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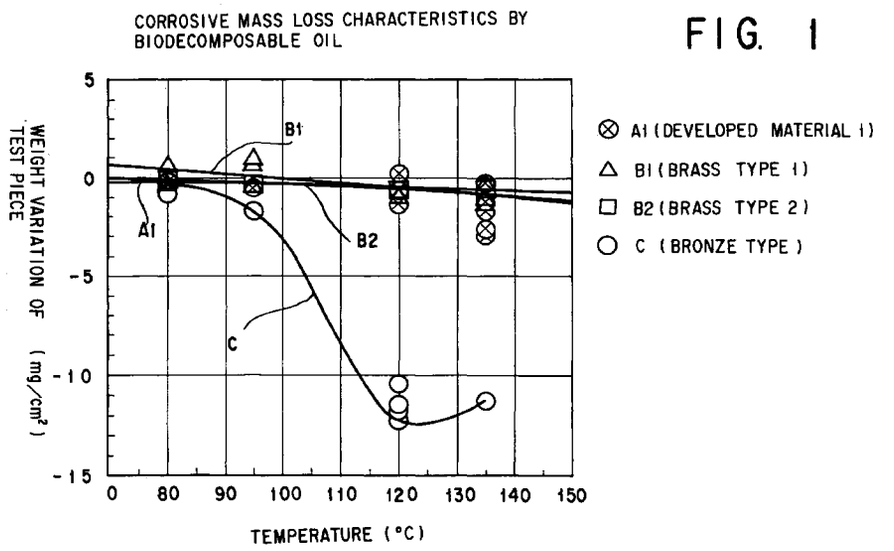
(54) MATERIAL FOR SLIDING SURFACE

(57) A material for a sliding surface has a composition range consisted of 9.0 to 15.0 Wt% of Sn, 8.5 to 11.0 Wt% of Pb, less than or equal to 13 Wt% of Ni, 3.0 to 10.0 Wt% of Zn and remainder of Cu.

FIG. 1



EP 0 860 508 A1

Description

TECHNICAL FIELD

The present invention relates to a material for a sliding surface employed in sliding parts and so forth of a hydraulic equipment, having a superior sliding ability and demonstrating a superior corrosion resistance against a biodecomposable oil.

BACKGROUND ART

Hydraulic equipments, such as a hydraulic pump, a hydraulic motor have the large number of parts sliding in contact with oil, for example, a cylinder block, a valve plate, a cradle, a piston shoe and so forth. Particularly, the sliding surfaces thereof are formed of materials which has a superior sliding ability.

However, in the hydraulic equipment such as the hydraulic pump, the hydraulic motor and so forth, petroleum oil is typically used. While the petroleum oil shows good lubricating characteristics, such oil cannot be decomposed in the natural world to be a cause of environmental contamination.

For example, a construction machine can be inspected and repaired in the open outdoors such as a construction site or so forth. Upon inspection and repair of the hydraulic equipment such as the hydraulic pump, the hydraulic motor or so forth, if the oil therein drops on the ground, the oil is not decomposed to contaminate the environment.

Therefore, there has been known oil added with an ability of decomposition by bacteria (biodecomposability) so as to be naturally decomposed in the natural world in order to avoid an environment pollution. When such biodecomposable oil is used in the hydraulic equipment, a problem is encountered in lowering a durability of the hydraulic equipment due to a corrosion of the material for the sliding surface.

Therefore, the inventors have made an extensive study for causes why the biodecomposable oil causes the corrosion of the material for the sliding surface and found that, many of biodecomposable oils are with a vegetable oil base and sometimes added with an extreme-pressure additive such as sulfur (S) for the purpose of prevention of a baking, since such S causes a solving out of Cu from a lead-bronze type material (Cu-Sn-Pb type), it can be a cause of the corrosion, and that a brass type (Cu-Zn type) material is much less corrosive against the same biodecomposable oil.

While it is unknown about a clear cause of difference between corrosion resistivities of the lead-bronze type material and the brass-type material against the biodecomposable oil, it is possible that a presence of zinc is effective for the prevention of a sulfur attack.

Further, when sliding characteristics of the lead-bronze type material and the brass-type material are compared, since the brass-type material has higher hardness and strength, a better sliding characteristics is achieved under the high bearing pressure, whereas when the bearing pressure is relatively low, the lead-bronze type material having a relatively low hardness which causes a higher conformability, is rather effective. The conformability represents a characteristics to increase a contact area with a counterpart material by causing a local abrading upon sliding. In case of the relatively soft lead-bronze material, an anti-bearing-pressure ability can be increased as a result of lowering of a local bearing pressure due to the local abrading.

From the foregoing, it has been found that not only superior corrosion resistivity against the biodecomposable oil but also good conformability are necessary for the material for a sliding surface.

Therefore, the present invention is worked out in view of the foregoing problems. It is an object of the present invention to provide a material for a sliding surface superior in the corrosion resistivity and the conformability.

DISCLOSURE OF THE INVENTION

The inventors has reached the present invention as a result of various experiments for obtaining a material for a sliding surface superior in the corrosion resistivity and the conformability.

