Exhibit 1002

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/410,241	12/13/2016	9518604	SHEL.3143	6897

152 7590 11/22/2016

CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
111 SW Columbia Street
Suite 725
PORTLAND, OR 97201

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 75 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Daniel BRAITHWAITE, Innaloo, AUSTRALIA;
Outotec (Finland) Oy, Espoo, FINLAND
Jeffrey Victor BELKE, Mt Pleasant, AUSTRALIA;
Daniel BRAITHWAITE, Innaloo, Western Australia, AUSTRALIA
Nicholas John GREEN, Rivervale, AUSTRALIA;
Jeffrey Victor BELKE, Mt Pleasant, Western Australia, AUSTRALIA
Chris TATE, Iluka, AUSTRALIA;
Nicholas John GREEN, Rivervale, Western Australia, AUSTRALIA
Oscar HARRISON, Balcatta, AUSTRALIA;
Chris TATE, Iluka, Western Australia, AUSTRALIA
Knut VAAGE, Oslo, NORWAY;
Oscar HARRISON, Balcatta, Western Australia, AUSTRALIA
Knut VAAGE, Oslo, NORWAY

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

Exhibit 1002
FLS v. Metso

SPECIFICATION AMENDMENTS

Please amend the specification in the following manners. The following instructions describe placement of amendments as *in the line following* a specific line on a page, meaning that an additional line should be added following the mentioned line, wherein the amendment should be made.

Replace "TITLE OF INVENTION" with "(a) TITLE OF THE INVENTION." on page 1, line 1.

Insert the following paragraph in the line following (a):

"(b) CROSS-REFERENCE TO RELATED APPLICATIONS. This is a national stage application filed under 35 USC 371 based on International Application No. PCT/IB2013/055305, filed June 28, 2013 and claims priority under 35 USC 119 of Australian Patent Application No. 2012902770 filed June 28, 2012."

Insert "(c) STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT. Not Applicable." in the line following (b).

Insert "(d) THE NAMES OF THE PARTIES TO A JOINT RESEARCH AGREEMENT. Not Applicable." in the line following (c).

Insert "(e) INCORPORATION-BY-REFERENCE OF MATERIAL SUBMITTED ON A COMPACT DISC OR AS A TEXT FILE VIA THE OFFICE ELECTRONIC FILING SYSTEM (EFS-WEB). Not Applicable." in the line following (d).

Insert "(f) STATEMENT REGARDING PRIOR DISCLOSURES BY THE INVENTOR OR A JOINT INVENTOR. Not Applicable." in the line following (e).

Replace "Background of the Invention" on page 1, with

"(g) BACKGROUND OF THE INVENTION.

Change(s) applied to document, /L.G./ 7/8/2016

Replace "SUMMARY OF INVENTION" on page ~~3~~ 2, with "(h) BRIEF SUMMARY OF THE INVENTION."

Change(s) applied
to document,
/L.G./
7/8/2016

Replace "Brief Description of the Drawings" on page ~~11~~ 9 with "(i) BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS."

Replace "Preferred Embodiments of the Invention" on page ~~14~~ 11 with "(j) DETAILED DESCRIPTION OF THE INVENTION."

Replace "CLAIMS" on page 29, with "(k) CLAIMS."

Replace "Abstract" with "(l) ABSTRACT OF THE DISCLOSURE" after (k).

Insert a new page with the heading "(m) SEQUENCE LISTING. Not Applicable". After (l).

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

152 7590 06/29/2016
CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/410,241	12/22/2014	Daniel BRAITHWAITE	SHEL.3143	6897

TITLE OF INVENTION: FLUID BEARINGS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/29/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
HANNON, THOMAS R	3656	384-114000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Outotec (Finland) Oy

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Espoo, Finland

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☒ Payment by credit card. ~~Form PTO-2038 is attached.~~
☒ The director is hereby authorized to charge ~~the required fee(s)~~, any deficiency, or credits any overpayment, to Deposit Account Number 03-1550 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
☐ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
☐ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Susan D. Pitchford/ Date August 3, 2016

Typed or printed name Susan D. Pitchford Registration No. 50,945

PTOL-85 Part B (10-13) Approved for use through 10/31/2013 OMB 0651-0033 U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Electronic Patent Application Fee Transmittal

Application Number:	14410241
Filing Date:	22-Dec-2014
Title of Invention:	FLUID BEARINGS
First Named Inventor/Applicant Name:	Daniel BRAITHWAITE
Filer:	Susan D. Pitchford/Laura Donnelley
Attorney Docket Number:	SHEL.3143

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Utility Appl Issue Fee	1501	1	960	960
Publ. Fee- Early, Voluntary, or Normal	1504	1	0	0
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**960**

Electronic Acknowledgement Receipt

EFS ID:	26531070
Application Number:	14410241
International Application Number:	
Confirmation Number:	6897
Title of Invention:	FLUID BEARINGS
First Named Inventor/Applicant Name:	Daniel BRAITHWAITE
Customer Number:	152
Filer:	Susan D. Pitchford/Laura Donnelley
Filer Authorized By:	Susan D. Pitchford
Attorney Docket Number:	SHEL.3143
Receipt Date:	03-AUG-2016
Filing Date:	22-DEC-2014
Time Stamp:	12:25:26
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$960
RAM confirmation Number	080316INTEFSW12274900
Deposit Account	1093
Authorized User	Laura Donnelley

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Exhibit 1002
FLS v. Metso

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	SHEL3143_Issue_Fee_Transmittal.pdf	188585 2ecf14999ecf83517dc71f423c1ac4ba40be3888	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	32194 78c021458f28aad2807034acfb011f99bf523f37	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	220779		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

152 7590 06/29/2016

CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157

EXAMINER
HANNON, THOMAS R

ART UNIT	PAPER NUMBER
3656	

DATE MAILED: 06/29/2016

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/410,241	12/22/2014	Daniel BRAITHWAITE	SHEL.3143	6897

TITLE OF INVENTION: FLUID BEARINGS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/29/2016

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

152 7590 06/29/2016
CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/410,241	12/22/2014	Daniel BRAITHWAITE	SHEL.3143	6897

TITLE OF INVENTION: FLUID BEARINGS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/29/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
HANNON, THOMAS R	3656	384-114000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29
  NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27
  NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status.
  NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/410,241	12/22/2014	Daniel BRAITHWAITE	SHEL.3143	6897

152 7590 06/29/2016

CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157

EXAMINER	
HANNON, THOMAS R	

ART UNIT	PAPER NUMBER
3656	

DATE MAILED: 06/29/2016

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 14/410,241	Applicant(s) BRAITHWAITE ET AL.	
	Examiner Thomas R. Hannon	Art Unit 3656	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *Applicant's communication filed June 10, 2016*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *53-66 and 68-79*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☒ All b) ☐ Some *c) ☐ None of the:
   1. ☒ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/Thomas R. Hannon/
Primary Examiner, Art Unit 3656

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14410241	BRAITHWAITE ET AL.
	Examiner	Art Unit
	THOMAS R HANNON	3656

CPC- SEARCHED		
Symbol	Date	Examiner
F16C 32/0666	4/25/2016	trh
update above	6/23/16	trh

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
PGPUb text search, see printout		6/23/16	trh

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BIB DATA SHEET

CONFIRMATION NO. 6897

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
14/410,241	12/22/2014	384	3656	SHEL.3143

APPLICANTS

Outotec (Finland) Oy, Espoo, FINLAND
Daniel BRAITHWAITE, Innaloo, Western Australia, AUSTRALIA
Jeffrey Victor BELKE, Mt Pleasant, Western Australia, AUSTRALIA
Nicholas John GREEN, Rivervale, Western Australia, AUSTRALIA
Chris TATE, Iluka, Western Australia, AUSTRALIA
Oscar HARRISON, Balcatta, Western Australia, AUSTRALIA
Knut VAAGE, Oslo, NORWAY

INVENTORS

Daniel BRAITHWAITE, Innaloo, AUSTRALIA;
Jeffrey Victor BELKE, Mt Pleasant, AUSTRALIA;
Nicholas John GREEN, Rivervale, AUSTRALIA;
Chris TATE, Iluka, AUSTRALIA;
Oscar HARRISON, Balcatta, AUSTRALIA;
Knut VAAGE, Oslo, NORWAY;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/IB2013/055305 06/28/2013

**** FOREIGN APPLICATIONS ***************************

AUSTRALIA 2012902770 06/28/2012

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

08/26/2015

Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /THOMAS R HANNON/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		AUSTRALIA	13	25	3

ADDRESS

CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157
UNITED STATES

TITLE

FLUID BEARINGS

FILING FEE RECEIVED		
2120	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue)

Exhibit 1002
FLS v. Metso

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L2	1	(bearing and journal and fluid and (polymer adj pad) and recess and mounting).clm.	US-PGPUB	OR	ON	2016/06/23 14:34

6/23/2016 2:38:22 PM

Exhibit 1002
FLS v. Metso

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14410241	BRAITHWAITE ET AL.
	Examiner	**Art Unit**
	THOMAS R HANNON	3656

CPC						
Symbol					**Type**	**Version**
F16C		32	/	0666	F	2013-01-01
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CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	26	
/THOMAS R. HANNON/ Primary Examiner, Art Unit 3656	06/23/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	6 & 7

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14410241	BRAITHWAITE ET AL.
	Examiner	**Art Unit**
	THOMAS R HANNON	3656

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION											
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED						
		F	1	6	C	32 / 06 (2006.01.01)							
CROSS REFERENCE(S)													
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)												

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	26	
/THOMAS R. HANNON/ Primary Examiner, Art Unit 3656	06/23/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	6 & 7

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14410241	BRAITHWAITE ET AL.
	Examiner	**Art Unit**
	THOMAS R HANNON	3656

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
-	1	-	17	-	33	-	49	23	65						
-	2	-	18	-	34	-	50	24	66						
-	3	-	19	-	35	-	51	-	67						
-	4	-	20	-	36	-	52	25	68						
-	5	-	21	-	37	1	53	26	69						
-	6	-	22	-	38	11	54	12	70						
-	7	-	23	-	39	2	55	13	71						
-	8	-	24	-	40	3	56	14	72						
-	9	-	25	-	41	4	57	15	73						
-	10	-	26	-	42	5	58	16	74						
-	11	-	27	-	43	6	59	17	75						
-	12	-	28	-	44	7	60	18	76						
-	13	-	29	-	45	8	61	19	77						
-	14	-	30	-	46	9	62	10	78						
-	15	-	31	-	47	21	63	20	79						
-	16	-	32	-	48	22	64								

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 26	
/THOMAS R. HANNON/ Primary Examiner, Art Unit 3656 (Primary Examiner)	06/23/2016 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 6 & 7

Document code: WFEE

United States Patent and Trademark Office
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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/410,241	Filing Date 12/22/2014	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **06/10/2016**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 26	Minus	** 25	= 1	X $80 =	80
Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	**80**

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/BRENDA J. DENNY/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Exhibit 1002
FLS v. Metso

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of
Daniel BRAITHWAITE et al.

Application No: 14/410,241

Filed: December 22, 2014

For: IMPROVEMENTS IN FLUID BEARINGS

Confirmation No: 6897

Art Unit: 3656

Examiner: Thomas R. Hannon

Docket: SHEL.3143

AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Sir:

In response to the Office Action of April 27, 2016, please amend the above-identified application as follows:

Amendments to the Abstract begin on page 2 of this paper.

Amendments to the Drawings begin on page 3 of this paper.

Amendments to the Claims begin on page 4 of this paper.

Remarks/Arguments begin on page 10 of this paper.

Amendments to the Abstract

Please replace the Abstract with the following amended Abstract:

The present invention provides improvements to a fluid bearing ~~(11, 12)~~ for a journal ~~(4)~~, one being a polymer bearing pad ~~(17) comprising~~ with an outer surface ~~(13)~~, at least one recess ~~(18)~~ for receiving lubricating fluid from a base ~~(14)~~ of ~~said~~ the fluid bearing and distributing ~~said~~ the lubricating fluid to ~~said~~ the outer surface and a ~~mounting means (8, 18A)~~ mount for securely mounting ~~said~~ the polymer bearing pad to ~~said~~ the base. Other improvements include a fluid bearing ~~(11, 12) comprising~~ with the polymer bearing pad ~~(17)~~, ~~methods of~~steps for making the polymer bearing pad and fluid bearing, a fluid bearing ~~comprising~~ with a polymer bearing pad ~~(17)~~ having a chamfer ~~(37)~~ and a multidirectional fluid bearing ~~(70)~~.

Amendments to the Drawings

Please replace Figure 11A with the following amended Figure 11A:

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of claims:

1. – 52. (canceled)

53. (currently amended) A bearing assembly for supporting a journal of a grinding mill body, comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a polymer bearing pad mounted to a base, said polymer bearing pad comprising an outer surface, at least one recess for receiving lubricating fluid from at least one passage of said base and distributing said lubricating fluid to said outer surface and mounting ~~means~~element for securely mounting said polymer bearing pad to said base, said base also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage, wherein said base is mounted to said frame so that said fluid bearings self adjust to changes in the angular position of the journal during operation of said grinding mill body.

54. (currently amended) A bearing assembly for supporting a journal of a grinding mill body, comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a polymer bearing pad mounted to a base, said polymer bearing pad comprising an outer surface, at least one recess for receiving lubricating fluid from at least one passage of said base and distributing said lubricating fluid to said outer surface and mounting ~~means~~element for securely mounting said polymer bearing pad to said base, said base also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage, wherein said base is fixedly mounted to said frame.

55. (currently amended) The bearing assembly of claim 53, wherein said mounting ~~means~~element comprises a mounting portion extending from said polymer bearing pad, said mounting portion comprising a protrusion from a mounting surface opposite to said outer surface for engaging a flange of said base, said flange being located at an outer edge of said base.

56. (currently amended) The bearing assembly of claim 53, wherein said mounting ~~means~~element comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base; said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess and said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess.

57. (currently amended) The bearing assembly of claim 53, wherein said mounting ~~means~~element comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base, said bearing assembly further comprising a locking element for retaining said at least one fastener within said at least one recess.

58. (currently amended) The bearing assembly of claim 53, wherein said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

59. (previously presented) The bearing assembly of claim 53, further comprising a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal, wherein said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer pad.

60. (previously presented) The bearing assembly of claim 53, said at least one recess of said polymer bearing pad comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage of said base.

61. (previously presented) The bearing assembly of claim 53, further comprising a plurality of said polymer bearing pads, wherein said respective outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal, wherein each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

62. (previously presented) The bearing assembly of claim 53, wherein said base further comprises a first surface, a second surface, a plurality of said at least one passages and a

plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

wherein there is a plurality of said polymer bearing pads, a first of said polymer bearing pads being mountable to said first surface and a second of said polymer bearing pads being mountable to said second surface,

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface,

wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

63. (currently amended) A multidirectional fluid bearing for a journal, comprising:

a base having a first surface orthogonal to a second surface, one or more lubricating fluid supply ports and a plurality of passages in fluid communication with said lubricating fluid supply ports, said first surface and said second surface,

a first polymer bearing pad mountable to said first surface, said polymer bearing pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer bearing pad mountable to said second surface, said second polymer bearing pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface,

wherein at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base, wherein said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess, said head portion being tapered to facilitate retention of said at least one fastener within said at least one recess by said locking

tab, and wherein said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess, said at least one fastener being partially received in said at least one passage.

64. (previously presented) The multidirectional fluid bearing of claim 63, said first polymer bearing pad substantially covers said first surface and said second polymer bearing pad substantially covers said second surface to respectively create fluid seals between said first and second polymer bearing pads and said base.

65. (previously presented) The multidirectional fluid bearing of claim 63, wherein at least one of said first and second polymer bearing pads comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal, wherein said chamfer has an outer edge that is displaced from a journal when said journal engages said at least one polymer bearing pad.

66. (previously presented) The multidirectional fluid bearing of claim 63, wherein there is a plurality of at least one of said first and second polymer bearing pads, wherein said respective outer surfaces of said plurality of at least one of said first and second polymer pads form a substantially uniform bearing surface for said journal, wherein each of said plurality of at least one of said first and second polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

67. (canceled)

68. (currently amended) The multidirectional fluid bearing of claim 63, wherein said base comprises at least one flange for engagement with a~~said~~ mounting portion of at least one of said first and second polymer bearing pads to securely mount said at least one polymer bearing pad to said base, said flange being located at an outer edge of said base.

69. (previously presented) The multidirectional fluid bearing of claim 63, wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial

hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

70. (currently amended) The bearing assembly of claim 54, wherein said mounting ~~means~~element comprises a mounting portion extending from said polymer bearing pad, said mounting portion comprising a protrusion from a mounting surface opposite to said outer surface for engaging a flange located at an outer edge of said base.

71. (currently amended) The bearing assembly of claim 54, wherein said mounting ~~means~~element comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base; said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess and said at least one fastener comprising a bore for conveying lubricating fluid from said at least one passage to said at least one recess.

72. (currently amended) The bearing assembly of claim 54, wherein said mounting ~~means~~element comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base, said bearing assembly further comprising a locking element for retaining said at least one fastener within said at least one recess.

73. (previously presented) The bearing assembly of claim 54, wherein said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

74. (previously presented) The bearing assembly of claim 54, further comprising a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal, said chamfer having an outer edge that is displaced from a journal when said journal engages said polymer pad.

75. (previously presented) The bearing assembly of claim 54, said at least one recess of said polymer bearing pad comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage of said base.

76. (previously presented) The bearing assembly of claim 54, further comprising a plurality of said polymer bearing pads, wherein said respective outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal, wherein each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

77. (previously presented). The bearing assembly of claim 54, wherein said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

wherein there is a plurality of said polymer bearing pads, a first of said polymer bearing pads being mountable to said first surface and a second of said polymer bearing pads being mountable to said second surface,

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface,

wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

78. (new) The bearing assembly of claim 53, wherein said polymer bearing pad is removably mounted to said base.

79. (new) The bearing assembly of claim 54, wherein said polymer bearing pad is removably mounted to said base.

REMARKS

Applicant hereby responds to the office action of April 27, 2016, and requests that the examiner examine the application in view of the following remarks:

The Applicant submits herewith amendments to the Abstract and to the claims, which obviate the Examiner's objections to these items. Further, substitute Figure 11A is submitted herewith to replace item 34 with "36" to overcome the objection to this drawing.

Claim 63 was rejected for being obvious in light of the combination of GB 1,508,384 (Chielens) and US 2012/0,099,993 (Guerenbourg). Claim 63 has now been amended to include the limitations of claim 67, which the Examiner deemed to be allowable. Accordingly, claim 63 as amended is now allowable over the cited prior art. It follows that the claims dependent therefrom are also allowable.

Applicant submits that no extension of time is required with this amendment, but provisionally petitions for an extension of time, if necessary. If any additional fees are required, the Commissioner is hereby authorized to charge any required additional fee for any extension of time or additional claims to Deposit Account No. 03-1550.

Date: June 10, 2016

Respectfully submitted,

/Susan D. Pitchford/
Susan D. Pitchford
Reg. No. 50,945

Chernoff, Vilhauer, McClung & Stenzel, LLP
601 SW Second Avenue, Suite 1600
Portland, OR 97204
Tel. (503) 278-3334
Fax (503) 228-4373

739703

7/13

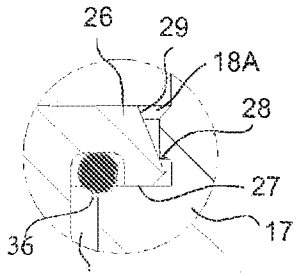


Fig. 11A

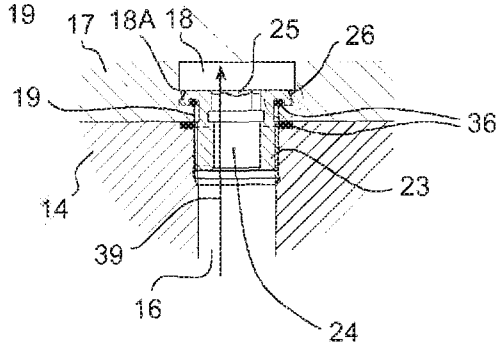


Fig. 11

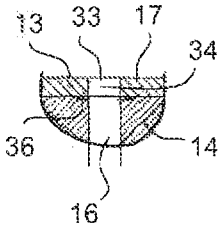


Fig. 12A

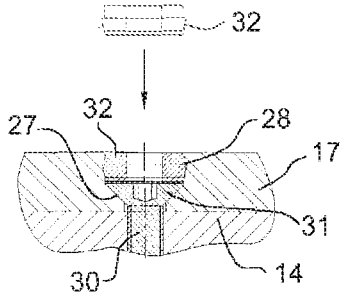


Fig. 12

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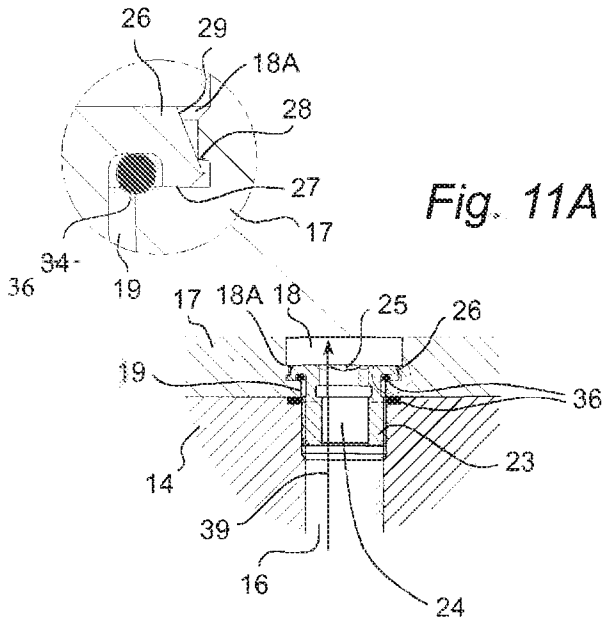


Fig. 11A

Fig. 11

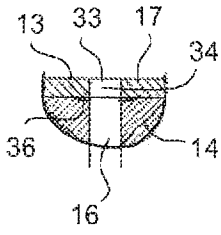


Fig. 12A

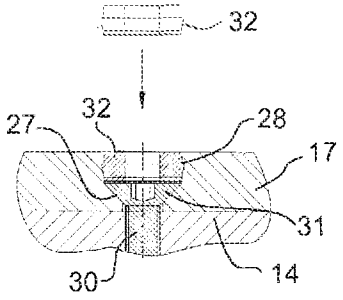


Fig. 12

Electronic Patent Application Fee Transmittal

Application Number:	14410241
Filing Date:	22-Dec-2014
Title of Invention:	FLUID BEARINGS
First Named Inventor/Applicant Name:	Daniel BRAITHWAITE
Filer:	Susan D. Pitchford/Laura Donnelley
Attorney Docket Number:	SHEL.3143

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in excess of 20	1615	2	80	160
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

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Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**160**

Electronic Acknowledgement Receipt

EFS ID:	26027299
Application Number:	14410241
International Application Number:	
Confirmation Number:	6897
Title of Invention:	FLUID BEARINGS
First Named Inventor/Applicant Name:	Daniel BRAITHWAITE
Customer Number:	152
Filer:	Susan D. Pitchford/Laura Donnelley
Filer Authorized By:	Susan D. Pitchford
Attorney Docket Number:	SHEL.3143
Receipt Date:	10-JUN-2016
Filing Date:	22-DEC-2014
Time Stamp:	12:31:35
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$160
RAM confirmation Number	9590
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Exhibit 1002
FLS v. Metso

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		SHEL3143_Response.pdf	79416 435039447500 18dacedf2430987cec406ae6b7b1	yes	10
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Amendment/Req. Reconsideration-After Non-Final Reject		1	1	
	Abstract		2	2	
	Drawings-only black and white line drawings		3	3	
	Claims		4	9	
	Applicant Arguments/Remarks Made in an Amendment		10	10	
Warnings:					
Information:					
2	Drawings-only black and white line drawings	SHEL3143_Replacement_Drawing_Clean.pdf	54930 8211508fe1ffb2aac96698a74eaa732dcef109b5	no	1
Warnings:					
Information:					
3	Drawings-only black and white line drawings	SHEL3143_Replacement_Drawing_Annotated.pdf	55290 71a7eb501d5b6a571a1e7c1cc15734d3c48c68a5	no	1
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30421 edde87f45213cef46058d541959c809a3aaabe49	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	220057		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/410,241	12/22/2014	Daniel BRAITHWAITE	SHEL.3143	6897

152 7590 04/27/2016

CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157

EXAMINER
HANNON, THOMAS R

ART UNIT	PAPER NUMBER
3656	

MAIL DATE	DELIVERY MODE
04/27/2016	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 14/410,241	Applicant(s) BRAITHWAITE ET AL.	
	Examiner Thomas R. Hannon	Art Unit 3656	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *December 22, 2014*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *53-77* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☒ Claim(s) *53-62 and 70-77* is/are allowed.

7)☒ Claim(s) *63,64,68 and 69* is/are rejected.

8)☒ Claim(s) *65-67* is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *12/22/14* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☒ All b)☐ Some** c)☐ None of the:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date *12/22/14*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

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The present application is being examined under the pre-AIA first to invent provisions.

Applicant is reminded of the proper language and format for an abstract of the disclosure.

The abstract should be in narrative form and generally limited to a single paragraph on a separate sheet within the range of 50 to 150 words. The form and legal phraseology often used in patent claims, such as "means" and "said," should be avoided. The abstract should describe the disclosure sufficiently to assist readers in deciding whether there is a need for consulting the full patent text for details.

The language should be clear and concise and should not repeat information given in the title. It should avoid using phrases which can be implied, such as, "The disclosure concerns," "The disclosure defined by this invention," "The disclosure describes," etc.

The abstract of the disclosure is objected to because of the legal phraseology “means” and “said”, and the implied language of “The present invention”. Correction is required. See MPEP § 608.01(b).

The drawings are objected to as failing to comply with 37 CFR 1.84(p)(4) because reference character “34” has been used to designate both an O-ring in Figure 11A and a bore in Figure 12A. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either “Replacement Sheet” or “New Sheet” pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

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Claim 68 is objected to because of the following informalities: in line 1, "wherein base" should be changed to --wherein said base--. Appropriate correction is required.

The following is a quotation of 35 U.S.C. 112(f):

> (f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

Claim limitation "mounting means for securely mounting said polymer bearing pad to said base" has been interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because it uses a generic placeholder "means" coupled with functional language "for securely mounting said polymer bearing pad to said base" without reciting sufficient structure to achieve the function. Furthermore, the generic placeholder is not preceded by a structural modifier, since "mounting" preceding "means" does not impart structure, and is thus not a structural modifier.

Since the claim limitation(s) invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, claims 53-62 and 70-77 have been interpreted to cover the corresponding structure described in the specification that achieves the claimed function, and equivalents thereof.

A review of the specification shows that the following appears to be the corresponding structure described in the specification for the 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph limitation: "a mounting portion extending from said polymer bearing pad" (paragraph [0015]) or "at least one opening for receiving at least one fastener" (paragraph [0016])..

If applicant wishes to provide further explanation or dispute the examiner's interpretation of the corresponding structure, applicant must identify the corresponding structure with reference to the specification by page and line number, and to the drawing, if any, by reference characters in response to this Office action.

If applicant does not intend to have the claim limitation(s) treated under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112 , sixth paragraph, applicant may amend the claim(s) so that it/they will clearly not invoke 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, or present a sufficient showing that the claim recites/recite sufficient structure, material, or acts for performing the claimed function to preclude application of 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

For more information, see MPEP § 2173 *et seq.* and *Supplementary Examination Guidelines for Determining Compliance With 35 U.S.C. 112 and for Treatment of Related Issues in Patent Applications*, 76 FR 7162, 7167 (Feb. 9, 2011).

The following is a quotation of 35 U.S.C. 112(b):
(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:
The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

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Claim 68 is rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Claim 68 recites the limitation "said mounting portion" in line 2. There is insufficient antecedent basis for this limitation in the claim.

The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 63, 64, and 69 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Chielens, GB 1,508,384, in view of Guerenbourg et al. US 2012/0099993.

Chielens discloses in Figure 5 multidirectional fluid bearing for a journal (12), comprising: a base (10) having a first surface orthogonal to a second surface, one or more lubricating fluid supply ports (20) and a plurality of passages (18, 22, 24) in fluid communication with said lubricating fluid supply ports, said first surface, and said second surface; a first antifriction material (16) bearing pad mountable to said first surface, said antifriction material bearing pad having a first outer surface and at least one recess (at 18) for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and a second antifriction material bearing pad mountable (adjacent 19, Figure 5) to said second surface, said second antifriction material bearing pad having a second outer surface and at least one recess (19) for receiving lubricating fluid at least one of said plurality of

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passages and distributing said lubricating fluid to said second outer surface. Chielens does not disclose the antifriction material as polymer.

Guerenbourg discloses a fluid bearing for a journal, in which the bearing pad lining comprises a polymer lining. It would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize known antifriction material in Chielens, including polymer, as taught by Guerenbourg as exhibiting favorable stability and stiffness, as well as other beneficial properties to fluid bearings.

With respect to claim 64, Chielens discloses said first antifriction material bearing pad substantially covers said first surface and said second antifriction material bearing pad substantially covers said second surface to respectively create fluid seals between said first and second antifriction material bearing pads and said base.

With respect to claim 69, Chielens discloses the first outer surface being partially curved such that the first bearing pad acts as a radial hydrostatic bearing and the second outer surface is substantially planar such that the second bearing pad acts as an axial bearing (Figure 5).

Claims 53-62 and 70-77 are allowed.

Claims 65-67 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Claim 68 would be allowable if rewritten to overcome the rejection(s) under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), 2nd paragraph, set forth in this Office action and to include all of the limitations of the base claim and any intervening claims.

As allowable subject matter has been indicated, applicant's reply must either comply with all formal requirements or specifically traverse each requirement not complied with. See 37 CFR 1.111(b) and MPEP § 707.07(a).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thomas R. Hannon whose telephone number is (571)272-7104. The examiner can normally be reached on Monday-Thursday (9:00-6:30).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Richard WL Ridley can be reached on (571) 272-6917. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Thomas R. Hannon/
Primary Examiner, Art Unit 3656

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Notice of References Cited	Application/Control No. 14/410,241	Applicant(s)/Patent Under Reexamination BRAITHWAITE ET AL.	
	Examiner Thomas R. Hannon	Art Unit 3656	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-2006/0063442 A1	03-2006	Taylor; Douglas Lee	B63H5/14	440/78
*	B	US-2012/0099993 A1	04-2012	Guerenbourg; Pierre-Antoine	F03D11/0008	416/174
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N	DE 10254864 B3	08-2004	DE	SCHULZ JOACHIM	F16C29/025
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 102 54 864 B3** 2004.08.05

(12) # Patentschrift

(21) Aktenzeichen: **102 54 864.1**
(22) Anmeldetag: **25.11.2002**
(43) Offenlegungstag: –
(45) Veröffentlichungstag der Patenterteilung: **05.08.2004**

(51) Int Cl.[7]: **F16C 33/20**
F16C 33/14, F16C 29/02, B23Q 1/01

Innerhalb von 3 Monaten nach Veröffentlichung der Erteilung kann Einspruch erhoben werden.

(71) Patentinhaber:
Diamant-Metallplastic GmbH, 41238 Mönchengladbach, DE

(74) Vertreter:
COHAUSZ & FLORACK, 40211 Düsseldorf

(72) Erfinder:
Schulz, Joachim, 41238 Mönchengladbach, DE

(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:
DE 34 16 833 A1
DD-PS 970 38
US 50 96 348
EP 02 67 390 A1

(54) Bezeichnung: **Verfahren zum Herstellen eines Lagerpartners eines Gleitlagers mit von einer glatten Oberfläche einer gleitfähigen Polymerschicht gebildeten Gleitfläche**

(57) Zusammenfassung: Verfahren zur Herstellung eines Lagerpartners eines Gleitlagers mit einer glatten, von einer gleitfähigen Polymerschicht (4) gebildeten, als Gleitfläche dienenden Oberfläche (1a), zu der mindestens ein im Lagerpartner des Gleitlagers eingeformter, an einer Versorgungseinrichtung für ein flüssiges oder gasförmiges Gleitmedium, insbesondere Luft, anschließbarer Kanal (6) mit einer Auslaßöffnung führt, aus der das Gleitmedium unter Ausbildung eines Kissens zwischen der Oberfläche der Polymerschicht (4) und einer entsprechenden Oberfläche des anderen Lagerpartners des Gleitlagers austreten kann. Das Verfahren ist dadurch gekennzeichnet, daß die gleitfähige Polymerschicht (4) an einer hochpräzise gefertigten Masterform (1) mit einer trennfähigen oder mit der Schicht eines Trennmittels versehenen Oberfläche (1a), die im Negativ die Gleitfläche des einen Lagerpartners abbildet, abgeformt wird. Dadurch werden die geforderten Eigenschaften der Oberfläche (1a), wie eine minimale Rauhigkeit und die gewünschte Oberflächengeometrie, in einem Prozeßschritt erreicht und kosten- und zeitaufwendige Nacharbeiten entfallen.

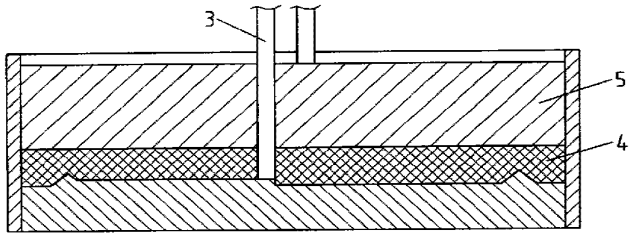


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Beschreibung

[0001] Die Erfindung betrifft ein Verfahren zur Herstellung eines Lagerpartners eines Gleitlagers mit einer glatten, von einer gleitfähigen Polymerschicht gebildeten, als Gleitfläche dienenden Oberfläche, zu der mindestens ein im Lagerpartner des Gleitlagers eingeformter, an einer Versorgungseinrichtung für ein flüssiges oder gasförmiges Gleitmedium, insbesondere Luft, anschließbarer Kanal mit einer Auslaßöffnung führt, aus der das Gleitmedium unter Ausbildung eines Kissens zwischen der Oberfläche der Polymerschicht und einer entsprechenden Oberfläche des anderen Lagerpartners des Gleitlagers austreten kann.

[0002] Gleitlager, die auf diesem Prinzip basieren, sind als dynamische und berührungslos arbeitende Gleitlager in den verschiedensten Ausführungen aus der Praxis bekannt. Sie kommen u.a. bei Linearführungen zum Einsatz. So werden beispielsweise hochpräzise Meßinstrumente, insbesondere 3-Koordinaten-Meßmaschinen zur räumlichen Vermessung von Bauteilen mit einer Genauigkeit im µm-Bereich, auf Schlitten gelagert, welche über Gleitelemente, die als der jeweils eine Lagerpartner dienen, mit aerostatischer Schmierung auf einer als der andere Lagerpartner dienenden, planar ausgebildeten Stahl-, Granit- oder auch Kunststoffplatte gelagert sind.

[0003] Ein aus der Praxis bekanntes, für diesen Einsatzzweck geeignetes Gleitelement ist scheibenförmig ausgelegt und weist auf seiner die Gleitfläche bildenden Unterseite die Schicht eines Polymers mit wegen eingebetteter Gleitstoffe guten Gleiteigenschaften auf. In das Gleitelement sind weiterhin Kanäle eingeformt, welche an der Oberfläche der Polymerschicht münden und der Zuführung von Luft oder eines anderen Gases als Gleitmedium dienen. Die hohe Gleitfähigkeit der Polymerschicht, die von der Oberflächenrauhigkeit und den spezifischen Werkstoffeigenschaften des jeweils verwendeten Polymers abhängt, ist insbesondere dann von Bedeutung, wenn infolge von Überlast das aus dem Gleitmedium zwischen den Lagerpartnern gebildete Kissen verdrängt wird, so daß es zu einer direkten Reibung zwischen den Lagerpartnern kommt. In einem solchen Falle muß die Polymerschicht hinreichend gute Notlaufeigenschaften aufweisen, um einen zumindest behelfsmäßigen Weiterbetrieb zu ermöglichen.

[0004] Neben den guten Gleiteigenschaften ist ebenso eine strenge Parallelität der Oberflächen der Lagerpartner erforderlich. Im Falle eines planaren Untergrundes muß somit die Oberfläche der Polymerschicht des Gleitelementes ebenfalls planar ausgebildet sein. Im Falle einer konvex oder konkav gewölbten Untergrundfläche gilt entsprechendes. Konventionell wird daher die Oberfläche der Polymerschicht in einem sehr aufwendigen Verfahren mittels Honen oder Läppen so lange bearbeitet, bis die gewünschte Geometrie und die geforderten minimalen Rauhigkeitswerte erreicht sind. Diese zeitaufwendige Bearbeitung kann nur durch qualifiziertes Fachpersonal ausgeführt werden, was insgesamt zu sehr hohen Produktionskosten führt.

Stand der Technik

[0005] In der US 5,096,348 ist eine Linearführung mit einer Führungsschiene und einem auf der Führungsschiene gleitenden Gleitschuh als Teil einer Werkzeugmaschine beschrieben. Der Gleitschuh der Linearführung weist an seinen die Führungsschiene formschlüssig umgreifenden Innenflächen Gleitschichten aus Kunststoff, vorzugsweise aus Epoxidharz, auf, die auf den korrespondierenden metallischen Oberflächen der Führungsschiene mit geringer Reibung gleiten. In der Druckschrift ist darüber hinaus ein Verfahren zur Abformung der Kunststoff-Gleitschichten auf den Innenflächen des Gleitschuhs als Substratflächen beschrieben. Demnach wird eine Form, deren unterseitige Oberfläche komplementär zu der entsprechenden Innenfläche des abzuformenden Gleitschicht ausgebildet ist, auf die Gleitschuhinnenfläche aufgesetzt und fixiert, so dass sich ein Hohlraum in den Dimensionen des zu formenden Gleitkissens bildet. Im folgenden wird der Kunststoff über eine im Gleitschuh vorgesehene, auf der Gleitschuhinnenfläche mündende Einspritzbohrung in den Hohlraum zwischen der Form und der Gleitschuhinnenfläche gespritzt.

[0006] Die gemäß dieser Verfahrensvorschrift hergestellte Kunststoffgleitfläche als Lagerpartner in dem Gleitlager der Linearführung kann präzise geformt werden und weist gute Gleiteigenschaften auf. Sie ist jedoch mit verhältnismäßig großem Aufwand in der Herstellung verbunden, da für die Abformung der Gleitschicht auf der Gleitschuhinnenfläche der Kunststoff in flüssiger Form durch eine im Gleitschuh eigens hierfür vorzusehende Einspritzbohrung in den Hohlraum zwischen der Form und der Gleitschuhinnenfläche eingeleitet werden muß.

Aufgabenstellung

[0007] Es ist daher Aufgabe der Erfindung, ein Verfahren zur Herstellung eines Lagerpartners eines Gleitlagers mit einer glatten, von einer gleitfähigen Polymerschicht gebildeten, als Gleitfläche dienenden Oberfläche anzugeben, welches kostengünstig mit geringem Zeit- und Arbeitsaufwand durchzuführen ist, wobei die gleitfähige Polymerschicht auf einer besonders einfach und variabel herzustellenden Substratfläche angeordnet sein sollte.

[0008] Die Aufgabe wird durch ein Verfahren der eingangs genannten Art durch folgende Verfahrensschritte gelöst:

- Auftragen der Polymerschicht auf eine von einem hochstehenden Rand begrenzte Masterform mit einer trennfähigen oder mit der Schicht eines Trennmittels versehenen Oberfläche, die im Ne-

gativ die Gleitfläche des einen Lagerpartners abbildet,
– Hintergießen der auf die Masterform aufgetragenen Polymerschicht mit einer Gußmasse,
– Aushärten der Polymerschicht und ggf. der Gußmasse und Abtrennen der Masterform von der Polymerschicht und
– Ausbildung des mindestens einen Kanals in der Polymerschicht und in der Gußmasse.

