an Fe-Mn-Si-based hard material is dispersed, the wear resistance as a sliding member improves.

[0017] The high temperature wear-resistant aluminum-bronze-based material according to the present embodiment has an Mn content of 8.5% by mass or more and 15.0% by mass or less, preferably 8.5% by mass or more and 13.0% by mass or less, and more preferably 8.5% by mass or more and 10.0% by mass or less. When the Mn content is within the above-described value range, Mn, together with Si, Mn and the like described later, causes an Fe-Si-Mn-based hard material to be deposited in the matrix material, thereby improving wear resistance. Also, when the Mn content ratio is increased, the matrix material can have suitable toughness.

[0018] When the Mn content is less than the above-described value range, toughness which is necessary and sufficient as the matrix material cannot be obtained. When the Mn content exceeds the above-described value range, toughness becomes more than necessary.

[0019] Also, the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment has an Fe content of 0.5% by mass or more and 5.0% by mass or less, preferably 1.0% by mass or more and 5.0% by mass or less, and more preferably 1.5% by mass or more and 5.0% by mass or less. When the Fe content is within the above-described value range, Fe is deposited together with Mn-Si and the like as a hard material in the matrix material, and particularly contributes to a finer structure of the above-described hard material, thereby improving the properties as a sliding member.

[0020] When the Fe content exceeds the above-described value range, corrosion resistance is reduced. Furthermore, Fe is dissolved to the degree that is the solubility limit (peritecteutectic point) or more thereby to be segregated in the structure, which leads to the increase of a friction coefficient. Therefore, aggression toward a mating material is increased. In consideration of the fact in which a mating material of sliding movements is mainly a steel material, excessive inclusion of Fe is likely to cause adhesion, which leads to reduced sliding properties.

[0021] Also, the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment has an Si content of 2.0% by mass or more and 4.0% by mass or less, preferably 2.0% by mass or more and 3.0% by mass or less, and more preferably 2.5% by mass or more and 3.0% by mass or less. When the Si content is within the above-described value range, Si, together with Mn and Fe, causes a eutectic hard material to be deposited, thereby improving sliding properties.

[0022] Also, the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment has a Co content of 0.01% by mass or more and 1.5% by mass or less. According to the present embodiment, the inclusion of Co improves heat resistance.

[0023] FIGs. 1 to 4 are each a diagram illustrating a configuration of a sliding member which adopts as a base material the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment. FIG. 1 illustrates a plate-like sliding member 1 which is the type having no solid lubricant. FIG. 2 illustrates a plate-like sliding member 2 which is the type having a plurality of pieces of a solid lubricant 3 embedded therein. FIG. 3 illustrates a hollow cylindrical sliding member 4 which is the type having no solid lubricant. FIG. 4 illustrates a hollow cylindrical sliding member 5 which is the type having a plurality of pieces of a solid lubricant 6 embedded therein. It is noted that FIGs. 1 to 4 illustrate examples of the form of a sliding member, and the form of the sliding member is not limited to these embodiments .

[0024] As illustrated in the drawings, a plurality of pieces of a solid lubricant having a self-lubricating action may be embedded in portions of a sliding surface formed from the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment. Examples of the solid lubricant according to the present embodiment to be used may include solid lubricants, such as a graphite-based solid lubricant, a PTFE-based solid lubricant, a MoS2-based solid lubricant, and a Pb alloy-based solid lubricant.

[0025] According to the present embodiment, the provision of the sliding surface in which a solid lubricant is embedded causes the lubricant to be dispersed on the sliding surface even in high-temperature environments. Therefore, the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment can have improved sliding properties, and becomes suitable as a sliding member.

[0026] Also, it is preferable that the high temperature wear-resistant aluminum-bronze-based material according to the present embodiment have a Vickers hardness of HV280 or more, an elongation of 0.5% or more, and a tensile strength of 500 N/mm^2 or more. When the hardness is equal to or more than HV280, surface pressure resistance and wear resistance in high-temperature environments are improved.