A material for a sliding surface according to the present invention, has a composition range consisted of 9.0 to 15.0 Wt% of Sn, 8.5 to 11.0 Wt% of Pb, less than or equal to 13 Wt% of Ni, 3.0 to 10.0 Wt% of Zn and remainder of Cu.

The reason of the composition range in the material for a sliding surface of the present invention will be discussed hereinafter.

Cu-Sn-Pb

These components are basic components of the lead-bronze material and the following upper and lower limits of the composition ranges are set for certainly providing sliding abilities.

Sn: 9 to 15 Wt%, Pb: 8.5 to 11.0 Wt%

Sn is a basic element of a lead-bronze. 9 Wt% required for strengthening a crystal of Cu is set as the lower

limit, and 15 Wt% for being completely solved into Cu is set as the upper limit.

Pb is also a basic element of a lead-bronze. 8.5 Wt% for certainly providing a workability in cutting is set as the lower limit. According to increasing of Pb, a strength tends to be lowered. In order to certainly maintain the strength (hardness) of the sliding material, the upper limit is set at 11 Wt%.

Zn

This element is an essential element for improving the corrosion resistance. The effect thereof becomes remarkable at greater than or equal to 3 Wt%. On the other hand, when the additive amount exceeds 10 Wt%, zinc is easily changed to zinc oxide to make the possibility of causing a material defect high. For the foregoing reason, the additive amount is set at 10 Wt% at maximum.

Ni

Ni is an element preventing a segregation of Pb and contributing for an improvement of strength. When it exceeds 3 Wt%, the hardness is increased, and on the other hand, the conformability with the counterpart sliding member is lowered. Therefore, in order to certainly obtain the conformability, 3 Wt% is set as maximum.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given herebelow and from the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to be limitative to the present invention, but are for the explanation and the understanding only.

In the drawings:

Fig. 1 is a graph showing corrosive mass loss characteristics of a developed material 1 and other material by a bio-decomposable oil;

Fig. 2 is a graph showing corrosive mass loss characteristics of a developed material 2 and other material by a bio-decomposable oil;

Fig. 3 is a graph showing corrosive mass loss characteristics of a developed material 3 and other material by a bio-decomposable oil;

Fig. 4 is a graph showing a limiting bearing pressure and an abrading amount between a bronze type material and the developed material 1 at a sliding speed of 4 kg/sec.;

Fig. 5 is a graph showing a limiting bearing pressure and an abrading amount between a bronze type material and the developed material 1 at a sliding speed of 10 kg/sec;

Fig. 6 is a section of a hydraulic pump;

Figs. 7A, 7B and 7C are sections respectively showing sliding parts, in which the material for a sliding surface is welded, in the hydraulic pump;

Fig. 8 is a section of a hydraulic motor; and

Fig. 9 is a section of a cylinder.

BASE MODE FOR IMPLEMENTING THE INVENTION

The preferred embodiment of a material for a sliding surface according to the present invention will be discussed hereinafter with reference to the drawings.

In the following table 1, chemical compositions of materials for a sliding surface (developed materials 1, 2 and 3) according to the present invention and comparative materials (brass type materials 1 and 2, bronze type material), with which corrosion resistance tests were performed, are shown.

TABLE 1

Chemical Compositions of Tested Materials								
	Sign	Sn	Pb	Ni	Si	Zn	Fe	Cu
Developed Material 1	A1	12.57	9.99	1.48	0	3.39	0.060	Remainder
Developed Material 2	A2	12.30	9.65	1.45	0	5.14	0.070	Remainder
Developed Material 3	A3	12.12	9.51	1.43	0	6.84	0.080	Remainder
Brass Type Material 1	B1	5.00	5.00	0		5.00	0	Remainder

TABLE 1 (continued)

Chemical Compositions of Tested Materials								
	Sign	Sn	Pb	Ni	Si	Zn	Fe	Cu
Brass Type Material 2	B2	0	0	3.0	1.0	30.0	1.0	Remainder
Bronze Type Material	C	13.00	9.50	2.00	0	1.00	0.30	Remainder

As the developed materials, three kinds respectively containing different Zn amount were tested. Also, as comparative examples, two kinds of brass type materials and one kind of bronze type material are tested. As a testing method of corrosion resistance, test pieces are dipped in vegetable oil as biodecomposable oil which was heated and held for 240 hours at a plurality of predetermined temperatures, and variations of weights of test pieces before and after the dipping were evaluated.

As a result, as shown in Figs. 1, 2 and 3, it has been found that, in comparison with the base material (sign C) as the conventional lead-bronze type material, the developed material has been significantly improved on the corrosion resistance under an environment of higher than or equal to 100 °C, and has a corrosion resistance comparable with the brass type material.

Next, in Figs. 4 and 5, there is shown results of constant speed friction abrasion test performed for the conventional bronze type material (C) and the developed material 1 with setting a sliding speed V at two levels of 4 and 10 m/sec. The testing method was a measure of the abrasion amount with sliding test pieces formed into a pin shaped configuration on a disc-shaped disc (SCM420H, a carburizing hardened material) under a condition of a constant load and constant rotation speed and a limiting bearing pressure causing a baking while the load was gradually increased. The testing condition are as follows.