[0009] Der zentrale Gedanke der Erfindung besteht darin, die aufwendige Einzelbearbeitung der Oberfläche der Polymerschicht des einen Lagerpartners durch eine einfache Abformung der Schichtoberfläche an einer Masterform zu ersetzen. Dadurch werden die für die Schichtoberfläche geforderten Eigenschaften, nämlich eine minimale Rauhigkeit und die gewünschte Oberflächengeometrie, von einer einmalig hochpräzise hergestellten Masterform in einem beliebig oft wiederholbaren Abformprozeß auf die Schichtoberfläche übertragen.

[0010] Die Masterform besteht vorzugsweise aus einem metallischen Werkstoff und ist von einem Rand umgeben, der ebenfalls aus Metall oder auch aus einem Kunststoff gefertigt sein kann. Vorzugsweise ist er lösbar mit der Masterform verbunden.

[0011] Die auf die Masterform aufgetragene Polymerschicht wird mittels einer Gußmasse zur Ausbildung eines Sockels hintergossen. Dazu sollte der die Masterform umgebende Rand eine entsprechende Höhe aufweisen. Der Sockel dient der Stabilisierung der vergleichsweise dünnen Polymerschicht.

[0012] Die Ausbildung des Kanals oder der Kanäle in der Polymerschicht und in der Gußmasse kann auf verschiedene Weise erfolgen. Beispielsweise können sie nach der Abtrennung der Masterform durch Bohren oder präzises Fräsen eingearbeitet werden. Nach einer bevorzugten Ausführungsform des erfindungsgemäßen Verfahrens ist jedoch vorgesehen, daß sie durch einen oder mehrere mit der Masterform verbundene rohrförmige Einsätze gebildet werden, die nach dem Aushärten der Polymerschicht und der Gußmasse herausgezogen werden. Dadurch ist sichergestellt, daß der oder die Kanäle an definierter Position und in der gewünschten Form in dem erfindungsgemäß hergestellten Gleitelement vorliegen, ohne daß eine Nachbearbeitung erforderlich ist. Sie können aber auch als „verlorene" Einsätze im Gleitelement verbleiben, was als weniger vorteilhaft angesehen wird. Die rohrförmigen Einsätze können sich in einem Abstand zur Oberfläche der Masterform zu einem nach oben oder auch seitlich nach außen weisenden Rohr, das dem Anschluß an eine Versorgungseinrichtung für das Gleitmedium dient, vereinen.

[0013] Nach dem Aushärten der Polymerschicht und der Gußmasse wird die Masterform von der gleitfähigen Schicht abgetrennt. Der die Masterform sowie die Polymerschicht und die Gußmasse umgebende Rand wird ebenfalls abgetrennt, kann aber auch als seitliche Umhüllung der Polymerschicht und der Gußmasse belassen werden. In diesem Falle muß er jedoch soweit beschnitten werden, daß er nicht mehr über die Polymerschicht hinausragt. Entscheidend ist bei dem erfindungsgemäßen Verfahren die gute Trennfähigkeit der Oberfläche der Masterform, so daß das Verbleiben von Rückständen des Polymers auf Formoberfläche ausgeschlossen ist, was die Oberflächenqualität der abgeformten Polymeroberfläche verschlechtern und zudem zu einer zunehmend unkontrollierten Formgebung in den folgenden Abformprozessen führen würde.

[0014] Zur Gewährleistung einer ausreichenden Trennfähigkeit kann die Formoberfläche mit einer dünnen Schicht eines Trennmittels, z.B. Teflonspray, versehen sein. Bevorzugt besteht jedoch zumindest die Oberfläche der Masterform aus einem Material, welches selbst derart gute Trenneigenschaften aufweist, daß auf das Aufbringen einer Trennmittelschicht verzichtet werden kann. Hierfür kommen insbesondere hochlegierte Stähle, Aluminium, Aluminiumlegierungen oder auch Kunststoffe in Frage. Polyamide erweisen sich dabei als besonders geeignete Kunststoffe.

[0015] Die gleitfähige Polymerschicht besteht bevorzugt aus einem Polymer auf Basis eines Epoxidharzes oder eines Epoxidharzgemisches unter Zugabe von Füllstoffen, Gleitmitteln, Stabilisatoren und ggf. weiteren Hilfsstoffen. Epoxidharze zeichnen sich aufgrund ihrer duroplastischen Eigenschaften durch eine hohe Abriebfestigkeit sowie gute Beständigkeit gegen atmosphärische Einflüsse, Wasser, Öle und eine Vielzahl anderer Chemikalien aus. Zudem lassen sich je nach gewünschter Verarbeitbarkeit und Aushärtezeit am Markt erhältliche ein- und mehrkomponentige Epoxidharzsysteme verwenden. Es versteht sich jedoch, daß der Einsatz auch anderer Bindemittel in dem erfindungsgemäßen Verfahren möglich ist.

[0016] Besonders gute Ergebnisse hinsichtlich der gewünschten Oberflächengeometrie und einer minimalen Oberflächenrauhigkeit lassen sich erzielen, wenn die Polymerschicht eine Dicke von ≥ 0,5 mm, vorzugsweise 2 mm, aufweist. Somit ist einerseits ein sparsamer Materialverbrauch während der Herstellung gewährleistet und andererseits die Schicht ausreichend dick, um eine lange Standzeit des Gleitelements auch bei schwierigen Einsatzbedingungen zu ermöglichen.

[0017] Je nach gewünschter Oberflächengeometrie der Polymerschicht, z.B. planar oder gleichmäßig gekrümmt, kann es zur Stabilisierung des durch das Gleitmedium ausgebildeten Gleitkissens von Vorteil sein, wenn die Masterform Erhebungen aufweist, die auf die Polymerschicht in Form von Nuten, Mulden o.ä. übertragen werden. Somit können auch Weiterentwicklungen im Bereich aerostatischer oder hydrostatischer Gleitlager, die zu einer Verbesserung der Gleiteigenschaften führen, bei den in der erfindungsgemäßen Weise hergestellten Gleitelementen durch

eine entsprechende Vorbereitung der Masterform Berücksichtigung finden.

Ausführungsbeispiel

[0018] Im folgenden wird die Erfindung anhand einer ein Ausführungsbeispiel darstellenden Zeichnung näher erläutert. Im einzelnen zeigen:

[0019] **Fig.** 1 eine Masterform für die Herstellung eines Lagerpartners mit einer von einer gleitfähigen Polymerschicht gebildeten Gleitfläche eines Gleitlagers in Draufsicht,

[0020] **Fig.** 2 die Masterform der **Fig.** 1 im Querschnitt nach Linie A-A in **Fig.** 1 und

[0021] **Fig.** 3a–c die Verfahrensschritte zur Herstellung des Lagerpartners nach **Fig.** 1.

[0022] Gemäß **Fig.** 1 und 2 ist die Masterform **1** als kreisrund geformte Scheibe ausgebildet und besteht aus einem hochlegierten Stahl mit einer extrem glatten und planaren, trennfähigen Oberfläche **1a**. An ihrem äußeren Rand ist sie von einem Ring **2** aus Aluminium umgeben, welcher auf der Seite der Oberfläche **1a** übersteht. Die Masterform **1** und der Ring **2** sind lösbar miteinander verbunden. Die Oberfläche **1a** der Masterform **1** weist verschiedene erhabene Strukturen auf. Diese sind als Ring **1b** mit dreieckigem Querschnitt und drei von dem Ring **1b** radial nach innen verlaufenden Wulste **1c** ausgebildet. Die drei Wulste **1c** sind symmetrisch in einem Winkel von jeweils 120° zueinander angeordnet. Ihre inneren Enden berühren einander nicht, sondern liegen in einem konstanten Abstand zum Mittelpunkt der Masterform **1** und sind mit senkrecht zur Oberfläche der Masterform **1** nach oben ragenden Stiften **1d** versehen. Auf diese ist jeweils ein dünnes Rohr **3** aufgesteckt, welches als ziehbarer Einsatz für die Zuführungskanäle eines auf der Masterform **1** abzuformenden Gleitelementes vorgesehen ist. Es versteht sich, daß die Oberfläche **1a** auch mit anders gestalteten erhabenen Strukturen versehen sein kann. Ebenso kann sie auch vollständig eben ausgebildet sein. In jedem Fall bildet sie als Negativ die herzustellende Gleitfläche des einen Lagerpartners des Gleitlagers ab.

[0023] In dem erfindungsgemäßen Verfahren wird auf die Masterform **1** zunächst eine Schicht **4** eines Epoxidharzgemisches mit einer Schichtdicke von ≥ 0,5 mm, bevorzugt ca. 2 mm, aufgetragen, welcher im ausgehärteten Zustand gute Gleiteigenschaften aufweist. Beim Auftragen der Schicht ist darauf zu achten, daß die Position der rohrförmigen Einsätze **3** nicht verändert wird. Als besonders geeignet hat sich dafür das im Handel unter der Marke „moglice" bekannte Epoxidharzgemisch der deutschen Firma Diamant Metallplastic erwiesen.

[0024] In einem Folgeschritt wird die Epoxidschicht **4** mit einer Gußmasse **5** zur Ausbildung eines Sockels, welcher Stabilisierung der dünnen Epoxidharzschicht **4** dient, hintergossen. Dafür eignen sich Stoffe, die zu einem formstabilen Block erhärten. Das sind insbesondere Kunstharze mit mineralisch und metallischen Füllstoffen für statische Anwendungen.

[0025] Sodann erfolgt das vollständige Aushärten der Epoxidharzschicht **4** und der Gußmasse **5**. Im Anschluß daran wird die Masterform **1** von der Epoxidharzschicht **4**, sowie der Rand **2** von der Epoxidharzschicht **4** und der Gußmasse **5** rückstandsfrei abgetrennt. In einem letzten Schritt werden die rohrförmigen Einsätze **3** aus dem abgeformten Gleitelement herausgezogen.

[0026] Im Ergebnis liegt dann ein in einem einfach und kostengünstig zu realisierenden Abformprozeß hergestelltes, aus zwei Schichten bestehendes Gleitelement als Lagerpartner eines Gleitlagers vor, in welchem senkrecht zur Oberfläche verlaufende Kanäle **6** zur Zuführung eines Gleitmediums ausgebildet sind. Die Oberfläche der Epoxidharzschicht **4** ist entsprechend den Eigenschaften der strukturierten Oberfläche **1a** der Masterform **1** glatt und planar ausgebildet. Die erhabenen Strukturen **1b**, **1c** der Oberfläche **1a** der Masterform **1** sind als radial angeordnete Nuten und als Ringnut zur günstigen Verteilung des Gleitmediums in die Oberfläche der ausgehärteten Epoxidharzschicht **4** eingeformt.

Patentansprüche

1. Verfahren zur Herstellung eines Lagerpartners eines Gleitlagers mit einer glatten, von einer gleitfähigen Polymerschicht (**4**) gebildeten, als Gleitfläche dienenden Oberfläche (**1a**), zu der mindestens ein im Lagerpartner des Gleitlagers eingeformter, an einer Versorgungseinrichtung für ein flüssiges oder gasförmiges Gleitmedium anschließbarer Kanal (**6**) mit einer Auslaßöffnung führt, aus der das Gleitmedium unter Ausbildung eines Kissens zwischen der Oberfläche der Polymerschicht (**4**) und einer entsprechenden Oberfläche des anderen Lagerpartners des Gleitlagers austreten kann, gekennzeichnet durch folgende Verfahrensschritte
– Auftragen der Polymerschicht (**4**) auf eine von einem hochstehenden Rand (**2**) begrenzte Masterform (**1**) mit einer trennfähigen oder mit der Schicht eines Trennmittels versehenen Oberfläche (**1a**), die im Negativ die Gleitfläche des einen Lagerpartners abbildet,
– Hintergießen der auf die Masterform (**1**) aufgetragenen Polymerschicht (**4**) mit einer Gußmasse (**5**) ,
– Aushärten der Polymerschicht (**4**) und der Gußmasse (**5**) und Abtrennen der Masterform (**1**) von der Polymerschicht (**4**) und
– Ausbildung des mindestens einen Kanals (**6**) in der Polymerschicht (**4**) und in der Gußmasse (**5**).

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der mindestens eine Kanal (**6**) durch einen rohrförmigen Einsatz (**3**) für jeden Kanal gebildet wird, der nach dem Aushärten der Polymerschicht (**4**) und der Gußmasse (**5**) herausgezogen wird.

3. Verfahren nach Anspruch 1 oder 2, dadurch

gekennzeichnet, daß die Masterform (**1**) mit der trennfähigen Oberfläche (**1a**) aus einem hochlegierten Stahl, Aluminium, einer Aluminiumlegierung oder einem Kunststoff besteht.

4. Verfahren nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die gleitfähige Polymerschicht (**4**) aus einem Polymer auf Epoxidharzbasis unter Zugabe von Füllstoffen, Gleitmitteln, Stabilisatoren und ggf. weiteren Hilfsstoffen besteht.

5. Verfahren nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die Polymerschicht (**4**) eine Dicke von ≥ 0,5 mm, vorzugsweise 2 mm, aufweist.

6. Verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß die Masterform (**1**) Erhebungen aufweist, die auf die Polymerschicht (**4**) übertragen werden.

Es folgen 2 Blatt Zeichnungen

Anhängende Zeichnungen

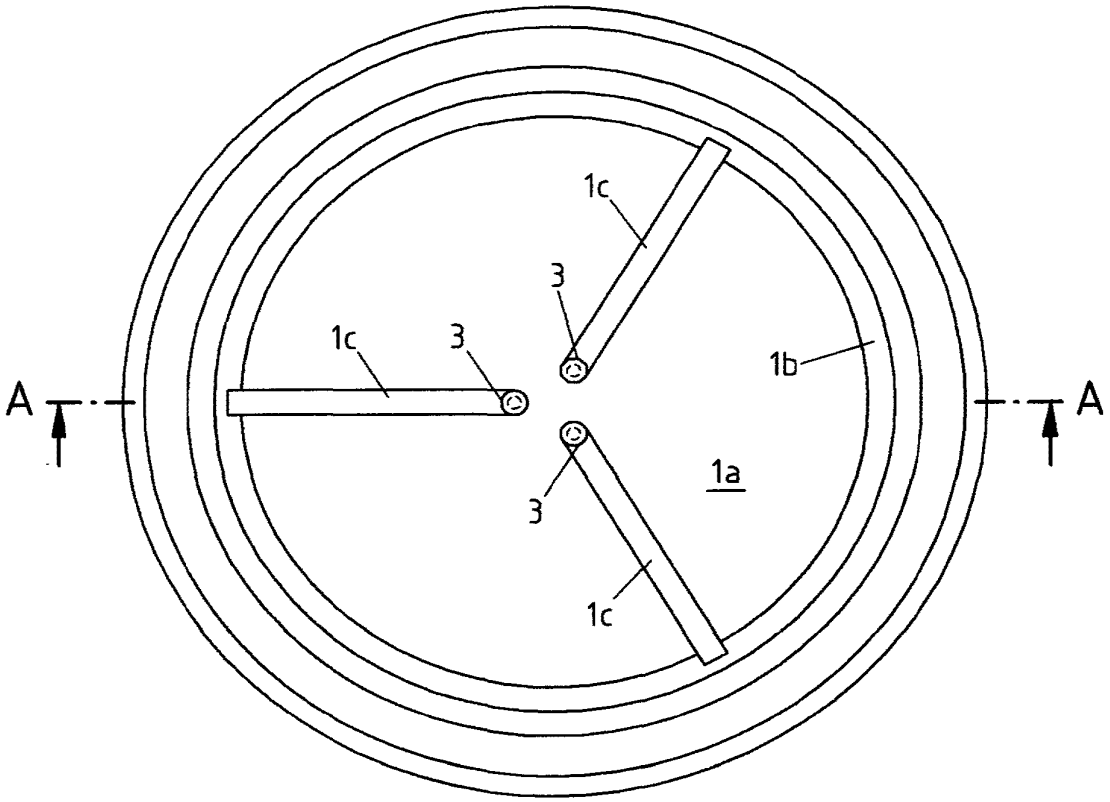


Fig.1

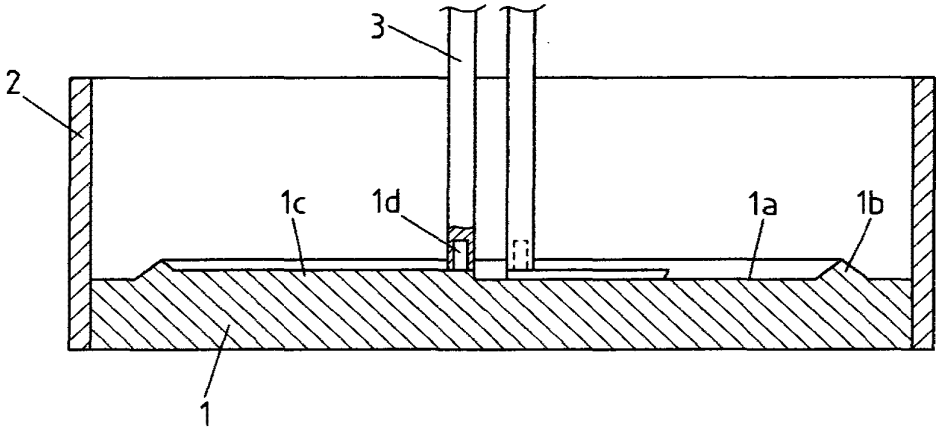


Fig.2

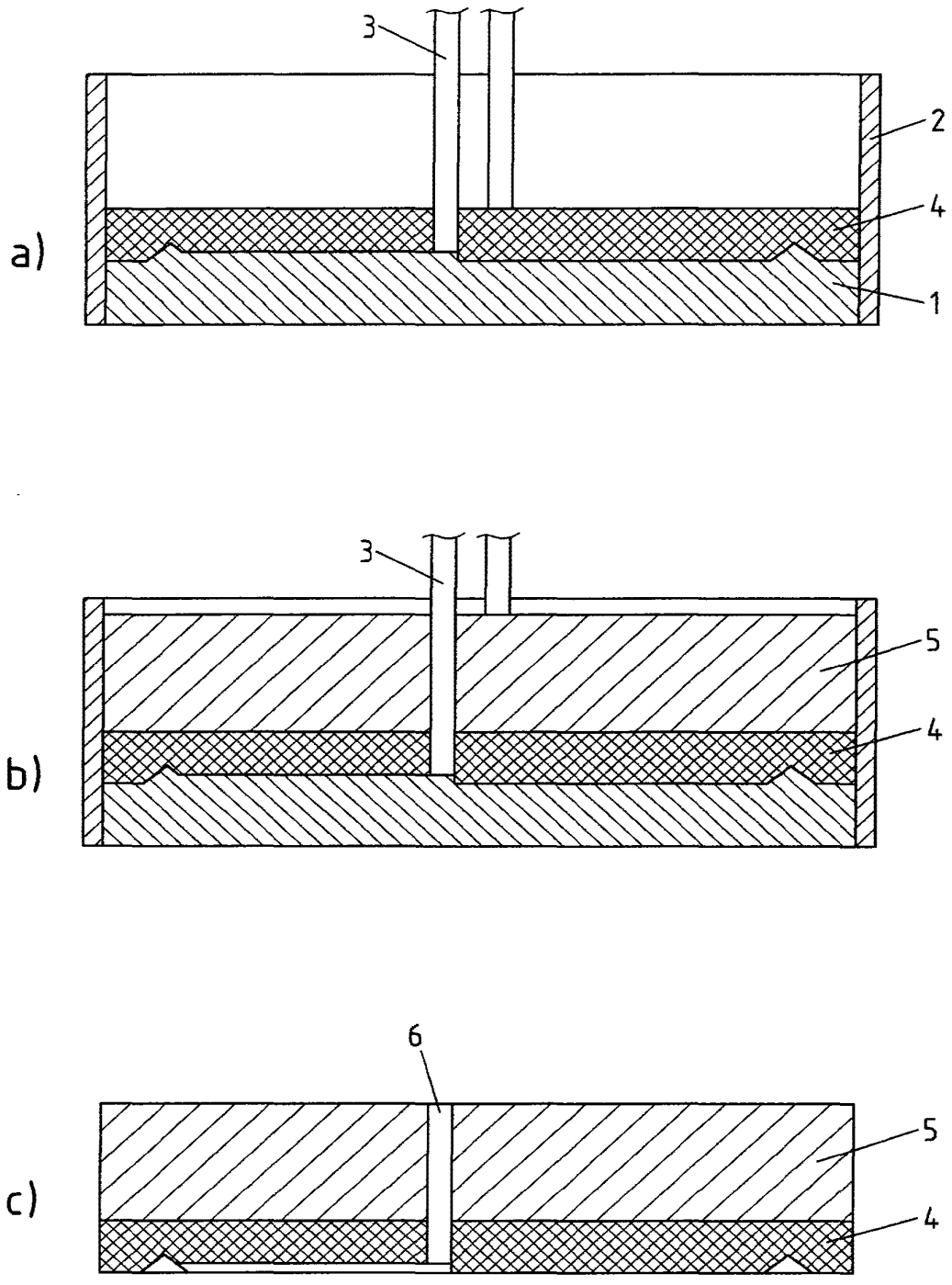


Fig.3

PUB-NO: DE010254864B3
DOCUMENT-IDENTIFIER: DE 10254864 B3
TITLE: Production of a bearing partner of a sliding bearing comprises applying a polymer layer to a master mold delimited by a protruding edge, back-casting the polymer layer
PUBN-DATE: August 5, 2004
PATENT-FAMILY-ID: 32667492

INVENTOR-INFORMATION:

NAME	COUNTRY
SCHULZ JOACHIM	DE

APPLICANT:

NAME	COUNTRY
DIAMANT METALLPLASTIC GMBH	DE

APPL-NO: DE 10254864 A
APPL-DATE: November 25, 2002

PRIORITY-DATA:

PRIORITY-NO	PRIORITY-APPL-DATE
DE 10254864 A	20021125

CPC-CURRENT:

TYPE	CPC/DATE
CPCI	F16C29/025 20130101
CPCI	F16C32/0666 20130101
CPCI	F16C33/201 20130101

INT-CL-CURRENT:

TYPE	IPC/DATE
IPCP	F16C29/02 20060101
IPCS	F16C33/20 20060101
IPCS	F16C32/06 20060101

Exhibit 1002
FLS v. Metso

REF-CITED:

PHASE-COUNTRY/NUMBER/KIND/DATE-NPL-INFO

SER EP 0267390 A1 19880518
SER US 5096348 A 19920317
SER DD 97038 C
SER DE 3416833 A1 19851107

ABSTRACT:

Production of a bearing partner of a sliding bearing comprises applying a polymer layer (4) to a master mold delimited by a protruding edge (2) and having a separating surface forming the sliding surface of one bearing partner, back-casting the polymer layer applied on the master mold. Production of a bearing partner of a sliding bearing comprises applying a polymer layer (4) to a master mold delimited by a protruding edge (2) and having a separating surface forming the sliding surface of one bearing partner, back-casting the polymer layer applied on the master mold with a casting composition (5), hardening the polymer layer and the casting composition and removing the master mold from the polymer layer, and forming a channel (6) in the polymer layer and in the casting composition.

PTO/SB/08a (01-10)
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(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Daniel BRAITHWAITE
Art Unit	
Examiner Name	
Attorney Docket Number	SHEL.3143

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4911554		1990-03-27	Henne et al.	

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	1	1508384	GB		1978-04-26	Fives-Cail Babcock		☐
	2	90/12216	WO		1990-10-18	Vickers PLC		☐
	3	2006009968	JP		2006-12-01	Oiles Ind. Co. Ltd.		☒

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /T.R.H/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	
Application Number	
Filing Date	
First Named Inventor	Daniel BRAITHWAITE
Art Unit	
Examiner Name	
Attorney Docket Number	SHEL.3143

	4	102007039364	DE		2008-03-06	Metso Paper		☒
	5	2012/145217	WO		2012-10-26	US Synthetic Corp.		☒

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report from corresponding PCT Application No. PCT/IB2013/055305, date of mailing October 30, 2013, 5 pgs.	☐

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EXAMINER SIGNATURE

Examiner Signature	/THOMAS R HANNON/	Date Considered	04/25/2016

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Daniel BRAITHWAITE
Art Unit	
Examiner Name	
Attorney Docket Number	SHEL.3143

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Susan D. Pitchford/	Date (YYYY-MM-DD)	2014-12-22
Name/Print	Susan D. Pitchford	Registration Number	50945

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /T.R.H/

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Exhibit 1002
FLS v. Metso

 REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /T.R.H/

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14410241	BRAITHWAITE ET AL.
	Examiner	Art Unit
	THOMAS R HANNON	3656

CPC- SEARCHED		
Symbol	Date	Examiner
F16C 32/0666	4/25/2016	trh

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/410,241	12/22/2014	Daniel BRAITHWAITE	SHEL.3143

CONFIRMATION NO. 6897

PUBLICATION NOTICE

152
CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157

OC00000079061756

Title:FLUID BEARINGS

Publication No.US-2015-0345556-A1
Publication Date:12/03/2015

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NUMBER NO.	FIRST NAMED INVENTOR	ATTY. DOCKET NO.
14/410,241	Daniel BRAITHWAITE	SHEL.3143

152
CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157

INTERNATIONAL APPLICATION NO.	
PCT/IB2013/055305	
I.A. FILING DATE	PRIORITY DATE
06/28/2013	06/28/2012

CONFIRMATION NO. 6897
371 ACCEPTANCE LETTER

OC000000077092270

Date Mailed: 08/26/2015

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office, in its capacity as a Designated / Elected Office (37 CFR 1.495), has ACCEPTED the above identified international application for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above. A Filing Receipt will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE or 371(c) DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1) and (c)(2) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN BELOW.** The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363)

12/22/2014
DATE OF RECEIPT OF 35 U.S.C.
371(c)(1) and (c)(2) REQUIREMENTS

The following items have been received:

- Copy of the International Application filed on 12/22/2014
- Copy of the International Search Report filed on 12/22/2014
- Copy of IPE Report filed on 12/22/2014
- Copy of Annexes to the IPER filed on 12/22/2014
- Preliminary Amendments filed on 12/22/2014
- Information Disclosure Statements filed on 12/22/2014
- Inventor's Oath or Declaration filed on 12/22/2014
- Request for Immediate Examination filed on 12/22/2014
- U.S. Basic National Fees filed on 12/22/2014
- Substitute Specification filed on 12/22/2014
- Priority Documents filed on 12/22/2014
- Power of Attorney filed on 12/22/2014
- Authorization to Permit Access filed on 12/22/2014
- Application Data Sheet (37 CFR 1.76) filed on 12/22/2014

Exhibit 1002
FLS v. Metso

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

MARILYN J YOUNGER

Telephone: (571) 272-8183

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/410,241

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	480
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	25 minus 20 =	* 5			OR	x 80 =	400
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 420 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1880

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

Exhibit 1002
FLS v. Metso

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/410,241	12/22/2014		1880	SHEL.3143	25	3

CONFIRMATION NO. 6897

FILING RECEIPT

152
CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
601 SW Second Avenue
Suite 1600
PORTLAND, OR 97204-3157

OC000000077092289

Date Mailed: 08/26/2015

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Daniel BRAITHWAITE, Innaloo, AUSTRALIA;
Jeffrey Victor BELKE, Mt Pleasant, AUSTRALIA;
Nicholas John GREEN, Rivervale, AUSTRALIA;
Chris TATE, Iluka, AUSTRALIA;
Oscar HARRISON, Balcatta, AUSTRALIA;
Knut VAAGE, Oslo, NORWAY;

Applicant(s)

Outotec (Finland) Oy, Espoo, FINLAND
Daniel BRAITHWAITE, Innaloo, Western Australia, AUSTRALIA
Jeffrey Victor BELKE, Mt Pleasant, Western Australia, AUSTRALIA
Nicholas John GREEN, Rivervale, Western Australia, AUSTRALIA
Chris TATE, Iluka, Western Australia, AUSTRALIA
Oscar HARRISON, Balcatta, Western Australia, AUSTRALIA
Knut VAAGE, Oslo, NORWAY

Assignment For Published Patent Application

Outotec (Finland) Oy, Espoo, FINLAND

Power of Attorney: The patent practitioners associated with Customer Number 00152

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/IB2013/055305 06/28/2013

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
AUSTRALIA 2012902770 06/28/2012 No Access Code Provided

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 08/26/2015
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/410,241**
Projected Publication Date: 12/03/2015
Non-Publication Request: No
Early Publication Request: No
Title

FLUID BEARINGS

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET

Substitute for Form PTO-1360
(For use with Form PTO/SB/06)

Application Number	Filing Date
14410241	

Applicant(s) Daniel BRAITHWAITE

* May be used for additional claims or amendments

CLAIMS	AS FILED		AFTER FIRST AMENDMENT		AFTER SECOND AMENDMENT	
	Indep	Depend	Indep	Depend	Indep	Depend
1	1		---	---		
2	1		---	---		
3		2	---	---		
4		2	---	---		
5		2	---	---		
6		(1)	---	---		
7		(1)	---	---		
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23		1	---	---		
24		2	---	---		
25		2	---	---		
26		1	---	---		
27		1	---	---		
28		(1)	---	---		
29		(1)	---	---		
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47				1		
48				1		
49				1		
50				1		
Total Indep	3		3		0	
Total Depend	34	↵	22	↵	0	↵
Total Claims	37		25		0	

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	Indep	Depend	Indep	Depend	Indep	Depend
51				1		
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Exhibit 1002
FLS v. Metso

PTO-1390 (06-13)
Approved for use through 6/30/2013. OMB 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.	U.S. Application No. (if known, see 37 CFR 1.5)
SHEL.3143	

International Application No.	International Filing Date	Priority Date Claimed
PCT/IB2013/055305	28 June 2013 (28.06.2013)	28 June 2012 (28.06.2012)

Title of Invention
IMPROVEMENTS IN FLUID BEARINGS

First Named Inventor
Daniel BRAITHWAITE

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ☑ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ☑ is attached hereto.
   b. ☑ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☑ is attached.
   b. ☑ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☑ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☑ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☑ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ☑ A preliminary amendment.
11. ☑ An Application Data Sheet under 37 CFR 1.76.
12. ☑ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☑ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: _____
16. ☑ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 15 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Exhibit 1002
FLS v. Metso

U.S. APPLN. No. (if known – see 37 CFR 1.5)	INTERNATIONAL APPLICATION No.	ATTORNEY DOCKET No.
	PCT/IB2013/055305	SHEL.3143

17. ☐ Other items or information:

PCT/IB306 mailed 10Sept2013
PCT/IB306 mailed 10June2014
PCT/IB306 mailed 16Oct2014

The following fees have been submitted.	CALCULATIONS	PTO USE ONLY
18. ☑ Basic national fee (37 CFR 1.492(a)) **$280**	$ 280.00	
19. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$720**	$ 720.00	
20. ☑ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .....**$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .....**$480** All other situations **$600**	$ 480.00	
TOTAL OF 18, 19, and 20 =	$ 1480.00	
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). Fee for each additional 50 sheets of paper or fraction thereof **$400**		

Total Sheets	Extra Sheets	Number of each addition 50 or fraction thereof (round **up** to a whole number)	RATE	
- 100 =	/ 50 =		x **$400**	$ 0

Surcharge of **$140.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$ 0

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	25 - 20 =	5	x **$80**	$ 400.00	
Independent claims	3 - 3 =	0	x **$420**	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			**+ $780**	$ 0	
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TOTAL OF ABOVE CALCULATIONS =				$ 1880.00	
☐ **Applicant asserts small entity status.** See 37 CFR 1.27. Fees above are reduced by ½.					
☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Fees above are reduced by ¾. Applicant must attach form PTO/SB/15A or B or equivalent.					
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TOTAL FEES ENCLOSED =				$ 1880.00	
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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File)Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013, and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE 1: By providing this statement under 37 CFR 1.55 or 1.78, **this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA**.

NOTE 2: A U.S. national stage application may not claim priority to the international application of which it is the national phase. The filing date of a U.S. national stage application is the international filing date. See 35 U.S.C. 363.

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(71) Applicant: **OUTOTEC OYJ** [FI/FI]; Puolikkotie 10, FI-02230 Espoo (FI).

(72) Inventors; and

(71) Applicants *(for US only)*: **BRAITHWAITE, Daniel** [AU/AU]; 5/17 Hertha Road, Innaloo, Western Australia 6018 (AU). **BELKE, Jeffrey, Victor** [AU/AU]; 11 Cowrie Cresent, Mt Pleasant, Western Australia 6153 (AU). **GREEN, Nicholas John** [AU/AU]; 98a Toorak Road, Rivervale, Western Australia 6103 (AU). **TATE, Chris** [AU/AU]; 187 Delgado Parade, Iluka, Western Australia 6028 (AU). **HARRISON, Oscar** [AU/AU]; 35 Campsbourne Street, Balcatta, Western Australia 6021 (AU). **VAAGE, Knut** [NO/NO]; Middlethunsgate 23, N-0368 Oslo (NO).

(74) Agent: **SHELSTON IP**; Shelston IP, Level 21, 60 Margaret Street, Sydney, New South Wales 2000 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title**: IMPROVEMENTS IN FLUID BEARINGS

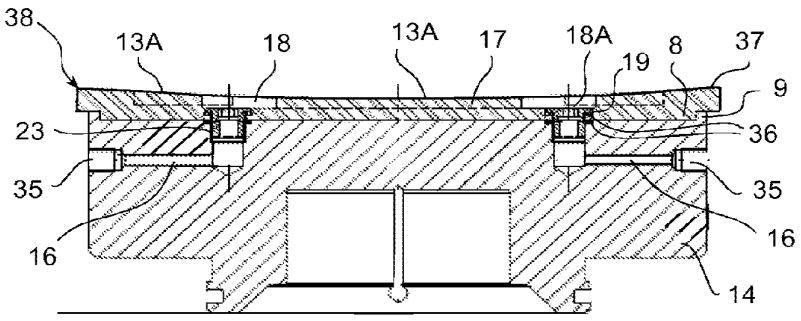


Fig. 6

(57) **Abstract**: The present invention provides improvements to a fluid bearing (11, 12) for a journal (4), one being a polymer bearing pad (17) comprising an outer surface (13), at least one recess (18) for receiving lubricating fluid from a base (14) of said fluid bearing and distributing said lubricating fluid to said outer surface and a mounting means (8, 8A) for securely mounting said polymer bearing pad to said base. Other improvements include a fluid bearing (11, 12) comprising the polymer bearing pad (17), methods of making the polymer bearing pad and fluid bearing, a fluid bearing comprising a polymer bearing pad (17) having a chamfer (37) and a multidirectional fluid bearing (70).

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Exhibit 1002
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"Improvements in fluid bearings"

Field of the Invention

[0001] The present invention relates to a fluid bearing and in a particular a hydrostatic polymeric bearing for use in a mill. The invention has been developed primarily for use as a hydrostatic polymeric bearing in grinding mills and will be described hereinafter by reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use, but also extends to other types of fluid bearings such as hydrodynamic bearings and hybrid bearings (i.e. bearings that use a combination of hydrodynamic and continuous hydrostatic flow for lubrication).

Background of the Invention

[0002] The following discussion of the prior art is intended to present the invention in an appropriate technical context and allow its advantages to be properly appreciated. Unless clearly indicated to the contrary, however, reference to any prior art in this specification should not be construed as an express or implied admission that such art is widely known or forms part of common general knowledge in the field.

[0003] A grinding mill has a mill chamber and two journal shafts, the journals being mounted upon supports for rotation. Typical bearings have two main components; a steel base for mounting to the support and a bearing pad or surface for contact with the mill journal. These mill bearings are installed between the mill journals and the supports so that the mill journals rotate on the bearing pads during operation of the grinding mill.

[0004] The applicant developed a hydrostatic pad bearing system for grinding mills that is currently in use. In this hydrostatic pad bearing system, an external oil supply system pumps high-pressure oil to recesses machined into the bearing so that the oil forms a thin film on the bearing pad surface. The resultant hydraulic pressure is sufficient to completely lift the mill journal off the hydrostatic pads and separate the sliding surfaces. Thus, mill actually “floats” on a film of oil between journal and bearing. As such the bearing will operate under both static and dynamic conditions. Since the surfaces are completely separated and the bearing is self aligning there is no metal-to-metal contact between the bearing surface and the mill journal due to the oil film, thus

resulting in only low friction. Consequently, maintaining the oil film between the surfaces means that there is virtually no wear in the bearing.

[0005] Despite the advantages conferred by this hydrostatic bearing system, a loss of oil pressure (and thus a reduction in the oil film thickness) can cause failure of the bearings, leading to damage to the bearing pad and/or the mill journal. For example, it can take a few seconds for a grinding mill to stop turning in the event of a power failure, and when this happens there is a high risk of damage to the mill bearing pads or journal surfaces due to a loss of oil reducing the oil film thickness, thereby bringing the journal and bearings into direct metal to metal contact. The consequential downtime for replacement of any damaged bearings and/or journals severely impairs operation of the mill, reducing its efficiency.

[0006] To prevent this type of damage, grinding mill lubrication systems usually have pressure accumulator systems that are typically used to store and deliver high pressure oil to the bearing in the event of a power failure and the oil supply system fails. These pressure accumulators are expensive, require frequent maintenance to ensure that they are at the appropriate pressure level and can interfere with control systems in the mill. Thus, there are increased operational and maintenance costs of the mill.

[0007] Typically, to manufacture hydrostatic bearings, the recesses are machined into the steel base and then the oil supply ports for delivering high pressure oil to the recesses are then drilled into the base. Bronze is spray welded or cast onto the relevant parts of the steel base to form the bearing pad or lining. Spray welding enables the bronze metal to form a seal with the base. White metal may be used instead of bronze, but is cast onto the base. Due to this manufacturing process, the repair and/or refurbishment of these bearings involves initially cleaning the damaged bearing surface, machining any parts of the steel base and either spray welding the bronze or re-casting the bronze/white metal. This repair process cannot be performed on-site but requires the bearing to be returned to the manufacturer. Consequently, mills must keep a sufficient stock of spare bearings to account for the absence of damaged bearings being repaired. This adds to the maintenance costs of the mill.

[0008] It is an object of the present invention to overcome or substantially ameliorate one or more of the disadvantages of prior art, or at least to provide a useful alternative.

[0009] It is an object of the invention in at least one preferred form to provide improved fluid bearings for mills that are more tolerant to the loss of oil film, distortions in the journal, require less strict manufacturing tolerances, can be easily repaired, minimise waste and reduce or eliminate the need for pressure accumulators, and a method for making such fluid bearings.

Summary of the Invention

[0010] According to a first aspect of the invention, there is provided a polymer bearing pad for a fluid bearing, comprising an outer surface, at least one recess for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface and a mounting means for securely mounting said polymer bearing pad to said base.

[0011] Unless the context clearly requires otherwise, throughout the description and the claims, the words “comprise”, “comprising”, and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of “including, but not limited to”.

[0012] As used herein, unless otherwise specified the use of the ordinal adjectives "first", "second", "third", etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0013] Preferably, said mounting means comprises a mounting portion extending from said polymer bearing pad. More preferably, said mounting portion comprises a protrusion from a mounting surface opposite to said outer surface for engaging a flange of said base. In one preferred form, said mounting surface comprises an inner surface of said polymer bearing pad. In another preferred form, said inner surface is the underside of said polymer bearing pad.

[0014] Alternatively or additionally, said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer bearing pad to

said base. More preferably, said at least one recess has a locking tab for retaining a head portion of said fastener within said at least one recess.

