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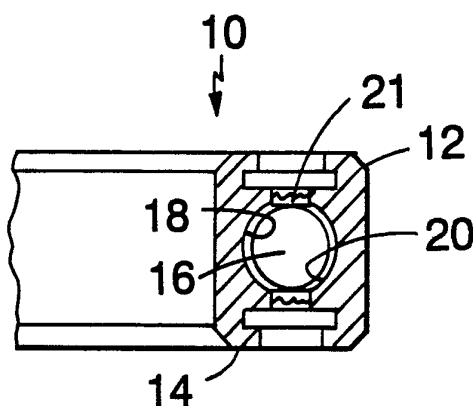
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(54) Title: CORROSION-RESISTANT ZINC-NICKEL PLATED BEARING RACES



(57) Abstract

A rolling element bearing (10) including a first element (12) having a first race (20); a second element (14) having a second race (18), the first and second elements being positioned so that the first and second races form a channel; a first zinc alloy plated layer (22) on the first race; a second zinc alloy plated layer (24) on the second race; and a plurality of rolling elements (16) disposed within the channel formed by the first and second races.

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CORROSION-RESISTANT ZINC-NICKEL PLATED BEARING RACESBackground of the Invention

The invention relates to corrosion resistant rolling element bearings.

5 Some bearing applications require bearings which are capable of both enduring extremely high loads and surviving in very corrosive environments. For example, the bearings in aircraft landing gear of naval airplanes must survive the pounding of repeated landings and the
10 constant exposure to salt spray. The high strength material from which high load bearings are typically made (e.g. 52100 bearing steel) does not provide the required level of corrosion resistance for such environments.

 In an effort to improve the corrosion resistance
15 of such bearings, other base materials, such as 316 steel, have been utilized. A problem with many such alternative base materials, however, is that they are not hardenable and thus are not capable of providing the required load handling capabilities of the high strength
20 steels. Another approach has been to deposit Thin Dense Chrome (TDC) (i.e., a very hard plating) onto the exposed areas including the functional surfaces. With TDC, however, it is very difficult to obtain sufficiently thick layers while still achieving the required level of
25 consistency (i.e., an absence of holes and surface flaws which provide focal points at which corrosive activity tends to occur). Yet another approach has been to deposit cadmium protective layers, which are soft in comparison to the hardened, high strength steel from
30 which the bearing is constructed. Due to its softness, however, cadmium is not appropriate for use on the functional surfaces. Under load conditions, the cadmium exhibits a "gummy" consistency which either interferes

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with the operation of the bearing or which results in its being quickly worn off thereby eliminating the protection which it originally provided.

Summary of the Invention

5 In general, in one aspect, the invention features a rolling element bearing including a first element having a first race and a second element having a second race. The first and second elements are positioned relative to each other so that the first and second races
10 form a channel. The rolling element bearing also includes a first zinc alloy plated layer on the first race, a second zinc alloy plated layer on the second race, and a plurality of rolling elements disposed within the channel formed by the first and second races.

15 Preferred embodiments include the following features. The rolling element bearing also includes a liquid lubricant (e.g. a grease) within the channel. The first and second zinc alloys exhibit a columnar structure. The first and second zinc alloys are zinc-
20 nickel alloys. The first element is an inner bearing ring and the second element is an outer bearing ring. Each of the rolling elements is a spherical bearing ball. The thickness of each of the first and second zinc alloy layers is less than about 0.0010 inch, and more
25 specifically less than about 0.0003 inch. Each of the rolling elements includes a zinc alloy plated layer on its surface, where the thickness of the zinc alloy layer is less than about 0.0001 inch.

 In general, in another aspect, the invention
30 features a rolling element bearing including an inner ring having an outer race; an outer ring having an inner race, the inner and outer rings being positioned so that the inner and outer races form a channel; a first zinc alloy plated layer on the inner race; a second zinc alloy

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plated layer on the outer race; a plurality of bearing balls disposed within the channel formed by the inner and outer races; and a liquid lubricant within the channel.