[0027] Also, when the elongation is equal to or more than 0.5%, there can be obtained the material strength which is suitable for a sliding member. It is noted that as described herein, the "elongation" refers to an elongation that is measured with a tensile test piece in accordance with JIS Z2241. Also, when the tensile strength is equal to or more than 500 N/mm^2 or more, load bearing properties in high-temperature environments are improved. The sliding properties of the present invention will be described in detail by way of examples.

Examples

[0028] Hereinafter, examples of the present invention will be described. It is noted that the present invention is not limited to the following examples.

[0029] A plurality of copper alloys of the composition as illustrated in Table 1 were melted in a high-frequency furnace and cast with a mold, thereby to prepare a block test piece according to each of Examples 1 to 8 and Comparative Examples 1 to 5. Table 1 indicates composition values [Wt%] of the test pieces according to Examples 1 to 8 and Comparative Examples 1 to 5. The composition values were obtained by ICP emission spectrochemical analysis.

[0030] As illustrated in Table 1, the test pieces according to Example 1 to Example 8 have a composition in which an Al content was 9.0% by mass or more and 11.0% by mass or less, an Mn content was 8.5% by mass or more and 15.0% by mass or less, an Fe content was 0.5% by mass or more and 5.0% by mass or less, an Ni content was 1.0% by mass or more and 3.0% by mass or less, an Si content was 2.0% by mass or more and 4.0% by mass or less, and a Co content was 0.01% by mass or more and 1.5% by mass or less, with the remainder being substantially Cu.

[0031] On the other hand, the composition of part of the metals contained in each of Comparative Example 1 to Comparative Example 5 is outside the range of the above-described examples.

[Table 1]

	Cu	Al	Ni	Mn	Si	Fe	Co
Example 1	Remainder	9.37	1.87	14.80	2.86	4.90	1.00
Example 2	Remainder	9.22	2.01	8.73	2.95	1.68	1.06
Example 3	Remainder	9.38	1.73	9.06	3.32	1.16	0.27
Example 4	Remainder	9.33	1.97	14.30	2.86	1.67	1.02
Example 5	Remainder	9.23	1.98	8.55	2.35	1.59	0.27
Example 6	Remainder	9.66	1. 97	10.90	2.87	1.62	1.00
Example 7	Remainder	9.24	1.91	8.84	2.87	4.75	1.06
Example 8	Remainder	9.34	2.03	10.80	2.95	4.99	0.047

(continued)

	Cu	Al	Ni	Mn	Si	Fe	Co
Comparative Example 1	Remainder	4.74	2.05	4.17	2.69	5.10	1.05
Comparative Example 2	Remainder	8.63	0.87	10.26	1.09	2.89	0.28
Comparative Example 3	Remainder	9.20	0.78	10.35	3.26	0.86	0.27
Comparative Example 4	Remainder	9.44	0.82	4.80	3.15	1.01	0.28
Comparative Example 5	Remainder	9.46	0.97	4.54	3.17	1.95	0.37

[0032] Table 2 indicates measurement results of the hardness and wear amount for the block test pieces according to Examples 1 to 8 and Comparative Examples 1 to 5.

[Table 2]

	Hardness [HV]	Wear amount [μm]
Example 1	372	42.8
Example 2	341	42.5
Example 3	334	42.3
Example 4	362	40.8
Example 5	302	40.5
Example 6	306	36.5
Example 7	342	35.5
Example 8	289	35.5
Comparative Example 1	181	48.0
Comparative Example 2	321	53.8
Comparative Example 3	334	51.5
Comparative Example 4	297	58.8
Comparative Example 5	410	49.8

[0033] The hardness was obtained by measuring the Vickers hardness of the block test pieces according to Examples 1 to 8 and Comparative Examples 1 to 5 at room temperature. As understood from Table 2, the hardness of the test pieces according to Examples 1 to 8 is 280 or more.