[0015] Preferably, said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

[0016] Preferably, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said base.

[0017] Preferably, said outer surface is partially curved. Alternatively, said outer surface is substantially planar.

[0018] Preferably, said polymer bearing pad comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said polymer bearing pad comprises two chamfers at opposing outer edges. In one preferred form, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In a particularly preferred form, said chamfer is inclined approximately 8° from said tangent.

[0019] Preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer bearing pad.

[0020] Preferably, said polymer bearing pad comprises at least one complementary connecting portion for connecting said polymer bearing pad to an adjacent polymer bearing pad. In a particularly preferred form, said polymer pad has at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of said adjacent polymer bearing pad.

[0021] Preferably, said polymer bearing pad is made from any suitable polymer, including, but not limited to, polyetheretherketone (PEEK), PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the polymer pad is made of PEEK.

[0022] According to a second aspect of the invention, there is provided a fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port, and

the polymer bearing pad of the first aspect of the present invention mountable to said base.

[0023] Preferably, said polymer bearing pad has the preferred features of the abovementioned first aspect of the invention. In this second aspect, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage.

[0024] Preferably, said base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base. More preferably, said at least one flange is located at an outer edge of said base. In one preferred form, said base comprises two of said flanges located at opposing outer edges of said base.

[0025] Preferably, said fluid bearing comprises at least one fastener for mounting said polymer bearing pad to said base. More preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said bore conveys lubricating fluid from said at least one passage to said interconnecting passage.

[0026] Preferably, said fluid bearing is a hydrostatic bearing. More preferably, said outer surface is partially curved such that said fluid bearing acts as a radial hydrostatic bearing. In one preferred form, said fluid bearing is a self-aligning radial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted radial hydrostatic bearing. In a further preferred form, said fluid bearing is a hydrostatic slipper bearing.

[0027] Alternatively, said outer surface is substantially planar such that said fluid bearing acts as an axial bearing. In one preferred form, said fluid bearing is a self-aligning axial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted axial hydrostatic bearing.

[0028] Preferably, said at least one fastener is partially received in said at least one passage. Preferably, said at least one fastener comprises a head portion for engagement with said at least one recess. More preferably, said at least one recess has a locking tab for retaining said head portion within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

[0029] Alternatively, said fluid bearing comprises a plug for engagement with said head portion and said at least one recess to retain said at least one fastener. In one preferred form, said at least one fastener is countersunk into said at least one recess.

[0030] Preferably, said at least one fastener is substantially retained within said at least one recess by a locking element. More preferably, said locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

[0031] Preferably, the fluid bearing comprises a plurality of said polymer pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

[0032] Preferably, said polymer pads are connected together. More preferably, each of said polymer pads has at least one complementary connecting portion for connecting said polymer pad to an adjacent polymer pad. In one preferred form, each of said polymer pads has at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0033] Preferably, said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

a first of said polymer bearing pads is mountable to said first surface and a second of said polymer bearing pads is mountable to said second surface,

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

[0034] Preferably, said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer bearing pad acts as a self-aligning radial hydrostatic bearing.

[0035] Preferably, said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing. In one preferred form, said second polymer bearing pad acts as a fixedly mounted axial hydrostatic bearing.

[0036] Preferably, said first surface is orthogonal to said second surface. In one preferred form, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0037] According to a third aspect of the invention, there is provided a method of making a polymer bearing pad for a fluid bearing, comprising forming a polymer pad having an outer surface, forming at least one recess in said polymer pad for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface, and forming a mounting means on said polymer pad for securely mounting said polymer pad to said base.

[0038] Preferably, said mounting means forming step comprises forming a mounting portion to extend from said polymer pad. More preferably, said mounting portion forming step comprises machining said polymer pad to form said mounting portion. Alternatively, said mounting portion forming step comprises placing said polymer pad in a mould to form said mounting portion. Alternatively or additionally, said mounting means forming step comprises forming an opening in said at least one recess for receiving at least one fastener. More preferably, said opening is drilled, punched, cut or machined into said at least one recess.

[0039] Preferably, said at least one recess forming step comprises machining said at least one recess in said polymer pad. More preferably, said at least one recess forming

step comprises machining at least one interconnecting passage to interconnect said at least one recess to said base.

[0040] Preferably, said method further comprises chamfering an outer edge of said polymer pad. In one preferred form, said chamfering step comprises chamfering two opposing outer edges of said polymer pad.

[0041] According to a fourth aspect of the invention, there is provided a method of making a fluid bearing for a journal, comprising the steps of:

providing a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port;

forming a polymer pad having an outer surface and at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to said outer surface, and

mounting said polymer bearing pad to said base.

[0042] Preferably, said method comprises each of the preferred steps in the abovementioned third aspect of the invention. In this aspect, said forming step further comprises machining at least one interconnecting passage to interconnect said at least one recess to said passage.

[0043] Preferably, said mounting step comprising mechanically fastening said polymer bearing pad to said base. More preferably, the method further comprises the steps of using a fastener to mechanically fasten said polymer bearing pad to said base and forming a bore in said at least one fastener for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said mounting step comprises bolting said polymer pads to said base.

[0044] Preferably, where there are a plurality of said polymer pads, said method further comprises the step of connecting said polymer bearing pads such that said outer surfaces of said polymer bearing pads form a substantially uniform bearing surface for said journal. More preferably, said forming step further comprises the step of forming at least one connecting portion in each said polymer bearing pad for connecting said polymer pad to an adjacent polymer bearing pad. In one preferred form, said forming step comprises forming at least one lateral connecting portion in each said polymer

bearing pad for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0045] Preferably, said method further comprises selecting one or more polymer bearing pads for mounting at the outer edges of said base and chamfering an outer edge of each selected polymer bearing pad.

[0046] Where said fluid bearing is a radial hydrostatic bearing, each of said polymer pads have curved outer surfaces such that said outer surfaces define a substantially curved uniform bearing surface.

[0047] According to a fifth aspect of the invention, there is provided a fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a polymer bearing pad having at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to an outer surface of said bearing pad,

said polymer bearing pad being mountable to said base and further comprising a chamfer at an outer edge for retaining said lubricating fluid thereon and transferring said lubricating fluid to said journal.

[0048] Preferably, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In one preferred form, said chamfer is inclined approximately 8° from a tangent of an edge of said outer surface.

[0049] Preferably, said chamfer has an outer edge that is displaced from said journal when said journal engages said polymer bearing pad.

[0050] Preferably, the polymer bearing pad is composed of a polymer material that includes, but is not limited to, PEEK, PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the bearing pad is composed of polyetheretherketone (PEEK).

[0051] Preferably, said fluid bearing is a hydrostatic bearing.

[0052] According to a sixth aspect of the invention, there is provided a multidirectional fluid bearing for a journal, comprising:

a base having a first surface, a second surface, at least one lubricating fluid supply port and a plurality of passages in fluid communication with said at least one lubricating fluid supply port, said first surface and said second surface,

a first polymer pad mountable to said first surface, said polymer pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer pad mountable to said second surface, said polymer pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

[0053] Preferably, said first polymer bearing pad substantially covers said first outer surface and said polymer bearing pad substantially covers said second outer surface to respectively create fluid seals between said first and second polymer bearing pads and said base.

[0054] Preferably, at least one of said first and second polymer bearing pads comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said at least one polymer bearing pad.

[0055] Preferably, at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base. More preferably, said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

[0056] Preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess, said at least one fastener being partially received in said at least one passage.

[0057] Preferably, at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base. Preferably, said at least one polymer bearing pad comprises a locking element for retaining said at least one fastener within said at least one recess.

[0058] Preferably, least one of said first and second polymer bearing pads comprises a plurality of said polymer bearing pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal. More preferably, each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0059] Preferably, said first outer surface is partially curved such that said first polymer pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer pad acts as a self-aligning radial hydrostatic bearing.

[0060] Preferably, said second outer surface is substantially planar such that said second polymer pad acts as an axial bearing. In one preferred form, said second polymer pad acts as a fixedly mounted axial hydrostatic bearing.

[0061] Preferably, said first surface is orthogonal to said second surface. In one preferred form, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0062] Preferably, said first polymer bearing pad and said second polymer bearing pad have the preferred features of the abovementioned aspects of the invention.

[0063] Preferably, said lubricating fluid includes oil or water.

Brief Description of the Drawings

[0064] Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0065] Figure 1 is a cross-sectional side view of a grinding mill for receiving a hydrostatic bearing according to a first embodiment of the invention;

[0066] Figure 2 is a perspective view of a bearing assembly in the mill of Figure 1;

[0067] Figure 3 is a front view of the bearing assembly of Figure 2;

[0068] Figure 4 is a schematic plan view of a radial hydrostatic bearing for the bearing assembly of Figure 3;

[0069] Figure 5 is a cross-sectional view of the radial hydrostatic bearing along section A-A of Figure 4;

[0070] Figure 5A is a expanded partial cross-sectional view of the chamfer of the radial hydrostatic bearing of Figure 4;

[0071] Figure 6 is a cross-sectional view of the radial hydrostatic bearing taken along section B-B of Figure 4;

[0072] Figure 7 is a schematic plan view of the base of the radial hydrostatic bearing of Figure 4;

[0073] Figure 8 is a schematic cross-sectional view of the base of Figure 7;

[0074] Figure 9 is a schematic cross-sectional view of an axial hydrostatic bearing for the bearing assembly of Figure 3;

[0075] Figure 10 is a schematic plan view of the axial hydrostatic bearing of Figure 9;

[0076] Figures 11 and 11A are schematic partial views of a fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0077] Figure 12 and 12A are schematic partial views of an alternative fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0078] Figure 13 is a schematic partial view of the chamfer of Figure 5A;

[0079] Figure 14 is a schematic cross-sectional view of a prior art hydrostatic bearing;

[0080] Figure 15 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with another embodiment of the invention;

[0081] Figures 16 and 16A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0082] Figures 17 and 17A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0083] Figures 18 and 18A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0084] Figure 19 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0085] Figure 20 is a schematic partial cross-sectional view of an axial hydrostatic bearing according to a further embodiment of the invention;

[0086] Figure 21 is a schematic partial expanded view of the axial hydrostatic bearing of Figure 20;

[0087] Figure 22 is a schematic side view of the axial hydrostatic bearing of Figure 20;

[0088] Figure 23 is a schematic plan view of a hydrostatic bearing in accordance with a further embodiment of the invention;

[0089] Figure 24 is a schematic end view of the hydrostatic bearing of Figure 23;

[0090] Figure 25 is a schematic side view of the hydrostatic bearing of Figure 23, and

[0091] Figure 26 is a schematic perspective view of a hydrostatic bearing in accordance with a further embodiment of the invention.

Preferred Embodiments of the Invention

[0092] Referring to Figure 1, a typical grinding mill 1 comprises a milling chamber or body 2 rotatably mounted on supports 3 via journal shafts 4 and bearing assemblies 5. The mill body 2 has an inlet 6 for introducing a charge for grinding and a discharge outlet 7 for removing the processed charge from the mill 1.

[0093] As best shown in Figures 2 and 3, each bearing assembly 5 has a frame 10 and a plurality of fluid bearings in the form of radial hydrostatic bearings 11 and axial hydrostatic bearings 12, which are designed to transport a lubricating fluid in the form of a high pressure oil to an outer surface 13A, 13B of each bearing 11, 12.

[0094] Referring to Figures 4 to 8, where corresponding features have been given the same reference numerals, each radial hydrostatic bearing 11 comprise a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. The hydrostatic bearings 11, 12 are self-aligning in that the hydrostatic bearings self-adjust to any changes in the angular position of the journals 4 during operation of the mill 1. This is typically achieved by having the base 14 mounted on a spherical seat (not shown) to permit self-adjustment to any angular movement of the journals 4. The base 14 is composed of cast iron, but can be made of any other suitable metal or material.

[0095] A polymer pad 17 is mountable to the base 14 of each radial hydrostatic bearing 11 via a mounting portion 8 extending from the polymer pad. In this embodiment, the mounting portion 8 is a protrusion extending from a mounting surface opposite the outer surface 13A to engage flanges 9 located at respective outer edges or sides of the base 14. Generally, the mounting surface will be an inner surface or the underside of the polymer pad 17, but in other embodiments can be located elsewhere. Likewise, the flanges 9 need not be located at opposing outer edges of the base 14, but

can be arranged in any manner that would act to hold captive the bearing pad 17, such as the flanges 9 being located closer to the centre of the base 14 rather than at the outer edges or the flanges 9 being opposed herringbone flanges positioned on the base 14 between which the mounting portions 8 are constrained.

[0096] The polymer bearing pad 17 has at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13A to act as a lubricating fluid between the radial hydrostatic bearing 11 and the journal shafts 4. In the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19. Also, the radial hydrostatic bearings 11 have a plurality of oil supply ports 15, oil galleries 16, recesses 18 and interconnecting passages 19.

[0097] The outer surface 13A of the polymer pad 17 of the radial hydrostatic bearings 11, 12 is curved to receive the curved bearing surface 20 of the journal 4, as best shown in Figures 1, 9, 11 and 11A. Thus, the outer surface 13A of the polymer pad 17 forms a bearing surface, and hence the polymer pad is a bearing pad for the bearings 11 when assembled with the base 14.

[0098] Referring to Figures 9 and 10, where corresponding features have been given the same reference numerals, each of the axial hydrostatic bearings 12 also comprises a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. A polymer pad 17 is mountable to the base 14 of each axial hydrostatic bearing 12, the polymer pad 17 having at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13B to act as a lubricating fluid between the axial hydrostatic bearings 12 and the journal shafts 4. Again, in the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19 in the polymer pad 17. In addition, the axial hydrostatic bearings 12 have a plurality of oil galleries 16 in the base 14, and recesses 18 and interconnecting passages 19 in the polymer pad 17.

[0099] Also, the outer surface 13B of the axial hydrostatic bearing 12 is substantially planar as it receives the substantially planar end surface 21 of the journal 4, as best shown in Figure 1. Similarly to outer surface 13A, the outer surface 13B of the polymer

pad 17 also forms a bearing surface, and hence the polymer pad is a bearing pad for the bearings 12 when assembled with the base 14.

[00100] In both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 substantially covers the entire outer surface 22 of the base 14 to form a substantially fluid impermeable seal between the base and the polymer pad. Also, the polymer pad 17 is mounted to the base 14 using at least one fastener in the form of bolts 23, as best shown in Figures 5 and 9. The fastening system for both the radial hydrostatic bearing 11 and the axial hydrostatic bearing 12 is described in more detail below.

[00101] The fastening system for mounting the polymer pad 17 to the bases 14 of the radial and axial hydrostatic bearings 11, 12 is illustrated in more detail in Figures 11 and 11A, where corresponding features have been given the same reference numerals. The fastening system comprises one of more bolts 23 that are inserted into corresponding openings 18A that are in fluid communication with the oil galleries 16. Each bolt 23 has a bore in the form of through bore 24 for conveying oil from the oil galleries 16 to the recesses 18 via a discharge port 25, as best shown in Figure 11. Thus, there is no need to provide separate oil passages between the oil galleries 16 in the base 14 and the recesses 18 in the polymer pad 17, unlike conventional bronze/white metal hydrostatic bearings. This reduces the complexity and cost in the manufacture of the hydrostatic polymer bearings. It will be appreciated that not all the bolts necessarily will have a bore as sometimes more fasteners are required to mount the polymer bearing pad 17 than the number of oil passages to connect the oil galleries 16 to the recesses 18.

[00102] The bolt 23 is inserted into the oil gallery 16 via the opening 18A and has a head portion 26 for engagement with a seat 27 of the recess 18, as best shown in Figure 11A. The bolt 23 engages the recess 18 to ensure that, in the event of the bolt becoming loose, it is held captive within the recess 18. This prevents any loose bolts 23 coming into contact with and damaging the journal 4. A locking tab 28 is also provided for retaining the head portion 26 within the recess 18. In addition, the head portion 26 has a tapered portion 29 to facilitate retention of the bolt 23 within the recess 18 by the locking tab 28.

[00103] Also, the mounting portion 8 of the polymer pad 17 engages the flanges 9 of the base 14 to help lock the polymer pad in place. This ensures that frictional loads

generated during the rotation of the journal 4 do not forcibly remove or "wipe" the polymer pad 17 from the base 14, even where the bolts 23 become loose, such that the mounting portion 8 and flanges 9 in effect replace the restraint of the bolts 23 against frictional related lateral loads. This makes for a very simple but reliable arrangement, with a level of redundancy to ensure correct operation even if the bolts 23 become loose.

[00104] Moreover, hydrostatic pressure acts between the journal 4 and the polymer bearing pad 17, while there is atmospheric pressure between the polymer bearing pad and the base 14. This pressure difference during operation of the fluid bearing 11, 12, together with the engagement of the mounting portion 8 and the flange or shoulder 9, acts to hold the polymer bearing pad 17 in place. In practice, the fastening system primarily assists in the initial installation of the polymer bearing pad 17 since there is no pressure between polymer bearing pad and the journal 4. This means that in the event bolts 23 are loose the polymer bearing pad 17 would be free to move or "float" until the hydrostatic pressure at the journal 4 is greater than the atmospheric pressure between polymer bearing pad and the base 14.

[00105] An alternative fastening arrangement is illustrated in Figure 12, where corresponding features have been given the same reference numerals. The fastener takes the form of a countersunk screw 30 having a tapered head portion 31 for engagement with a seat 27 recessed in the polymer pad 17. Due to the screw 30 being countersunk into the base 14 and the polymer pad 17, the head portion 31 is tapered in the reverse direction to the taper of the head portion 26 of the bolt 23. To prevent any screw 30 becoming loose and coming into contact with the journal 4, a plug 32 is used to engage the head portion 31 and a locking tab 28 is used to retain the plug 32, and thus the screw 30, within the seat 27. Oil is delivered to the outer surface 13 through a separate recess in the form of a hole 33 that is connected to a bore 34 located over the same position as the oil gallery 16 in the base 14 below, as best shown in Figure 12A.

[00106] In either fastening arrangement, separate O-rings 36 are fitted to the base 14 to provide a fluid seal preventing oil leaking in between the polymer pad 17 and the base, as best shown in Figures 9, 11, 11A and 12A. The thread into which the bolts 23 also assists in forming a fluid seal between the polymer bearing pad 17 and the base 14.

The threads 35 act as plugs to close off holes that are required for machining the oil galleries 16 that direct lubricating fluid into the corner pockets from the central pocket.

[00107] In operation, the radial and axial hydrostatic bearings 11, 12 are installed in the bearing assembly 5 in the positions generally shown in Figure 3 in a manner readily understood by a person skilled in the art. The mill body 2 is then mounted on the bearing assembly 5 via the journals 4. An oil supply system is fluidly connected to the oil supply ports 15 in the base 14 of each radial and axial hydrostatic bearing 11, 12. Typically, the oil is positively pumped to the oil supply ports 15. However, in some variants, the oil need not be supplied by positive displacement pump. In either case, high pressure oil is conveyed from the oil supply ports 15 through the passages 16, bores 23 and interconnecting passages 19 to the recesses 18 and discharge ports 25 and up to the outer surfaces 13A, 13B, as best shown by arrow 39 in Figure 11. The oil collects on the outer surfaces 13A, 13B to create an oil film and lubricate the bearing surfaces 20, 21 of the journals 4.

[00108] Where there is a loss of oil due to a failure in the oil supply system, the polymer pad 17 absorbs most, if not all, of the detrimental effects so any damage is limited to the polymer pad 17 rather than the bearing surfaces 20, 21 of the journal 4 or the base 14. Thus, the base 14 (and its oil galleries 16 and oil supply ports 15) are protected from damage and any damage is suffered by the polymer pad 17. Thus, by having the polymer pad 17 provided with recesses 18 for distributing oil to the outer surface 13, rather than the base 14, the polymer pad can be easily replaced in the event of damage without having to repair the entire bearing. In addition, this advantage is further facilitated by using mechanical fasteners described above to mount the polymer pad 17. Thus, a damaged polymer pad 17 can be removed simply by removing the fasteners 23, 30, enabling easy replacement of the polymer pads 17. Thus, maintenance and operational costs of the mill 1 are reduced, increasing the efficiency of the mill.

[00109] It has also been discovered that providing a polymer pad for the hydrostatic bearings 11, 12 confer numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads, as follows:

(1) It has been discovered that the polymer pad 17 behaves similar to white metal/bronze pads, but is able to self-mould to the journal 4. That is, the polymer pad 17 is able to modify its outer surface 13A, 13B to accommodate circumferential surface imperfections on the bearing surfaces 20, 21 of the journal 4. This reduces or eliminates the need for tight machining tolerances required for bronze bearings, and can subsequently reduce the associated machining costs. Hence, there is a reduced manufacturing cost for the hydrostatic bearings by using a polymer pad.

(2) The polymer bearing pads 17 enable reduced lubrication rates to be used over traditional bronze bearing pads due to the running in characteristics of polymer material, thus conserving lubricating fluid. However, where necessary or desirable, the polymer pads 17 operate equally well at the same lubrication rates used for conventional bronze/white metal bearing pads.

(3) The hydrostatic polymer bearing pads 17 have a lower modulus of elasticity, and thus are able to create a "hovercraft" type cushion around the perimeter of the polymer pad. This acts to accommodate journal imperfections whilst maintaining pressure, much like the cushioning effect produced when a hovercraft moves over bumpy ground.

(4) The hydrostatic polymer bearing pads 17 are much more tolerant than traditional materials to a loss of oil to the bearing 11,12, to contact between journal 4 and outer surface 13A, 13B, and to deformations in the journal bearing surfaces 20, 21. Thus, a loss of oil film due to oil viscosity being too low (from such causes as a high temperature or oil degradation) can be more tolerably managed by the polymer pad 17.

(5) The polymer is elastic, unlike bronze, and is significantly softer than bronze. Thus, the elastic nature of the polymer pads 17 dampen excessive forces that are applied to the hydrostatic bearings 11, 12. For example, where there is a loss of oil through a shock load placed on the hydrostatic bearing 11, 12 there is little or no risk of damage to the metal journal 4 because the polymer pad 17 dampens the shock to some extent and any damage sustained is suffered by the polymer pad rather than the journal. By way of contrast, with white metal/bronze bearings there

is a significant risk of damage to metal journals, resulting in on-site machining and costly stoppages. This advantage of the elasticity of the polymer bearing pads also extends to white metal bearing pads, which are brittle and so are more easily damaged when subjected to typical shock loads.

(6) Any contaminants in the oil that would normally damage the bearing surfaces of the journal 4 or a standard bearing pad tend to be embedded into the polymer pad 17 without adversely affecting operation of the hydrostatic bearing 11, 12.

(7) The self-moulding property of the polymer pads 17 means that the outer surfaces 13A, 13B of the polymer pads tend to conform to the profile of the bearing surface 21 of the journal 4 that it is running against. As a consequence, the polymer pads 17 (and hence bearing 11) do not necessarily require a self-alignment mechanism (such as a spherical seat) within certain limits, unlike conventional bearings. It is also contemplated that the self-moulding property also permits the design and installation of hydrostatic bearings that ordinarily would be outside of the capacity of conventional bearings, since the polymer pad 17 can provide some degree of self-alignment in addition to a conventional self-alignment mechanism.

[00110] These advantages of the polymer pad 17 means that the hydrostatic bearings can be operated at lower oil film thicknesses. This has a flow on effect, permitting the use of smaller and cheaper lubrication systems, reducing power consumption and conserving the use of oil. Also, in the event of operational problems damage to the journals 4 and polymer bearing pads 17 is significantly reduced, increasing product life and reducing the frequency of maintenance and repair. Furthermore, any damage is limited to the polymer bearing pads 17 and does not adversely affect operation of the journal 4. Finally, the complex and expensive accumulator systems can be removed, saving installation costs and eliminating their associated maintenance costs.

[00111] Referring now to Figures 5A, 9 and 13, another aspect of the invention is described, where corresponding features have been given the same reference numerals. In this aspect of the invention, a chamfer is provided at an outer edge of a bearing pad for retaining lubricating fluid on the chamfer, thus enabling recycling of lubricating fluid in the bearing. In applying this aspect of the invention to both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 has a chamfer 37 at both

outer edges 38 for retaining oil on the chamfer, as best shown in Figures 5A, 9 and 13. The chamfer 37 creates a lead-in and lead-out for the oil, especially when residual oil on the outer surfaces 13A, 13B must be relied upon for lubrication in the event of an unexpected loss of normal oil supply to the bearings 11, 12. The chamfer 37 inhibits or prevents oil being wiped off the journal 4, as would occur with a bearing having a sharp straight edge. Thus, the chamfer 37 helps to ensure that there is a residual amount of oil between the polymer pad 17 and the metal journal 4.

[00112] In a conventional bearing, the straight edge would wipe off oil from the journal and thus increase the loss of oil from the bearing. By way of contrast, in this aspect of the invention, the chamfer 37 provides a capture point for the oil that may be lost during operation. As the journal 4 rotates on the hydrostatic bearing 11, 12 the "lead-in" chamfer 37 enables the bearing surface 20 of the journal 4 to capture oil from the chamfer 37 and thus is lubricated before coming into contact with the outer surface 13A, 13B of the hydrostatic bearing. The inventors believe that the oil held by the "lead-in" chamfer 37 is recaptured by the journal 4 due to a hydrodynamic effect produced by its rotation. When the bearing surface 20 of the journal 4 leaves the outer surface 13A, 13B of the hydrostatic bearing, the "lead-out" chamfer 37 on the other side of the hydrostatic bearing 11, 12 feeds any discharging oil from the outer surface 13A, 13B onto the journal to provide a consistent oil thickness over the journal, thus maintaining its lubrication. The provision of chamfers 37 at each outer edge 38 enables the mill journal 4 to be operated in either rotational direction. As a consequence, the use of the chamfers 37 minimises the loss of oil and effectively removes the need to provide oil pressure accumulators with their associated high maintenance and installation costs. Therefore, the chamfers 37 provide the radial and axial hydrostatic bearings 11, 12 provide a cost effective solution and safety measure for the hydrostatic bearings.

[0100] The chamfer 37 is inclined approximately at an angle α to the outer surface 13A, 13B. In the case of the radial hydrostatic bearing 11, the angle α is defined relative to a tangent 39 from the curved outer surface 13A, as best shown in Figure 13. In the case of the axial hydrostatic bearing 12, the angle α is defined relative to the horizontal plane of the planar outer surface 13B. In either case, the angle α is in the range of 0.01° to 89°, and is preferably 8°.

[0101] In addition, the chamfer 37 has an outer edge 40 that is displaced from the journal 4 when the journal engages the polymer pad 17. In both the radial and axial hydrostatic bearings 11, 12 the outer edge 40 of the chamfer 27 is displaced approximately 0.5mm to 1.5 mm from the journal 4. The displacement β is preferably displaced by approximately 0.85 mm from the journal 4.

[0102] It will be appreciated by a person skilled in the art that the chamfer 37 could also be applied to existing bronze/white metal hydrostatic bearings and is not limited to hydrostatic bearings having a polymer pad.

[0103] Referring now to Figures 14 to 19, various methods of making the polymer pads 17 and the hydrostatic bearings 11, 12 of Figures 4 to 10 are illustrated, where corresponding features have been given the same reference numerals. As best shown in Figure 14, manufacturing the curved surface for a radial hydrostatic bearing involves removing the hatched area 41 from the material. This waste material can be a significant, especially on larger bearings, and contributes to unnecessary additional manufacturing costs. Furthermore, the manufacturing process is not environmentally sustainable.

[0104] With the hydrostatic bearings of Figures 4 to 10, polymer material can be purchased "off the shelf" in sheet form and subsequently formed to produce the polymer pads 17. One method involves heating the polymer material to a holding temperature which does not melt the material, but the polymer retains some structural integrity while having some malleability or pliability to be able to be formed. There are various procedures that can be used to heat and form the polymer readily understood by the person skilled in the art.

[0105] In one example, the polymer can be placed in a shaped former or mould and lightly clamped. The former or mould is then heated to an intermediate temperature, removed from oven, fully clamped and returned to the oven. After heating to a holding temperature, the former is held for a set period of time, removed from oven and allowed to cool.

[0106] In another example, the polymer is placed in a shaped former and clamped using springs or a dead weight. The former is heated to the holding temperature and

kept at this temperature for a set period of time. After being allowed to cool, the polymer is removed from the former.

[0107] In a further example, the polymer sheet is heated to the holding temperature for set period of time to ensure uniform heating of material. The polymer is then removed from the heat, immediately placed in cold former and pressed to profile. In the case of a radial hydrostatic bearing 11, the former also creates the curved outer surface 13A. After being allowed to cool, the polymer pad 17 is removed from the former.

[0108] After assuming the required shape for the hydrostatic bearing 11, 12, the recesses 18 and interconnecting passages 19 are machined into the outer surface 13A, 13B of the polymer pad 17. Also, the chamfer 37 is machined at the same time. The mounting portion 8 is machined, either before or after machining of the recesses 18, interconnecting passages 19 and the chamfer 37. Alternatively, the mounting portion 8 is formed during the initial moulding of the polymer sheet. The openings 18A can also be formed either during the initial moulding or by drilling, punching, cutting or machining the polymer pad 17. The machined polymer pad 17 is then mechanically mounted to the base 14 using the fastener systems described above to complete assembly of the hydrostatic bearing 11, 12.

[0109] Referring now to Figures 15 to 16, another method of making the hydrostatic bearings is illustrated, where corresponding features have been given the same reference numerals. This method involves making a plurality of polymer pads in the form of slats 50 each having outer surfaces 51 that form a substantially uniform bearing surface 52 for the journal 4, as best shown in Figure 15. The slats 50 are produced using the same heating and forming method described above, and then fastened to the base 14 using either of the fastener systems as described in relation to Figures 4 to 10. As best shown in Figure 15, the resultant amount of removed material indicated by hatched area 53 is considerably less than the amount of material removed in a conventional bearing indicated by hatched area 41.

[0110] Also, the polymer pad 17 can be divided into any number of smaller polymer pads or slats 50 of any shape and/or size, as required. For example, there could be six polymeric slats 50 that are rectangular and uniform in shape but have differently shaped

recesses, as best shown in Figures 16, 16A, 17 and 17A. Similarly, the polymeric slats 50 could be larger in size, as best shown in Figures 18 and 18A.

[0111] In a further variation to this method, the polymeric slats 55 each have complementary connecting portions 56 to connect with an adjacent polymer pad 55, as best shown in Figure 19. The complementary connecting portions in this variation take the form of teeth 56 that are splayed together so that the slats 55 form a complete polymer pad 17. The polymer pads 55 are then mounted to the base 14 using either of the fastener systems as described in relation to Figures 4 to 10. Once in position, glue may be applied at adjacent surfaces of the polymer slats and their teeth 56 to enhance sealing. Then, the polymer slats 55 are clamped and heated to cure the adhesive joint. The joint formed by the connecting teeth 56 is such that the weight of mill journal 4 on the polymeric slats 55 works to ensure the joint is always in compression. It has been found by testing such bearings that they are strong enough as a bearing surface for the journal 4. It will be appreciated that other profiles for the connecting portions 56 can be used, such as tabs and detents of any polygonal shape.

[0112] The inventors believe that segmenting the surface area of the polymer pad 17 into individual polymer pads or slats 50reduces the amount of wastage involved with machining standard bearings, as indicated in area 41 of Figure 14, and provides a suitable supplementary option to heating and forming the entire polymer pad 17 as described above.

[0113] While the hydrostatic bearings 11, 12 have been described in the context of self-aligning hydrostatic bearings, it will be appreciated that the various aspects of the invention are also equally applicable to fixedly mounted hydrostatic bearings. Referring now to Figures 20 to 22, one example of a fixedly mounted hydrostatic bearing 60 is illustrated, where corresponding features have been given the same reference numerals. In this embodiment, the fixedly mounted hydrostatic bearing is an axial hydrostatic bearing 60 comprises a polymer pad 17 mounted on a base 14, which is fixedly mounted to mounting plate 61 via fasteners 62. Due to the polymeric nature of the polymer bearing pad 17, the outer surface 13B of the polymer pad will conform to the profile of the bearing surface 21 of the journal 4 that it is running against. This means that the axial hydrostatic bearing can provide some degree of self-alignment, if necessary, which is not possible in a conventional axial hydrostatic bearing. Aside from

the manner of its mounting, the axial hydrostatic bearing 60 operates in substantially same manner as the self-aligning axial hydrostatic bearing 12 described above. Furthermore, while this embodiment concerns as axial hydrostatic bearing, it is also applicable to a fixedly mounted radial hydrostatic bearing.

[0114] Referring now to Figures 23 to 25, a fluid bearing 70 according to another aspect of the invention is illustrated, where corresponding features have been given the same reference numerals. The fluid bearing 70 is a hydrostatic bearing that is a combination of the radial and axial hydrostatic bearings 11, 12, 60 described above. The base 71 has been adapted to receive both a polymer pad 17A having a radial or curved outer surface 13A mounted on its outer surface 72 and two polymer pads 17B having a substantially planar outer surface 13B mounted on opposing side surfaces 73 that are orthogonal to the outer surface 72. Thus, the combination hydrostatic bearing 70 acts as a self-aligning radial hydrostatic bearing 11 in one direction and as two fixedly mounted axial hydrostatic bearings 60 in two other directions, as best shown in Figure 25. Again, due to the polymer's characteristics the outer surfaces 13B of the polymer pads 17B with conform to the profile of the bearing surface 21 of the journal 4 that it is running against. Thus, there is no need for a separate base for the axial hydrostatic bearings. The inventors contemplate that this combination hydrostatic bearing 70 avoids the need to install three separate hydrostatic bearings and thus allows for ease of installation in the mill 1. Due to the easy replacement of the polymer pads 17A, 17B, there is no need to remove the base 71 in the event one or more of the polymer pads 17A, 17B are damaged during operation of the mill 1. Thus, the combination hydrostatic bearing 70 creates cost savings in installation and repair.

[0115] The inventors also contemplate that the combination bearing 70 can be modified so as to minimise or eliminate the "axial float". Axial float is the difference between the distance between axial bearing pads and the distance between axial journal faces. Axial float is generally required so that the axial hydrostatic bearings are not tightly fitted with the mill journal 4. Typically, this axial float is set to around 0.5 to 1mm, meaning that the mill journal is able to freely float in the axial direction by this 0.5 to 1mm. A potential advantage of this combination bearing 70 is that the amount of axial float can be reduced or eliminated, since one of the axial bearings on the combination bearing 70 can be configured to move axially on a piston which is supplied by pressurised oil. This effectively ensures that axial float is minimised or removed.

[0116] In other embodiments, the hydrostatic bearing takes the form of a slipper bearing 80, as best shown in Figure 26. Due to the larger size of the bearing pad for a slipper bearing and its 120° curvature, it could be difficult to mould a single polymer pad 17. Thus, segmenting the bearing pad surface into multiple polymer pads or slats 81 having curved outer surfaces and laterally connected together enables the invention to be used for a slipper bearing. The lateral connections can be formed as described in relation to Figure 19. Thus, the advantages of the polymer pad 17 can be extended to a slipper bearing.

[0117] In the preferred embodiments of the invention, the polymer pad 17 is made of polyetheretherketone (PEEK). However, it will be appreciated that other polymer materials are also suitable for the hydrostatic bearings 11, 12, such as PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. Also, while the preferred embodiments of the invention have been described as employing oil as the lubricating fluid, other lubricating fluids can be used such as water.

[0118] It will be appreciated by a person skilled in the art that the hydrostatic bearings of the preferred embodiments of the invention can be readily retrofitted into existing bearing assemblies, and thus do not require the replacement of each bearing in a milling apparatus.

[0119] While the preferred embodiments of the invention have been described using one of two possible fastener arrangements as illustrated in Figures 11, 11A, 12 and 12A, it will be appreciated that other fastener type arrangements may be used to implement the invention. For example, in one preferred form the fasteners are substantially retained within the recesses 18 by a locking element. The locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

[0120] In another embodiment, the outer (bearing) surface of the polymer bearing pad comprises two co-planar surfaces at 45° to each other. In this embodiment, the polymer bearing pad acts as both a linear and axial bearing pad simultaneously, similar to a lathe bed bearing.

[0121] It will further be appreciated that any of the features in the preferred embodiments of the invention can be combined together and are not necessarily applied in isolation from each other. For example, the chamfer 37 could be readily applied to the outermost polymer slats 81 in the slipper bearing to provide the advantages of reducing oil loss and elimination of oil pressure accumulators.

[0122] Also, while the preferred embodiment of the invention have been described in relation to hydrostatic bearings in general, it will be appreciated that each of the aspects of the invention and the corresponding preferred features are also applicable to other types of fluid bearings, such as hydrodynamic bearings and hybrid bearings that use a combination of hydrodynamic and a continuous hydrostatic flow for lubrication.

[0123] By providing a polymer bearing pad for a hydrostatic bearing, the invention confers numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads. The polymer bearing pads 17 reduces or eliminates damage to the journal and the base of the hydrostatic bearing, thus increasing product life and reducing the frequency of maintenance and repair. Moreover, the polymer pads 17 are easily replaceable, enabling easy installation and removal for repair. This advantage is facilitated by the use of the mounting portion 8, flange 9 and a mechanical fastening system to mount the polymer pad 17 to the base 14.

[0124] Also, the polymer pads 17 do not require tight machining tolerances, can conform to the profile of the journal, have reduced lubrication rates enabling the use of less oil, resistant to damage caused by the loss of oil or contaminants, and dampen any excessive shock forces, protecting the journal bearing surface. These advantages permits the operation of the hydrostatic bearings of the preferred embodiments of the invention at lower oil film thicknesses, thus reducing oil consumption, permitting the use of smaller and cheaper lubrication systems and more efficient power consumption and conserving the use of oil.

[0125] Also, the use of chamfer in hydrostatic bearings in general obviates the need for expensive accumulator systems that are difficult to operate and maintain. Furthermore, the chamfer conserves the use of oil and thus reduces oil consumption. Furthermore, since the base is of a standard design, the hydrostatic bearings of the

invention can be readily retrofitted to existing mills. In all these respects, the invention represents a practical and commercially significant improvement over the prior art.

[0126] Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

Claims

1. A polymer bearing pad for a fluid bearing, comprising an outer surface, at least one recess for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad to said base.

2. The polymer bearing pad of claim 1, wherein said mounting means comprises a mounting portion extending from said polymer bearing pad.

3. The polymer bearing pad of claim 2, wherein said mounting portion comprises a protrusion from a mounting surface opposite to said outer surface for engaging a flange of said base.

4. The polymer bearing pad of any one of the preceding claims, wherein said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base.

5. The polymer bearing pad of claim 4, wherein said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess.

6. The polymer bearing pad of any one of the preceding claims, wherein said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

7. The polymer bearing pad of any one of the preceding claims, further comprising a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal.

8. The polymer bearing pad of claim 7, wherein said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer pad.

9. The polymer bearing pad of any one of the preceding claims, wherein said outer surface is partially curved. .

10. The polymer bearing pad of any one of claims 1 to 8, wherein said outer surface is substantially planar.

11. The polymer bearing pad of any one of the preceding claims, further comprising at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

12. A fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port, and

the polymer bearing pad of any one of the preceding claims mountable to said base.

13. The fluid bearing of claim 12, wherein base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base.

14. The fluid bearing of claim 13, wherein said flange is located at an outer edge of said base.

15. The fluid bearing of any one of claims 10 to 14, said at least one recess of said polymer bearing pad comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage of said base.

16. The fluid bearing of any one of claims 10 to 15, further comprising at least one fastener for mounting said polymer bearing pad to said base, said at least one fastener comprising a bore for conveying lubricating fluid from said at least one passage to said at least one recess.

17. The fluid bearing of claim 16, wherein said at least one recess has a locking tab for retaining said head portion within said at least one recess.