(Constant Speed Friction Abrasion Test Condition)

(1) Counterpart material: SCM420H
(2) Lubrication Oil: 80 °C
(3) Sliding Speed: 4 m/sec, 10 m/sec
(4) Load Condition: In a bearing pressure region higher than or equal to 200 kg/cm^2, the load was increased per 50 kg/cm^2 after testing for 5 minutes at a constant load.

From Fig. 4 (in case of the sliding speed of 4 m/sec) and Fig. 5 (in case of the sliding speed of 10 m/sec), it can be appreciated that, in comparison with the conventional bronze material (C), the abrasion amount and the limiting bearing pressure of the developed material (A1 material), to which 3 Wt% of Zn is added, is comparable level.

Next, one example of the sliding part using a copper type material for a sliding surface according to the present invention will be discussed.

As shown in Fig. 6, in a hydraulic pump, there are cylinder block 3 having a cylinder bore 2 in which a piston 1 is slidably inserted, a valve plate 4 sliding on the cylinder block 3, a cradle 5, a piston shoe 6 and so forth.

Then, these show the copper type materials for a sliding surface according to the present invention are welded on an inner surface 2a of the cylinder 2 of the cylinder block and a valve plate sliding surface 3a, as shown in Fig. 7A, on a sliding surface 4a of the valve plate 4, as shown in Fig. 7B, and on a sliding surface 5a of the cradle 5, as shown in Fig. 7C.

On the other hand, as shown in Fig. 8, the sliding parts are also a cylinder block 10, a valve plate 11, a bearing 12, a center ball 13 and so forth of a hydraulic motor.

Furthermore, as shown in Fig. 9, the sliding parts is a bushing 21 slidably guiding a piston rod 20 of a cylinder.

As set forth above, the material for a sliding surface according to the present invention is superior in corrosion resistance in the biodecomposable oil, and has good conformability with the counterpart member.

Although the invention has been illustrated and described with respect to exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out above but to include all possible embodiments which can be embodied within a scope encompassed and equivalents thereof with respect to the feature set out in the appended claims.

Claims

1. A material for a sliding surface having a composition range consisted of 9.0 to 15.0 Wt% of Sn, 8.5 to 11.0 Wt% of

Pb, less than or equal to 13 Wt% of Ni, 3.0 to 10.0 Wt% of Zn and remainder of Cu.

2. A material for a sliding surface having a composition range consisted of 12.57 Wt% of Sn, 9.99 Wt% of Pb, 1.48 Wt% of Ni, 3.39 Wt% of Zn and remainder of Cu.

3. A material for a sliding surface having a composition range consisted of 12.30 Wt% of Sn, 9.65 Wt% of Pb, 1.45 Wt% of Ni, 5.14 Wt% of Zn and remainder of Cu.

4. A material for a sliding surface having a composition range consisted of 12.12 Wt% of Sn, 9.51 Wt% of Pb, 1.43 Wt% of Ni, 6.84 Wt% of Zn and remainder of Cu.