[0034] The wear amount was measured by performing a block-on-ring type sliding test for the block test pieces according to Examples 1 to 8 and Comparative Examples 1 to 5. The condition of the sliding test is a surface pressure of 10 MPa, a sliding speed of 10 m/min, an environment temperature of 250°C, and a sliding distance of 500 m. The sliding test was performed with a dedicated test machine. The block test piece was pressed against a ring test piece in a state where the temperature in the test machine was maintained at 250°C thereby to apply a load, and the ring test piece was rotated at a constant speed. It is noted that S45C (quenched and tempered at high frequency) was used as the ring test piece that is a mating material.

[0035] As understood from Table 2, the wear amount of the block test pieces according to Examples 1 to 8 is 35.5 μm or more and 42.8 μm or less, indicating that the wear amount is small. On the other hand, the wear amount of the block test pieces according to Comparative Examples 1 to 5 is 48.0 μm or more and 58.8 μm or less, indicating that the wear amount is large. Thus, the effects of the examples of the present invention were confirmed.

[0036] In particular, the wear amount is 40.8 μm or less in Example 4 to Example 8. Therefore, it is understood that these compositions are preferable. Furthermore, the wear amount is 36.5 μm or less in Example 6 to Example 8. Therefore, it is understood that these compositions are more preferable.

[0037] As described above, according to the high temperature wear-resistant aluminum-bronze-based material of the present invention, there can be provided a sliding member which has both surface pressure resistance and wear resistance even in high-temperature environments. Furthermore, by reducing the wear amount of the sliding member, the replacement frequency of the sliding member can be drastically reduced in industrial machines of which the sliding members are not easy to replace.