18. The fluid bearing of claim 16, further comprising a plug for engagement with said head portion and said at least one recess.

19. The fluid bearing of claim 16 or 18, further comprising a locking element for retaining said at least one fastener within said at least one recess.

20. The fluid bearing of any one of claims 12 to 19, further comprising a plurality of said polymer bearing pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

21. The fluid bearing of claim 20, wherein each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

22. The fluid bearing of any one of claims 12 to 21, wherein said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

a first of said polymer bearing pads is mountable to said first surface and a second of said polymer bearing pads is mountable to said second surface.

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

23. The fluid bearing of claim 22, wherein said first surface is orthogonal to said second surface.

24. The fluid bearing of claim 22 or 23, wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

25. The fluid bearing of any one of claims 12 to 21, wherein said fluid bearing is at least one of a radial hydrostatic bearing, a self-aligning radial hydrostatic bearing, a

fixedly mounted radial hydrostatic bearing, a hydrostatic slipper bearing, an axial bearing, a self-aligning axial hydrostatic bearing and a fixedly mounted axial hydrostatic bearing.

26. A method of making a polymer bearing pad for a fluid bearing, comprising forming a polymer pad having an outer surface, forming at least one recess in said polymer pad for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface, and forming a mounting means on said polymer pad for securely mounting said polymer pad to said base.

27. The method of claim 26, wherein said mounting means forming step comprises machining said polymer pad to form a mounting portion extending from said polymer pad.

28. The method of claim 26, wherein said mounting means forming step comprises drilling, punching, cutting or machining an opening in said at least one recess to receive at least one fastener.

29. The method of claim 26 or 28, further comprising chamfering an outer edge of said polymer pad.

30. The method of any one of claims 26 to 29, wherein said at least one recess forming step comprises machining said at least one recess in said polymer pad and machining at least one interconnecting passage to interconnect said at least one recess to said base.

31. A method of making a fluid bearing for a journal, comprising:

providing a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port and at least one flange;

making a polymer bearing pad in accordance with the method of any one of claims 26 to 30, and

mounting said polymer bearing pad to said base.

32. The method of claim 31, wherein said mounting step comprising mechanically fastening said polymer bearing pad to said base.

33. The method of claim 31 or 32, wherein there are a plurality of said polymer pads, said method further comprising connecting said polymer bearing pads such that said outer surfaces of said polymer bearing pads form a substantially uniform bearing surface for said journal.

34. The method of claim 33, further comprising forming at least one lateral connecting portion in each said polymer bearing pad for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

35. The method of claim 33 or 34, wherein said further comprises selecting one or more polymer bearing pads for mounting at the outer edges of said base and chamfering an outer edge of each selected polymer bearing pad.

36. A fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a polymer bearing pad having at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to an outer surface of said bearing pad,

said polymer bearing pad being mountable to said base and further comprising a chamfer at an outer edge for retaining said lubricating fluid thereon and transferring said lubricating fluid to said journal.

37. The fluid bearing of claim 36, wherein said chamfer is inclined approximately 8° from a tangent of an edge of said outer surface.

38. The fluid bearing of claim 36 or 37, wherein said chamfer has an outer edge that is displaced from said journal when said journal engages said polymer bearing pad.

39. A multidirectional fluid bearing for a journal, comprising:

a base having a first surface, a second surface, one or more lubricating fluid supply ports and a plurality of passages in fluid communication with said lubricating fluid supply ports, said first surface and said second surface,

a first polymer bearing pad mountable to said first surface, said polymer bearing pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer bearing pad mountable to said second surface, said second polymer bearing pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

40. The multidirectional fluid bearing of claim 39, said first polymer bearing pad substantially covers said first outer surface and said polymer bearing pad substantially covers said second outer surface to respectively create fluid seals between said first and second polymer bearing pads and said base.

41. The multidirectional fluid bearing of claim 40, wherein at least one of said first and second polymer bearing pads comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal.

42. The multidirectional fluid bearing of claim 41, wherein said chamfer has an outer edge that is displaced from a journal when said journal engages said at least one polymer bearing pad.

43. The multidirectional fluid bearing of any one of claims 39 to 42, wherein at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base, wherein said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess, said head portion being tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

44. The multidirectional fluid bearing of any one of claims 39 to 43, wherein said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess, said at least one fastener being partially received in said at least one passage.

45. The multidirectional fluid bearing of any one of claims 39 to 42, wherein at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base, and further comprising a locking element for retaining said at least one fastener within said at least one recess.

46. The multidirectional fluid bearing of any one of claims 39 to 45, wherein at least one of said first and second polymer bearing pads comprises a plurality of said polymer bearing pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

47. The fluid bearing of claim 46, wherein each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

48. The multidirectional fluid bearing of claim 39, wherein at least one of said first polymer bearing pad and said second polymer bearing pad comprises said polymer bearing pad of any one of claims 1 to 11.

49. The multidirectional fluid bearing of claim 48, wherein base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base.

50. The multidirectional fluid bearing of claim 49, wherein said flange is located at an outer edge of said base.

51. The multidirectional fluid bearing of any one of claims 39 to 50, wherein said first surface is orthogonal to said second surface.

52. The multidirectional fluid bearing of any one of claims 39 to 51, wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

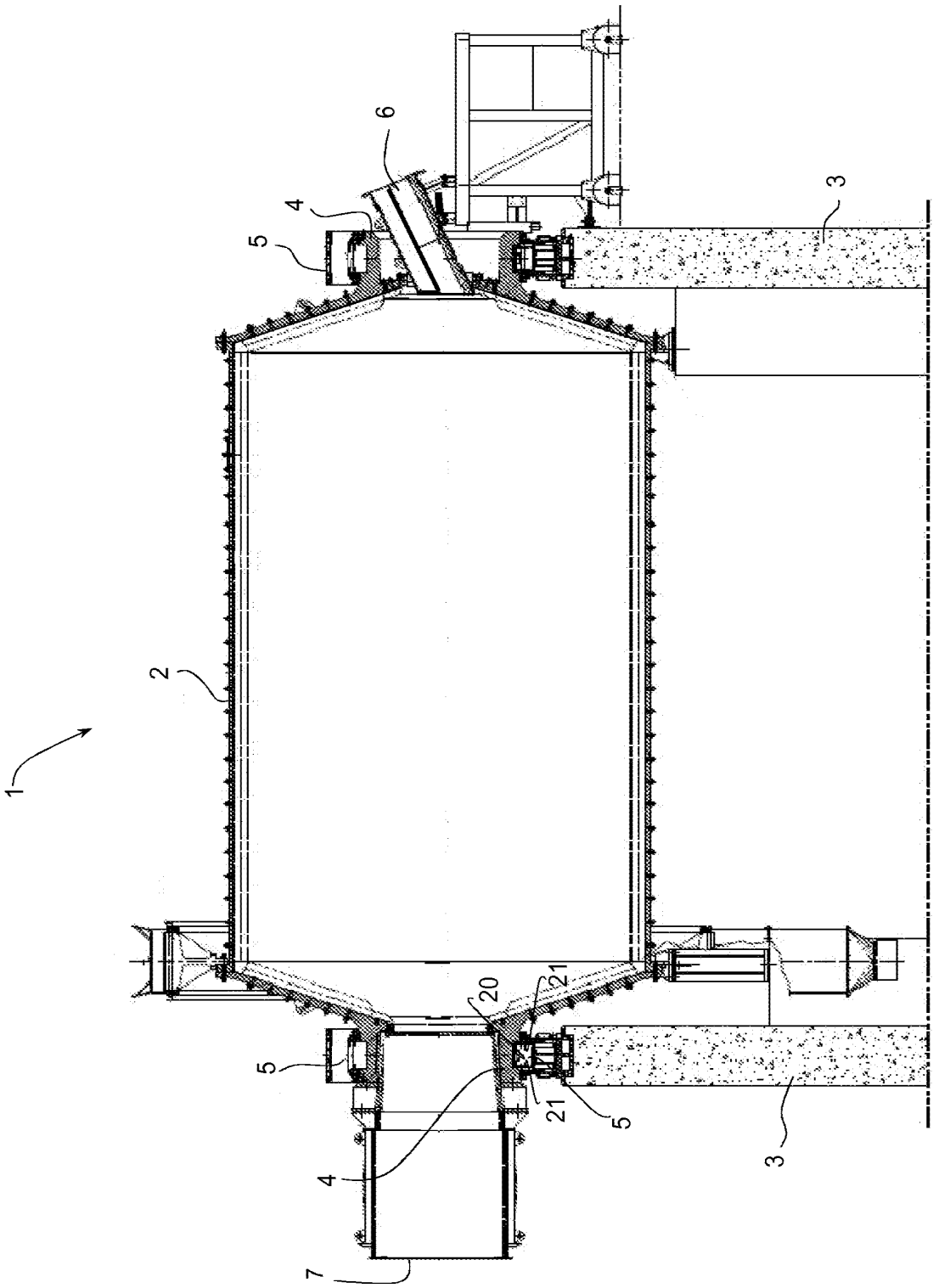


Fig. 1

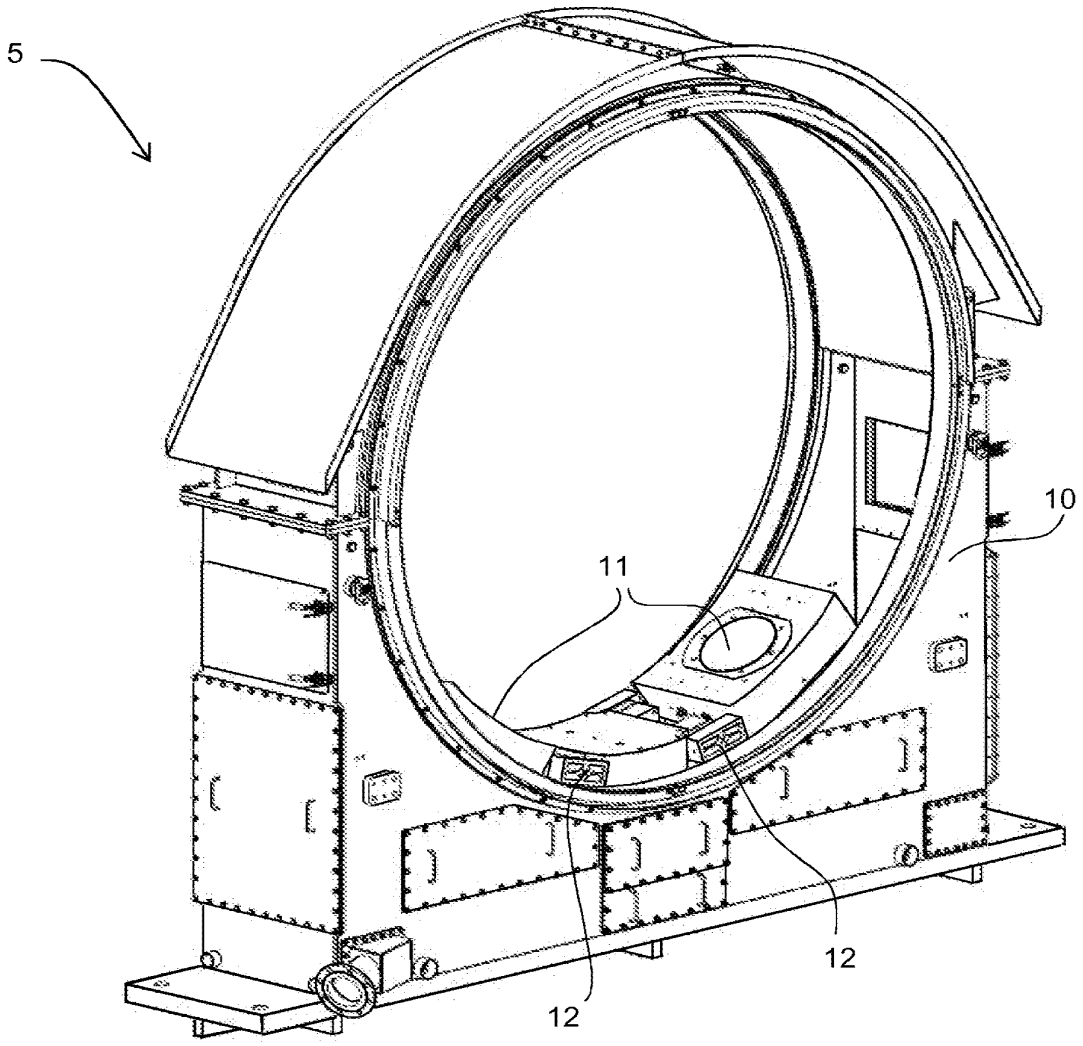


Fig. 2

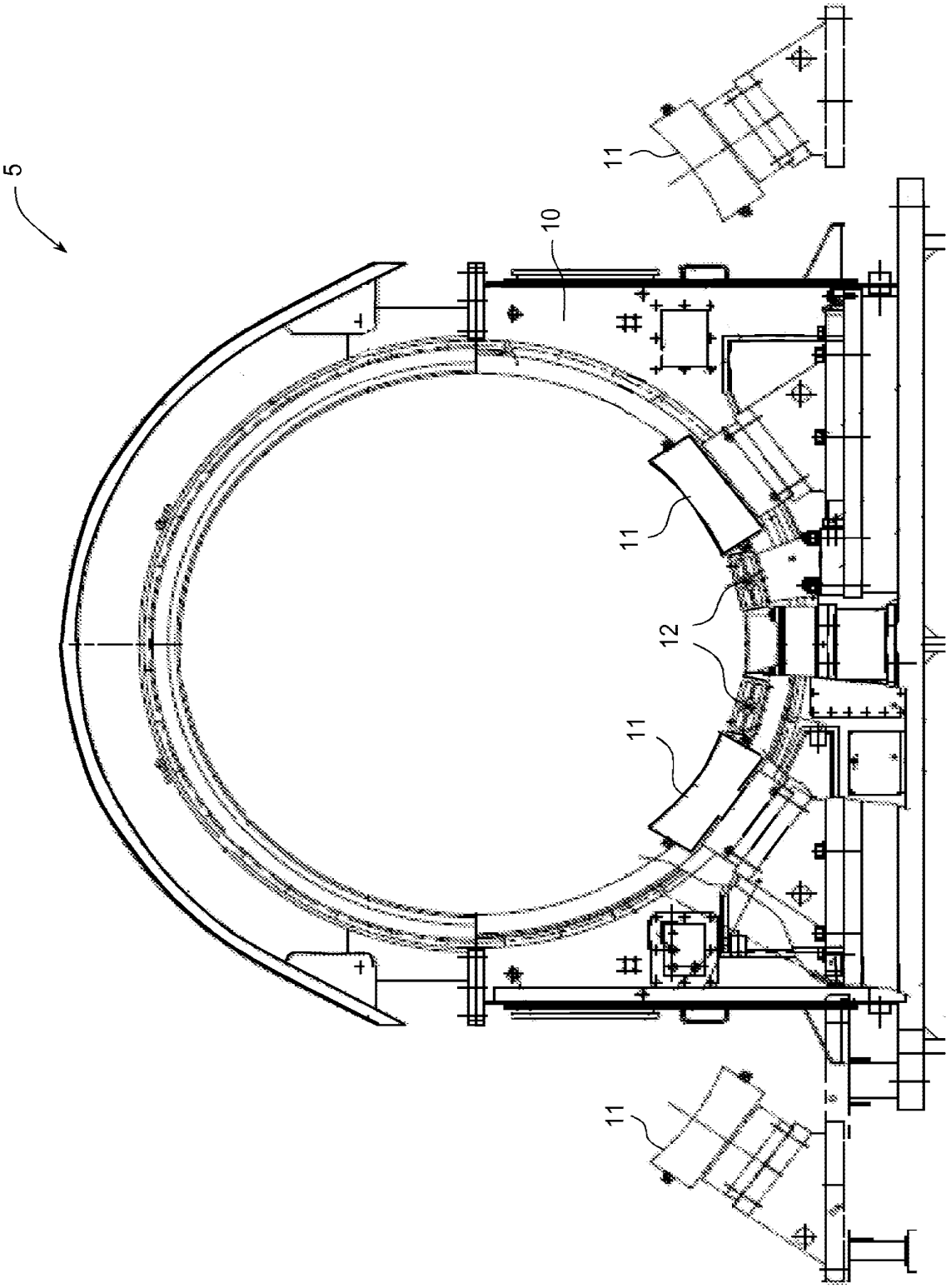


Fig. 3

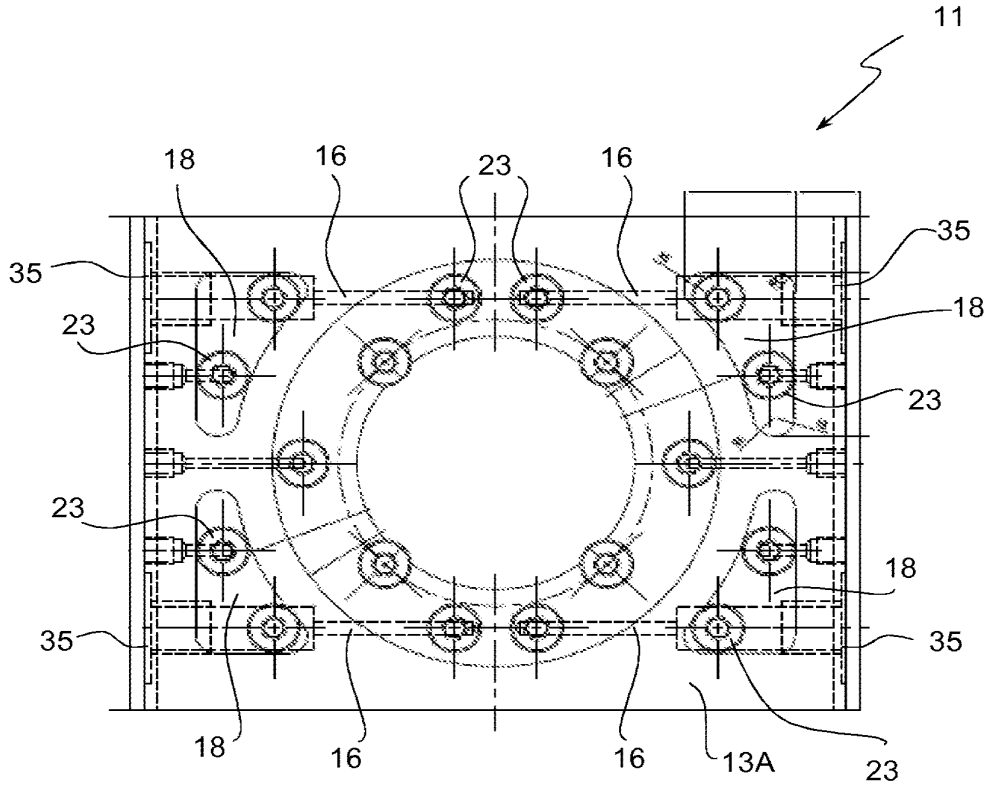


Fig. 4

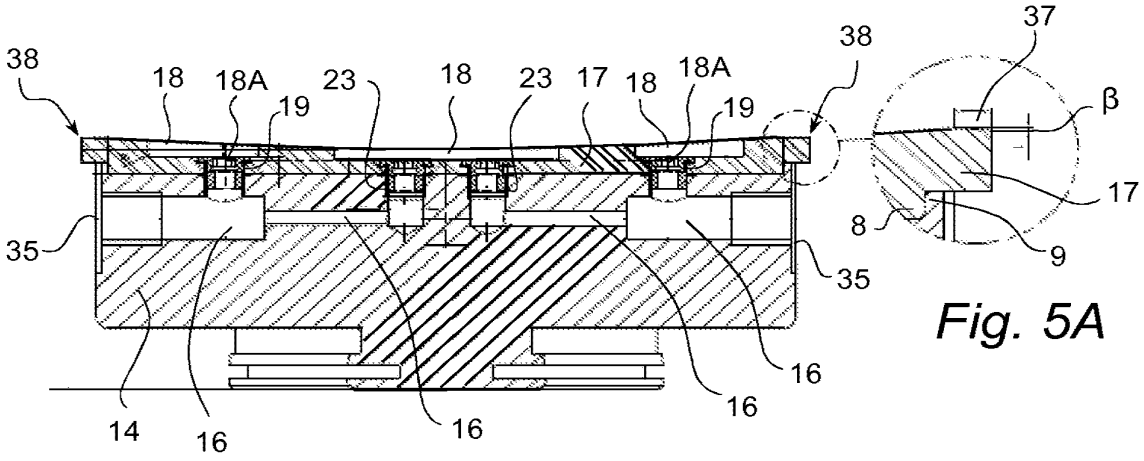


Fig. 5A

Fig. 5

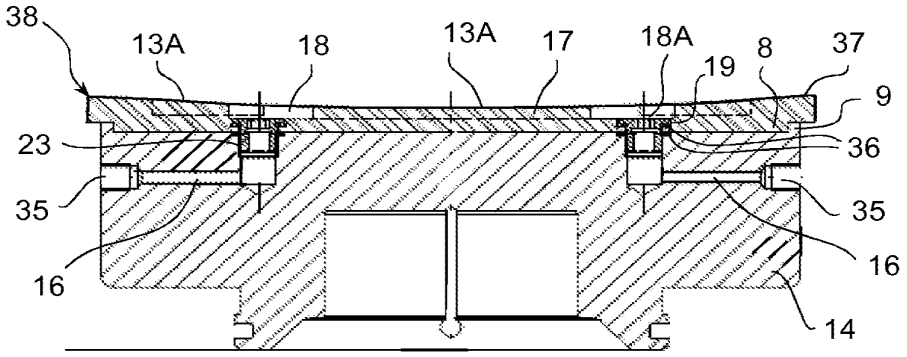


Fig. 6

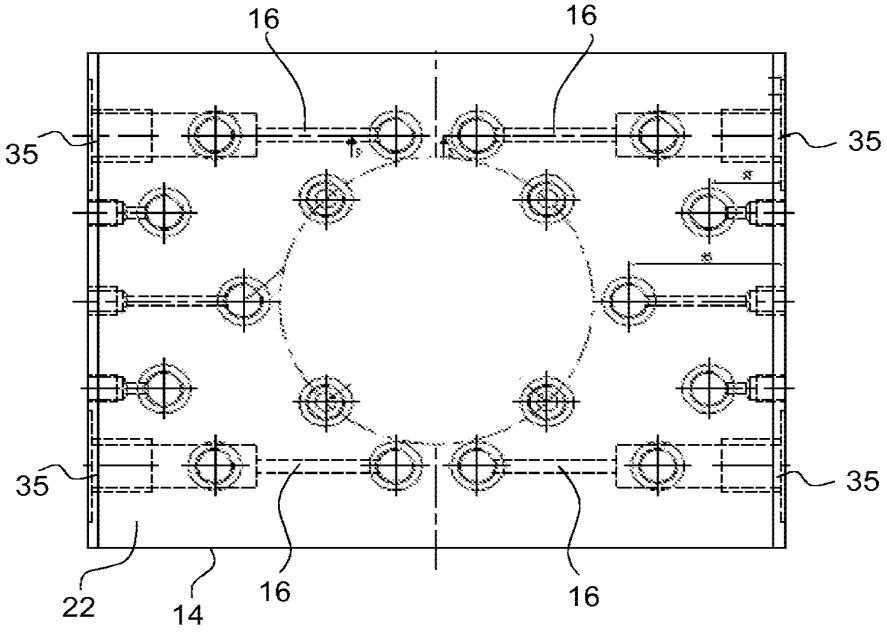


Fig. 7

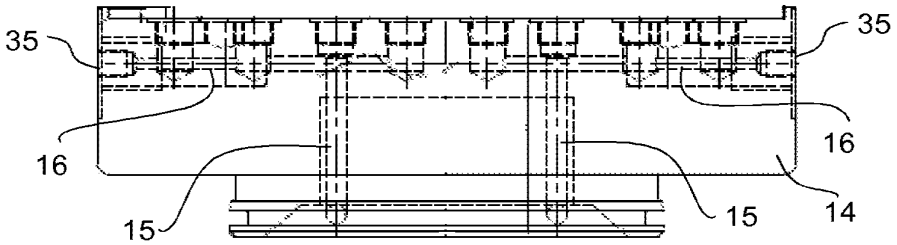


Fig. 8

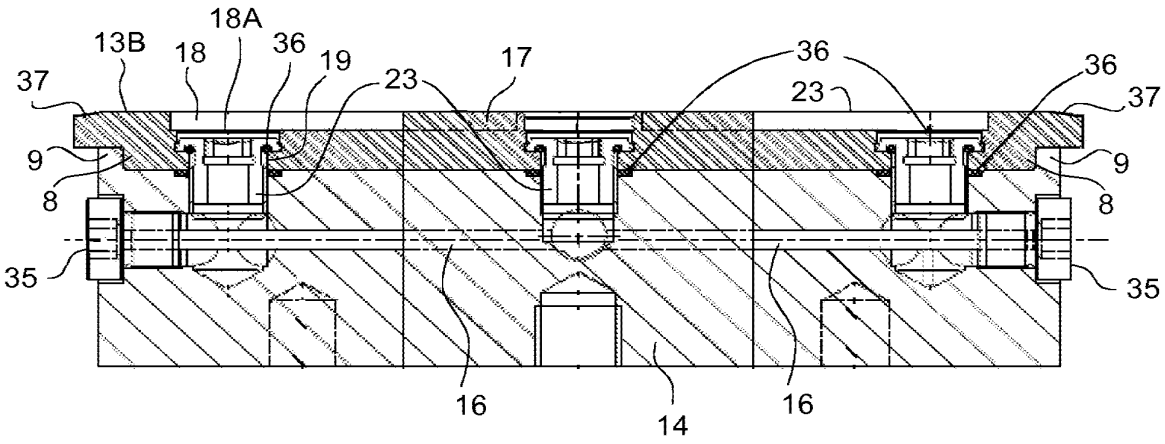

18A
13B
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Fig. 9

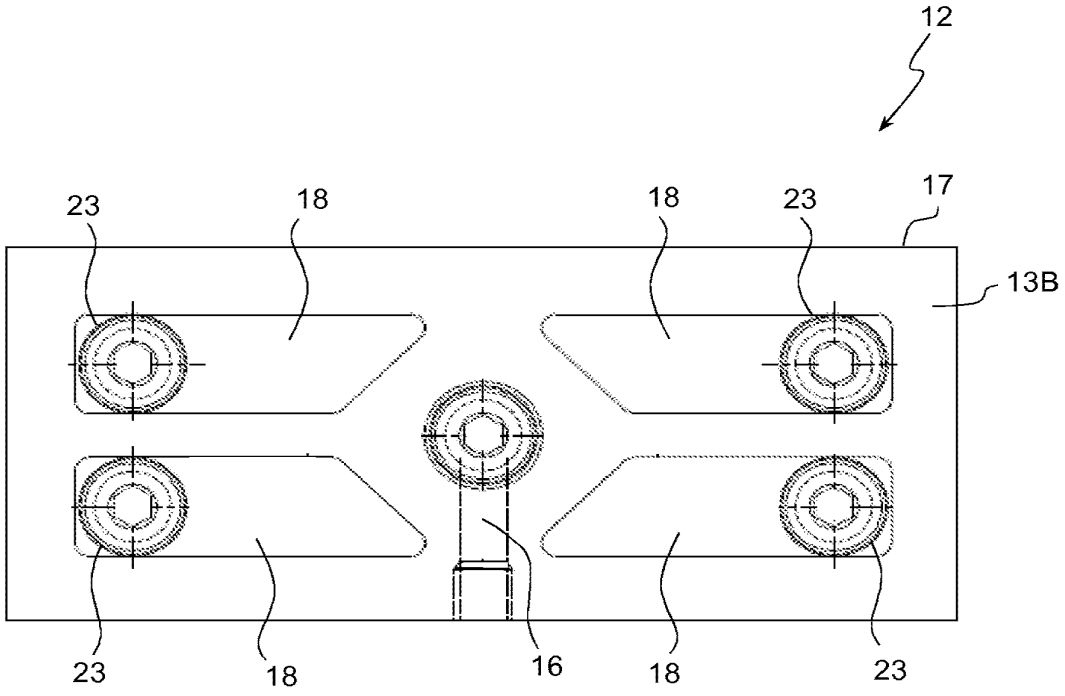

12
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13B
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18
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Fig. 10