FIG. 1

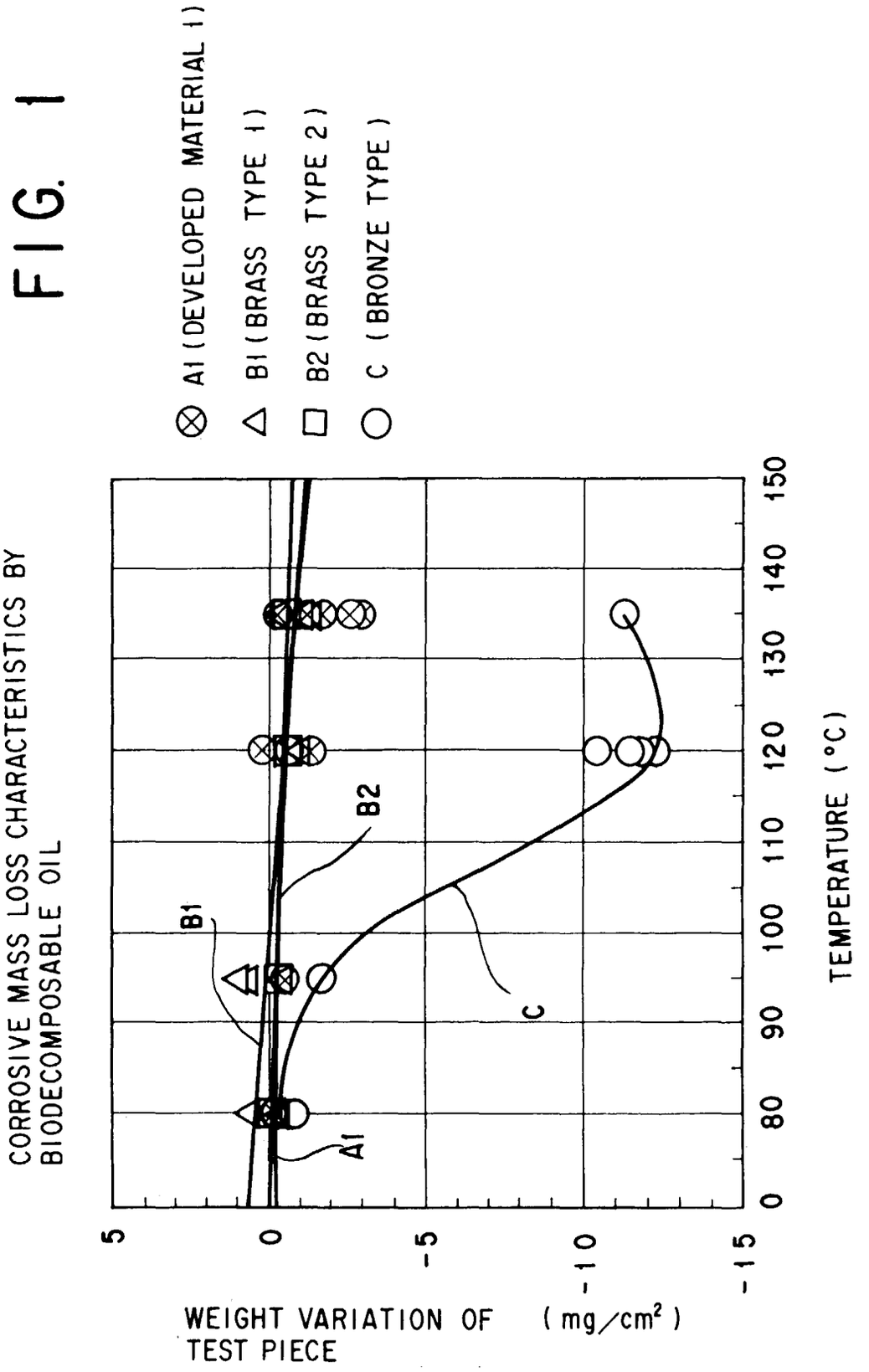

CORROSIVE MASS LOSS CHARACTERISTICS BY BIODECOMPOSABLE OIL
A1 (DEVELOPED MATERIAL 1)
B1 (BRASS TYPE 1)
B2 (BRASS TYPE 2)
C (BRONZE TYPE)
B1
B2
C
A1
5
0
-5
-10
-15
WEIGHT VARIATION OF TEST PIECE (mg/cm²)
0
80
90
100
110
120
130
140
150
TEMPERATURE (°C)