Claims

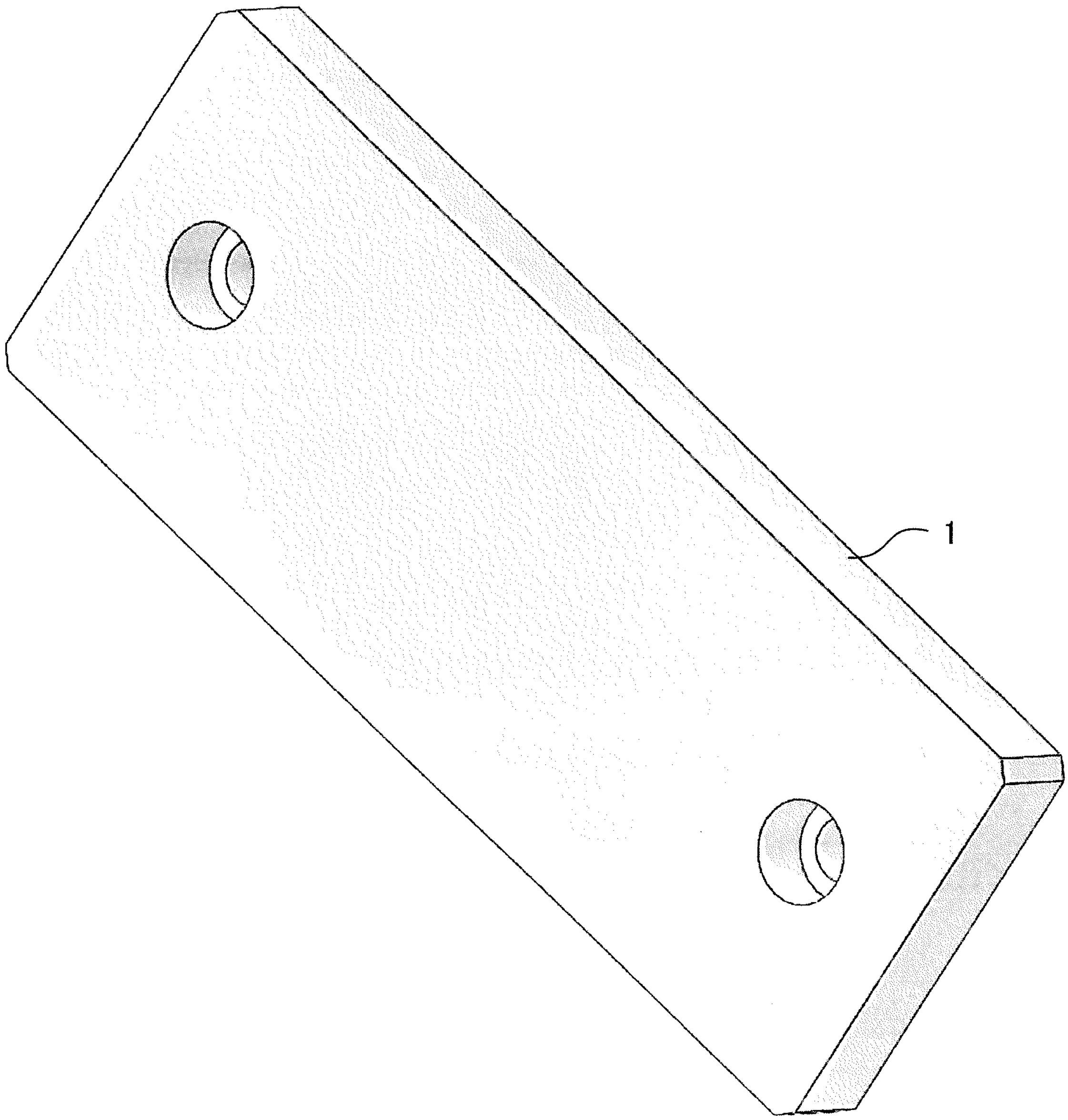
1. A high temperature wear-resistant aluminum-bronze-based material, wherein
an Al content is 9.0% by mass or more and 11.0% by mass or less,
an Ni content is 1.0% by mass or more and 3.0% by mass or less, an Mn content is 8.5% by mass or more and 15.0% by mass or less,
an Si content is 2.0% by mass or more and 4.0% by mass or less, an Fe content is 0.5% by mass or more and 5.0% by mass or less, and
a Co content is 0.01% by mass or more and 1.5% by mass or less, with the remainder being substantially Cu.

2. The high temperature wear-resistant aluminum-bronze-based material according to claim 1, wherein the high temperature wear-resistant aluminum-bronze-based material has a structure in which an Fe-Mn-Si-based hard material is dispersed.