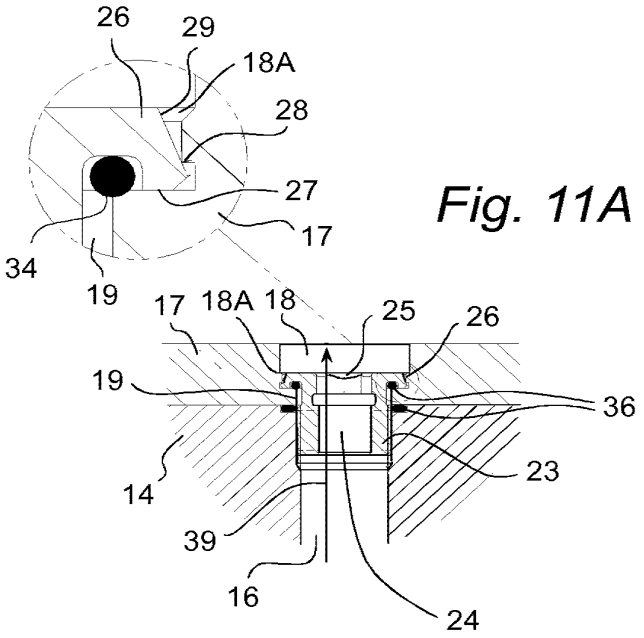


Fig. 11A

Fig. 11

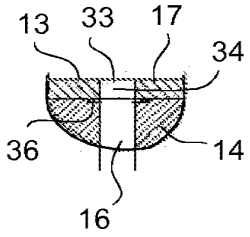


Fig. 12A

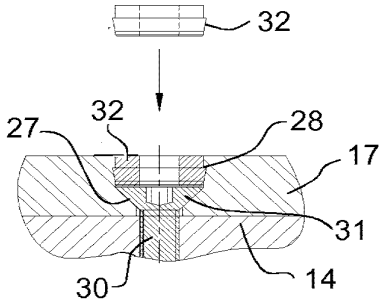


Fig. 12

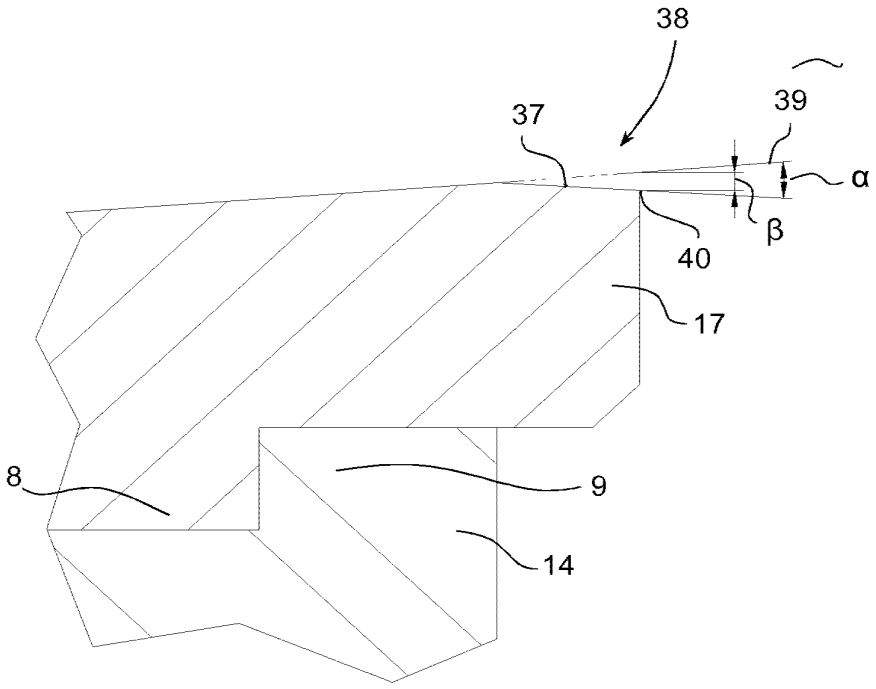


Fig. 13

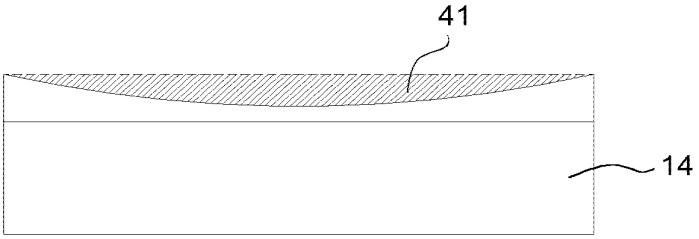


Fig. 14

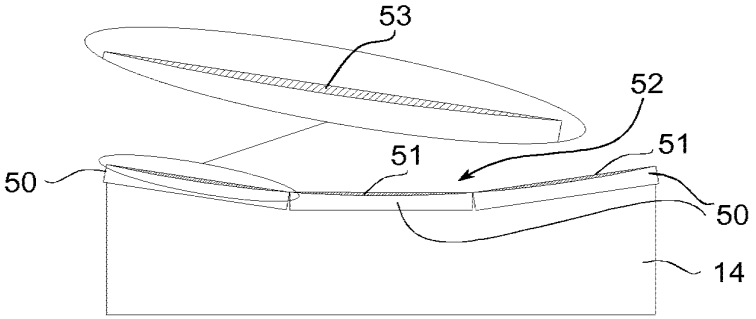


Fig. 15

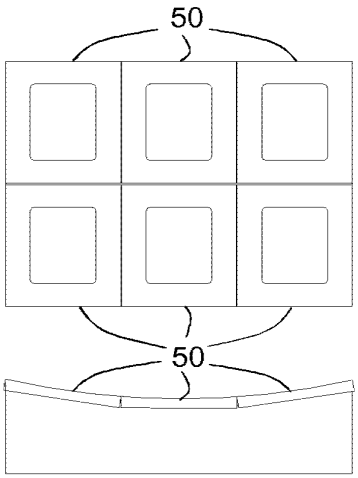


Fig.16

Fig.16A

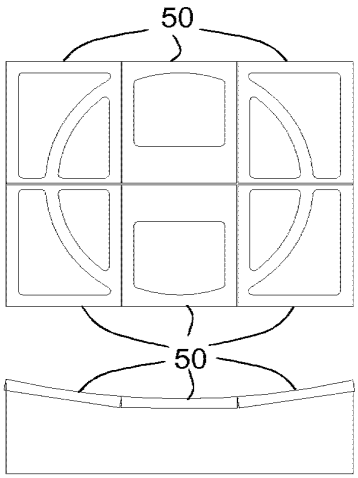


Fig.17

Fig.17A

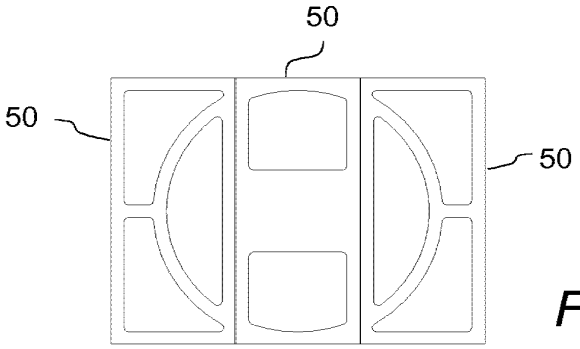


Fig. 18

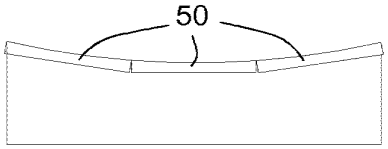


Fig. 18A

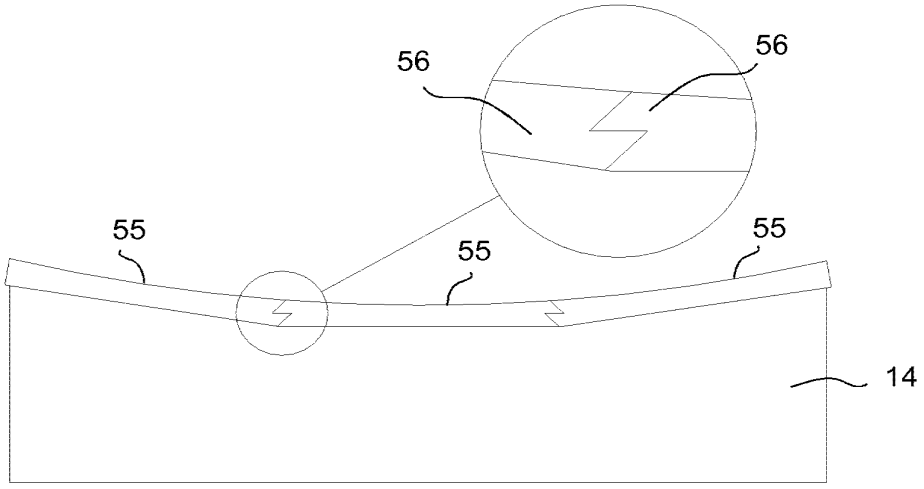


Fig. 19

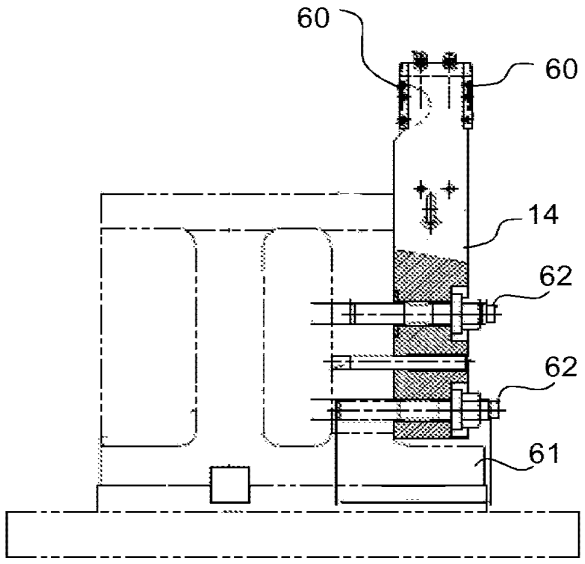


Fig. 22

Fig. 21

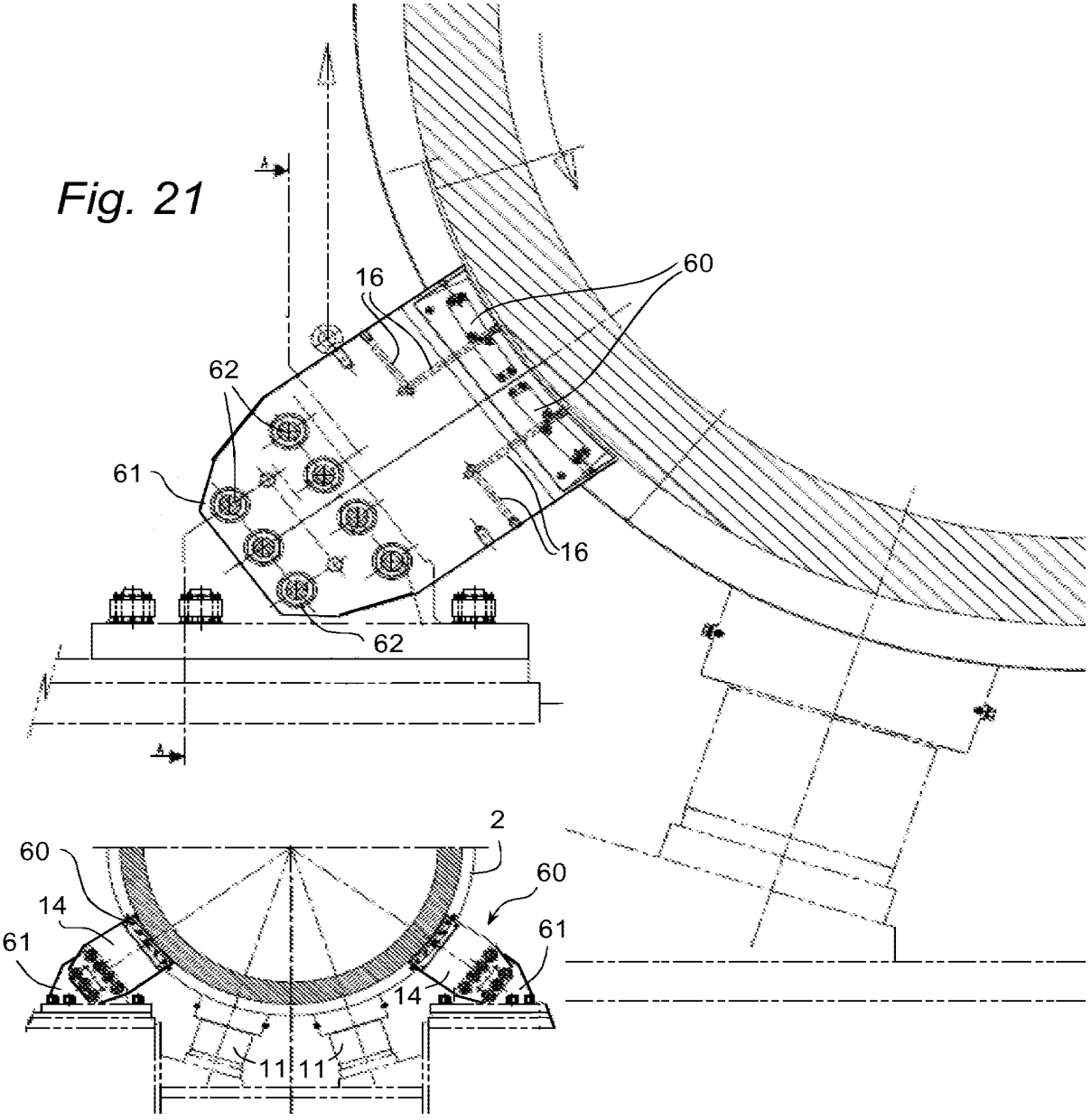


Fig. 20

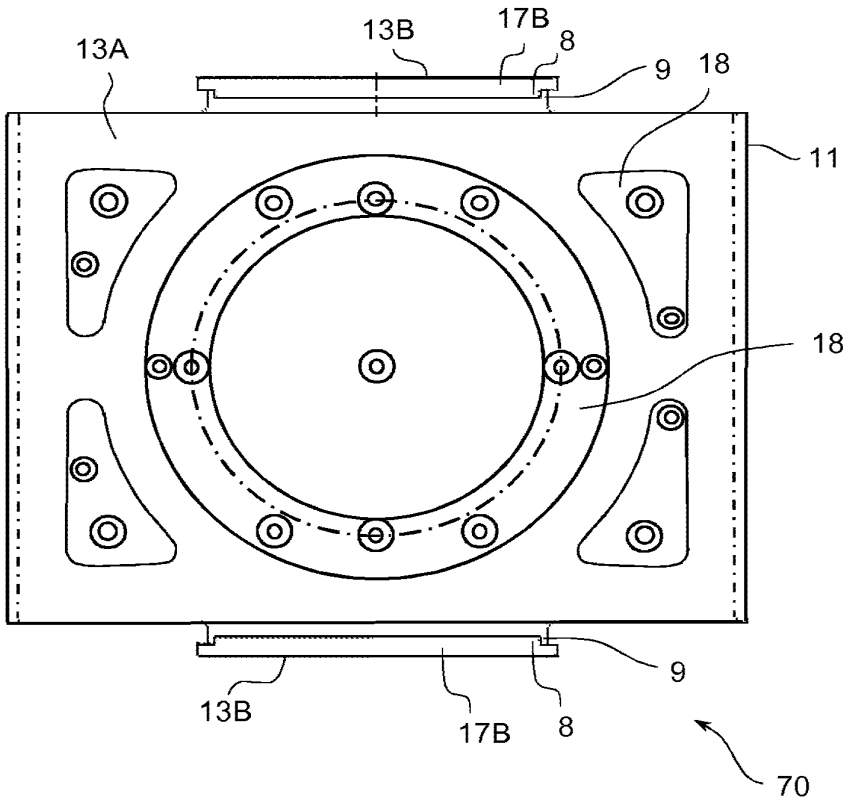


Fig. 23

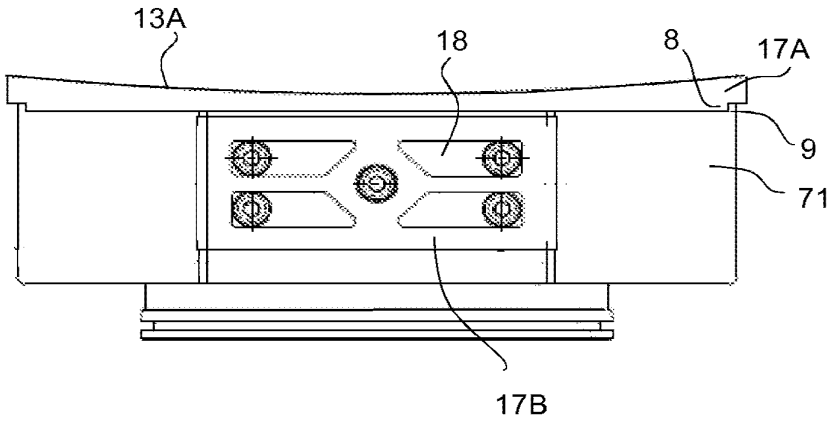


Fig. 24

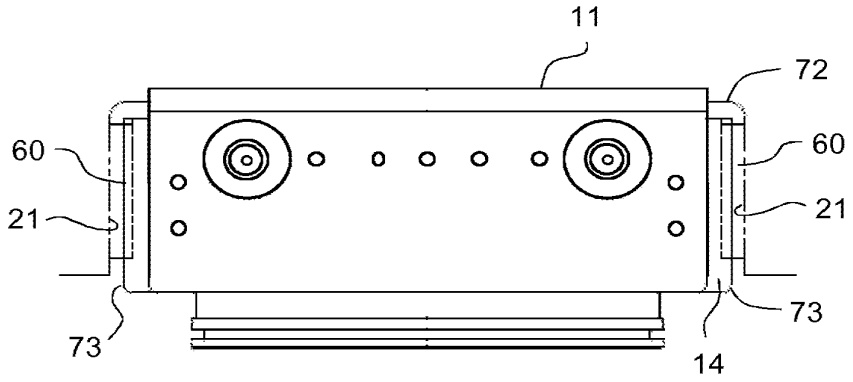


Fig. 25

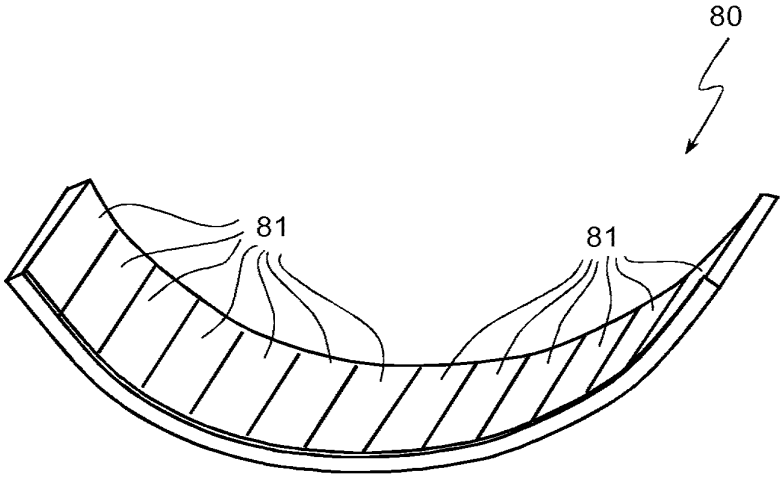


Fig. 26

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/055305

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16C32/06
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)
F16C

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, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2007 039364 A1 (METSO PAPER INC [FI]) 6 March 2008 (2008-03-06)	1-4,6-9, 12-16, 18, 25-32, 36,38
Y	page 4, right-hand column, line 27 - line 30 paragraph [0025]; figures 3A-4C	5,10,11, 17, 19-24, 33-35, 39-52

Y	WO 90/12216 A1 (VICKERS PLC [GB]) 18 October 1990 (1990-10-18)	10,20, 22-24, 39-42, 44,46, 48-52
	page 9, line 20 - line 36; claims 1-3,9-14; figures	

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] 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

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 October 2013	30/10/2013

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	Martin, Christophe

Exhibit 1002
FLS v. Metso

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2006 009968 A (OILES INDUSTRY CO LTD) 12 January 2006 (2006-01-12) paragraph [0027] - paragraph [0028]; figures 1-3	5,17,19, 43,45
Y,P	WO 2012/145217 A1 (US SYNTHETIC CORP [US]; COOLEY CRAIG H [US]; SEXTON TIMOTHY N [US]) 26 October 2012 (2012-10-26) page 2, line 19 - page 3, line 3; figures 1c-3	11,21, 33-35,47

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2013/055305

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6, 9, 10, 12-20, 24-28, 30-33, 40, 43-46, 49, 50, 52

   Bearing pad, bearing and method characterized by mounting means.

   ---

2. claims: 7-10, 20, 24, 25, 29, 30, 33, 35-38, 40-42, 46, 52

   Bearing pad, bearing and method characterized by a chamfer.

   ---

3. claims: 9-11, 20, 21, 24, 25, 30, 33, 34, 40, 46, 47, 52

   Bearing pad, bearing and method characterized by lateral connecting portions.

   ---

4. claims: 9, 10, 20, 22-25, 30, 33, 39, 40, 46, 48, 51, 52

   Bearing pad, bearing and method characterized by first and second surfaces of the bearing base.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102007039364 A1	06-03-2008	AT 504091 A2	15-03-2008
		DE 102007039364 A1	06-03-2008
		FI 20065532 A	29-02-2008
WO 9012216 A1	18-10-1990	AU 5419590 A	05-11-1990
		EP 0466762 A1	22-01-1992
		GB 2230305 A	17-10-1990
		WO 9012216 A1	18-10-1990
JP 2006009968 A	12-01-2006	JP 4483430 B2	16-06-2010
		JP 2006009968 A	12-01-2006
WO 2012145217 A1	26-10-2012	US 8545103 B1	01-10-2013
		US 2013192899 A1	01-08-2013
		WO 2012145217 A1	26-10-2012

Box No. VIII (iv) DECLARATION: INVENTORSHIP (only for the purposes of the designation of the United States of America)

The declaration must conform to the following standardized wording provided for in Section 214; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (iv). If this Box is not used, this sheet should not be included in the request.

Declaration of inventorship (Rules 4.17(iv) and 51 *bis*.1(a)(iv))
for the purposes of the designation of the United States of America:

I hereby declare that I believe I am the original inventor or an original joint inventor of a claimed invention in the application.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/IB2013/055305 (if furnishing declaration pursuant to Rule 26*ter*).

I hereby declare that the above-identified international application was made or authorized to be made by me.

I hereby acknowledge that any wilful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Name: Daniel BRAITHWAITE

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 5/17 Hertha Road, Innaloo, Western Australia 6018, Australia

Inventor's Signature: _____ Date: 30/8/2013
(The signature must be that of the inventor, not that of the agent)

Name: Jeffrey Victor BELKE

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 11 Cowrie Cresent, Mt Pleasant, Western Australia 6153, Australia

Inventor's Signature: _____ Date: 30/8/13
(The signature must be that of the inventor, not that of the agent)

Name: Nicholas John GREEN

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 98a Toorak Road, Rivervale, Western Australia 6103, Australia

Inventor's Signature: _____ Date: 3/9/2013
(The signature must be that of the inventor, not that of the agent)

Name: Chris TATE

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 187 Delgado Parade, Iluka, Western Australia 6028, Australia

Inventor's Signature: _____ Date: 09/09/13
(The signature must be that of the inventor, not that of the agent)

Name: Oscar HARRISON

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 35 Campsbourne Street, Balcatta, Western Australia 6021, Australia

Inventor's Signature: _____ Date: 9/9/2013
(The signature must be that of the inventor, not that of the agent)

Name: Knut VAAGE

Residence: Oslo, Norway
(city and either US state, if applicable, or country)

Mailing Address: Middlethunsgate 23, 0368, Oslo, Norway

Inventor's Signature: _____ Date: 20/9/2013
(The signature must be that of the inventor, not that of the agent)

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 74861WOP00	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/IB2013/055305	International filing date *(day/month/year)* 28.06.2013	Priority date *(day/month/year)* 28.06.2012

International Patent Classification (IPC) or national classification and IPC
INV. F16C32/06

Applicant
Outotec Oyj

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 8 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *(sent to the applicant and to the International Bureau)* a total of 36 sheets, as follows:
      - ☒ sheets of the description, claims and/or drawings which have been amended and/or sheets containing rectifications authorized by this Authority, unless those sheets were superseded or cancelled, and any accompanying letters (see Rules 46.5, 66.8, 70.16, 91.2, and Section 607 of the Administrative Instructions).
      - ☐ sheets containing rectifications, where the decision was made by this Authority not to take them into account because they were not authorized by or notified to this Authority at the time when this Authority began to draw up this report, and any accompanying letters (Rules 66.4bis, 70.2(e), 70.16 and 91.2).
      - ☐ superseded sheets and any accompanying letters, where this Authority either considers that the superseding sheets contain an amendment that goes beyond the disclosure in the international application as filed, or the superseding sheets were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in item 4 of Box No. I and the Supplemental Box (see Rule 70.16(b)).

   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see paragraph 3*bis* of Annex C of the Administrative Instructions).

4. This report contains indications relating to the following items:
   - ☒ Box No. I Basis of the report
   - ☐ Box No. II Priority
   - ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - ☐ Box No. IV Lack of unity of invention
   - ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - ☒ Box No. VI Certain documents cited
   - ☐ Box No. VII Certain defects in the international application
   - ☒ Box No. VIII Certain observations on the international application

Date of submission of the demand	Date of completion of this report
22.04.2014	08.10.2014

Name and mailing address of the international preliminary examining authority:

European Patent Office P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040
Fax: +31 70 340 - 3016

Authorized officer

Martin, Christophe

Telephone No. +31 70 340-4492

Exhibit 1002
FLS v. Metso

Box No. I Basis of the report

1. With regard to the **language**, this report is based on

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:

   ☐ international search (under Rules 12.3(a) and 23.1(b))
   ☐ publication of the international application (under Rule 12.4(a))
   ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a) and (b))

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1, 2	as originally filed	
3-28	filed with the letter of	22-04-2014

Claims, Numbers

1-32	filed with the letter of	22-04-2014

Drawings, Sheets

1/13-13/13	as originally filed

☐ a sequence listing - see Supplemental Box Relating to Sequence Listing.

3. ☒ The amendments have resulted in the cancellation of:
   ☐ the description, pages
   ☒ the claims, Nos. 33-52
   ☐ the drawings, sheets/figs
   ☐ the sequence listing *(specify)*:
   ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (c-bis)):
   ☐ the description, pages
   ☐ the claims, Nos.
   ☐ the drawings, sheets/figs
   ☐ the sequence listing *(specify)*:

5. ☐ This report has been established:
   ☐ taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rules 66.1(d-bis) and 70.2(e)).
   ☐ without taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91(Rules 66.4bis and 70.2(e)).

6. ☒ With regard to top-up searches (Rules 66.1 ter and 70.2(f)):
   ☒ A top-up search was carried out by this Authority on 29.09.2014 (all discovered documents are listed in the Supplemental Box Relating to Top-up Search).
   ☐ No top-up search was carried out by this Authority.

7. ☐ Supplementary international search report(s) from Authority(ies) has/have been received and taken into account in establishing this report (Rule 45bis.8(b) and (c)).

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-32
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-32
Industrial applicability (IA)	Yes:	Claims	1-32
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VI Certain documents cited

1. Certain published documents (Rule 70.10)

   and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Exhibit 1002
FLS v. Metso

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 The attention of the applicant is drawn to the time limit for reply specified on the cover sheet of the present written opinion.

2 Reference is made to the following documents:

D1 : DE 10 2007 039 364 A1

D2 : WO 90/12216 A

D3 : JP 2006-9968 A

D4 : WO 2012/145217 A1

3 Furthermore, due to the extensive amendments filed by the applicant in reply to the international search report, a further search has been considered necessary, especially in the field of grinding mills. This search has revealed the following documents, a copy of which is attached to the present written opinion.

D5 : GB 1 508 384

D6 : US 4,911,554

4 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of independent claim 1 does not involve an inventive step in the sense of Article 33(3) PCT.

4.1 D5 discloses "a bearing assembly for supporting a journal (12) of a grinding mill body (see page 3, lines 20-27), comprising a frame (17) and a plurality of fluid bearings, said fluid bearings each comprising a ~~*polymer*~~ bearing pad (16) mounted to a base (10), said ~~*polymer*~~ bearing pad (16) comprising an outer surface, at least one recess (18) for receiving lubricating fluid from at least one passage (20) of said base (10) and distributing said lubricating fluid to said outer surface (implicit feature) and mounting means (11, 13) for securely mounting said ~~*polymer*~~ bearing pad (16) to said base (10), said base (10) also comprising at least one lubricating fluid supply port (see figure 2) in fluid communication with said at least one passage (20), wherein said base (10) is mounted to said frame (17) so that said fluid bearings self adjust to changes in the angular position of the journal (12) during operation of said grinding mill body (see page 2, lines 45-54)".

4.1.1 The subject-matter of claim 1 differs therefrom in that the bearing pad is explicitly made of "polymer".

4.1.2 Such a difference is considered as being a mere constructional option which is obvious to the skilled person.

4.2 The subject-matter of claim 1 therefore lacks inventive step on the basis of D5 and the general knowledge of the skilled person.

5 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of independent claim 2 does not involve an inventive step in the sense of Article 33(3) PCT.

5.1 D6 discloses "a bearing assembly for supporting a journal of a grinding mill body (see column 2, lines 28-37), comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a ~~*polymer*~~ bearing pad (18, 18a) mounted to a base (17, 17a), said ~~*polymer*~~ bearing pad (18, 18a) comprising an outer surface, at least one recess for receiving lubricating fluid (implicit feature) from at least one passage of said base (31) (see column 3, line 57-column 4, line 2) and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad (18, 18a) to said base (17, 17a) (implicit feature), said base (17, 17a)also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage (see 31), wherein said base (18, 18a) is fixedly mounted to said frame (see column 3, lines 28-38)".

5.1.1 The subject-matter of claim 2 differs therefrom in that the bearing pad is explicitly made of "polymer".

5.1.2 Such a difference is considered as being a mere constructional option which is obvious to the skilled person.

5.2 The subject-matter of claim 2 therefore lacks inventive step on the basis of D6 and the general knowledge of the skilled person.

6 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of independent claim 22 does not involve an inventive step in the sense of Article 33(3) PCT.

6.1 D5 discloses "a multidirectional fluid bearing for a journal (12), comprising:

a base (10) having a first surface orthogonal to a second surface, one or more lubricating fluid supply ports (see figure 2) and a plurality of passages (20) in fluid communication with said lubricating fluid supply ports, said first surface and said second surface,

a first ~~polymer~~ bearing pad (16) mountable to said first surface, said ~~polymer~~ bearing pad (16) having a first outer surface and at least one recess (18) for receiving lubricating fluid from at least one of said plurality of passages (10) and distributing said lubricating fluid to said first outer surface, and

a ~~second~~ polymer bearing pad (16) mountable to said second surface, said second ~~polymer~~ bearing pad (16) having a second outer surface and at least one recess (19) for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface (see figures 3 and 5)".

6.2 The subject-matter of claim 22 differs therefrom in that the bearing pad is explicitly made of "polymer".

6.2.1 Such a difference is considered as being a mere constructional option which is obvious to the skilled person.

6.3 The subject-matter of claim 22 therefore lacks inventive step on the basis of D5 and the general knowledge of the skilled person.

6.4 The subject-matter of claim 22 also lacks an inventive step in view of D6 (see in particular the orthogonally oriented pads (10 and 18a) in figure 2 of D6). Indeed, the subject-matter of claim 22 differs therefrom in that the bearing pad is explicitly made of "polymer". As argued before, such a difference is considered as being a mere constructional option which is obvious to the skilled person.

7 Dependent claims 3-21 and 23-32 do not contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step, the reasons being as follows:

7.1 The features of claims 3-5 are known from D1, see e.g. the beveled edge of pad (30) in cooperation with the corresponding undercut notch of shoe (5) in figure 3A.

7.2 The features of claim 6 are known from D1, see figures 4A and 4B.

7.3 The features of claim 7 are a well-known means for retaining the head portion of a fastener in a recess and fi their equivalent in D3, see paragraphs [0027] and [0028], an automated English translation of which is found here below:

"[0027] Moreover, according to the combination structure 6, after inserting ring 9 in the ring mounting groove|channel 7 in the decomposition|degradation state shown in FIG. 3, it can assemble simply in the state shown in FIG. 1 by inserting the hemisphere part 37 in a concave-part 8, and engaging the end face 45 of the hemisphere part 37 with ring 9.

[0028] In addition, as ring 9, an elastic O ring is preferable, However If it is the objective of mere connection, although it is a rigid material -- a diameter-expansion -- free and the diameter reduction -- free E ring or a C-ring may be sufficient. Even if it uses such E ring or a C-ring, it can connect, as that the gap adjustment member 5 may not be dropped off in the static-pressure gas bearing pad 3, and a cost reduction can be intended".

7.4 The features of claim 8 are known from D1, see Figure 4A and page 5/8, left column, lines 5-7 and 23-26.

7.5 The features of claim 9 are known or derivable from D1, see the schematically represented sleeve like plug under the head of elements "17" in Figure 4B.

7.6 The features of claim 10 are a well-known means for retaining the head portion of a fastener in a recess and fi their equivalent in D3, see paragraphs [0027] and [0028].

7.7 The features of claim 11 are known from D1, see figure 4A and the material used for the pad.

7.8 The features of claims 12 and 13 are known from D5, see column 2, lines 83-column 3, line 8; figures 3, 6 and 7.

7.9 The features of claim 14 are known from D5, see figure 2.

7.10 The features of claim 15 are implicitly known from D6, see the pads (18, 18a) in figure 2.

7.11 The features of claim 16 are known from D5, see figure 2.

7.12 The features of claim 17 are obvious in view of a combination of the teachings of D6 to the arrangement shown in figure 5 of D2.

7.13 In claim 18 a slight constructional change in the bearing of claim 17 is defined which comes within the scope of the customary practice followed by persons skilled in the art, especially as the advantages thus achieved can readily be foreseen.

7.14 The features of claims 19-21 are known from D5 and/or D6, see the reasoning in paragraphs 5.1 to 5.4 above.

7.15 The features of claims 23-26, have already been discussed w.r.t. claim 11 (corresponding to claim 23), claim 12 (corresponding to claim 24), claim 13 (corresponding to claim 25), claim 17 (corresponding to claim 26).

7.16 In claim 27 a slight constructional change in the bearing of claim 26 is defined which comes within the scope of the customary practice followed by persons skilled in the art, especially as the advantages thus achieved can readily be foreseen.

7.17 The features of claim 28 are obtained from a combination of D1 (opening for receiving a fastener) and D3 (locking tab).

7.18 The features of claims 29-32 have already been discussed w.r.t. claim 8 (corresponding to claim 29), claim 4 (corresponding to claim 30), claim 5 (corresponding to claim 31), 21 (corresponding to claim 32).

Re Item VI

Certain documents cited

Application No Patent No	Publication date *(day/month/year)*	Filing date *(day/month/year)*	Priority date *(valid claim)* *(day/month/year)*
WO 2012/145217 A1	26.10.2012	12.04.2012	19.04.2011

Re Item VIII

Certain observations on the international application

8 Since originally filed claim 18, on which present claim 9 is based, depends on originally filed claim 16, on which present claim 8 is based, present claim 9 should depend on present claim 8 and not on present claim 7.

Shelston IP

ABN 58 855 816 942

International Preliminary Examining Authority
European Patent Office
P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk – Pays Bas
THE NETHERLANDS

22 April 2014

Our Ref: 74861WOP00

Attention: Christophe Martin

Contact: Andrew Lowe

PCT Patent Application No. PCT/IB2013/055305
Applicant: Outotec Oyj
Title: Improvements in fluid bearings

STATEMENT OF AMENDMENTS – ARTICLE 34

Complete Specification

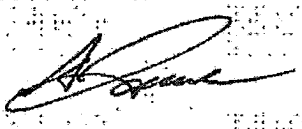
Description

1. Cancel pages 3 to 28 now on file and replace with new pages 3 to 28.

Claims

2. Cancel pages 29 to 36 now on file and replace with new pages 29 to 33.

DATED this 22nd day of April 2014
OUTOTEC OYJ



Andrew Lowe
Registered Patent Attorney
Email: *AndrewLowe@ShelstonIP.com*

Sydney
Level 21
60 Margaret Street
Sydney, NSW 2000
Australia
T +61 2 9777 1111

Brisbane
7 Clunies Ross Court
Brisbane Technology Park
Eight Mile Plains, QLD 4113
Australia
T +61 7 3147 8020

Newcastle
Level 1, IDC House
University Drive
Callaghan, NSW 2308
Australia
T +61 2 4921 7366

Auckland
Level 13, AA Building
99 Albert Street
Auckland 1010
New Zealand
T +64 9 638 5300

email@ShelstonIP.com www.ShelstonIP.com fax +61 2 9241 4666
Australian and New Zealand Patent and Trade Mark Attorneys in association with Shelston IP Lawyers

Shelston ip

Confidential Communication
Facsimile No. +31 70 340 3016
CONFIRMATION BY MAIL

ABN 58 855 816 942

International Preliminary Examining Authority
European Patent Office
P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk – Pays Bas
THE NETHERLANDS

Attention: Christophe Martin

CONFIRMATION

22 April 2014

Our Ref: 74861WOP00

Contact: Andrew Lowe

Dear Sirs

PCT Patent Application No. PCT/IB2013/055305
Applicant: Outotec Oyj
Title: Improvements in fluid bearings

We refer to the First Written Opinion of the International Preliminary Examining Authority mailed on 30 October 2013 in respect of the above application.

Article 34 amendments

Pursuant to Article 34, the Applicant requires the International Preliminary Examining Authority to take into account the amendments on the enclosed replacement pages as set forth on the attached Statement of Amendments.

The proposed amendments have cancelled claims 11 to 13, 25, 26 to 38, 45, 48 and 51.

Claims 1 to 10 and 14 to 24 have been reworded and are now directed to a bearing assembly comprising a frame and a plurality of fluid bearings, each fluid bearing comprising a base and the polymer bearing pad of original claim 1 mounted to the base. Support for this amendment is found at page 14, paragraph [0093] of the specification as filed

Claim 1 has also been amended claim to define that the base is mounted to the frame so that the fluid bearings self adjust to changes in the angular position of the journal during operation of the grinding mill body. Support for this amendment is found at page 14, paragraph [0094] of the specification as filed.

A new claim 2 has been added, which also defines a bearing assembly comprising a frame and a plurality of fluid bearings, each fluid bearing comprising the polymer bearing pad of original claim 1 mounted to the base. New claim 2, however, defines that the base is fixedly mounted to the frame. Support for this amendment is found at page 24, paragraph [0113] of the specification as filed.

Sydney
Level 21
60 Margaret Street
Sydney, NSW 2000
Australia
T +61 2 9777 1111

Brisbane
7 Clunies Ross Court
Brisbane Technology Park
Eight Mile Plains, QLD 4113
Australia
T +61 7 3147 8020

Newcastle
Level 1, IDC House
University Drive
Callaghan, NSW 2308
Australia
T +61 2 4921 7366

Auckland
Level 13, AA Building
99 Albert Street
Auckland 1010
New Zealand
T +64 9 638 5300

email@ShelstonIP.com www.ShelstonIP.com fax +61 2 9241 4666
Australian and New Zealand Patent and Trade Mark Attorneys in association with Shelston IP Lawyers

Claim 39 has been amended to include the subject matter of original claim 51, and has now been renumbered as claim 22. Support for this amendment is found at page 11, paragraph [0061] and page 25, paragraph [0114] of the specification as filed

As a result, claims 2 to 10, 14 to 24, 40 to 44, 46, 47, 49, 50 and 52 have been renumbered as new claims 3 to 21 and 23 to 32.

Some clarifying amendments have also been made to claims 20, 22, 40, 46 and 47, now new claims 17, 19, 23, 26 and 27.

It is submitted that the proposed amendments are supported by the specification as filed and favourable consideration is requested.

Response to written opinion

In response to the Written Opinion, the Applicant submits that invention as now claimed is novel and involves an inventive step over the cited prior art referred to in Box V, and the claims no longer have the clarity problems noted in Box VIII.

Box V - novelty and inventive step

Of the claims that are now pending in the international application, the following documents have been cited by the Examiner as being relevant to novelty and inventive step:

D1: DE 10 2007 039 364 (Metso Paper)

D2: WO 90/12216 (Vickers plc)

D3: JP 2006-9968A (Oiles Industry Co Ltd)

It is submitted that claims 1 to 21 are novel and involve an inventive step over the cited prior art. Independent claims 1 and 2 now define a bearing assembly comprising a frame and a plurality of fluid bearings, each fluid bearing comprising a polymer bearing pad mounted to a base.

Claim 1 further defines that the base is mounted to the frame so that the fluid bearings self adjust to changes in the angular position of the journal during operation of said grinding mill body. It is submitted that none of the cited prior art, especially D1, discloses or teaches this claimed feature.

D1 discloses a bearing pad 30 for a flexible sheet 10 forming a nip with a roller 2 in a paper or cardboard making machine. The bearing pad is mounted on a shoe 5, 31 that is supported by a piston 4 movably located in a shaft or axle 3. The axle 3 has a central well 15' that acts as a supply for lubricating fluid to be delivered to recesses 22 in the pad 30. The piston 4 operates to move the bearing pad 30 and shoe 5, 31 in a radial direction into engagement the flexible sheet 10, thus applying a pressure or force to the sheet 10 against the nip roller 2.

As such, it is submitted that any movement of the roller 2 relative to the sheet 10 and bearing pad 30, including its angular position, can only be adjusted for by operating the piston 4 so that the bearing pad 30 re-engages the roller 2 and pinch the flexible sheet 10. Hence, it is submitted that changes in angular position need to be manually corrected by operating the piston 4 – the fluid bearing comprising the bearing pad 30 and the shoe 5, 31 cannot correct for changes in the angular position of the roller 2 on its own. As a consequence, the fluid bearing does not stabilise the sheet 10 or roller 2 in an axial position, but rather allows the sheet 10 to "float" on the axle part 3 and applies a force to the internal surface of the sheet 10 so that a pressure is maintained against the roller 2.

By way of contrast, the bearing assembly of the claimed invention has the base of the fluid bearing mounted to the frame so that the fluid bearing self-adjusts to changes in the angular position of the journal shaft 4; ie. the fluid bearing is self-aligning on its own in response to movements of the journal shaft 4. Thus, the bearing assembly of the claimed invention acts to positively locate the supported journal shaft 4 in a fixed position such that mating precision components can be correctly located. As a consequence, the invention of claim 1 has the technical advantage of avoiding the need for manual

adjustment in response to changes in the angular position of the journal or a mechanical device such as a piston to perform that adjustment.

It is submitted that the skilled person would not be able to modify the arrangement of D1 to arrive at the technical solution defined in amended claim 1, since this would involve substantial redesign to take into account the removal of the piston arrangement disclosed in D1. Furthermore, it is submitted that there is no teaching in D1 that would motivate the skilled person to consider or attempt such a modification of such a central element of the designed bearing arrangement as taught in that document. Thus, it is submitted that claim 1 has an inventive step over D1.

Likewise, claim 2 defines that the base is fixedly mounted to the frame, whereas in D1 the shoe 5, 31 is able to move in a radial direction relative to the shaft 3 via the piston 4. Therefore, it is submitted that D1 fails to teach the technical solution proposed by claim 2, and in fact teaches the opposite arrangement – a moveable mounting of the shoe 5, 31 to the "base", being the shaft 3. Thus, for the same reasons outlined above, it is submitted that claim 2 also has an inventive step over D1.

Since the teaching in D3 relates only to particular fastening arrangements for mounting the bearing pad to the base, it is submitted that a combination of D1 with D3 would also fail to render the claimed invention obvious for the same reasons stated above.

Thus, it is submitted that claims 1 to 21 involve an inventive step over the cited prior art.

In relation to claims 22 to 32, it is also submitted that these claims involve an inventive step over D1 and D2, the Examiner having previously conceded that original claim 39 was novel.

Claim 22 now includes the subject matter of original claims 39 and 51. It is submitted that a combination of D1 and D2 fails to disclose or teach the claimed multidirectional fluid bearing having polymer bearing pads mounted to orthogonal surfaces of a base.

D1 only discloses a polymer bearing pad that supports a load in a single radial direction. Therefore, there is no disclosure or teaching of using the polymer bearing pad for supporting loads in multiple directions.

D2 describes a thrust bearing or shoe and particular reference is made to Figure 4 which shows multiple bearings 10a, 10b arranged on a thrust ring or disc that rotates with a shaft. The shoes or bearing pads 10a, 10b are arranged on opposite faces of the disc 44. Thus, in D2 the surfaces supporting the bearing pads face in opposing directions and are in axial alignment (ie. coaxial). Therefore, there is no disclosure or teaching of an orthogonal arrangement of the surfaces upon which are mounted the bearing pads.

Hence, it is submitted that a combination of D1 and D2 would not lead the skilled person to the claimed invention. It is submitted that the skilled person reading D1 and D2 would simply mount the polymer bearing pads on the opposed, axially aligned surfaces taught in D2, rather than arrive at the multidirectional bearing as now claimed.

It is also submitted that there is no motivation for the skilled person to modify the coaxial arrangement of the surfaces in D2 to orthogonal surfaces because there is no teaching or suggestion to do so in either D1 or D2, especially as D2 is solely concerned with axial loads (albeit in opposite directions) along the single, same axis.

By contrast, the multidirectional fluid bearing of claim 22 is concerned with supporting loads from orthogonal directions, particularly the radial and axial loads of a journal shaft connected to the mill body.

Thus, it is submitted that D1 and D2 would teach away from the claimed invention. Therefore, it is submitted that claims 22 to 32 involve an inventive step over the cited prior art.

Box VIII – certain observations

It is submitted that the cancellation of claims 35, 36, 45 and 48 have rendered the objections at items 14.3, 14.4, 14.6 and 14.8 moot.

In relation to items 14.1 and 14.2, it is submitted that the redefinition of claim 1 as a bearing assembly comprising, *inter alia*, a polymer bearing pad and base has resolved the objections against claims 6, 15 and 16 (now claims 11, 16 and 8, respectively).

Similarly, it is submitted that the amendments to claim 40 (now claim 23) have overcome the objection at item 14.5 by correcting the references to "first outer surface", "second outer surface" and "said polymer bearing pad" to "first surface", "second surface" and "said second polymer bearing pad", respectively.

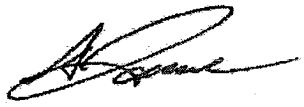
In reply to item 14.7, claim 46 (now claim 26) has clarified that there is a plurality of at least one of the first and second polymer bearing pads. Accordingly, it is submitted that this objection has now been overcome.

Thus, in conclusion, it is submitted that all of the observations made in Box VIII have now been resolved.

Closing comments

As the Examiner's objections have now been overcome, the Applicant requests a clear and favourable International Preliminary Report on Patentability.

Yours respectfully
Shelston IP



Andrew Lowe
Registered Patent Attorney
Email: *AndrewLowe@ShelstonIP.com*

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Daniel BRAITHWAITE
Art Unit	
Examiner Name	
Attorney Docket Number	SHEL.3143

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	1	4911554		1990-03-27	Henne et al.	

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	1	1508384	GB		1978-04-26	Fives-Cail Babcock		☐
	2	90/12216	WO		1990-10-18	Vickers PLC		☐
	3	2006009968	JP		2006-12-01	Oiles Ind. Co. Ltd.		☒

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Daniel BRAITHWAITE
	Art Unit	
	Examiner Name	
	Attorney Docket Number	SHEL.3143

	4	102007039364	DE		2008-03-06	Metso Paper		☒
	5	2012/145217	WO		2012-10-26	US Synthetic Corp.		☒

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	Application Number	
	Filing Date	
	First Named Inventor	Daniel BRAITHWAITE
	Art Unit	
	Examiner Name	
	Attorney Docket Number	SHEL.3143

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☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Susan D. Pitchford/	Date (YYYY-MM-DD)	2014-12-22
Name/Print	Susan D. Pitchford	Registration Number	50945

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PATENT SPECIFICATION (11) 1 508 384

1 508 384

(21) Application No. 6857/76 (22) Filed 20 Feb. 1976
(44) Complete Specification published 26 April 1978
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(52) Index at acceptance
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B2A 2R11D 2R8
F4B A9A

(72) Inventor ALAIN CHIELENS



(54) DEVICE FOR SUPPORTING A ROTATING BODY

(71) We, FIVES-CAIL BABCOCK, a French Body Corporate of 7, Rue Montalivet, 75383 Paris Cedex 08, France, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates to a device suitable for use in supporting a rotating body, more particularly of large diameter, and if necessary taking up axial stresses whereto said body is subjected, which device comprises at least one shoe mounted on a fixed frame by means of a ball joint and sliding on a circular track provided on the rotating body, coaxially with its axis of rotation.

In previously proposed such devices, the centre of the ball joint has been situated spaced from and below a sliding surface of the shoe so that any deformation (bending, ovalisation, or expansion) of the supported body has caused a displacement of the shoe relative to the supported body which has brought about a shearing stress on a film of oil formed between the shoe and the rotating body, and such shearing effect may have been harmful to the stability of said film and may consequently have been detrimental to lubrication of the sliding surfaces. Furthermore, any axial force acting on the shoe has had a tendency to make the shoe rock, which has resulted in a non-uniform distribution of bearing pressures over the width of a sliding track. This is why these devices have not been generally used for taking up axial forces to which the rotating body have been subjected.

It is an object of the present invention to provide a device for supporting a rotating body, wherein the above-indicated disadvantages are eliminated or substantially reduced.

According to the present invention, therefore, we provide a device for supporting a rotating body which device comprises at least one shoe mounted on a fixed frame by means of a part spherical member of the shoe locating in a corresponding recess in the frame, the centre of curvature of the part spherical member being at or adjacent a relatively slidable surface of the shoe and the ratio of the radius of curvature of the part spherical member to the maximum dimension of the shoe parallel to the intended axis of a rotating body being from 0.35:1 to 0.5:1.

In the present device for supporting a rotating body, when in use, lubrication of the relatively slidable surface of the shoe may be effected in known manner by means of oil introduced into a transverse channel extending substantially parallel to the axis of the rotating body formed on said surface and not opening on to sides of the shoe.

To take up axial forces, flanges or collars may, if desired, be provided on the rotating body, and may be arranged with a small clearance at each side of the shoe. The lubrication of the sides of the shoe can then be ensured by means of two circumferential grooves formed at the junctions of the flanges or collars with the rotating body and two passages opening on to the relatively slidable surface of the shoe and providing communication between the transverse channel and the two grooves, the cross-sectional areas of the orifices being partly defined by the slidable track of the rotating body so as to be equal when the shoe is centred relatively to the flanges and so that a said cross-sectional area increases when the shoe approaches the flange adjacent the respective passage in question; when the shoe abuts a flange, the other orifice may be completely masked. These passages can be constituted by sloping recesses formed in end walls of the transverse channel. The sides of the

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shoe may be formed with recesses forming containers for oil.