FIG. 2

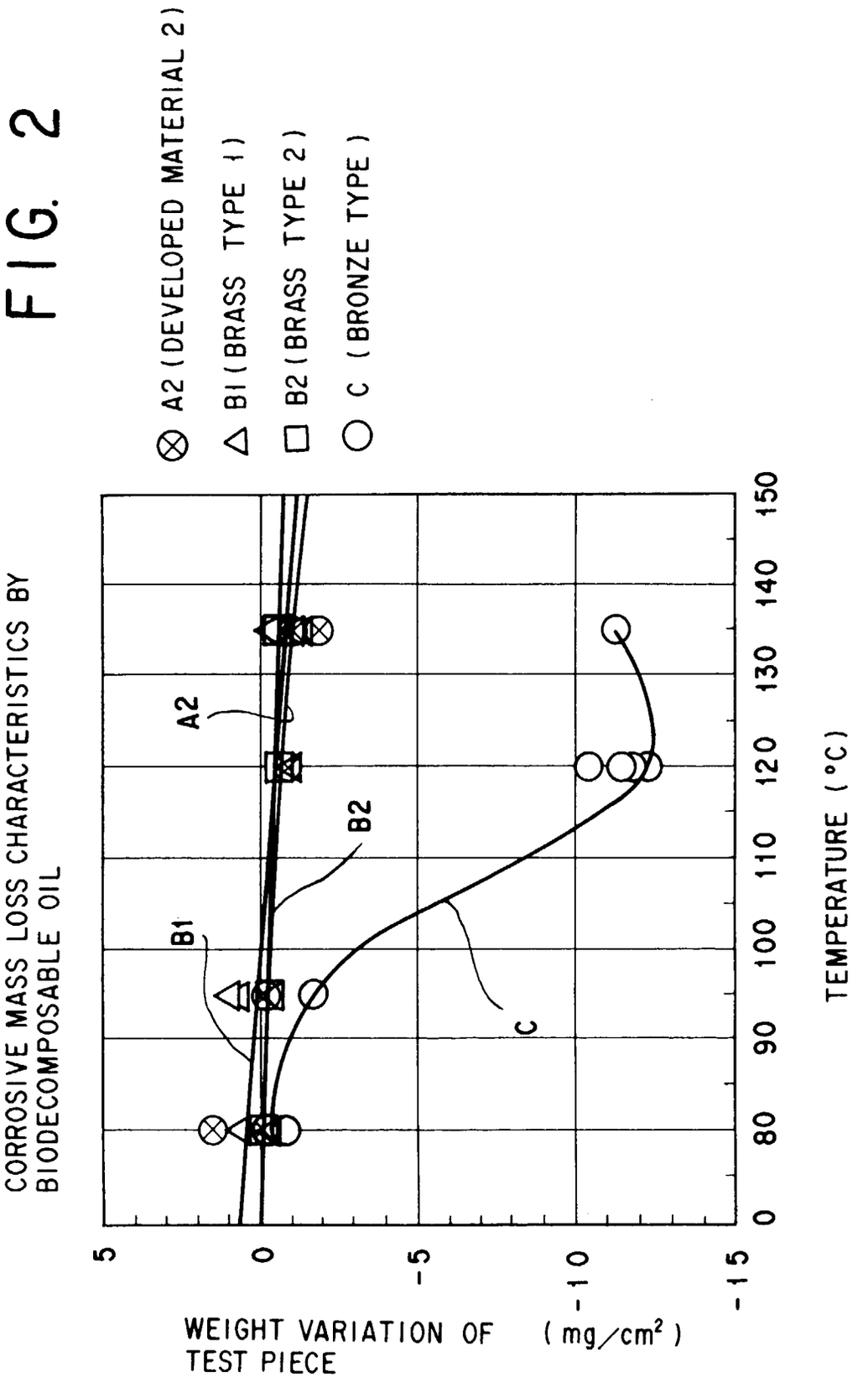

⊗ A2 (DEVELOPED MATERIAL 2)
△ B1 (BRASS TYPE 1)
□ B2 (BRASS TYPE 2)
○ C (BRONZE TYPE)
CORROSIVE MASS LOSS CHARACTERISTICS BY BIODECOMPOSABLE OIL
A2
B2
B1
C
5
0
-5
-10
-15
WEIGHT VARIATION OF TEST PIECE (mg/cm²)
0
80
90
100
110
120
130
140
150
TEMPERATURE (°C)