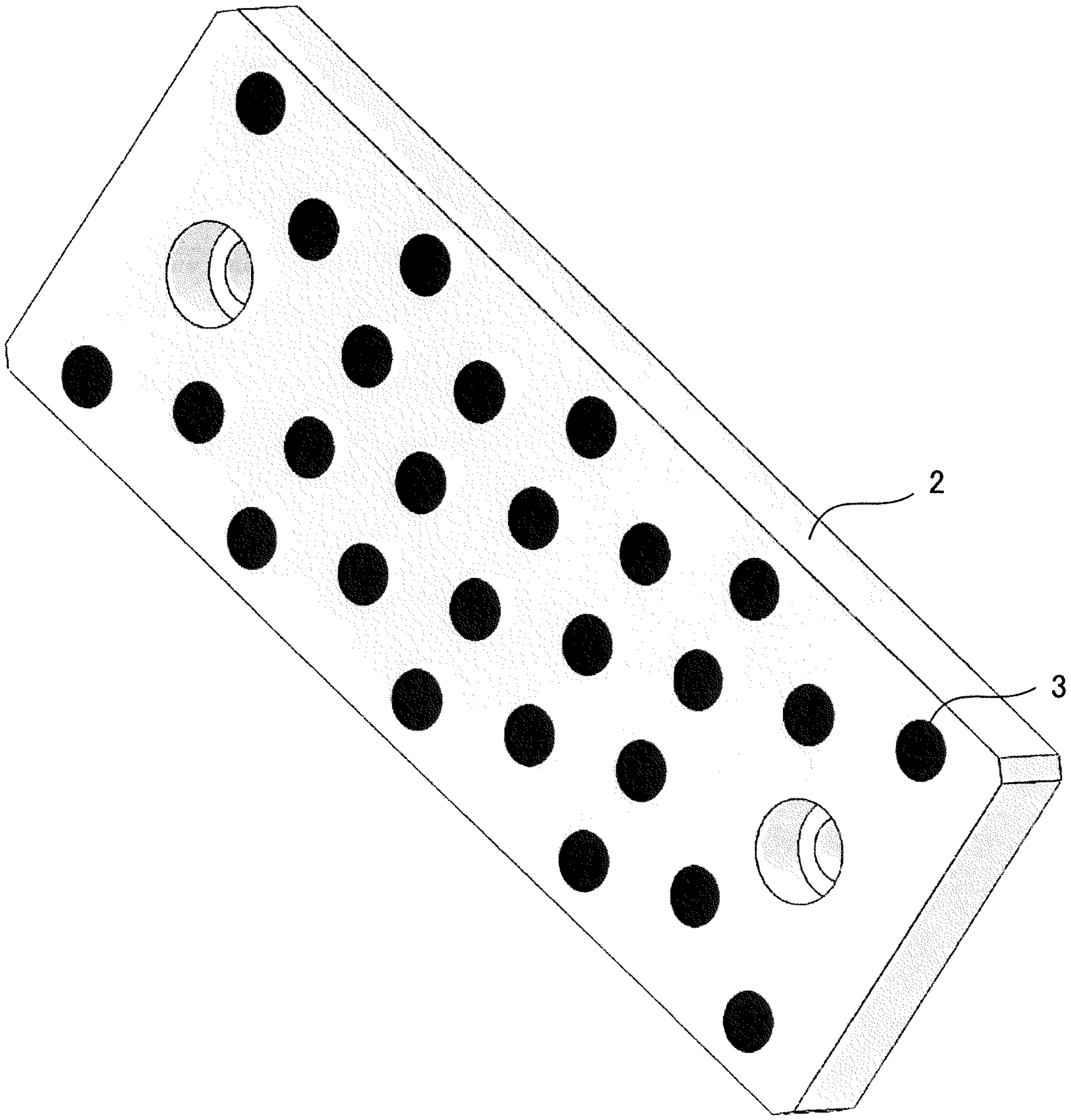
3. The high temperature wear-resistant aluminum-bronze-based material according to claim 1 or 2, wherein the high temperature wear-resistant aluminum-bronze-based material has a Vickers hardness of HV280 or more, an elongation of 0.5% or more, and a tensile strength of 500 N/mm^2 or more.

4. A sliding member having a base material of the high temperature wear-resistant aluminum-bronze-based material according to any one of claims 1 to 3.