By way of a variant, axial forces can be taken up by flanges of the shoes enclosing or bounding the slidable track of the rotating body.

The invention will now be more particularly described with reference to the accompanying drawings, wherein:—

Figure 1 is an elevational view of the present device for supporting a rotating body, certain parts of the device being shown in section;

Figure 2 is a longitudinal section through a shoe;

Figure 3 is a sectional view, taken along the line 3-3 of Figure 2, of the shoe shown in Figure 2;

Figure 4 is a view showing to a larger scale than that of Figure 3 a detail of the shoe shown in Figures 2 and 3;

Figure 5 is a perspective view of the shoe shown in Figures 2 to 4;

Figure 6 is a sectional view illustrating to a larger scale than that of Figure 1 a detail of the device shown in Figure 1 with the shoe shown in Figures 2 to 5 in a first position; and

Figure 7 is a view similar to Figure 6 showing a position of the shoe shown in Figures 2 to 5 in a position other than that of Figure 6.

Referring to the drawings, a supporting device shown in Figure 1 is intended to support a rotating body 12 of large diameter; an identical device is arranged symmetrically relatively to a vertical plane containing the axis of the rotating body 12.

The device illustrated is constituted by a shoe 10 on which the body 10 slides when the device for supporting the rotating body 12 is in use. Relatively slidable surfaces of the shoe 10 and the rotating body 12 are part-spherical and concentric with the axis of rotation. The shoe 10 comprises an extending portion 11 fitted into a central bore of an annular member 13 forming a ball joint. The member 13 has a part-spherical lower surface and a centre 30 situated on the sliding surface of the shoe 10. The lower surface of the member 13 bears on an upper, part-spherical surface of a seat 15 of annular cross-section fitted on to the frame 17.

The diameter of the ball joint is between 0.7 and 1.0 times the width of the shoe 10 (dimension as measured parallel to the axis of the rotating body 12). Instead of being situated exactly on the sliding surface of the shoe 10 the centre 30 of the ball joint may be situated above or below said surface at a distance therefrom equal to at most 1/10 of the width of the shoe 10.

Axial movements of the part 12 are limited by two flanges 14 arranged to be integral with said body 12 the flanges 14 are arranged with a small clearance at each respective side of the shoe 10.

An upper face of the shoe 10 and an upper portion of sides thereof are covered with a lining 16 of anti-friction material Recesses 19 (Figure 5) forming containers for oil are formed in the sides of the shoe 10.

A transverse channel 18 is formed in the relatively slidable surface of the shoe 10; this channel 18 does not open on to the sides of the shoe 10, and a slight thickness of material remains at ends thereof. Oil may be introduced into the channel 18 by a duct 20 (Figure 2) and thus supplied to the channel 18.

Sloping recesses 22 (Figures 4, 6, and 7) are formed in two end walls of the channel 18, as is illustrated in Figures 6 and 7. These recesses 22 provide communication between the channel 18 and two circumferential grooves 24 formed at the junction of the flanges 14 with the rotating body 12. The cross-sectional area of two passages provided by each of these recesses 22 between the channel 18 and the respective groove 24 is at a maximum when the shoe 10 (Figures 1 to 3 and 5) abuts a corresponding one of the flanges 14 (Figures 1 and 3), as Figure 6 illustrates; communication between the channel 18 and the groove 24 is interrupted when the shoe 10 abuts the opposite flange 14 (Figure 7). In intermediate positions of the shoe 10 the channel 18 communicates with both of the grooves 24; more particularly when the shoe 10 is centred relatively to the flanges 14 the useful cross-sectional areas of the two passages are equal. The recesses 22 provide passages which open on to said relatively slidable surface of the shoe 10.

Orifices of these passages are partly masked by a slidable track of the body 12 so that cross-sectional areas of the orifices are equal when the shoe 10 is centred relatively to the flanges 14.

These recesses 22 allow the oil to flow from the channel 18 into the groove 24 and then into the lateral containers 19 for oil, to provide lubrication for the sides of the shoe 10.

An advantage of such an arrangement consists in that a flow of oil towards each side of the shoe 10 is larger in proportion as the corresponding flange 14 is nearer to this side. In fact, relative axial movement of the shoe 10 and the body 12 (Figures 1 to 3) has a result of increasing the cross-sectional area of each orifice allowing communication between the channel 18 (Figure 2) and the groove 24 (Figures 6 and 7) in a region where a bearing and the shoe 10 approach the flange 14 adjacent the orifice

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concerned, and reducing this cross sectional area at another side. Therefore, this cross-sectional area is larger in proportion as that side of the shoe 10 is nearer to the flange 14, and lubrication must be more effective. Thus means are provided for bringing a lubricant in between the sides of the shoe 10 and the respective flanges 14.

In a limiting case, the recess 22 situated in the region of the side furthest from the respective flange 14 and the orifice of each passage may be completely masked as represented in Figure 7, in which case a maximum amount of oil is directed towards an opposite side of the shoe 10 when that side abuts the adjacent flange 14. Therefore by this means an optimum automatic distribution of lubricating oil is obtained for the sides of the shoe 10.

The present device for supporting a rotating body is applicable to all supporting and thrust-bearing devices for rotating parts sliding on shoes by means of a hydrostatic or hydrodynamic film of oil and more particularly, for example, bearings of tubular grinding mills and bearings supporting rotary oven wheels.

WHAT WE CLAIM IS:—

1. A device for supporting a rotating body which device comprises at least one shoe mounted on a fixed frame by means of a part spherical member of the shoe locating in a corresponding recess in the frame, the centre of curvature of the part spherical member being at or adjacent a relatively slidable surface of the shoe and the ratio of the radius of curvature of the part spherical member to the maximum dimension of the shoe parallel to the intended axis of a rotating body being from 0.35:1 to 0.5:1.

2. A device for supporting a rotating body, as claimed in claim 1, in which means are provided for supplying a lubricant to the surface of the shoe intended to undergo sliding relative to the rotating body.

3. A device for supporting a rotating body, as claimed in claim 2, in which device the shoe is formed with a transverse channel extending substantially parallel to the intended axis of the rotating body formed in the relatively slidable surface, arranged to be supplied with oil.

4. A device for supporting a rotating body, as claimed in claim 3 or claim 4, in which said channel is formed with sloping recesses in its end walls.

5. A device for supporting a rotating body, as claimed in any of claims 1 to 4, in which device the sides of the shoe are formed with recesses forming containers for oil.

6. A device for supporting a rotating body, substantially as hereinbefore described with reference to the accompanying drawings.

7. An assembly comprising a device as claimed in any preceding claim and a body slidably supported by said device for rotation.

8. An assembly as claimed in claim 7, in which the rotatable body is provided with two integral circumferential flanges arranged with a small clearance at each respective side of the shoe, and means are provided for bringing a lubricant in between the sides of the shoe and the respective flanges.

9. An assembly as claimed in claim 8, in which the shoe is formed with a transverse channel extending substantially parallel to the axis of the rotating body formed in the relatively slidable surface thereof, arranged to be supplied with oil, two circumferential grooves being formed at the junctions of the flanges with the rotating body, and two passages opening onto said relatively slidable surface of the shoe and providing communication between the channel and the two grooves, the cross-sectional areas of the passages being partly defined by the slidable track of the rotating body so as to be equal when the shoe is centred relatively to the flanges and so that a said cross-sectional area increases when the shoe approaches the flange adjacent the respective passage.

10. An assembly, as claimed in claim 8, in which the cross-sectional area of a said passage is reduced to zero when a side of the shoe abuts the flange adjacent thereto.

11. An assembly of a device as claimed in claim 1 and a body slidably supported by said device for rotation, substantially as hereinbefore described with reference to Figs. 1 to 3, 6 and 7 of the accompanying drawings.

12. An assembly as claimed in any of claims 7 to 11, wherein the said body comprises a tubular grinding mill.

13. An assembly as claimed in any of claims 7 to 11, wherein the said body comprises a rotary oven.

STANLEY, POPPLEWELL, FRANCIS & ROSS
Agents for the Applicants,
Chartered Patent Agents,
1, Dyers Buildings,
Holborn, EC1N 2JT.

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1 508 384
2 SHEETS

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

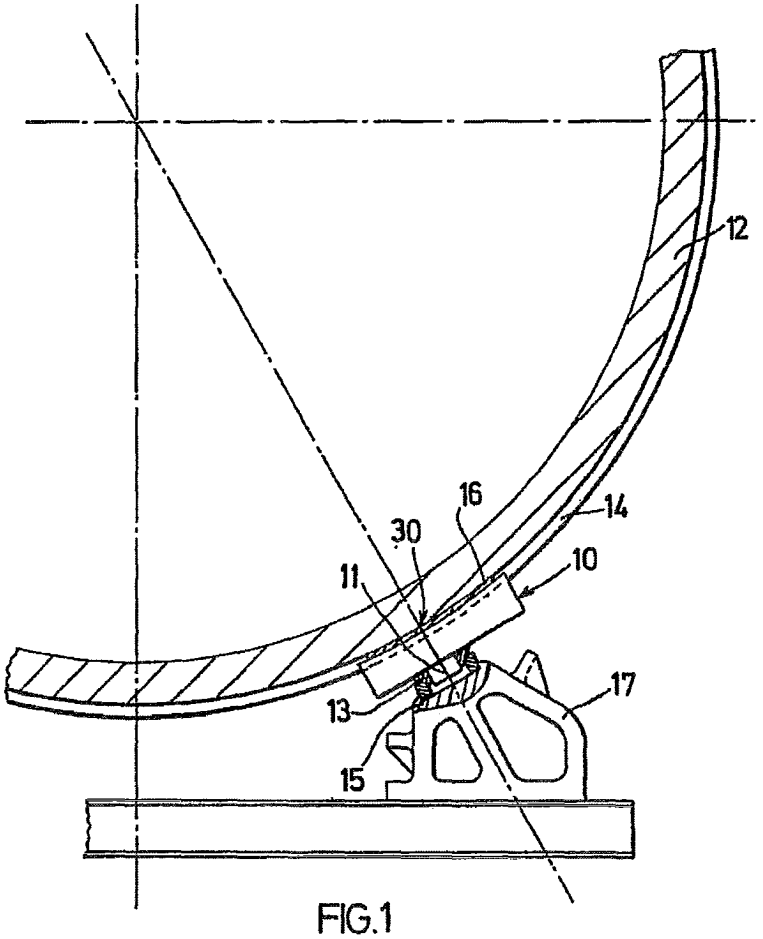


FIG.1

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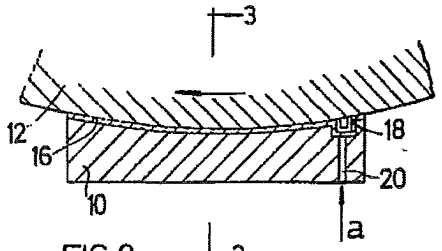


FIG. 2

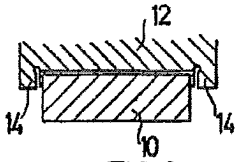


FIG. 3

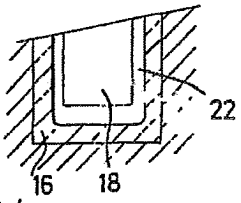


FIG. 4

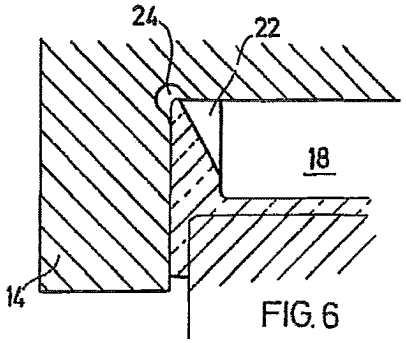


FIG. 6

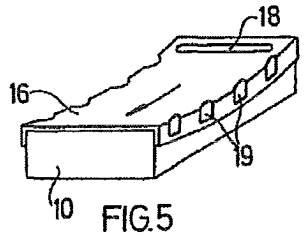


FIG. 5

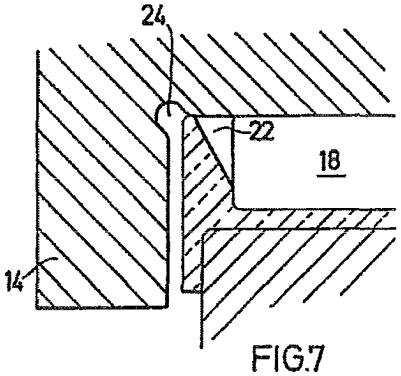


FIG. 7

DOCID: <GB_____1508384A_I_>

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(71) Applicant *(for all designated States except US):* VICKERS PLC [GB/GB]; Vickers House, Millbank Towers, Millbank SW1P 4RA (GB).

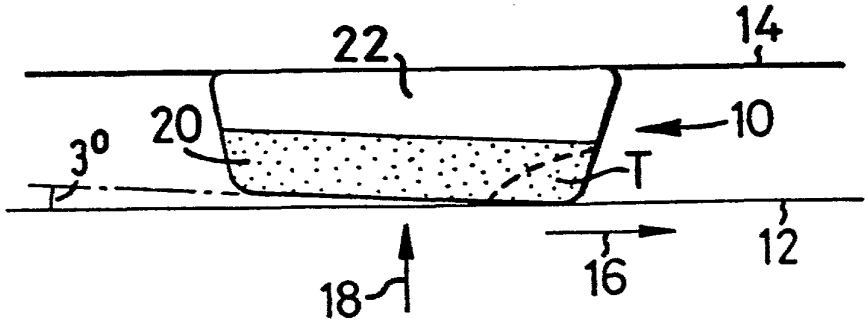
(72) Inventor; and
(75) Inventor/Applicant *(for US only) :* BOWERS, Norman, Kenneth [GB/GB]; 18 Semaphore Road, Guildford, Surrey GU1 3PT (GB).

(74) Agent: SKONE JAMES, Robert, Edmund; 53/64 Chancery Lane, London WC2A 1HN (GB).

(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), + CH, CH (European patent), CM (OAPI patent), DE, + DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

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(54) Title: THRUST BEARING



(57) Abstract

A fluid film lubricated thrust bearing comprises a rotatory member (12) such as a thrust collar on a shaft subject to axial load (18) and shoes (10) of elastomeric material (20) for reacting the axial load. Starting of rotation when the member (12) is subject to load is enabled by tilting the faces of the shoes against which the rotatory member (12) runs e.g. by interposing a wedge-shaped backing (22) between the elastomeric material (20) and a support or backing member (14) to assist formation of fluid films as the member (12) rotates. Introduction of pressure fluid between the members (12, 14) can provide hydrostatic reaction of the axial load (18) and further reduce starting torque. The fluid may be oil or water.

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THRUST BEARING

The present invention relates to a thrust bearing for use particularly, though not exclusively, on a rotary shaft which may be a horizontal or vertical shaft of e.g. a pump or generator or may be a marine propeller shaft. The invention also relates to a shoe for such a bearing.

Pivoted segmental thrust bearings in which a load on a shaft shoulder or collar is reacted by tiltable shoes or pads in a bearing housing with an oil-film between the shaft shoulder or collar and the pads (so-called Kingsbury or Michell bearings) are known.

GB-A-1271774 mentions the use of curved bearing pads and plain pads for journal bearings, but for thrust bearings it proposes the use of flat pads parallel to the thrust face or collar (in the circumferential direction) with curved entries and exits. This will not be an effective arrangement, and will only allow the use of light loadings.

GB-A-1197850 discloses the use of rubber lined bearings for journals and thrust bearings. However it uses very large diameter bearings to reduce the specific loading and to increase the surface velocity as rubber bearings are said to function best when the surface velocity is high and the load per unit area is low. Convex faces are used on the thrust faces to give maximum lubrication.

In accordance with one aspect of the present invention, a fluid film lubricated thrust bearing comprises a rotary member subject to axial load and shoes of elastomeric material for reacting the axial load, wherein the faces of the shoes against which the rotary member runs are substantially planar and oriented so as to present an acute lead-in angle to the rotary member.

The invention provides a fluid film lubricated thrust bearing that does not require pivoted shoes, has a lower power consumption, and can be stopped and restarted repeatedly without seizing. The invention also provides a fluid film lubricated thrust bearing of simpler structure than a Kingsbury or Michell bearing that can nevertheless react high axial loads. The thrust bearing will carry a high specific load at a relatively low surface speed so that bearing size can be kept small and losses minimised.

The present invention provides a fluid film lubricated thrust bearing in which the fluid can be oil or grease but particularly water (including fresh and sea water).

In a bearing as aforesaid the faces of the shoes against which the rotary member runs are preferably of natural or synthetic rubber. If the rubber is an oil-resistant rubber the lubricating fluid may be an oil or grease. But the use of water as the fluid is preferred for many applications (e.g. marine propulsion shafts).

Thus, in accordance with a second aspect of the present invention, a method of operating a load bearing assembly comprising a thrust bearing according to the first aspect of the present invention comprises supplying lubricating fluid to the thrust bearing, the fluid being selected from, for example, oil, grease and water.

At the entry sides of the shoes with reference to an intended primary direction of shaft rotation the shoes converge towards the rotary member. Thus the faces of the shoes against which the rotary member runs are inclined at least at their entry sides at an acute, preferably small, angle. This angle may be in the range 0.75-4.5° when each shoe is in an unloaded condition and is preferably about 3°. Tests have shown surprisingly

that the bearing can sustain very high loads, up to three times those expected.

To reduce the likelihood of break-away of material at the trailing edges of the pads or shoes under high applied loads, the exit sides of the shoes preferably diverge from the rotary member at a relatively large angle, e.g. 15° or 30°. Surprisingly it has been found that reverse running can take place under considerable load with these large angles on the side which is the exit side when running in the normal direction.

The shoes may be disposed in a single ring coaxial with the axis of rotation of the member, or they may be disposed in a multiplicity of concentric rings coaxial with the axis of rotation of the member.

This should be contrasted with conventional bearings in which the radial dimensions of shoes in a single ring are increased as necessary.

The shoes do not need to be pivoted as in a Michell bearing, and thus the bearing may comprise a support and means attaching the shoes to the support so that the shoes maintain a fixed attutude to the rotary member.

Each shoe may comprise a pad of elastomeric material attached to a backing of rigid material which may be a metallic or non metallic material such as ebonite and the backing of each pad may be mechanically connected to a support by bolts or studs or other suitable means. The pads may be generally rectangular when viewed in plan (i.e. when viewed in the direction of the shaft axis of rotation) or may be segments of a ring, are preferably radially directed and may have lengths greater than their widths. To enable a damaged pad to be removed without dismantling the whole of the bearing, it is preferred that the backing is formed in radial segments each carrying one or more pads, each segment being independently removable.

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The rotary member may be a shaft shoulder or collar, and first and second sets of shoes may be provided that can run against opposed end faces of the shaft shoulder or collar if it is desired to react load in either axial direction.

Particularly from the standpoint of ease of starting rotation it is in some applications desirable to provide means for applying fluid pressure to the rotary member to react at least part of the axial load and reduce the thrust on the pads or shoes. Thus the bearing preferably has a housing, the rotary member fits within the housing and has a cylindrical side surface, a seal in the housing acts on the side surface of the rotary member to provide a fluid chamber containing a set of bearing pads, and means is provided for feeding pressure fluid into the fluid chamber to react axial load.

In a further aspect, the invention provides a shoe for a thrust bearing comprising an elastomeric pad and a rigid backing member on which the pad is mounted, wherein opposed planar faces of the pad and backing member extend at an acute angle to one another.

A bearing as aforesaid may have a housing that is also provided with a journal bearing or the like to maintain trueness of the bearing housing relative to the shaft or other rotary member during rotation thereof.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figures 1 and 2 are a transverse section and a plan of a first form of shoe forming part of a thrust bearing;

Figure 3 is a transverse section of a second form of shoe forming part of a thrust bearing;

Figure 4 is a diagrammatic exploded view of a thrust bearing in which load is reacted using the shoes of Figure 1 or Figure 3; and

Figure 5 is a diagrammatic longitudinal section of the thrust bearing.

In Figures 1 and 3 a shoe 10 for a seawater lubricated thrust bearing is in compression between a rotary member or disc 12 and a stationary support member 14, the direction of rotation of member 12 being indicated by arrow 16 and the axial load on the member 12 being indicated by the arrow 18. The shoe 10 comprises a constant thickness rubber pad 20 typically of Shore A hardness 70 to 80, attached onto a rigid backing member 22 of ebonite or other suitable material and may be laminated with carbon fibre, kevlar or polyester fibres to resist tensile loads and minimise stress cracking (see below).

The pad 20 may be generally rectangular as shown or may be keystone-shaped, conveniently has a radial length greater than its circumferential width with a typical aspect ratio of about 2:1 or more, is radially directed and occupies only a small angular sector of rotary member 12, there being at least one ring of pads. It may have two or more rings of concentric pads with a multiplicity of pads in each ring thereby maximising the number of working pads and hence the load that can be carried. Thus for a thrust bearing

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for a large marine propeller shaft there might be four rings with about 50 shoes in the inner ring and about 90 shoes in the outer ring, but a smaller installation might have a single ring with 6, 8 or 12 shoes in the ring. The backing member 22 is formed with fixing holes 24 that receive bolts or studs for attachment of the pad 10 to the support member 14. It is of wedge profile as shown in Figure 1, so as to cause the face of the pad 20 to present an angle of about 3° to the adjoining face of rotary member 12 when there is no substantial axial load 18 on the member 12. It will be appreciated that as the axial load 18 increases to several tonnes or tens of tonnes as may happen in normal running, the rubber pad 20 will distort so that its surface approaches parallelism with the adjoining face of the rotary member 12.

It has been found that a water-lubricated thrust bearing using shoes as shown can run under high applied loads, and further that it can be brought to rest and restarted under load with a reduced tendency to seize and a comparatively low starting torque. The convergent taper of the face of rubber pad 20 relative to the member 12 (as viewed in the direction of

rotation 16 of the member 12) is believed to promote formation of a lubricating film of water between the members 12 and 20, and its ability to do so has been observed to persist under axial load. In contrast, it has been found that an initially parallel pad does not generate a lubricating film so easily and can only sustain comparatively small axial loads. If need be, hydrostatic pressure is applied to the bearing to react at least part of the shaft load as described below. An advantage of non-brittle pad materials such as rubber is that they are resistant to shock loads which could lead to catastrophic failure of pads of brittle material, Consequently a bearing using an elastomeric pad material is likely to be reliable in service under a range of adverse conditions.

It has been shown that the mode of failure of elastomeric (rubber) faced fixed taper thrust pads is by the breaking off of small portions (see the dotted line in Figure 1) of the elastomeric (rubber) pad at the trailing edge. This breaking off is caused by the high peak pressure on the face of the pad together with the tension T in the pad (Figure 1) caused by the drag of the disc on the pad surface. The load at which portions break off can be significantly increased by re-inforcing the rubber in the direction of motion of

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the thrust disc e.g. transversely across the pad. Such reinforcement may be in the form of fibres such as polyester or kevlar or carbon embedded in the rubber. Such re-inforcement will stiffen the pad surface and resist fracture due to tension. It will also help to resist penetration of the rubber by the high peak pressure that occurs towards the trailing edge of the pad. To minimise the risk of break-away, a modified pad structure (Figure 3) has a tapered trailing edge 24 which typically makes an angle of 15 to 30° with the member 12. The pad profile may be modified if the shaft rotates in both directions by providing tapers on a pair of opposite edges. The pad profile may be curved as well as angular.

In Figures 4 and 5, a thrust bearing 30 for reacting axial load 31 on a shaft 32 comprises a housing through which the shaft 30 passes and defined by cover 34, stationary support 36 and sets of side plates 38, 40 (only one group shown) that together make up a cylindrical side surface of the housing. The shaft 30 has an integral collar 42 attached to which is a thrust collar or disc 44 that rotates with the shaft 32. Under the normal load direction in shaft 32 which is indicated by arrow 31, the thrust at collar 42 is

reacted by shoes 10a attached to shoe carrier 46. As seen in Figure 4, the carrier 46 carries several rings of the shoes 10a and is divided into quadrants or sectors 46a, 46b etc, that are attached to and individually removable from the support 36. This arrangement permits inspection of the shoes 10a and replacement of any damaged ones by pulling the quadrants or sectors out radially without dismantling of the bearing assembly in the axial direction, and cover plates 40 are divided into matching quadrants or sectors to permit inspection and shoe removal to be carried out. For occasions when load direction 31 is reversed, the cover 34 has a second carrier 48 in sectors 48a-48b etc, and carrying a second set of shoes 10b. The support 36 also carries a journal bearing 50 (which is advantageously also water-lubricated) to maintain the housing closely concentric with the shaft 30 as the latter rotates.

To further facilitate shaft rotation, especially when starting from rest under axial load, it is preferable to react at least part of the shaft load 31 hydrostatically. For this purpose an annular seal 52 supported in a groove 54 of side plates 38 and energised by pressure fluid at line 56 runs on the cylindrical surface of collar 44. A fluid-tight

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internal chamber 58 of the housing containing the set of shoes 10a is thereby defined. Supply of pressure fluid from line 60 by pump 62 or other suitable means into the chamber 58 reacts the pressure at collar 44. By selection of the pressure provided by pump 62, the axial load 31 may be partly relieved, may be balanced out so that the shaft 30 "floats" hydrostatically in the bearing, or may be over-compensated so that a reverse thrust is reacted by shoes 10b. If the pressure provided by pump 62 almost cancels out the axial thrust 31, the frictional resistance to shaft rotation is reduced, and the starting torque necessary for shaft rotation is reduced. If desired the bearing can be run in normal operation for extended periods with hydrostatic reaction of the load as aforesaid.

CLAIMS

1. A fluid film lubricated thrust bearing comprising a rotary member subject to axial load and shoes of elastomeric material for reacting the axial load, wherein the faces of the shoes against which the rotary member runs are substantially planar and oriented so as to present an acute lead-in angle to the rotary member.

2. A bearing according to claim 1, wherein the faces of the shoes against which the rotary member runs are of natural or synthetic rubber.

3. A bearing according to claim 2, wherein the rubber is an oil-resistant rubber for use with a lubricating fluid of oil or grease.

4. A bearing according to any of claims 1 to 3, wherein the acute lead-in angle lies in the range 0.75-4.5° when each shoe is in an unloaded condition.

5. A bearing according to claim 4, wherein the faces of the shoes against which the rotary member runs are inclined at an angle of about 3° to the surface of the rotary member when in an unloaded condition.

6. A bearing according to any preceding claim, wherein the exit sides of the shoes diverge from the rotary member.

7. A bearing according to claim 6, wherein the exit sides of the shoes diverge from the rotary member at an angle in the range 15-30°.

8. A bearing according to any preceding claim, wherein the shoes are disposed in a single ring coaxial with the axis of rotation of the member.

9. A bearing according to any of claims 1 to 7, wherein the shoes are disposed in a multiplicity of concentric rings coaxial with the axis of rotation of the member.

10. A bearing accoring to any preceding claim, further comprising a support and means attaching the shoes to the

support so that the shoes maintain a fixed attitude to the rotary member.

11. A bearing according to any preceding claim, wherein each shoe comprises a pad of elastomeric material attached to a backing of rigid material.

12. A bearing according to claim 13, wherein the rigid material is ebonite or another rigid plastics material.

13. A bearing according to claim 11 or 12, wherein the backings of rigid material are bolted to the support.

14. A bearing according to claim 13, wherein the support is formed in radial segments each carrying one or more shoes, each segment being independently removable.

15. A bearing according to any preceding claim, wherein the shoes have an elongate dimension which is directed radially.

16. A bearing according to claim 15, wherein the shoes have lengths greater than their widths.

17. A bearing according to any preceding claim, wherein the rotary member is a shaft shoulder or collar.

18. A bearing according to claim 17, wherein first and second sets of shoes are provided that can run against opposed end faces of the shaft shoulder or collar for reacting load in either axial direction.

19. A bearing according to any preceding claim, further comprising means for applying fluid pressure to the rotary member to react at least part of the axial load.

20. A bearing according to any preceding claim, further comprising a housing, wherein the rotary member has a cylindrical side surface, a seal in the housing acts on the side surface of the rotary member to provide a fluid chamber containing a set of bearing pads, and means is provided for feeding pressure fluid into the fluid chamber to react axial load.

21. A bearing according to any preceding claim, further comprising journal bearing means maintaining the bearing closely concentric with the rotary member.

22. A method of operating a load bearing assembly comprising a thrust bearing according to any of the preceding claims in which lubricating fluid is supplied to the thrust bearing.

23. A method according to claim 22, wherein the lubricating fluid is oil or grease.

24. A method according to claim 22, wherein the lubricating fluid is water.

25. A shoe for a thrust bearing, the shoe comprising an elastomeric pad and a rigid backing member on which the pad is mounted, wherein opposed planar faces of the pad and backing member extend at an acute angle to one another.

26. A shoe according to claim 25, wherein the pad has substantially parallel opposed faces, one of the pad faces being mounted on a face of the backing member, wherein opposed faces of the backing member extend at the acute angle to one another.

27. A shoe according to claim 25 or claim 26, wherein the elastomeric pad is cut back at its edge facing away from the direction in which the planar faces of the pad and backing member extend at an acute angle to define in use a relatively large exit angle with an applied rotary member.

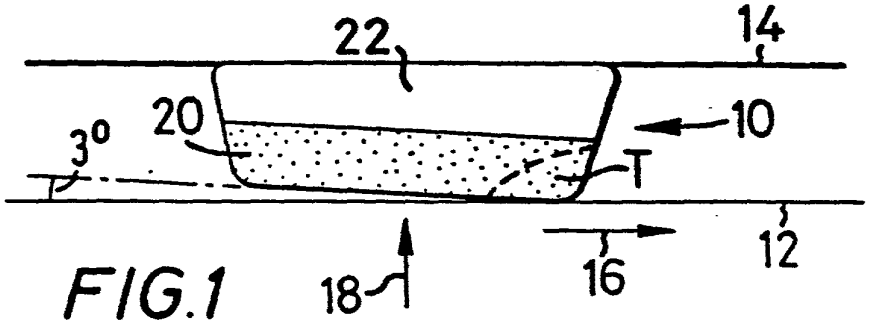


FIG.1

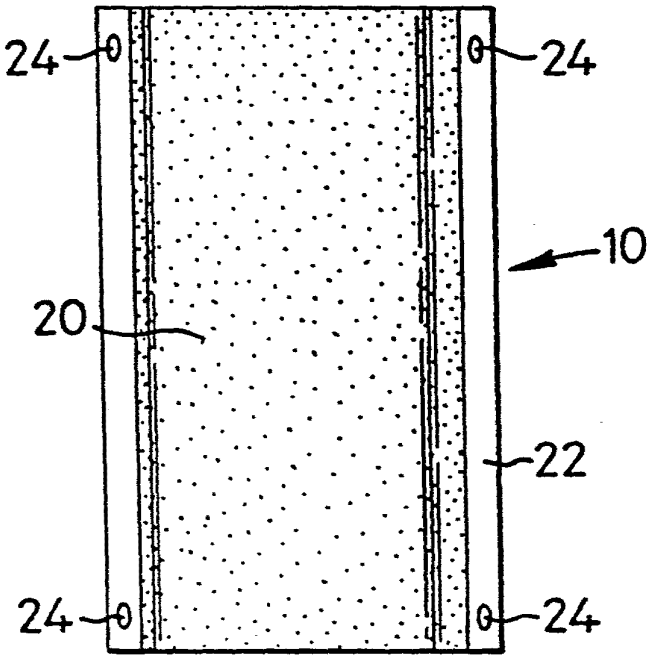


FIG.2

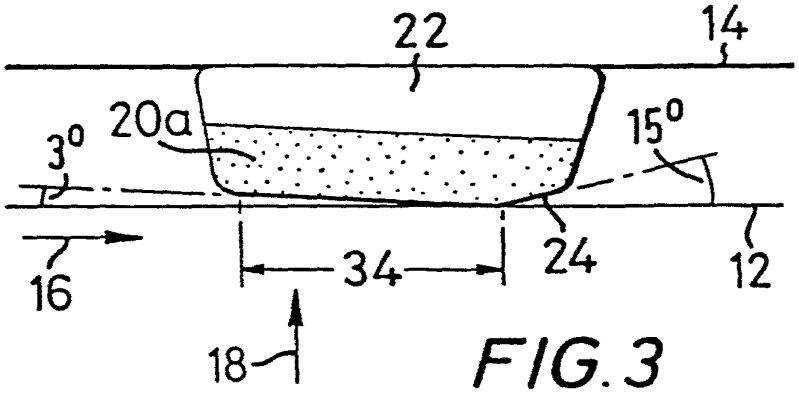


FIG.3

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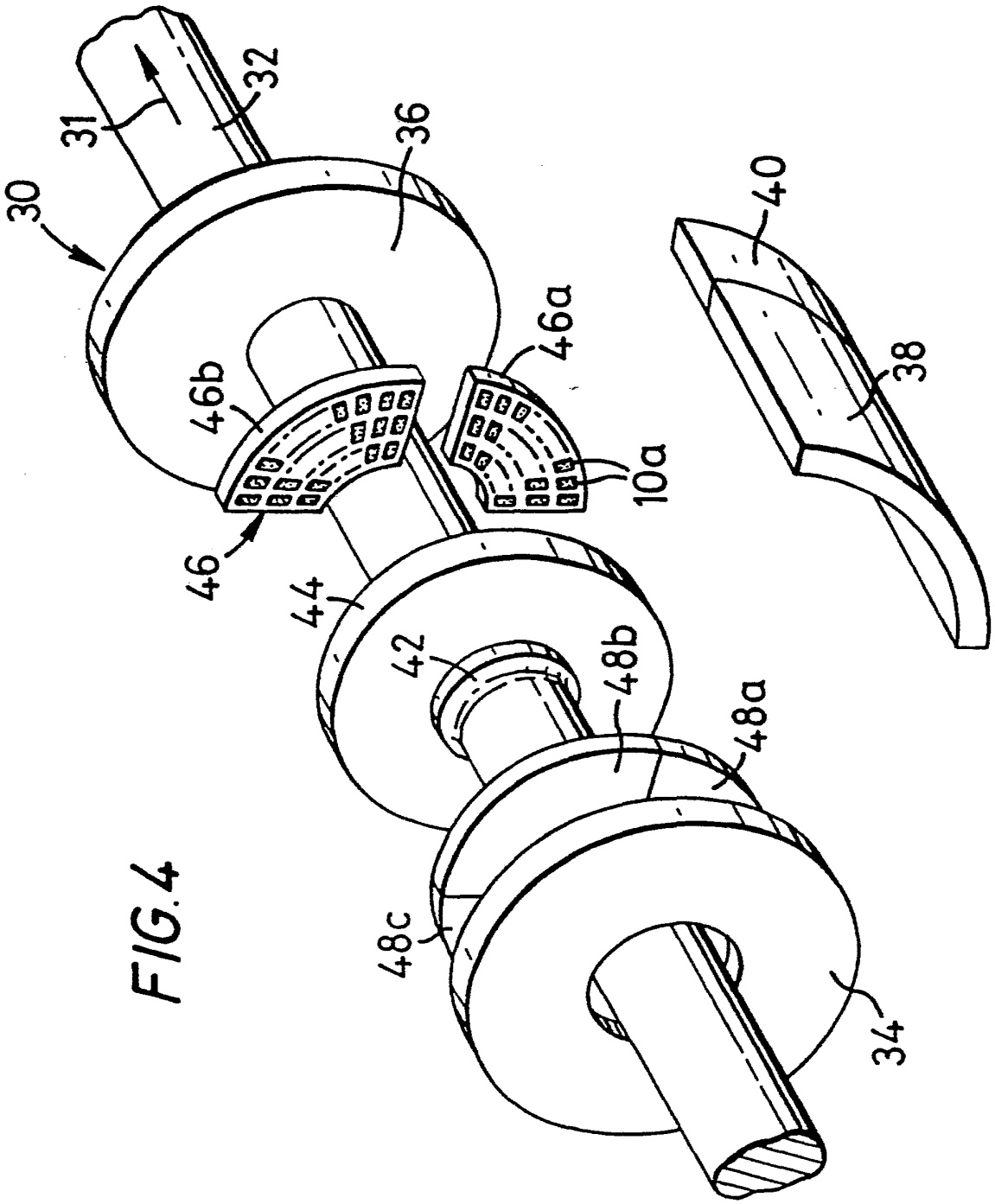


FIG.4

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FIG.5

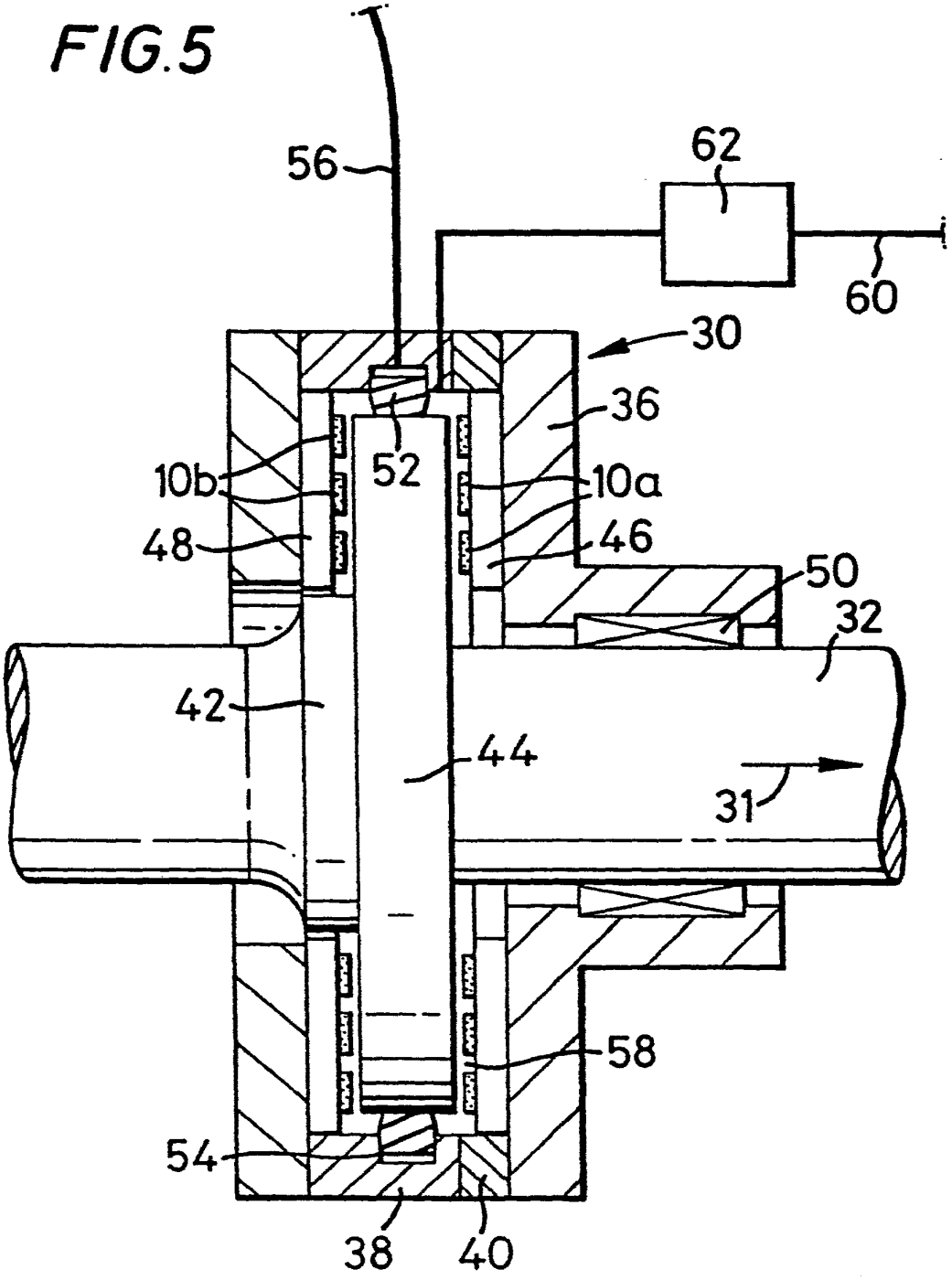


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INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/00510

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: F 16 C 33/22

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC[5]	F 16 C, B 63 H

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [6]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [7]

Category [8]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No [13]
A	EP, A, 0039114 (IHC HOLLAND) 4 November 1981 see figure 2; page 6	1
A	EP, A, 0038602 (IHC HOLLAND) 28 October 1981 see the whole document	1
A	GB, A, 960152 (MCCUTCHEN) 10 June 1964 see figure 11	1
A	US, A, 3298751 (ELWELL) 17 January 1967 see figure 5	1

* Special categories of cited documents: [10]

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
29th May 1990	20. 06. 90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	H. DANIELS

Form PCT/ISA/210 (second sheet) (January 1985)

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US, A, 4290656 (DAUGHTERTY) 22 September 1981	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9000510 SA 35898

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 15/06/90
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0039114	04-11-81	NL-A- 8002280	16-11-81
		AT-T- E6882	15-04-84
		JP-A- 56167918	23-12-81
		US-A- 4381127	26-04-83
EP-A- 0038602	28-10-81	NL-A- 8002281	16-11-81
		AT-T- E6541	15-03-84
		JP-A,B,C56164222	17-12-81
		US-A- 4362343	07-12-82
GB-A- 960152		None	
US-A- 3298751		None	
US-A- 4290656	22-09-81	None	

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

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EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 2006009968
PUBLICATION DATE : 12-01-06

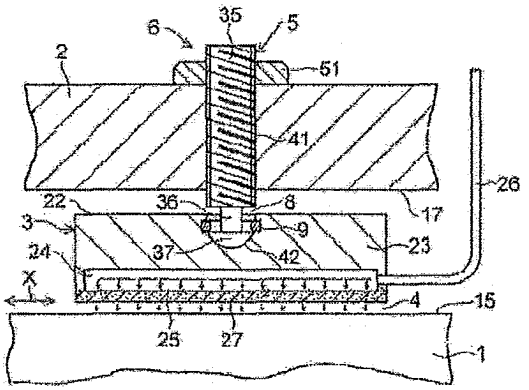
APPLICATION DATE : 25-06-04
APPLICATION NUMBER : 2004188738

APPLICANT : OILES IND CO LTD;

INVENTOR : SATO HIKARI;

INT.CL. : F16C 32/06 (2006.01)

TITLE : COMBINING STRUCTURE OF STATIC PRESSURE GAS BEARING PAD AND GAP ADJUSTING MEMBER, AND STATIC PRESSURE GAS BEARING MECHANISM USING THE SAME



ABSTRACT : PROBLEM TO BE SOLVED: To provide a combining structure of a static pressure gas bearing pad and a gap adjusting member by which a gap adjusting member can be coupled to a static pressure gas bearing pad so as not to fall off without employing a screw or the like and which achieves cost reduction, a static pressure gas bearing pad and a gap adjusting member which are most suitable for the structure, and a static pressure gas bearing mechanism using the same.