FIG. 3

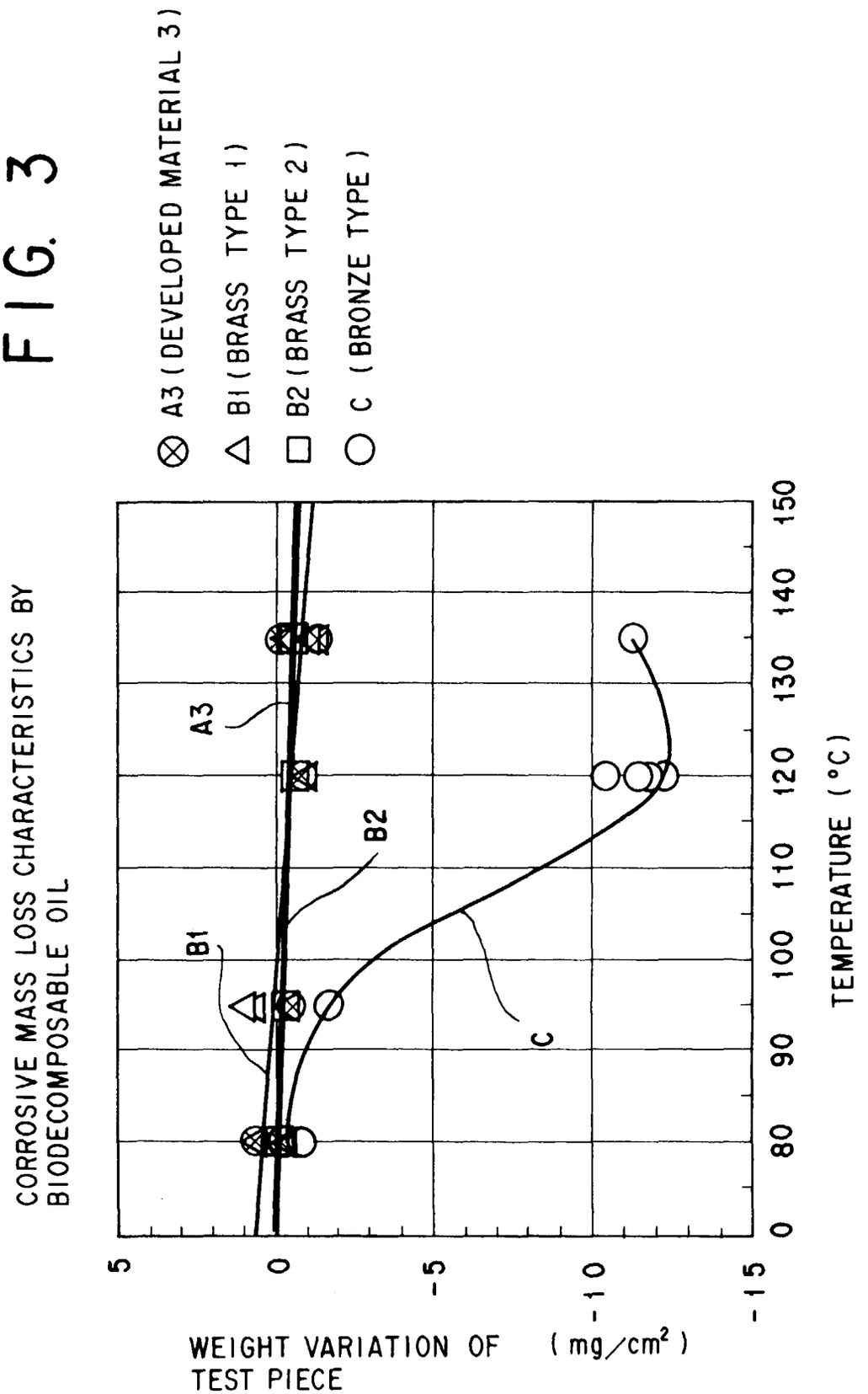