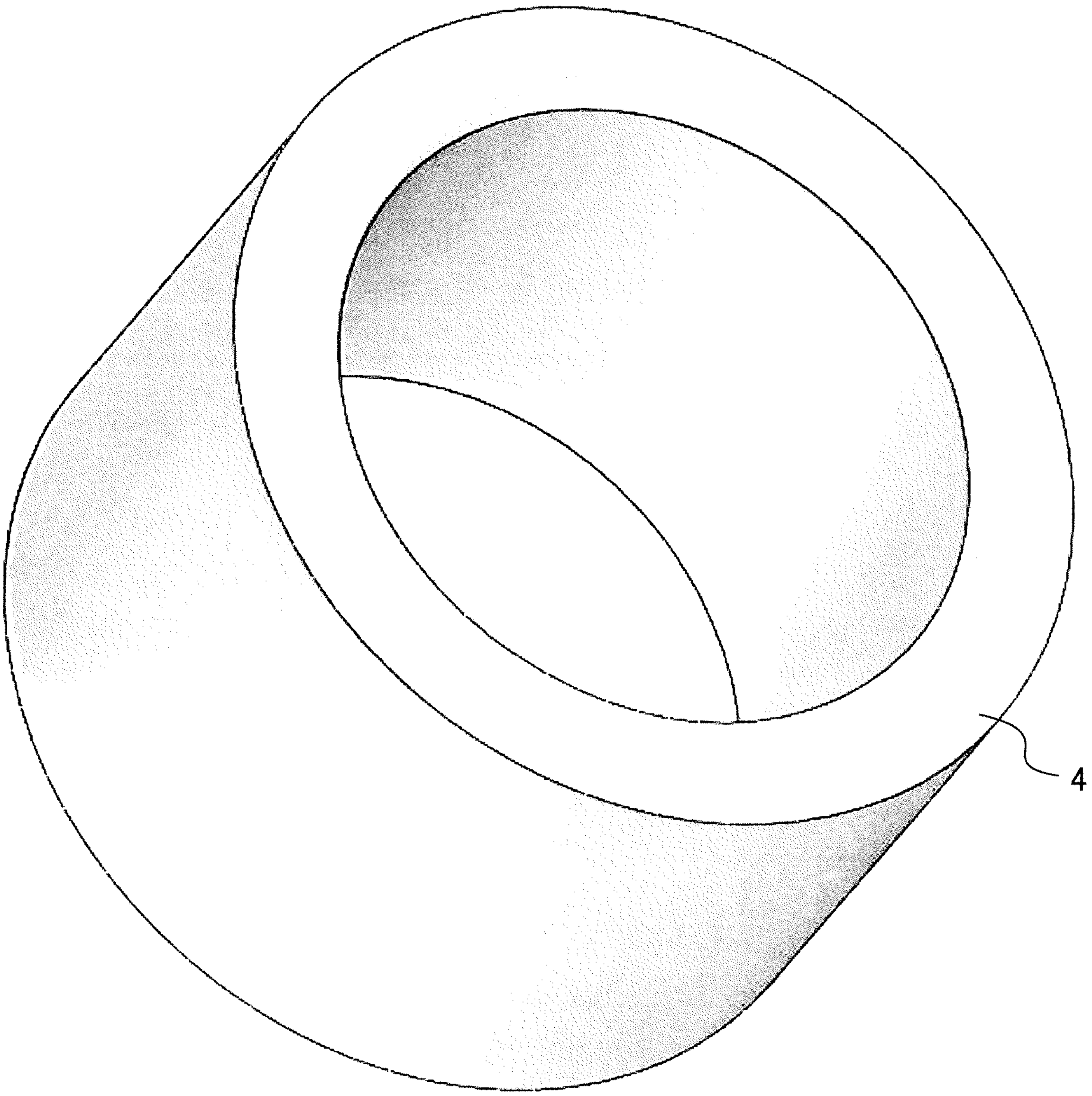
[FIG. 1]