SOLUTION: A combining structure 6 of a static pressure gas bearing pad 3 interposed between a movable body 1 and a fixed body 2 so as to freely movably hold the movable body 1 in an X direction with respect to the fixed body 2 and a gap adjusting member 5 for adjusting a gap 4 between the static pressure gas bearing pad 3 and the movable body 1 is equipped with a recess 8 which is provided to the static pressure gas bearing pad 3 and which has a ring mounting groove 7, a ring 9 made up of a freely expandable elastic O ring mounted in the ring mounting groove 7 and a receiving groove 11 which is provided to the gap adjusting member 5 and which receives the ring 9 partially projected from a recess specifying surface of the static pressure gas bearing pad 3 for specifying the recess 8.

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1 **JP2006009968A** 2006-01-12 **COMBINING STRUCTURE OF STATIC PRESSURE GAS BEARING PAD AND GAP ADJUSTING MEMBER, AND STATIC PRESSURE GAS BEARING MECHANISM USING THE SAME** (en)
静圧気体軸受パッドと隙間調節部材との組み合わせ構造及びこれを用いた静圧気体軸受機構 (ja)

Abstract

English Abstract:

PROBLEM TO BE SOLVED: To provide a combining structure of a static pressure gas bearing pad and a gap adjusting member by which a gap adjusting member can be coupled to a static pressure gas bearing pad so as not to fall off without employing a screw or the like and which achieves cost reduction, a static pressure gas bearing pad and a gap adjusting member which are most suitable for the structure, and a static pressure gas bearing mechanism using the same.

SOLUTION: A combining structure 6 of a static pressure gas bearing pad 3 interposed between a movable body 1 and a fixed body 2 so as to freely movably hold the movable body 1 in an X direction with respect to the fixed body 2 and a gap adjusting member 5 for adjusting a gap 4 between the static pressure gas bearing pad 3 and the movable body 1 is equipped with a recess 8 which is provided to the static pressure gas bearing pad 3 and which has a ring mounting groove 7, a ring 9 made up of a freely expandable elastic O ring mounted in the ring mounting groove 7 and a receiving groove 11 which is provided to the gap adjusting member 5 and which receives the ring 9 partially projected from a recess specifying surface of the static pressure gas bearing pad 3 for specifying the recess 8.

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Other Abstract:

【課題】 ねじ等を用いないでも静圧気体軸受パッドに隙間調節部材を脱落しないように連結できて、而して、コスト低下を図り得る静圧気体軸受パッドと隙間調節部材との組み合わせ構造、それに最適な静圧気体軸受パッド及び隙間調節部材並びにそれを用いた静圧気体軸受機構を提供すること。【解決手段】 可動体１を固定体２に対してＸ方向に移動自在に保持すべく可動体１と固定体２との間に介在させる静圧気体軸受パッド３と、静圧気体軸受パッド３と可動体１との間の隙間４を調節する隙間調節部材５との組み合わせ構造６は、静圧気体軸受パッド３に設けられていると共にリング装着溝７を有する凹所８と、リング装着溝７に装着された拡径自在な弾性Ｏリングからなるリング９と、隙間調節部材５に設けられていると共に凹所８を規定する静圧気体軸受パッド３の凹所規定面１０から部分的に突出するリング９を受容する受容溝１１とを具備している。【選択図】図１

Bibliographic Data

Original Assignees: OILES INDUSTRY CO LTD

Inventors: SATO HIKARI

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Patent References Cited-Backward:

Retrieve Selected

	Publication Number	Publication Date	Title	Applicant/Assignee	Cited By
☐	JP828564				Was cited by the applicant
☐	JP2000199522A	2000-07-18	STATIC PRESSURE BEARING PAD	NSK LTD	Was cited by the applicant
☐	JP2002349569A	2002-12-04	STATIC PRESSURE BEARING DEVICE AND STAGE DEVICE USING IT	CANON KK	Was cited by the applicant

Patent References Cited-Forward:

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	Publication Number	Publication Date	Title	Applicant/Assignee
☐	JP5016232B2	2012-09-05	The slider device	株式会社ミツトヨ
☐	JP2007218404A	2007-08-30	SLIDER DEVICE	MITUTOYO CORP

Description

English Description:

TECHNICAL FIELD

The present invention, the movable body relative to a fixed body and the movable body to movably hold the dog is interposed between the fixed body and the static pressure gas bearing pad, the static pressure gas bearing pad to adjust the clearance between the movable body and a gap between the adjusting member and a combination structure of a hydrostatic gas bearing mechanism using the same.

BACKGROUND ART

Japanese Patent Publication Number 8-28564 publication In the patent Number 2000-199522 publication In the patent Number 2002-349569 publication

The hydrostatic gas bearing, in particular, to a porous metal sintered body using the static pressure gas bearing, and high-speed stability and an excellent load capacity having an extremely small movement of the bearing is known as many of these excellent advantages and used in the field. A static pressure gas bearing protodetector between the movable body and a fixed body in the form of a pad (present invention form a static pressure gas bearing pad hydrostatic gas bearing pads that) when the interposed, normally, the clearance between the movable body, for example with a clearance of about 5 μm hydrostatic gas bearing pad is arranged.

DISCLOSURE

TECH PROBLEM

The gap, the bearing rigidity, which largely affects the load capability and speed characteristics in order, to adjust the clearance between the movable body through the gap adjusting member the hydrostatic gas bearing pad interposed between the movable body and the fixed body in, the clearance adjusting member, usually, a static pressure gas bearing pad is oscillated by (oscillating), moreover, a static pressure gas bearing pad does not fall off from the pressing member by the tip and through a screw or the like connected to the static pressure gas bearing pad.

Incidentally, a static pressure gas bearing pad protodetector and gap adjusting member and combination of structure, in order to use a screw or the like, assembly and maintenance time, and cost increase.

The present invention, in view of the above advantages, in which, for the purpose and predischarging, without employing a screw or static pressure gas bearing pad clearance adjusting member can be coupled to so as not to fall off, therefore, cost reduction and hydrostatic gas bearing pad combination structure of gap adjusting member, and a static pressure gas bearing pad clearance adjusting member and a hydrostatic gas bearing mechanism using the same.

TECH SOLUTION

The movable body relative to a fixed body and the movable body to movably hold the dog is interposed between the fixed body and the static pressure gas bearing pad, and the static pressure gas bearing pad between the movable body of the present invention to adjust the clearance gap adjusting member of the combination of the structure, a static pressure gas bearing pads are provided in the recess and having a ring mounting groove, the ring mounting groove diameter and mounted on the ring, and the clearance adjusting member is provided with a recess to define a recess defining a hydrostatic gas bearing pad partially projecting from the surface of the ring and a receiving groove.

The combination of the present invention according to the structure, which is mounted in the ring mounting groove diameter ring is partially received in the receiving groove in order that, using a screw or the like through a protodetector ring without a gap adjusting member can be connected so as not to fall off, therefore, cost reduction.

In the present invention, the recess defining surface, and a concave semispherical concave or conical and cylindrical recess is provided, the ring mounting groove, and a concave conical or hemispherical concave cylindrical recess is provided between the high and, moreover, the clearance adjusting member, and a large diameter column portion, the large diameter column portion integrally connected to the large diameter column portion and a smaller diameter than that of the small diameter column and, integrally connected to the small diameter column is larger in diameter than the small-diameter cylindrical portion and a hemispherical portion and a good and, in this case, the receiving groove, and a large diameter column portion and is disposed between the hemispherical section. As the hemispherical section, circularity of the approximate semi-circular or even in a ball part, comprising the true elliptic or semi-elliptic ball is similar to ellipse.

In a preferred example of the present invention, the hemispherical portion of the hemispherical convex, concave or hemispherical concave recess defining surface is in contact with a conical, cylindrical and hemispherical concave recess defining surface is concave and includes a case, a hemispherical part of the hemispherical convex surface, and concave hemispherical recess defining surface of approximately the same curvature or curvature of the same and has a curvature larger than required. Also a hemispherical convex and semispherical concave, hemispherical section and similarly, consist of circular or elliptical or oval approximately from true circularity of the same or similar, similar conical concave.

In the preferred embodiment of the present invention also, the large diameter column portion, has a threaded portion on its outer surface, the threaded part is screwed through the fixing body and, the hemispherical portion, the large diameter column portion has a diameter smaller than the diameter, of the ring mounting groove and each has an annular receiving groove, the hydrostatic gas bearing pad, and porous surface opposed to the movable body, and a fixed body opposed to the face having no holes, recessed, non-porous surface opens, the static pressure gas bearing pad comprises a sintered porous metal layer is provided, a sintered porous metal layer on one surface of the movable body and the porous surface and facing, an elastic O ring from the ring.

As a sintered porous metal layer and the metal powder is mixed and inorganic powder, sintering can be cited as an example of one preferred that, in this case, the metal powder, at least tin, copper and includes dephosphorizing, further, at least one of nickel and manganese containing high and, the inorganic powder, graphite, boron nitride, graphite fluoride, calcium fluoride, aluminum oxide, silicon oxide and silicon carbide and at least one of which contains a good, the present invention is not limited to these.

The ring has the elastic O-ring made of elastic material and preferably is, in the present invention, is not limited to protodetector ring, elastic diameter reducing the diameter in which E or C ring made of rigid material and can be a ring or the like, moreover, the hemispherical portion of the hemispherical convex surface, the recess defining a surface in contact with the entire hemispherical concave, preferably in freely slidable contact which may, instead, of hemispherical concave recess partially defined surface contact, preferably slidably in contact.

ADVANTAGEOUS EFFECTS

According to the present invention, even without using a screw or the like in a hydrostatic gas bearing pad clearance adjusting member can be coupled to so as not to fall off, therefore, cost reduction and gap adjusting member combination structure of a bearing pad, a static pressure gas bearing pad and gap adjusting member and using it to provide a hydrostatic gas bearing mechanism.

BEST MODE

Next, the present invention and the best mode for implementing same based on preferred embodiments shown in the drawing and explained in detail. Furthermore, the present invention is not limited by any of these embodiments.

[...] from fig. 1 to fig. 3, the movable body 1 with respect to the fixed body 2 movably held in the X direction to the movable body 1 v interposed between the fixed body 2 and a static pressure gas bearing pad 3 and, static pressure gas bearing pad 3 and the movable body 1 for adjusting the gap 4 between the clearance adjusting member 5 of the combination structure 6, static pressure gas bearing pads 3 are provided in the ring mounting groove 7 and having a recess 8, the ring mounting groove 7 mounted on the elastic O-ring diameter and a ring 9, and a gap adjusting member 5 is provided with a recess 8, a static pressure gas bearing pad 3 defining a recess defining surface 10 partially projecting from a ring 9 and a receiving groove 11.

The movable body 1 and the fixed body 2 tracks.then, in an example shown in the cross -sectionally U-shaped rail of a rectangular plate, respectively, and are constituted, for example, precision machine tool or the like, the combination structure 6 when applied, a movable body 1 the head itself or a workpiece, or the head is placed in a form suitable for work mount base and therefore, also the fixed body 2, in the form of a movable body 1 protodetector movably held in the X direction and a form suitable becomes, therefore, the movable body 1 and the fixed body 2 tracks.then, rectangular U-shaped cross section and is not limited to each of the rails.

The movable body 1 and each of the side faces 15 and 16 of the fixing body 2 interposed between the inner surfaces 17 and 18 of a plurality of hydrostatic gas bearing pad 3 and the movable body 1 and the bottom 19 of the fixed body 2 is interposed between the upper surface of the base of 20 a plurality of static pressure air bearing pads 3 tracks.then configured the same as the other, each hydrostatic bearing pad 3 mounted on the fixed body 2 corresponding to the clearance adjusting member 5 respectively are constituted in the same manner with each other, respectively, of the static pressure gas bearing pad 3 and the clearance adjusting member 5 corresponding to each of the other combination structure of 6 also is constituted in the same manner, or lower, side face 15 of the body 1 and the fixed body 2 is interposed between the inside surface 17 of a hydrostatic gas bearing pad 3 and the static pressure gas bearing pad 3 mounted on the fixed body 2 corresponding to the clearance adjusting member 5

and these hydrostatic gas bearing pads 3 and gap adjusting member 5 with respect to the combination of the structure 6.

The hydrostatic gas bearing pad 3, facing the inner surface 17 of the fixed body 2 of a non-porous surface plane 22 is opened substantially at the center of the recess 8 23 and is provided with a disc-shaped back plate, back plate 23 integrally formed in the other plane of the fixed back plate 23 and the gas passage 24 is formed to cooperate with the disk-shaped porous metallic sintered layer 25 and is provided with, a flexible pipe 26 to the gas passage 24 through the high pressure air is supplied to the porous metallic sintered layer 25 of the movable body 1 via a large number of pores is injected toward the side face 15. In this way, the static pressure gas bearing pad 3, facing the movable body 1 and the side face 15 of the porous surface 27, facing the inner surface 17 of the fixed body 2 as a non-surface and a plane 22, and inorganic powder mixture and metal powder, sintering of the porous metallic sintered layer 25 and the flat surface of one of the perforated face 27.

Static pressure gas bearing pad 3 defining a recess defining surface 10 of the recess 8, and semi-cylindrical concave surface 31 and the concave hemispherical concave surface 32 is provided, with an annular ring mounting groove 7 is, in the direction orthogonal to the X direction and Y cylindrical recess 31 is provided between the hemispherical concave surface 32.

Static pressure gas bearing pad 3 of the body 1 and the side face 15 of the porous surface 27 of the size of the gap 4 between the width in the direction (Y) for adjusting the clearance adjusting member 5, and a large diameter column portion 35, the large diameter column portion 35 is integrally connected to the large diameter column portion 35 and cylindrical recess 31 and a smaller diameter than that of the small diameter column 36 and, small diameter column 36 is integrally connected to the small-diameter cylindrical part 36 has a diameter larger than the large diameter column portion 35 has a diameter smaller than the diameter of the hemispherical portion 37 and a semicircular section is provided, the annular receiving groove 11, and in the Y direction of the large diameter column portion 35 is provided between the hemispherical part 37. The large diameter column portion 35, the end face 44 side partially arranged in recess 8 may, in this case, the large diameter column portion 35, a static pressure gas bearing pad 3 and capable of rocking (oscillating) so as to, cylindrical recess 31 has a diameter smaller than the diameter of the can.

The large diameter column portion 35, and has a threaded portion 41 on its outer surface, a fixed body 2 via the threaded portion 41 is screwed in, the clearance adjusting member 5, the large diameter column portion 35 by the rotation axis direction, i.e. in the direction Y and, a static pressure gas bearing pads 3 protodetector by forward and backward movement of the movable body 1 and the side face 15 of the porous surface 27 for adjusting the size of the gap between the 4.

The semi-spherical convex hemispherical part 37 of the hemispherical convex surface 42, a hemispherical concave surface 32 of the recess defining surface 10 almost the same curvature and the curvature of the recess defining surface 10 has a hemispherical concave 32 and is slidably in contact with the whole. The hemispherical convex surface 42, a hemispherical concave surface 32 has a curvature larger than the radius of curvature may, in this case, hemispherical concave 32 slidably contacts a partially.

The annular receiving groove 11, and the outer peripheral surface 43 of the small diameter cylindrical portion 36, a large diameter column portion 35 and an annular end surface 44, and the hemispherical portion 37 defined by an annular end surface 45.

The combination of the structure 6 than is provided by a hydrostatic gas bearing mechanism 50, the movable body 1 from the porous surface 27 by high pressure air ejected toward the movable body 1 with a clearance 4 with respect to the fixed body 2 movably held in the X direction. Furthermore, the size of the gap 4, gap adjusting member 5 in the direction of Y is set to an optimum value, which is set to the optimal value after the clearance adjusting member 5, the lock nut 51 can be advanced and retreated in the direction Y by the fixed body 2 is not fixed.

Incidentally, in this combination structure 6, an annular ring mounting groove 7 diameter mounted on a ring 9 is partially received in the receiving groove 11 a, hemispherical section 37 engages the end face 45 of the ring 9, so as not to be pulled from the recess 8 of the hemispherical portion 37 in order that, even without using a screw or the like through the ring 9 protodetector hydrostatic gas bearing pad 3, a gap adjusting member 5 can be connected so as not to fall off, therefore, the cost is reduced. Moreover, in the combined structure 6, hemispherical section 37 of the hemispherical convex surface 42 is slidably in contact with the concave hemispherical

32 since, oscillation of the static pressure gas bearing pad 3 and as a result of a possible (oscillating), can be kept optimum gap 4, moreover, an elastic O ring of somewhat by the elastic force of the ring 9 with the hemispherical convex surface 42 with a hemispherical portion 37 is a hemispherical concave surface 32 in order to elastically pressed, elastic O-ring damper material ring 9 () and damping material becomes static pressure gas bearing pad 3 oscillation of effectively suppressing the occurrence of vibration.

According to the combination structure 6, in a disassembled state shown in fig. 3 the ring 9 is fitted in the ring mounting groove 7 after the hemispherical section 37 is inserted into the recess 8 of the hemispherical portion 37 is engaged with the end surface 45 by a ring 9 shown in fig. 1 can be easily assembled.

Furthermore, as the ring 9, elastic O-ring is preferred in which, if the purpose for connection, with a rigid material which is capable of reducing the diameter or C ring diameter and the ring E, E-ring or C-ring is used protodetector, static pressure gas bearing pad 3 so as not to fall off the clearance adjusting member 5 can be coupled to a reduction in cost can be achieved.

Furthermore, the recess defining surface 10 defining a recess 8, cylindrical recess 31 in place and hemispherical concave 32 and, as shown in fig. 4 and provided with a conical recessed surface 52 and a cylindrical concave surface 31, and they may, as shown in fig. 4 and a surface defining a recess 10 formed in it which are easily obtained. Furthermore, in the recess defining surface 10, instead of the square cylindrical concave cylindrical recess 31.

One example of the embodiment of the present invention the plane of illustration of preferred. In the example of fig. 1 shows an entire perspective view. An example of a part of the decomposition of fig. 1 is an explanatory drawing. Another example of the embodiment of the present invention preferably part of the illustration.

Description of the code

1 movable body
2 fixed body
3 hydrostatic gas bearing pad
4 clearance
5 gap adjusting member
6 combination structure
7 ring mounting groove
8 recess
9 ring
10 recess defining surface
11 receiving grooves

Other Description:

TECHNICAL FIELD

本発明は、可動体を固定体に対して移動自在に保持すべく可動体と固定体との間に介在させる静圧気体軸受パッドと、この静圧気体軸受パッドと可動体との間の隙間を調節する隙間調節部材との組み合わせ構造及びこれを用いた静圧気体軸受機構に関する。

BACKGROUND ART

特開平８－２８５６４号公報特開２０００－１９９５２２号公報特開２００２－３４９５６９号公報

静圧気体軸受、特に、多孔質金属焼結体を用いた多孔質静圧気体軸受は、すぐれた高速安定性と高い負荷容量並びに極めて小さい移動抵抗をもつ軸受として知られていると共にこれら優れた利点のために多くの分野に用いられている。斯かる静圧気体軸受を可動体と固定体との間にパッド形態（本発明ではパッド形態の静圧気体軸受を静圧気体軸受パッドという）をもって介在させる場合には、通常、可動体との間に微小の隙間、例えば５μｍ程度の隙間をもって静圧気体軸受パッドを配置する。

DISCLOSURE

TECH PROBLEM

この隙間は、軸受剛性、負荷能力及び速度特性に大きく影響を与えるために、可動体との間の隙間を調節できる隙間調節部材を介して静圧気体軸受パッドは可動体と固定体との間に介在されるのであるが、隙

間調節部材は、通常、静圧気体軸受パッドが揺動（首振り）できるようにして、しかも、静圧気体軸受パッドから脱落しないようにその先端部で押え部材及びねじ等を介して静圧気体軸受パッドに連結される。

ところで、斯かる静圧気体軸受パッドと隙間調節部材との組み合わせ構造であると、ねじ等を用いるために、組立及び保守に時間が掛かり、コストアップの要因となる。

本発明は、前記諸点に鑑みてなされたものであって、その目的とするところは、ねじ等を用いないでも静圧気体軸受パッドに隙間調節部材を脱落しないように連結できて、而して、コスト低下を図り得る静圧気体軸受パッドと隙間調節部材との組み合わせ構造、それに最適な静圧気体軸受パッド及び隙間調節部材並びにそれを用いた静圧気体軸受機構を提供することにある。

TECH SOLUTION

可動体を固定体に対して移動自在に保持すべく可動体と固定体との間に介在させる静圧気体軸受パッドと、この静圧気体軸受パッドと可動体との間の隙間を調節する隙間調節部材との本発明の組み合わせ構造は、静圧気体軸受パッドに設けられていると共にリング装着溝を有する凹所と、リング装着溝に装着された拡径自在なリングと、隙間調節部材に設けられていると共に凹所を規定する静圧気体軸受パッドの凹所規定面から部分的に突出するリングを受容する受容溝とを具備している。

本発明の組み合わせ構造によれば、リング装着溝に装着された拡径自在なリングが部分的に受容溝に受容されているために、斯かるリングを介してねじ等を用いないでも静圧気体軸受パッドに隙間調節部材を脱落しないように連結でき、而して、コスト低下を図り得る。

本発明において、凹所規定面は、円筒凹面と半球凹面又は円錐凹面とを具備しており、リング装着溝は、円筒凹面と半球凹面又は円錐凹面との間に設けられているとよく、また、隙間調節部材は、大径円柱部と、大径円柱部に一体的に連接されていると共に大径円柱部よりも小径の小径円柱部と、小径円柱部に一体的に連接されていると共に小径円柱部よりも大径の半球部とを具備しているとよく、この場合、受容溝は、大径円柱部と半球部との間に設けられているとよい。半球部としては、真円又はそれに近似の円からなる半円球部であっても、真楕円又はそれに近似の楕円からなる半楕円球部であってもよい。

本発明において好ましい例では、半球部の半球凸面は、凹所規定面の半球凹面又は円錐凹面に接触しており、凹所規定面が円筒凹面と半球凹面とを具備している場合、半球部の半球凸面は、凹所規定面の半球凹面の曲率と略同一の曲率又はそれよりも大きな曲率を有しているとよい。半球凸面及び半球凹面もまた、半球部と同様に、真円若しくはそれに近似の円又は真楕円若しくはそれに近似の楕円からなるものであってもよく、円錐凹面も同様である。

また本発明の好ましい例では、大径円柱部は、その外面にねじ部を有しており、このねじ部を介して固定体に螺合されるようになっており、半球部は、大径円柱部の径よりも小さな径を有しており、リング装着溝及び受容溝の夫々は環状であり、静圧気体軸受パッドは、可動体に対面する多孔面と、固定体に対面する無孔面とを有しており、凹所は、無孔面において開口しており、静圧気体軸受パッドは多孔質金属焼結層を具備しており、多孔質金属焼結層の一方の面が可動体に対面する多孔面となっており、リングは弾性Ｏリングからなる。

多孔質金属焼結層としては金属粉末と無機質粉末とを混合、焼結してなるものを好ましい一例として挙げることができ、ここで、金属粉末は、少なくとも錫、燐及び銅を含んでおり、更には、ニッケル及びマンガンのうちの少なくとも一方を含んでいるとよく、無機質粉末は、黒鉛、窒化ホウ素、フッ化黒鉛、フッ化カルシウム、酸化アルミニウム、酸化ケイ素及び炭化ケイ素のうちの少なくとも一つを含んでいるとよいが、本発明はこれらに限定されない。

リングは上記のように弾性材料からなる弾性Ｏリングからなっていると好ましいが、本発明は、斯かるリングに限定されず、弾性的に拡径自在であって縮径自在であると共に剛性材料からなるＥリング又はＣリング等であってもよく、また、半球部の半球凸面は、凹所規定面の半球凹面に全体的に接触、好ましくは摺動自在に接触していてもよいが、これに代えて、部分的に凹所規定面の半球凹面に接触、好ましくは摺動自在に接触していてもよい。

ADVANTAGEOUS EFFECTS

本発明によれば、ねじ等を用いないでも静圧気体軸受パッドに隙間調節部材を脱落しないように連結できて、而して、コスト低下を図り得る静圧気体軸受パッドと隙間調節部材との組み合わせ構造、それに最適な静圧気体軸受パッド及び隙間調節部材並びにそれを用いた静圧気体軸受機構を提供することができる。

BEST MODE

次に本発明及びそれを実施するための最良の形態を図に示す好ましい実施例に基づいて更に詳細に説明する。なお、本発明はこれら実施例に何等限定されないのである。

図１から図３において、可動体１を固定体２に対してＸ方向に移動自在に保持すべく可動体１と固定体２との間に介在させる静圧気体軸受パッド３と、静圧気体軸受パッド３と可動体１との間の隙間４を調節する隙間調節部材５との組み合わせ構造６は、静圧気体軸受パッド３に設けられていると共にリング装着溝７を有する凹所８と、リング装着溝７に装着された拡径自在な弾性Ｏリングからなるリング９と、隙

間調節部材５に設けられていると共に凹所８を規定する静圧気体軸受パッド３の凹所規定面１０から部分的に突出するリング９を受容する受容溝１１とを具備している。

可動体１及び固定体２の夫々は、図示の例では矩形板及び断面コ字状のレールの夫々で構成されているが、組み合わせ構造６が例えば精密工作機械等に適用される場合には、可動体１は工作ヘッド自体若しくは工作ヘッドが載置される基台又はワーク載置台に適した形態となり、固定体２もまた、斯かる形態の可動体１をＸ方向に移動自在に保持するに適した形態となり、したがって、可動体１及び固定体２の夫々は、矩形板及び断面コ字状のレールの夫々に限定されない。

可動体１の側面１５及び１６の夫々と固定体２の内側面１７及び１８との間に介在された複数の静圧気体軸受パッド３並びに可動体１の底面１９と固定体２の基部上面２０との間に介在された複数の静圧気体軸受パッド３の夫々は互いに同様に構成されており、また各静圧気体軸受パッド３に対応して固定体２に装着されている隙間調節部材５の夫々も互いに同様に構成されており、更に静圧気体軸受パッド３の夫々とこれに対応の隙間調節部材５の夫々との組み合わせ構造６もまた互いに同様に構成されているので、以下、可動体１の側面１５と固定体２の内側面１７との間に介在された静圧気体軸受パッド３及びこの静圧気体軸受パッド３に対応して固定体２に装着されている隙間調節部材５並びにこれら静圧気体軸受パッド３と隙間調節部材５との組み合わせ構造６について詳述する。

静圧気体軸受パッド３は、固定体２の内側面１７に対面する無孔面である平面２２の略中央部で開口している凹所８を有している円盤状の裏金２３と、裏金２３の他方の平面に一体に形成されて固着されていると共に裏金２３と協働して気体通路２４を形成した円盤状の多孔質金属焼結層２５とを具備しており、可撓性の配管２６を介して気体通路２４に供給された高圧空気を多孔質金属焼結層２５の多数の細孔を介して可動体１の側面１５に向かって噴出するようになっている。このように静圧気体軸受パッド３は、可動体１の側面１５に対面する多孔面２７と、固定体２の内側面１７に対面する無孔面としての平面２２とを有しており、金属粉末と無機質粉末とを混合、焼結してなる多孔質金属焼結層２５の一方の平坦な面が多孔面２７となっている。

静圧気体軸受パッド３の凹所８を規定する凹所規定面１０は、円筒凹面３１と半円球凹面からなる半球凹面３２とを具備しており、円環状のリング装着溝７は、Ｘ方向に直交するＹ方向において円筒凹面３１と半球凹面３２との間に設けられている。

静圧気体軸受パッド３の多孔面２７と可動体１の側面１５との間の隙間４の大きさ（Ｙ方向の幅）を調節する隙間調節部材５は、大径円柱部３５と、大径円柱部３５に一体的に連接されていると共に大径円柱部３５及び円筒凹面３１よりも小径の小径円柱部３６と、小径円柱部３６に一体的に連接されていると共に小径円柱部３６よりも大径であって大径円柱部３５の径よりも小さな径を有している半円球部からなる半球部３７とを具備しており、環状の受容溝１１は、Ｙ方向において大径円柱部３５と半球部３７との間に設けられている。大径円柱部３５は、端面４４側で部分的に凹所８内に配されていてもよく、この場合には、大径円柱部３５は、静圧気体軸受パッド３の揺動（首振り）を可能とするように、円筒凹面３１の径よりも小さい径を有しているとよい。

大径円柱部３５は、その外面にねじ部４１を有しており、ねじ部４１を介して固定体２に螺合されており、隙間調節部材５は、大径円柱部３５を回転させることにより軸方向、即ちＹ方向に進退されるようになっており、斯かる進退により静圧気体軸受パッド３の多孔面２７と可動体１の側面１５との間の隙間４の大きさを調節するようになっている。

半球部３７の半円球凸面からなる半球凸面４２は、凹所規定面１０の半球凹面３２の曲率と略同一の曲率有していると共に凹所規定面１０の半球凹面３２に摺動自在に全体的に接触している。半球凸面４２は、半球凹面３２の曲率よりも大きな曲率を有していてもよく、この場合には、半球凹面３２に摺動自在に部分的に接触することになる。

環状の受容溝１１は、小径円柱部３６の外周面４３と、大径円柱部３５の環状の端面４４と、半球部３７の環状の端面４５とによって規定されている。

以上の組み合わせ構造６を具備した静圧気体軸受機構５０によれば、多孔面２７から可動体１に向かって噴出する高圧空気により可動体１を固定体２に対して隙間４をもってＸ方向に移動自在に保持する。そして、隙間４の大きさは、隙間調節部材５のＹ方向の進退で最適値に設定され、この最適値に設定された後に隙間調節部材５は、ロックナット５１によりＹ方向に進退できないように固定体２に固定される。

ところで、組み合わせ構造６によれば、環状のリング装着溝７に装着された拡径自在なリング９が部分的に受容溝１１に受容されて、半球部３７の端面４５がリング９に係合し、凹所８から半球部３７が抜け出さないようになっているために、ねじ等を用いないでも斯かるリング９を介して静圧気体軸受パッド３に隙間調節部材５を脱落しないように連結でき、而して、コスト低下を図ることができる。しかも、組み合わせ構造６では、半球部３７の半球凸面４２が半球凹面３２に摺動自在に接触しているために、静圧気体軸受パッド３の揺動（首振り）を可能とする結果、隙間４を最適に保持でき、しかも、弾性Ｏリングからなるリング９の多少の弾性力でもって半球部３７がその半球凸面４２で半球凹面３２に弾性的に押し付けられるために、弾性Ｏリングからなるリング９がダンパ材（減衰材）となり静圧気体軸受パッド３の首振り振動の発生を効果的に抑制できて好ましい。

また組み合わせ構造６によれば、図３に示す分解状態でリング９をリング装着溝７に嵌装した後に半球部３７を凹所８に挿入して半球部３７の端面４５をリング９に係合させることにより図１に示す状態に簡

単に組立てることができる。

なお、リング９としては、弾性Ｏリングが好ましいのであるが、単なる連結という目的であれば、剛性材料であるが拡径自在且つ縮径自在なＥリング又はＣリングであってもよく、斯かるＥリング又はＣリングを用いても、静圧気体軸受パッド３に隙間調節部材５を脱落しないように連結できてコスト低下を図ることができる。

また、凹所８を規定する凹所規定面１０は、円筒凹面３１と半球凹面３２とに代えて、図４に示すように円筒凹面３１と円錐凹面５２とを具備していてもよく、図４に示すような凹所規定面１０であるとそれを容易に形成し得て好ましい。加えて、凹所規定面１０において、円筒凹面３１に代えて角筒凹面であってもよい。

本発明の実施の形態の好ましい一例の平面説明図である。図１に示す例の全体斜視図である。図１の例の一部の分解説明図である。本発明の実施の形態の好ましい他の例の一部説明図である。

符号の説明

１ 可動体
２ 固定体
３ 静圧気体軸受パッド
４ 隙間
５ 隙間調節部材
６ 組み合わせ構造
７ リング装着溝
８ 凹所
９ リング
１０ 凹所規定面
１１ 受容溝

Claims

Number of Claims: 14

ENGLISH CLAIMS:

The movable body relative to a fixed body and the movable body to movably hold the dog is interposed between the fixed body and the static pressure gas bearing pad, the static pressure gas bearing pad and movable to adjust the clearance between the clearance adjusting member in the combination of structure, static pressure gas bearing pads are provided in the recess and having a ring mounting groove, the ring mounting groove diameter and mounted on the ring, and the clearance adjusting member is provided with a recess to define a recess defining a hydrostatic gas bearing pad partially projecting from the surface of the ring is provided with a receiving groove and a static pressure gas bearing pad and a combination structure of a gap adjusting member.

The surface defining the recess, and a concave semispherical concave or conical and cylindrical recess is provided, the ring mounting groove, and a concave conical or hemispherical concave cylindrical recess is provided between the combination described in claim 1.

The gap adjusting member, and a large diameter column portion, the large diameter column portion integrally connected to the large diameter column portion and a smaller diameter than that of the small diameter column and, integrally connected to the small diameter column is larger in diameter than the small-diameter cylindrical portion and hemispherical section is provided, the receiving groove, and the hemispherical portion of the large diameter column portion is provided between the combination structure described in claim 1 or 2.

The surface defining the recess, and a concave semispherical concave or conical and cylindrical recess is provided, the ring mounting groove, and a concave conical concave or hemispherical concave cylindrical provided between, the clearance adjusting member, and a large diameter column portion, the large diameter column portion integrally connected to the large diameter column portion and a smaller diameter than that of the small diameter column and, integrally connected to the small diameter column is larger in diameter than the small-diameter cylindrical portion and hemispherical section is provided, the receiving groove, and a large diameter column portion is provided between the semi-spherical, hemispherical part of the hemispherical convex, concave or hemispherical concave conical recess defining surface of claim 1 is in contact with the combination of the structure described.

The surface defining the recess, and cylindrical and hemispherical concave and is provided with a concave, hemispherical section of the hemispherical convex surface,

and the recess defining surface of approximately the same curvature of the hemispherical concave curvature or a curvature larger than that described in claim 4 is the combination of the structure.

The large diameter column portion, has a threaded portion on its outer surface, the threaded part is screwed through a fixed body so that any one of the claim 3, described in the claim 5 from the combination structure.

The hemispherical portion, the large diameter column portion has a diameter smaller than the diameter of any one of claim 3, described in the claim 6 from the combination structure.

The ring mounting groove and having an annular receiving groove of claim 1 tracks.then 7 from any one of a combination structure described in claim.

The hydrostatic gas bearing pad, and porous surface opposed to the movable body, and a fixed body opposed to the face having no holes, recessed, non-porous surface 8 is opened in any one of claim 1 from the structure described in the combination.

The hydrostatic gas bearing pad of a sintered porous metal layer is provided, a sintered porous metal layer on one surface of the porous surface opposite to the movable body as described in claim 9 and the combination of the structure.

An elastic O ring of claim 1 comprising the ring 10 from either one of the combination structure described in claim.

11 from any one of claim 1 described in the combination structure of the hydrostatic gas bearing for use in the pad.

11 from any one of claim 1 described in the gap adjusting member for use in a combined structure.

11 from claim 1 described in any one of a combination structure of a hydrostatic gas bearing mechanism is provided.