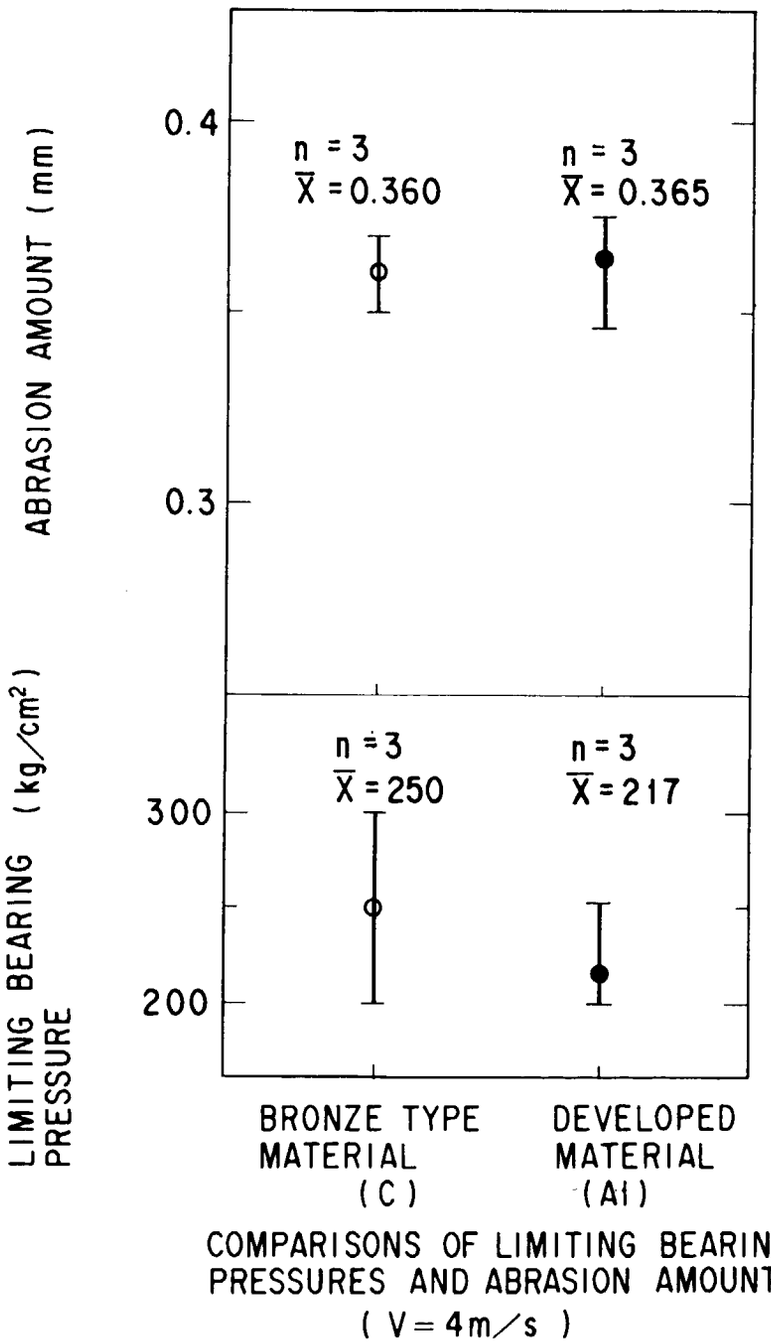
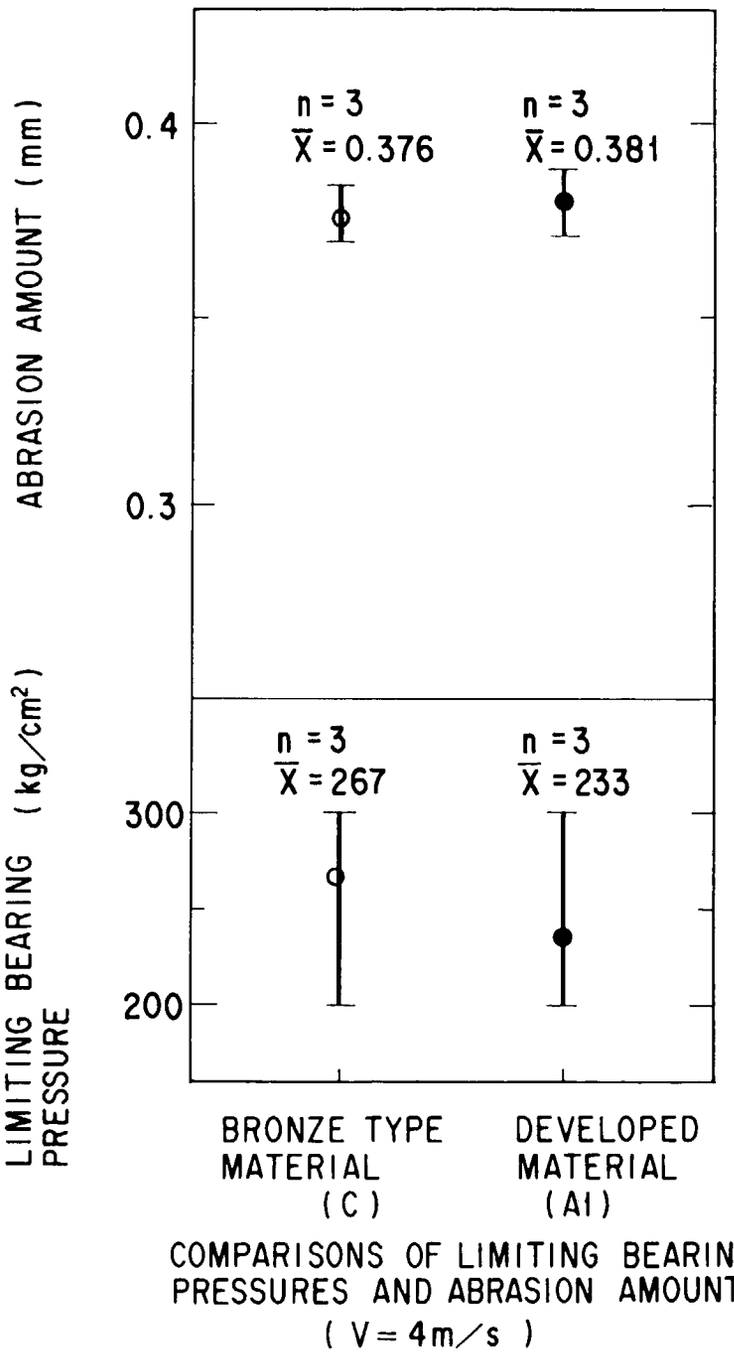