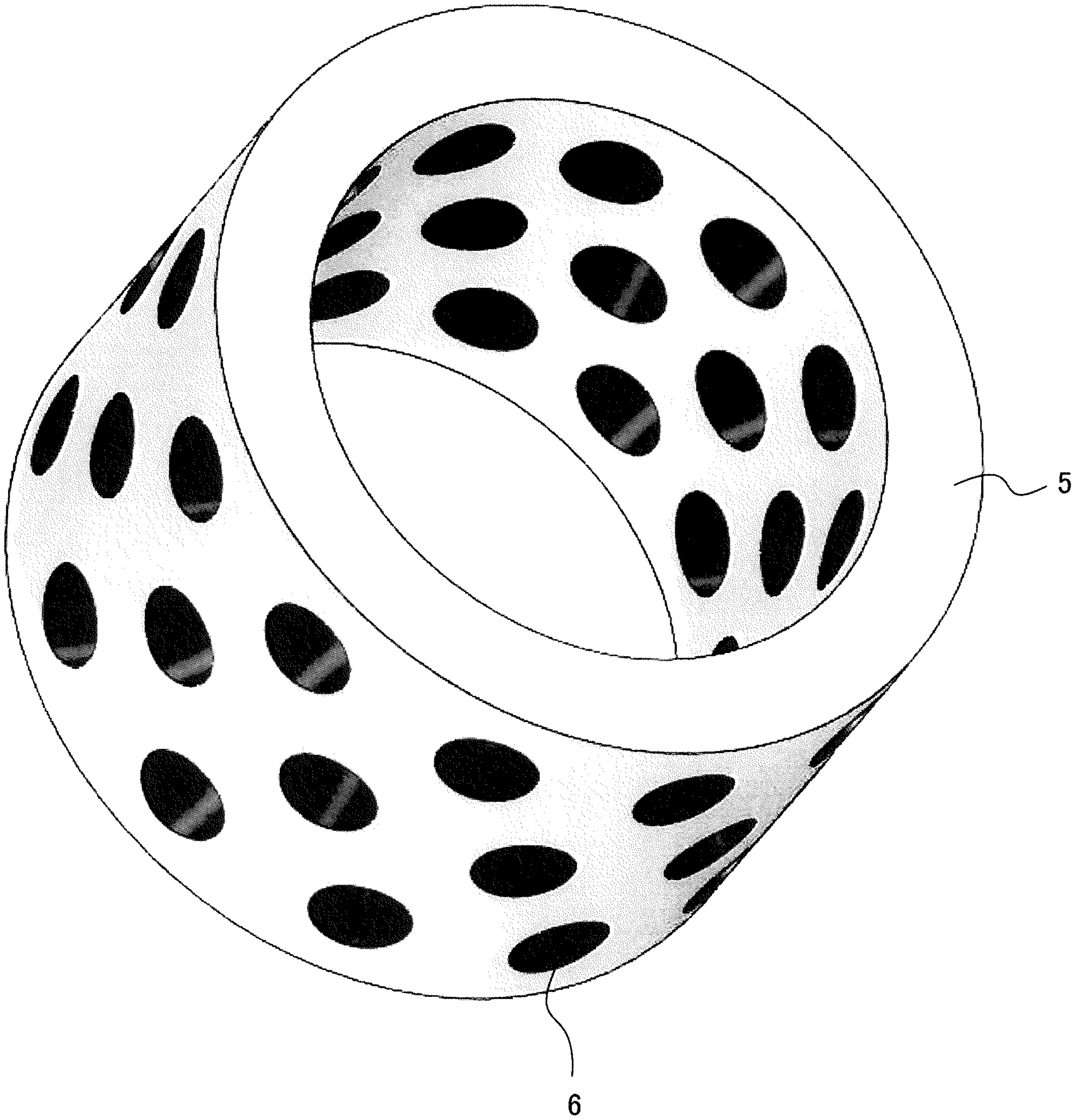
[FIG. 2]



[FIG. 3]



[FIG. 4]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/000987

A. CLASSIFICATION OF SUBJECT MATTER
C22C9/01(2006.01)i, *B22D27/20*(2006.01)i, *C22C9/05*(2006.01)i

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)
C22C9/01, B22D27/20, C22C9/05

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 62-235446 A (Kobe Steel, Ltd.), 15 October 1987 (15.10.1987), claims; page 1, right column, lines 2 to 5; page 2, lower left column, line 6 to page 4, upper right column, line 4; page 5, upper left column, line 9 to page 5, upper right column, line 7; page 5, table 1 (Family: none)	1-4
A	JP 2003-147458 A (Taiho Kogyo Co., Ltd.), 21 May 2003 (21.05.2003), (Family: none)	1-4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
27 April 2016 (27.04.16)	17 May 2016 (17.05.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	 Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

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Patent documents cited in the description

- JP 3929288 B **[0004]**