One advantage of the invention is that it exhibits
5 excellent corrosion protection on the high load, plated functional surfaces (e.g. the races) of rolling element bearings. Experiments have shown that even after 100 hours of exposure to salt spray in accordance with ASTM B117, the functional surfaces of the bearing rings which
10 have been plated with zinc-nickel showed an absence of corrosion.

In addition, the zinc-nickel plating does not interfere with or degrade the lubrication properties of the lubricants (e.g. greases) which are typically
15 necessary in such bearings.

Moreover, though the zinc-nickel plating is softer than the underlying high strength steel from which the bearing is made, it withstands the rolling contact under high load conditions (e.g. in excess of 150,000 p.s.i.).
20 In addition, it does not degrade the underlying base material and thereby limit the load carrying capabilities of the bearing.

Other advantages and features will become apparent from the following description of the preferred
25 embodiment and from the claims.

Description of the Preferred Embodiment

Fig. 1 is a cross-sectional view of a portion of a bearing assembly;

Fig. 2 is a cross-sectional view and Fig. 2a is an
30 enlargement of a portion of the outer ring with an expanded view of the zinc-nickel plated layer on the inner race; and

Fig. 3 is a cross-sectional view and Fig. 3a is an enlargement of a portion of the inner ring with an

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expanded view of the zinc-nickel plated layer on the outer race.

Structure and Operation

Fig. 1 shows a bearing assembly 10 which will be used to illustrate the invention. Bearing assembly 10 includes an outer ring 12, an inner ring 14 and a set of bearing balls 16 (only one of which is shown). An outer race 20 is formed around the inside circumference of outer ring 12 and an inner race 18 is formed around the outside circumference of inner ring 14. When inner ring 14 is assembled into outer ring 12, outer and inner races 20 and 18 are aligned with respect to each other so as to form a channel which holds the set of bearing balls 16. Thus, inner ring 14 is free to rotate within outer ring 12 about a common axis which is perpendicular to the plane of both rings. The channel also contains a conventional lubricant 21, e.g. Mobil 28 grease sold by Mobil Oil Corporation.

As shown in greater detail in the exploded views in Figs. 2 and 3, a zinc-nickel plated layer 22 covers outer race 20 and a zinc-nickel plated layer 24 covers inner race 18. In the described embodiment, the thickness of the plated layers 22 and 24 within the races is approximately 0.0003 inch. Zinc-nickel plated layers 22 and 24 provide protection against corrosion which might tend to be caused by environmental conditions, e.g. the presence of salt water.

Zinc-nickel layers 22 and 24 are applied by an electrical plating process as described in U.S. Patent 4,765,871 issued to Hsu et al. on August 23, 1988, incorporated herein by reference. In the described embodiment, inner ring 14 and outer ring 12 zinc-nickel is electroplated onto the entire ring including the races. During the plating process, however, inner ring

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14 is oriented within the electroplating bath relative to the zinc and nickel anodes so as to control the thickness of the plating which is formed on the outboard faces 28 of inner ring 14 to be within the range of 0.0002 to 0.0005 inch. The thickness of the plating elsewhere on inner ring 14 is typically less than the controlled thickness. Similarly with outer ring 12, during the plating process, it is oriented within the electroplating bath relative to the zinc and nickel anodes so as to control the thickness of the plating which is formed on the outside surface 30 and outboard faces 33 of outer ring 12 to also be within the range of 0.0002 to 0.0005 inch. Thus, as with inner ring 14 the thickness of the plating elsewhere on outer ring 12 is also typically less than this controlled thickness.

The zinc-nickel plated layers appear to exhibit a hardness that is in the range of about Rockwell c 30 to 45, significantly softer than the underlying hardened, high strength steel and significantly softer than the thin dense chrome layers which have been traditionally used to achieve corrosion resistance on the functional surfaces of high load bearings.

It is believed that the zinc-nickel plated layers exhibit a columnar structure and that this also makes them more resistant (as compared to a laminar structure, for example) to detaching from the race under heavy load conditions. Experiments have indicated that the zinc-nickel plating on the races survives 150,000 cycles under 20% of the maximum rated load. This is about 2.5 times the normal design life.