⊗ A3 (DEVELOPED MATERIAL 3)
△ B1 (BRASS TYPE 1)
□ B2 (BRASS TYPE 2)
○ C (BRONZE TYPE)
CORROSIVE MASS LOSS CHARACTERISTICS BY BIODECOMPOSABLE OIL
A3
B2
B1
C
5
0
-5
-10
-15
WEIGHT VARIATION OF TEST PIECE (mg/cm²)
0
80
90
100
110
120
130
140
150
TEMPERATURE (°C)

FIG. 4



COMPARISONS OF LIMITING BEARING PRESSURES AND ABRASION AMOUNTS
(V = 4m/s)

FIG. 5



COMPARISONS OF LIMITING BEARING PRESSURES AND ABRASION AMOUNTS
(V = 4m/s)

FIG. 6

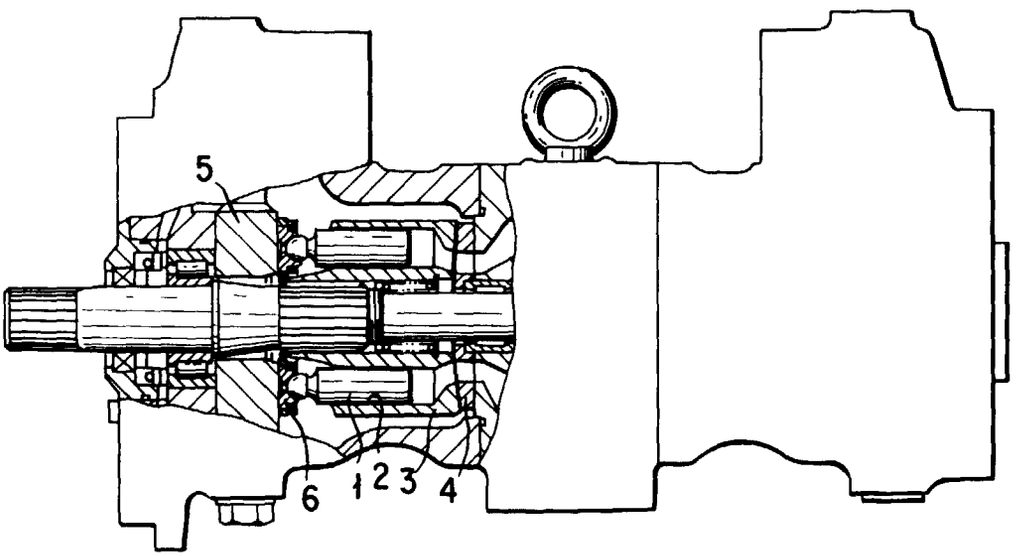


FIG. 7A

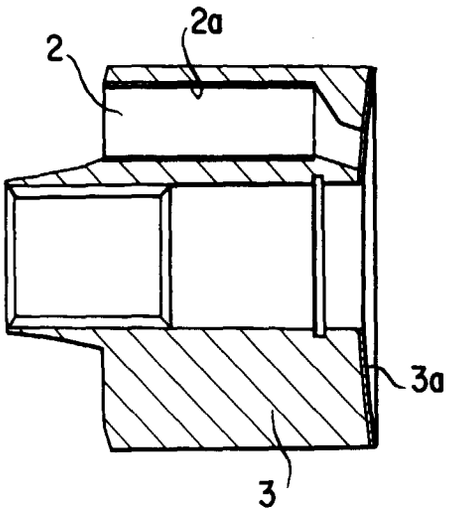


FIG. 7B

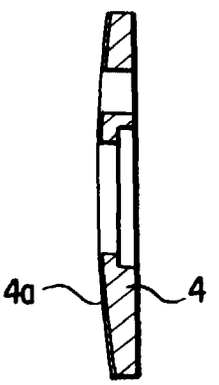


FIG. 7C

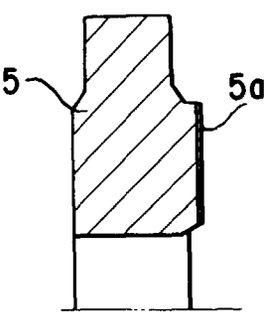


FIG. 8

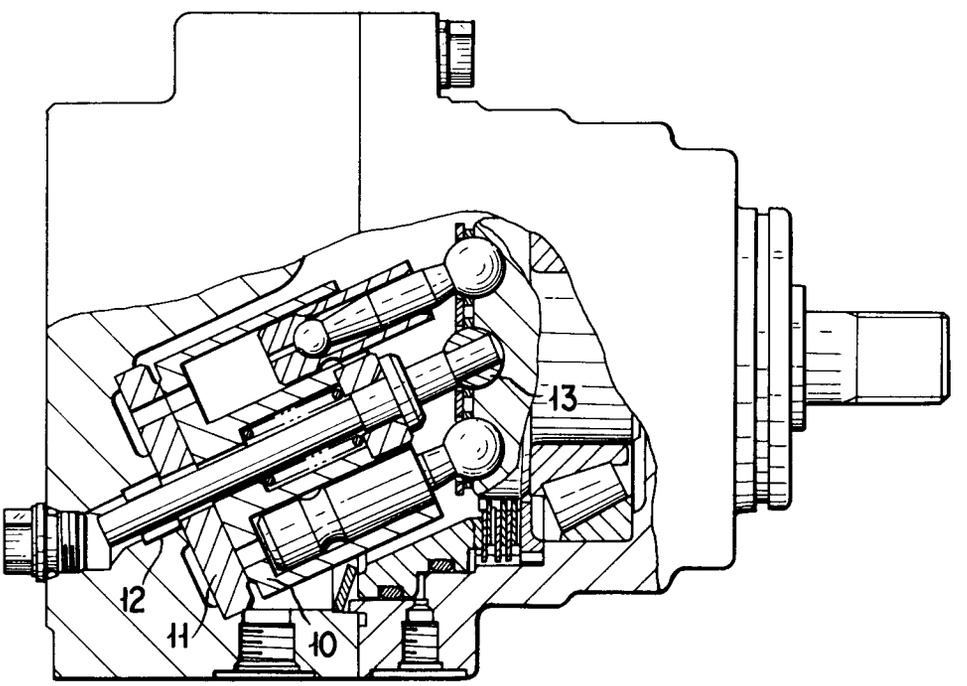
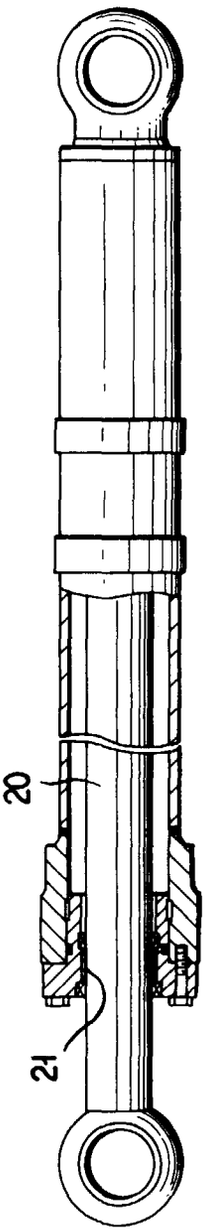


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP96/02429

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl^6 C22C9/02

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)
Int. Cl^6 C22C9/00-9/10, F16C33/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926 - 1995
Kokai Jitsuyo Shinan Koho 1971 - 1995
Toroku Jitsuyo Shinan Koho 1994 - 1996

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.
A	JP, 5-279772, A (Daido Metal Co., Ltd.), October 26, 1993 (26. 10. 93)(Family: none)	1 - 4
A	JP, 56-53623, B2 (Daido Metal Co., Ltd.), December 19, 1981 (19. 12. 81)(Family: none)	1 - 4
A	JP, 57-94501, A (Taiho Kogyo K.K.), June 12, 1982 (12. 06. 82)(Family: none)	
A	JP, 54-65121, A (Glyco Metall Werke Daelen and Loos GmbH.), May 25, 1979 (25. 05. 79) & US, 4206268, A & FR, 2406671, A1	1 - 4
A	EP, 224619, A1 (D.A.B. Industries Inc.), June 10, 1987 (10. 06. 87) & US, 4551395, A	1 - 4
A	US, 4551395, A (Smith International, Inc.), February 10, 1987 (10. 02. 87)(Family: none)	1 - 4

☐ 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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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
November 25, 1996 (25. 11. 96)	December 3, 1996 (03. 12. 96)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)