Both outer ring 12 and inner ring 14 may be made of metal capable of withstanding stress levels of greater than 150,000 p.s.i., including for example, thru-hardened, high strength steel (e.g. 52100 bearing steel heat treated to Rockwell c 60 or higher) or case-hardened

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steel with a 0.0005-0.0010 inch thick case-hardened layer. In the described embodiment, rings 12 and 14 are fabricated from annealed steel in a conventional manner. The rough stock is heat treated at 1800-2000 °F, tempered
5 one or more times at 300-400 °F to improve the toughness of the steel (e.g. Rockwell c 58-62) and then precision ground on all surfaces except the inner bore of inner ring 14. As an optional step, the precision ground rings may be baked for 3.5 hours at a temperature of 350 °F
10 prior to the plating process. After the optional pre-plating bake, a zinc-nickel layer is electroplated onto rings 12 and 14, including the functional surfaces. To perform the plating, rings 12 and 14 are rack mounted in the plating bath. They are suspended on the racks in
15 such a way as to not obstruct plating onto the functional surfaces.

After the plating process is complete, the rings are again baked for 3.5 hours at 350 °F to avoid hydrogen embrittlement of the base metal. This post-plating bake
20 is done within four hours of when the plating process was completed.

To extend the life of the bearings, it may also be desirable to administer a chromate treatment to the surface of the zinc-nickel layers followed by another
25 bake out. The chromate treatment prevents "white rust" from forming on the zinc-nickel surface and postpones degradation of the zinc-nickel layers.

Other embodiments are within the following claims. For example, the invention has applicability to the
30 general category of rolling element bearings, which includes among others, bearings which use tapered rolling bearings and those which use cylindrical rollers. In addition, any one of a broad range of zinc alloy plated deposits may be used to provide similar corrosion
35 resistance on the functional surfaces. Other appropriate

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zinc alloys include zinc-tin, zinc-cobalt and zinc-iron, to name a few.

Also, it may be desireable to plate the rolling elements as well as the races. The plating process is as
5 described in the above-mentioned U.S. Patent 4,765,871 patent. The bath might be, for example, a conventional barrel plating arrangement rather than the rack mount arrangement used for plating the rings. Due to the micro
10 sliding which the balls experience, it may be desirable to keep the thickness of the plated layer to less than 0.0001 inch.

What is claimed is:

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Claims

1. A rolling element bearing comprising:
a first element having a first race;
a second element having a second race, said first
5 and second elements being positioned so that said first
and second races form a channel;
a first zinc alloy plated layer on said first
race;
a second zinc alloy plated layer on said second
10 race; and
a plurality of rolling elements disposed within
said channel formed by said first and second races.
2. The rolling element bearing of claim 1
further comprising a liquid lubricant within said
15 channel.
3. The rolling element bearing of claim 1
wherein said liquid lubricant is a grease.
4. The rolling element bearing of claim 1
wherein said first and second zinc alloys exhibit a
20 columnar structure.
5. The rolling element bearing of claim 1
wherein said first and second zinc alloys are zinc-nickel
alloys.
6. The rolling element bearing of claim 2
25 wherein said first element is an inner bearing ring and
said second element is an outer bearing ring.
7. The rolling element bearing of claim 6
wherein each of said rolling elements of said plurality
of rolling elements is a spherical bearing ball.

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8. The rolling element bearing of claim 1 wherein the thickness of each of the first and second zinc alloy layers is less than about 0.0010 inch.

9. The rolling element bearing of claim 8
5 wherein the thickness of each of the first and second zinc alloy layers is less than about 0.0003 inch.

10. The rolling element bearing of claim 1 wherein each of said plurality of rolling elements includes a zinc alloy plated layer on its surface.

10 11. The rolling element bearing of claim 10 wherein the zinc alloy plated layer on each of said plurality of rolling elements is less than about 0.0001 inch.

12. A rolling element bearing comprising:
15 an inner ring having an outer race;
an outer ring having an inner race, said inner and outer rings being positioned so that said inner and outer races form a channel;
a first zinc alloy plated layer on said inner
20 race;
a second zinc alloy plated layer on said outer race;
a plurality of bearing balls disposed within said channel formed by said inner and outer races; and
25 a liquid lubricant within said channel.

13. The rolling element bearing of claim 5 wherein the first and second elements are made of steel.

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14. The rolling element bearing of claim 13 wherein said steel is case-hardened steel.

15. The rolling element bearing of claim 13 wherein said steel is thru-hardened high-strength steel.

16. The rolling element bearing of claim 13 further comprising a liquid lubricant within said channel.

17. The rolling element bearing of claim 16 wherein said lubricant is a grease.

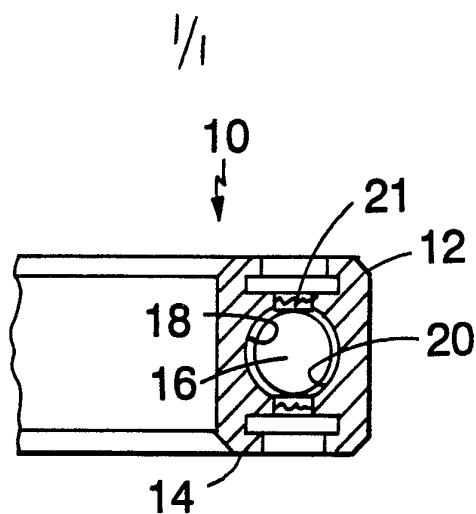


FIG. 1

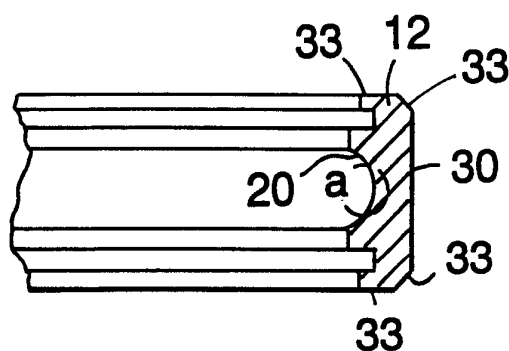


FIG. 2

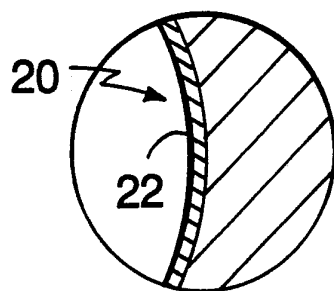


FIG. 2a

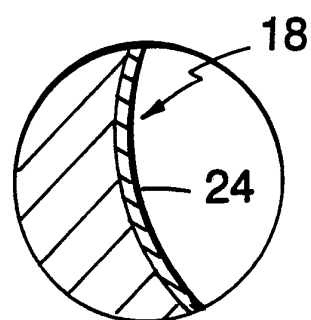


FIG. 3a

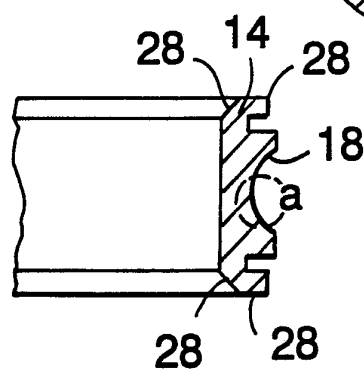


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US92/03947

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :F16C 33/62

US CL :384/492

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)

U.S. : 384/492; 384/276, 491, 625, 912, 913; 204/44.2

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)

APS: ZINC or ZN 384/Class and Layer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
<u>X</u> Y	DE, A, 1,907,897 (LIEBAU ET AL.) 09 October 1969, page 3 lines 1-7, 12-16.	<u>1</u> 2-17
Y	US, A, 4,765,871 (HSU ET AL.) 23 August 1988 col. 1 line, 12-17, 47-48.	1-17
Y	US, A, 3,212,834 (MAYER ET AL.) 19 Mayer 1965, col. 1 lines 25-31.	1-17
A	US, A, 4,972,764 (OHYA ET AL.) 27 November 1990	1-17

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

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Date of the actual completion of the international search

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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