OTHER CLAIMS:

可動体を固定体に対して移動自在に保持すべく可動体と固定体との間に介在させる静圧気体軸受パッドと、この静圧気体軸受パッドと可動体との間の隙間を調節する隙間調節部材との組み合わせ構造であって、静圧気体軸受パッドに設けられていると共にリング装着溝を有する凹所と、リング装着溝に装着された拡径自在なリングと、隙間調節部材に設けられていると共に凹所を規定する静圧気体軸受パッドの凹所規定面から部分的に突出するリングを受容する受容溝とを具備した静圧気体軸受パッドと隙間調節部材との組み合わせ構造。

凹所規定面は、円筒凹面と半球凹面又は円錐凹面とを具備しており、リング装着溝は、円筒凹面と半球凹面又は円錐凹面との間に設けられている請求項1に記載の組み合わせ構造。

隙間調節部材は、大径円柱部と、大径円柱部に一体的に連接されていると共に大径円柱部よりも小径の小径円柱部と、小径円柱部に一体的に連接されていると共に小径円柱部よりも大径の半球部とを具備しており、受容溝は、大径円柱部と半球部との間に設けられている請求項1又は2に記載の組み合わせ構造。

凹所規定面は、円筒凹面と半球凹面又は円錐凹面とを具備しており、リング装着溝は、円筒凹面と半球凹面又は円錐凹面との間に設けられており、隙間調節部材は、大径円柱部と、大径円柱部に一体的に連接されていると共に大径円柱部よりも小径の小径円柱部と、小径円柱部に一体的に連接されていると共に小径円柱部よりも大径の半球部とを具備しており、受容溝は、大径円柱部と半球部との間に設けられており、半球部の半球凸面は、凹所規定面の半球凹面又は円錐凹面に接触している請求項1に記載の組み合わせ構造。

凹所規定面は、円筒凹面と半球凹面とを具備しており、半球部の半球凸面は、凹所規定面の半球凹面の曲率と略同一の曲率又はそれよりも大きな曲率を有している請求項4に記載の組み合わせ構造。

大径円柱部は、その外面にねじ部を有しており、このねじ部を介して固定体に螺合されるようになっている請求項3から5のいずれか一項に記載の組み合わせ構造。

半球部は、大径円柱部の径よりも小さな径を有している請求項3から6のいずれか一項に記載の組み合わせ構造。

リング装着溝及び受容溝の夫々は環状である請求項1から7のいずれか一項に記載の組み合わせ構造。

静圧気体軸受パッドは、可動体に対面する多孔面と、固定体に対面する無孔面とを有しており、凹所は、無孔面において開口している請求項１から８のいずれか一項に記載の組み合わせ構造。

静圧気体軸受パッドは多孔質金属焼結層を具備しており、多孔質金属焼結層の一方の面が可動体に対面する多孔面となっている請求項９に記載の組み合わせ構造。

リングは弾性Ｏリングからなる請求項１から１０のいずれか一項に記載の組み合わせ構造。

請求項１から１１のいずれか一項に記載の組み合わせ構造に用いるための静圧気体軸受パッド。

請求項１から１１のいずれか一項に記載の組み合わせ構造に用いるための隙間調節部材。

請求項１から１１のいずれか一項に記載の組み合わせ構造を具備した静圧気体軸受機構。

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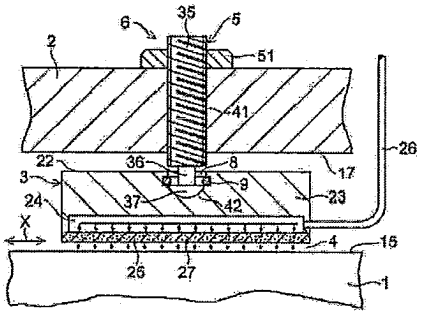
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(71)出願人　000103644
オイレス工業株式会社
東京都港区浜松町一丁目３０番５号
(74)代理人　100098095
弁理士　高田　武志
(72)発明者　佐藤　光
神奈川県藤沢市桐原町８番地　オイレス工業株式会社藤沢事業場内

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(54)【発明の名称】静圧気体軸受パッドと隙間調節部材との組み合わせ構造及びこれを用いた静圧気体軸受機構

(57)【要約】
【課題】　ねじ等を用いないでも静圧気体軸受パッドに隙間調節部材を脱落しないように連結できて、而して、コスト低下を図り得る静圧気体軸受パッドと隙間調節部材との組み合わせ構造、それに最適な静圧気体軸受パッド及び隙間調節部材並びにそれを用いた静圧気体軸受機構を提供すること。
【解決手段】　可動体１を固定体２に対してＸ方向に移動自在に保持すべく可動体１と固定体２との間に介在させる静圧気体軸受パッド３と、静圧気体軸受パッド３と可動体１との間の隙間４を調節する隙間調節部材５との組み合わせ構造６は、静圧気体軸受パッド３に設けられていると共にリング装着溝７を有する凹所８と、リング装着溝７に装着された拡径自在な弾性Ｏリングからなるリング９と、隙間調節部材５に設けられていると共に凹所８を規定する静圧気体軸受パッド３の凹所規定面１０から部分的に突出するリング９を受容する受容溝１１とを具備している。
【選択図】図１



【特許請求の範囲】
【請求項1】
可動体を固定体に対して移動自在に保持すべく可動体と固定体との間に介在させる静圧気体軸受パッドと、この静圧気体軸受パッドと可動体との間の隙間を調節する隙間調節部材との組み合わせ構造であって、静圧気体軸受パッドに設けられていると共にリング装着溝を有する凹所と、リング装着溝に装着された拡径自在なリングと、隙間調節部材に設けられていると共に凹所を規定する静圧気体軸受パッドの凹所規定面から部分的に突出するリングを受容する受容溝とを具備した静圧気体軸受パッドと隙間調節部材との組み合わせ構造。
【請求項2】
凹所規定面は、円筒凹面と半球凹面又は円錐凹面とを具備しており、リング装着溝は、円筒凹面と半球凹面又は円錐凹面との間に設けられている請求項１に記載の組み合わせ構造。
【請求項3】
隙間調節部材は、大径円柱部と、大径円柱部に一体的に連接されていると共に大径円柱部よりも小径の小径円柱部と、小径円柱部に一体的に連接されていると共に小径円柱部よりも大径の半球部とを具備しており、受容溝は、大径円柱部と半球部との間に設けられている請求項１又は２に記載の組み合わせ構造。
【請求項4】
凹所規定面は、円筒凹面と半球凹面又は円錐凹面とを具備しており、リング装着溝は、円筒凹面と半球凹面又は円錐凹面との間に設けられており、隙間調節部材は、大径円柱部と、大径円柱部に一体的に連接されていると共に大径円柱部よりも小径の小径円柱部と、小径円柱部に一体的に連接されていると共に小径円柱部よりも大径の半球部とを具備しており、受容溝は、大径円柱部と半球部との間に設けられており、半球部の半球凸面は、凹所規定面の半球凹面又は円錐凹面に接触している請求項１に記載の組み合わせ構造。
【請求項5】
凹所規定面は、円筒凹面と半球凹面とを具備しており、半球部の半球凸面は、凹所規定面の半球凹面の曲率と略同一の曲率又はそれよりも大きな曲率を有している請求項４に記載の組み合わせ構造。
【請求項6】
大径円柱部は、その外面にねじ部を有しており、このねじ部を介して固定体に螺合されるようになっている請求項３から５のいずれか一項に記載の組み合わせ構造。
【請求項7】
半球部は、大径円柱部の径よりも小さな径を有している請求項３から６のいずれか一項に記載の組み合わせ構造。
【請求項8】
リング装着溝及び受容溝の夫々は環状である請求項１から７のいずれか一項に記載の組み合わせ構造。
【請求項9】
静圧気体軸受パッドは、可動体に対面する多孔面と、固定体に対面する無孔面とを有しており、凹所は、無孔面において開口している請求項１から８のいずれか一項に記載の組み合わせ構造。
【請求項10】
静圧気体軸受パッドは多孔質金属焼結層を具備しており、多孔質金属焼結層の一方の面が可動体に対面する多孔面となっている請求項９に記載の組み合わせ構造。
【請求項11】
リングは弾性Ｏリングからなる請求項１から１０のいずれか一項に記載の組み合わせ構造。
【請求項12】

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請求項１から１１のいずれか一項に記載の組み合わせ構造に用いるための静圧気体軸受パッド。
【請求項13】
請求項１から１１のいずれか一項に記載の組み合わせ構造に用いるための隙間調節部材。
【請求項14】
請求項１から１１のいずれか一項に記載の組み合わせ構造を具備した静圧気体軸受機構
【発明の詳細な説明】
【技術分野】
【0001】
本発明は、可動体を固定体に対して移動自在に保持すべく可動体と固定体との間に介在させる静圧気体軸受パッドと、この静圧気体軸受パッドと可動体との間の隙間を調節する隙間調節部材との組み合わせ構造及びこれを用いた静圧気体軸受機構に関する。
【背景技術】
【0002】
【特許文献1】特開平８－２８５６４号公報
【特許文献2】特開２０００－１９９５２２号公報
【特許文献3】特開２００２－３４９５６９号公報
【0003】
静圧気体軸受、特に、多孔質金属焼結体を用いた多孔質静圧気体軸受は、すぐれた高速安定性と高い負荷容量並びに極めて小さい移動抵抗をもつ軸受として知られていると共にこれら優れた利点のために多くの分野に用いられている。斯かる静圧気体軸受を可動体と固定体との間にパッド形態（本発明ではパッド形態の静圧気体軸受を静圧気体軸受パッドという）をもって介在させる場合には、通常、可動体との間に微小の隙間、例えば５μｍ程度の隙間をもって静圧気体軸受パッドを配置する。
【発明の開示】
【発明が解決しようとする課題】
【0004】
この隙間は、軸受剛性、負荷能力及び速度特性に大きく影響を与えるために、可動体との間の隙間を調節できる隙間調節部材を介して静圧気体軸受パッドは可動体と固定体との間に介在されるのであるが、隙間調節部材は、通常、静圧気体軸受パッドが揺動（首振り）できるようにして、しかも、静圧気体軸受パッドから脱落しないようにその先端部で押え部材及びねじ等を介して静圧気体軸受パッドに連結される。
【0005】
ところで、斯かる静圧気体軸受パッドと隙間調節部材との組み合わせ構造であると、ねじ等を用いるために、組立及び保守に時間が掛かり、コストアップの要因となる。
【0006】
本発明は、前記諸点に鑑みてなされたものであって、その目的とするところは、ねじ等を用いないでも静圧気体軸受パッドに隙間調節部材を脱落しないように連結できて、而して、コスト低下を図り得る静圧気体軸受パッドと隙間調節部材との組み合わせ構造、それに最適な静圧気体軸受パッド及び隙間調節部材並びにそれを用いた静圧気体軸受機構を提供することにある。
【課題を解決するための手段】
【0007】
可動体を固定体に対して移動自在に保持すべく可動体と固定体との間に介在させる静圧気体軸受パッドと、この静圧気体軸受パッドと可動体との間の隙間を調節する隙間調節部材との本発明の組み合わせ構造は、静圧気体軸受パッドに設けられていると共にリング装着溝を有する凹所と、リング装着溝に装着された拡径自在なリングと、隙間調節部材に設けられていると共に凹所を規定する静圧気体軸受パッドの凹所規定面から部分的に突出するリングを受容する受容溝とを具備している。

【0008】
本発明の組み合わせ構造によれば、リング装着溝に装着された拡径自在なリングが部分的に受容溝に受容されているために、斯かるリングを介してねじ等を用いないでも静圧気体軸受パッドに隙間調節部材を脱落しないように連結でき、而して、コスト低下を図り得る。
【0009】
本発明において、凹所規定面は、円筒凹面と半球凹面又は円錐凹面とを具備しており、リング装着溝は、円筒凹面と半球凹面又は円錐凹面との間に設けられているとよく、また、隙間調節部材は、大径円柱部と、大径円柱部に一体的に連接されていると共に大径円柱部よりも小径の小径円柱部と、小径円柱部に一体的に連接されていると共に小径円柱部よりも大径の半球部とを具備しているとよく、この場合、受容溝は、大径円柱部と半球部との間に設けられているとよい。半球部としては、真円又はそれに近似の円からなる半円球部であっても、真楕円又はそれに近似の楕円からなる半楕円球部であってもよい。
【0010】
本発明において好ましい例では、半球部の半球凸面は、凹所規定面の半球凹面又は円錐凹面に接触しており、凹所規定面が円筒凹面と半球凹面とを具備している場合、半球部の半球凸面は、凹所規定面の半球凹面の曲率と略同一の曲率又はそれよりも大きな曲率を有しているとよい。半球凸面及び半球凹面もまた、半球部と同様に、真円若しくはそれに近似の円又は真楕円若しくはそれに近似の楕円からなるものであってもよく、円錐凹面も同様である。
【0011】
また本発明の好ましい例では、大径円柱部は、その外面にねじ部を有しており、このねじ部を介して固定体に螺合されるようになっており、半球部は、大径円柱部の径よりも小さな径を有しており、リング装着溝及び受容溝の夫々は環状であり、静圧気体軸受パッドは、可動体に対面する多孔面と、固定体に対面する無孔面とを有しており、凹所は、無孔面において開口しており、静圧気体軸受パッドは多孔質金属焼結層を具備しており、多孔質金属焼結層の一方の面が可動体に対面する多孔面となっており、リングは弾性Ｏリングからなる。
【0012】
多孔質金属焼結層としては金属粉末と無機質粉末とを混合、焼結してなるものを好ましい一例として挙げることができ、ここで、金属粉末は、少なくとも錫、燐及び銅を含んでおり、更には、ニッケル及びマンガンのうちの少なくとも一方を含んでいるとよく、無機質粉末は、黒鉛、窒化ホウ素、フッ化黒鉛、フッ化カルシウム、酸化アルミニウム、酸化ケイ素及び炭化ケイ素のうちの少なくとも一つを含んでいるとよいが、本発明はこれらに限定されない。
【0013】
リングは上記のように弾性材料からなる弾性Ｏリングからなっていると好ましいが、本発明は、斯かるリングに限定されず、弾性的に拡径自在であって縮径自在であると共に剛性材料からなるＥリング又はＣリング等であってもよく、また、半球部の半球凸面は、凹所規定面の半球凹面に全体的に接触、好ましくは摺動自在に接触していてもよいが、これに代えて、部分的に凹所規定面の半球凹面に接触、好ましくは摺動自在に接触していてもよい。
【発明の効果】
【0014】
本発明によれば、ねじ等を用いないでも静圧気体軸受パッドに隙間調節部材を脱落しないように連結できて、而して、コスト低下を図り得る静圧気体軸受パッドと隙間調節部材との組み合わせ構造、それに最適な静圧気体軸受パッド及び隙間調節部材並びにそれを用いた静圧気体軸受機構を提供することができる。
【発明を実施するための最良の形態】
【0015】

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次に本発明及びそれを実施するための最良の形態を図に示す好ましい実施例に基づいて更に詳細に説明する。なお、本発明はこれら実施例に何等限定されないのである。

【0016】

図１から図３において、可動体１を固定体２に対してＸ方向に移動自在に保持すべく可動体１と固定体２との間に介在させる静圧気体軸受パッド３と、静圧気体軸受パッド３と可動体１との間の隙間４を調節する隙間調節部材５との組み合わせ構造６は、静圧気体軸受パッド３に設けられていると共にリング装着溝７を有する凹所８と、リング装着溝７に装着された拡径自在な弾性Ｏリングからなるリング９と、隙間調節部材５に設けられていると共に凹所８を規定する静圧気体軸受パッド３の凹所規定面１０から部分的に突出するリング９を受容する受容溝１１とを具備している。

【0017】

可動体１及び固定体２の夫々は、図示の例では矩形板及び断面コ字状のレールの夫々で構成されているが、組み合わせ構造６が例えば精密工作機械等に適用される場合には、可動体１は工作ヘッド自体若しくは工作ヘッドが載置される基台又はワーク載置台に適した形態となり、固定体２もまた、斯かる形態の可動体１をＸ方向に移動自在に保持するに適した形態となり、したがって、可動体１及び固定体２の夫々は、矩形板及び断面コ字状のレールの夫々に限定されない。

【0018】

可動体１の側面１５及び１６の夫々と固定体２の内側面１７及び１８との間に介在された複数の静圧気体軸受パッド３並びに可動体１の底面１９と固定体２の基部上面２０との間に介在された複数の静圧気体軸受パッド３の夫々は互いに同様に構成されており、また各静圧気体軸受パッド３に対応して固定体２に装着されている隙間調節部材５の夫々も互いに同様に構成されており、更に静圧気体軸受パッド３の夫々とこれに対応の隙間調節部材５の夫々との組み合わせ構造６もまた互いに同様に構成されているので、以下、可動体１の側面１５と固定体２の内側面１７との間に介在された静圧気体軸受パッド３及びこの静圧気体軸受パッド３に対応して固定体２に装着されている隙間調節部材５並びにこれら静圧気体軸受パッド３と隙間調節部材５との組み合わせ構造６について詳述する。

【0019】

静圧気体軸受パッド３は、固定体２の内側面１７に対面する無孔面である平面２２の略中央部で開口している凹所８を有している円盤状の裏金２３と、裏金２３の他方の平面に一体に形成されて固着されていると共に裏金２３と協働して気体通路２４を形成した円盤状の多孔質金属焼結層２５とを具備しており、可撓性の配管２６を介して気体通路２４に供給された高圧空気を多孔質金属焼結層２５の多数の細孔を介して可動体１の側面１５に向かって噴出するようになっている。このように静圧気体軸受パッド３は、可動体１の側面１５に対面する多孔面２７と、固定体２の内側面１７に対面する無孔面としての平面２２とを有しており、金属粉末と無機質粉末とを混合、焼結してなる多孔質金属焼結層２５の一方の平坦な面が多孔面２７となっている。

【0020】

静圧気体軸受パッド３の凹所８を規定する凹所規定面１０は、円筒凹面３１と半円球凹面からなる半球凹面３２とを具備しており、円環状のリング装着溝７は、Ｘ方向に直交するＹ方向において円筒凹面３１と半球凹面３２との間に設けられている。

【0021】

静圧気体軸受パッド３の多孔面２７と可動体１の側面１５との間の隙間４の大きさ（Ｙ方向の幅）を調節する隙間調節部材５は、大径円柱部３５と、大径円柱部３５に一体的に連接されていると共に大径円柱部３５及び円筒凹面３１よりも小径の小径円柱部３６と、小径円柱部３６に一体的に連接されていると共に小径円柱部３６よりも大径であって大径円柱部３５の径よりも小さな径を有している半円球部からなる半球部３７とを具備しており、環状の受容溝１１は、Ｙ方向において大径円柱部３５と半球部３７との間に設けられている。大径円柱部３５は、端面４４側で部分的に凹所８内に配されていてもよく、この場合には、大径円柱部３５は、静圧気体軸受パッド３の揺動（首振り）を可能とするよう

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に、円筒凹面３１の径よりも小さい径を有しているとよい。

【0022】

大径円柱部３５は、その外面にねじ部４１を有しており、ねじ部４１を介して固定体２に螺合されており、隙間調節部材５は、大径円柱部３５を回転させることにより軸方向、即ちＹ方向に進退されるようになっており、斯かる進退により静圧気体軸受パッド３の多孔面２７と可動体１の側面１５との間の隙間４の大きさを調節するようになっている。

【0023】

半球部３７の半円球凸面からなる半球凸面４２は、凹所規定面１０の半球凹面３２の曲率と略同一の曲率有していると共に凹所規定面１０の半球凹面３２に摺動自在に全体的に接触している。半球凸面４２は、半球凹面３２の曲率よりも大きな曲率を有していてもよく、この場合には、半球凹面３２に摺動自在に部分的に接触することになる。

【0024】

環状の受容溝１１は、小径円柱部３６の外周面４３と、大径円柱部３５の環状の端面４４と、半球部３７の環状の端面４５とによって規定されている。

【0025】

以上の組み合わせ構造６を具備した静圧気体軸受機構５０によれば、多孔面２７から可動体１に向かって噴出する高圧空気により可動体１を固定体２に対して隙間４をもってＸ方向に移動自在に保持する。そして、隙間４の大きさは、隙間調節部材５のＹ方向の進退で最適値に設定され、この最適値に設定された後に隙間調節部材５は、ロックナット５１によりＹ方向に進退できないように固定体２に固定される。

【0026】

ところで、組み合わせ構造６によれば、環状のリング装着溝７に装着された拡径自在なリング９が部分的に受容溝１１に受容されて、半球部３７の端面４５がリング９に係合し、凹所８から半球部３７が抜け出さないようになっているために、ねじ等を用いないでも斯かるリング９を介して静圧気体軸受パッド３に隙間調節部材５を脱落しないように連結でき、而して、コスト低下を図ることができる。しかも、組み合わせ構造６では、半球部３７の半球凸面４２が半球凹面３２に摺動自在に接触しているために、静圧気体軸受パッド３の揺動（首振り）を可能とする結果、隙間４を最適に保持でき、しかも、弾性Ｏリングからなるリング９の多少の弾性力でもって半球部３７がその半球凸面４２で半球凹面３２に弾性的に押し付けられるために、弾性Ｏリングからなるリング９がダンパ材（減衰材）となり静圧気体軸受パッド３の首振り振動の発生を効果的に抑制できて好ましい。

【0027】

また組み合わせ構造６によれば、図３に示す分解状態でリング９をリング装着溝７に嵌装した後に半球部３７を凹所８に挿入して半球部３７の端面４５をリング９に係合させることにより図１に示す状態に簡単に組立てることができる。

【0028】

なお、リング９としては、弾性Ｏリングが好ましいのであるが、単なる連結という目的であれば、剛性材料であるが拡径自在且つ縮径自在なＥリング又はＣリングであってもよく、斯かるＥリング又はＣリングを用いても、静圧気体軸受パッド３に隙間調節部材５を脱落しないように連結できてコスト低下を図ることができる。

【0029】

また、凹所８を規定する凹所規定面１０は、円筒凹面３１と半球凹面３２とに代えて、図４に示すように円筒凹面３１と円錐凹面５２とを具備していてもよく、図４に示すような凹所規定面１０であるとそれを容易に形成し得て好ましい。加えて、凹所規定面１０において、円筒凹面３１に代えて角筒凹面であってもよい。

【図面の簡単な説明】

【0030】

【図1】本発明の実施の形態の好ましい一例の平面説明図である。

【図2】図１に示す例の全体斜視図である。

【図3】図１の例の一部の分解説明図である。

Exhibit 1002
FLS v. Metso

BNSDOCID: <JP_____2006009968A__L>

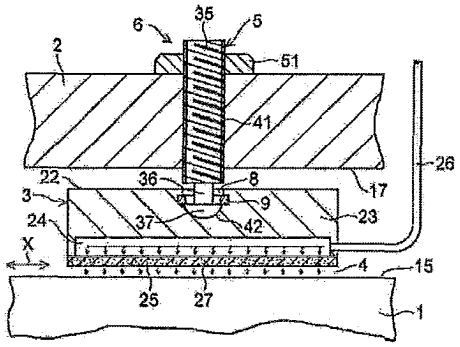
【図4】本発明の実施の形態の好ましい他の例の一部説明図である。

【符号の説明】

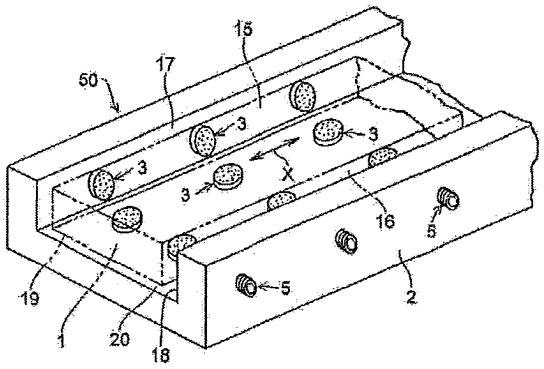
【0031】

１　可動体
２　固定体
３　静圧気体軸受パッド
４　隙間
５　隙間調節部材
６　組み合わせ構造
７　リング装着溝
８　凹所
９　リング
１０　凹所規定面
１１　受容溝

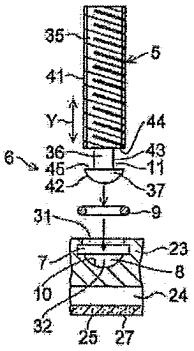
【図1】



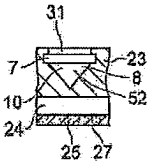
【図2】



【図3】



【図4】



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Exhibit 1002
FLS v. Metso

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Document

1 of 1

FULL CLAIMS IMAGE KWIC FAMILY LEGAL COURTLINK PDF NOTES Add Notes NEW WIN.

Language

1 **DE102007039364A1** 2008-03-06 **Roller and shoe arrangement for machine making fibrous web in papermaking industry, includes shoe with replaceable, advanced thermoplastic wear section** (en)
Walze für eine Faserstoffbahn-Herstellungsmaschine (de)

Abstract

English Abstract:

Roller for a fibrous material course manufacture machine, the one supporting element in form of a shoe (5;) exhibits 20, whereby this roller as well as its Gegenwalze (2) a Nip (N) forms and the Nipdruck (P) in this Nip by one in connection with the shoe (5; 20) arranged load piston (4) one causes. The shoe (5; a replaceable wearing part (30) has 20) of the roller, that to the Nip (N) arranged surface of the shoe (5; 20) arranged is and itself at least over that range to the Nip (N) arranged surface of the shoe (5; 20) extends, in which the Nipdruck (P) works.

German Abstract:

Walze für eine Faserstoffbahn-Herstellungsmaschine, die ein Stützelement in Form eines Schuhs (5; 20) aufweist, wobei diese Walze zusammen mit ihrer Gegenwalze (2) einen Nip (N) bildet und der Nipdruck (P) in diesem Nip durch einen in Verbindung mit dem Schuh (5; 20) angeordneten Belastungskolben (4) bewirkt wird. Der Schuh (5; 20) der Walze hat ein auswechselbares Verschleißteil (30), das an der zum Nip (N) hin gerichteten Fläche des Schuhs (5; 20) angeordnet ist und sich wenigstens über jenen Bereich der zum Nip (N) hin gerichteten Fläche des Schuhs (5; 20) erstreckt, in welchem der Nipdruck (P) wirkt.

Bibliographic Data

Normalized Assignees: METSO PAPER

Standardized Assignees: METSO PAPER

Original Assignees: METSO PAPER INC.

Inventors: KOROLAINEN, TOMMI, Republic of Finland;
SNELLMAN, JORMA, Republic of Finland

Attorneys: Lorenz und Kollegen, 89522 Heidenheim

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CPC: F16C17/246 (2013-01-01; I 2013-01-01; B, H, EP)
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IPC[8]: F16C13/00 (2006-01-01; A, L, I, 2007-08-21; B, H, DE)

Description

English Description:

The available invention concerns rollers for fibrous material course manufacture machines, like paper and board machines. The roller intended for a fibrous material course manufacture machine is more exactly said after the generic term by patent claim 1 the subject of this invention.

A type of roller assigned in fibrous material course manufacture machines, with which supporting elements, i.e. supporting shoes are used, is the deflection attitude roller, which exhibits a stationary roller axle with a load cavity for a medium which are at pressure and a load arrangement, like a supporting shoe, and a Walzenmantel rotatable around the roller axle, which are loaded by an internal load arrangement, which is loaded/pressed in the load cavity radially against the roller coat inner surface, whereby the load arrangement exhibits to the roller coat inner surface open recesses, which form chambers together with the roller coat inner surface, into which under pressure standing medium is led. Deflection attitude rollers are generally used as Nipwalzen. Those already well-known shoe rollers so called are usually hydraulically deflection-regulated zone-steered rollers, with which the coat is supported and loaded from the being certain roller axle by a hydrostatic load arrangement, like for example by a number of supporting shoes. The shoe row is divided usually also into zones, whereby the load printing can be steered transverse to the direction of travel of the fibrous material course, i.e. transverse to the MD direction, thus in CD direction depending upon shaping need. With such a zone-steered shoe roller the zones can consist even of one individual component each of the load arrangement, whereby the zone number of the load arrangement can amount to up to over 60 - for which as examples the shoe rollers brought of the Anmelderin under the registered trade marks SymCD TM and SymCDS TM can be stated on the market, or from groups with ever unites elements of the load arrangement, whereby the roller and the load arrangement exhibit normally eight zones - as examples the shoe rollers brought of the Anmelderin under the registered trade marks SymZ TM, SymZS TM, SymZL TM and SymZLC TM on the market can be stated. In deflection attitude rollers one used Walzenmäntel from cast irons and as sliding bearing material of the shoes lead tin bronze. With certain applications it was necessary to use coats from steel. The lead tin bronze shoes proved in connection with steel casings as problematic, because these materials are not well suitable as pair of materials, which is in mutual contact, and it came every now and then to seizing shoes and thus to the damage of the coat inner surface up to their unserviceableness. The sliding bearing material does not have to be ductile verschleißfest, to the Gegenfläche seizing, by sufficient firmness, ermüdungsfest and, so that it withstands the tilting back and into it can penetrate hard particles, in certain degrees. In order to fulfill these demands, one coated the sliding surface every now and then with polymer material.

A further type of roller with supporting element, used in fibrous material course manufacture machines, i.e. shoe, is the shoe or Breitnipwalze, the one axle part, which supports a stationary press shoe, and as well as the axle part surrounding flexible coat it covers two front disks, which are stored at the axle part rotatable, whose edge portions are fastened to the front disks by fastening parts like that the coat as well as the front disks rotates, whereby the individual coat zones slide successively over the surface of the press shoe. Breitnipwalzen are used among other things in the press portion of the paper-making machine and with Kalandern. In the press zone of the Breitnippresse or the Breitnipkalanders the flexible coat of the Breitnipwalze is forced with the help of the Gegenwalze in slide contact with the press shoe. The out different accumulations of material resulting volume damage form a problem with Breitnippressen. With the occurrence of such accumulations the lubricant film present between volume and shoe is destroyed, whereby then the volume a strong shear stress affects and the volume a tear gets, from which outgoing a Delaminierung of the volume begins and possibly also the Gegenwalze is damaged. In such a situation it often comes to a damage of the shoe, which must be replaced then in its whole. For this reason the friction between shoe and volume (coat) must be kept small, so that the shoe functions also in border situations of the kind described above.

From the state of the art an arrangement is well-known ago, with which the aforementioned problems were tried to solve, by up-bringing on the shoes to the Nipstelle a border construction, which consists which is enough border of over the entire transverse direction, i.e. Niplänge a thickness certain. A lack with the fact is however that it concerns a level construction, so that she is not suitable for all shoes, like for

example in connection with Breitnipwalzen, used into fibrous material course manufacture machines in connection with rollers. A such arrangement is for example in the US patent specification 6.045.492 descriptive.

Further one tried problems to solve also by coating the coat inner surface with a suitable material, which however possibly for technical reasons can be difficult and for all shoes, like for example in connection with Breitnipwalzen, used into fibrous material course manufacture machines in connection with rollers, is not also suitable. Such a concept is descriptive in the US patent specification 5.785.636.

In the EP-Offenlegungsschrift 1 an arrangement is descriptive,394,424, with which entire upper section of the shoe between the retaining structure and the Gegenfläche is manufactured or the shoe upper section including retaining structure from plastic. This is however a quite expensive arrangement, which does not correspond in addition with applications, which require a high rigidity, to this demand possibly.

Major task of the available invention is the supply of one for fibrous material course manufacture machines determined roller, with which the problems specified above eliminated or are at least substantially reduced.

Specified the above and the task coming out from the following text are reached mainly with the characteristic characteristics of the invention-measured roller specified in the characteristic part of patent claim 1.

With the invention a replaceable wearing part is thus made available, with which the wearing out part of the supporting element/shoe can be replaced either in its whole or in parts.

In accordance with a preferential execution form of the invention the frame construction of the shoe/supporting element is equipped with a wearing part easily replaceable with the occurrence of a damage.

With the invention as sliding bearing material of the shoe of the roller of the fibrous material course manufacture machine a highly developed thermoplastic (Advanced engineering plastic), for example Polyetherketon (PEEK) PP imide (PAI) or Polyimid (pi), which for the improvement of the sliding qualities prefers with a small quantity Polytetrafluorethen (ptfe) and/or graphite is endowed, begun. The new highly developed thermoplastics have a good abrasion resistance, seize at the steel surface and are not ductile in certain of degrees, so that they can withstand the edge printings of the shoe well and in addition penetrate possible particles into them. They have however no particularly good rigidity, why the construction also prefers a rigid, for example supporting piece manufactured from steel contains. Replaceable wearing part according to invention is thus in as sliding bearing material functioning part, which is fastened to the remaining shoe construction including its possible reinforcement by means of the nozzles of the supporting elements replaceable. This arrangement has at the same time the advantage that expensive plastic is only needed for the sliding bearing part, while the reinforcement part from more economical material, for example, prefers metal cast irons or steel, or from fiber-reinforced polymer compound material is manufactured. The reinforcement and the sliding bearing part are for example fastened by screws, adhesive or rivets together. And the shoe wearing parts according to invention are naturally provided with the channels necessary for the oil flow.

With the invention against the volume the part of the shoe from any plastic, coming, whose friction with the volume is substantially smaller with lubrication border lines than those of the steel or other metal material used at present, exists to lie. The plastic part can extend in a piece over the entire shoe length (i.e. in CD direction) or be manufactured from sections, whereby then in the case of a damage the damaged section needs to be only replaced. The part is fastened to the framework preferentially by dove tail joint, screws or in other suitable way. The part has a thickness of at least 5 mm.

The replaceable part extends at the shoe surface of the beginning of the contact at least into the range loaded by pressure, however replaceable wearing part can extend also over the entire surface range.

Further advantage exists therein that plastic causes smaller damages of the Gegenwalze compared with steel in cases of damage, in which the shoe rubs against the Gegenwalze. Also the plastic works warm-damming and prevents in such a way the fact that frictional heat turns into on the metal frame of the shoe whereby forgave temperature-dependent the shoe, which could lead to profile problems, is avoided.

In its remaining parts the supporting element consists/the shoe typically of metal, like aluminum, steel or aluminium bronze.

In the following the invention is described on the basis some for favourably found execution forms and with reference to the attached designs, to whose details the invention is to be limited however in no way closely, in detail. Show:

1 Breitnippresse appropriate in schematic representation the state of the art;

2 in schematic representation the state of the art appropriate deflection attitude roller;

3A-3B in schematic representation an execution form of the invention in connection with a Breitnipwalze;

4A-4C in schematic representation an execution form of the invention for a deflection attitude roller.

Appropriate parts became each other in the designs, if not differently indicated, in each case the same reference symbols assigned.

1 shows appropriate Breitnippresse, which is carried enclosure, led a Breitnipwalze 1 and a Gegenwalze 2, which forms together a widened Pressnip N in schematic representation the state of the art, by which the paper and/or Kartonbahn, by (not represented) a Pressfilz. The Breitnipwalze 1 has a stationary axle part 3, which is only partly represented in the design. At this part the press shoe 5 and the supporting elements 4, supported with those the press shoe 5, are in order to obtain the desired pressing power, against the Gegenwalze 2 are pressed. The axle part of 3 is surrounded by a flexible hose-like coat 10, which is fastened to (only suggested ones) the two front disks 11 of the roller. The front disks 11 are rotatable stored around the axle part of 3. When rotating the coat 10 around the axle part 3 the zones of the coat slide successively over the surface of the press shoe 5.

the state of the art appropriate deflection attitude roller with a coat 10 rotatable around a stationary axle 3, which forms a Nip N together with the surface of the Gegenwalze 2, shows 2, where the Niplast trachtet to cause a deformation at the coat 10. Between the stationary axle 3 and the Walzenmantel 10 a load arrangement is inserted, which exhibits in machine transverse direction, i.e. CD direction running number of hydraulic load pistons 4 for compensating the roll deflection and for pressing the Walzenmantels against the Gegenwalze. The roller can exhibit several dozen of such load pistons 4. At the stationary axle 3 a hydraulic load chamber 4 is trained ' for each load piston 4, into which over the supply channel 15 a medium which is at pressure prefers, is led, hydraulic oil. Each load piston 4 its own supply channel 15 can be assigned. Into the roller to be led the printing media can do for example over the central drilling 15 ' of the stationary axle 3rd over the supply channel 15 the printing media, in order to induce the supporting element 20 radially to the axle 3, into the load chamber 4 ' led. The supporting element 20 consists the supporting element 20 essentially firmly of a load piston 4 and one or more sliding elements added to it 5. with the pressure, which is caused with the hydraulic medium in the load chamber 4 ', can against the inner surface of the coat 10 be loaded/pressed, so that the sliding surface of the sliding element 5 comes to lie against the mentioned inner surface of the coat 10. Between the sliding surface and the inner surface of the coat 10 by introducing printing media by the capillaries 15 " the supporting element 20 through into the recesses 22 trained functioning as lubrication chambers at the sliding surface a lubricant film is put. The lubrication chambers 22 are through „from each other separate bars " 16 and can be one behind the other arranged in machine transverse direction (CD direction) to several.

In 3A-3B an execution form of the invention in connection with a Breitnipwalze is represented. 3A shows the widened Nip N formed of the Breitnipwalze and their Gegenwalze 2. the shoe of the Breitnipwalze, in order to cause the desired Nipdruck P within the flexible coat 10 or volume 10, pressed against the Gegenwalze 2. Over the channel 15 trained at the shoe 5 for the lubricating of the Nips N lubricant is led into the recess 22 trained at the surface of the shoe 5. As shown in 3A-3B, the shoe 5 has a replaceable wearing part 30. This wearing part 30 is inserted and so arranged into a recess trained at the shoe 5 that it extends at the surface of the shoe 5, which is directed against the inner surface of the flexible coat 10 at least over that range, in which the Nipdruck works. At the inner surface of the volume 10 lying close wearing part 30 is preferentially manufactured from plastic, whose friction with the volume is substantially smaller 10 in lubrication border lines than those of the steel or other metal material used at present. The wearing part the 30 can extend in a piece over the entire length of the shoe 5 (in CD direction) or be manufactured from sections, whereby then

in the case of a damage the damaged section needs to be only replaced. That is fastened wearing part to the framework of the shoe 5 preferentially by dove tail joint, screws or on other suitable, a replacement making possible way. The wearing part the 30 has a thickness of at least 5 mm. As framework material of the shoe for example metal, like aluminum, serves 5 steel or aluminium bronze. As evident from 3A, replaceable wearing part 30 at the surface of the shoe 5 reaches beginning from the contact beginning at least up to the end of the range loaded by pressure P, can extend in addition, over the entire surface range.

In 4A-4C an execution form according to invention for a deflection attitude roller is descriptive represented. The supporting element 20 covers a surface part 32, i.e. a sliding bearing part, and a supporting piece 31. The supporting element 20 fastened to the load piston 4 over the nozzles 17 is, in which the medium channels, i.e. the capillaries 15 run ". The surface part of 30 of the supporting element 20 functions as sliding bearing. As material for the surface part prefers highly developed thermoplastic serves, for example Polyetherketon (PEEK) PP imide (PAI) or Polyimid (pi), which prefers Polytetrafluorethen (ptfe) for the improvement of the sliding qualities with a small quantity and/or graphite is endowed. For the increase of the rigidity replaceable wearing part has with this execution form the rigid, made of metal, for example steel, or from compound material manufactured supporting piece 31. Replaceable wearing part 30 consists thus of the part 32 functioning as sliding bearing material, which is fastened to the remaining shoe construction including its supporting piece 31 for example by means of the nozzles 17 dismantlable. The supporting piece 31 and the sliding bearing part of 32 of the replaceable wearing part 32 are for example fastened by screws, adhesive or rivets together.

The invention was preceding only described on the basis some preferential execution forms, on whose details the invention was to be limited however in no way closely.

German Description:

Die vorliegende Erfindung betrifft Walzen für Faserstoffbahn-Herstellungsmaschinen, wie Papier- und Kartonmaschinen. Genauer gesagt ist die für eine Faserstoffbahn-Herstellungsmaschine bestimmte Walze nach dem Oberbegriff von Patentanspruch 1 Gegenstand dieser Erfindung.

Ein in Faserstoffbahn-Herstellungsmaschinen eingesetzter Walzentyp, bei dem Stützelemente, d.h. Stützschuhe benutzt werden, ist die Durchbiegungseinstellwalze, die eine stationäre Walzenachse mit einem Belastungshohlraum für ein unter Druck stehendes Medium und eine Belastungsanordnung, wie einen Stützschuh, und einen um die Walzenachse rotierbaren Walzenmantel aufweist, der durch eine innere Belastungsanordnung belastet wird, die in dem Belastungshohlraum radial gegen die Walzenmantelinnenfläche belastet/gedrückt wird, wobei die Belastungsanordnung zur Walzenmantelinnenfläche hin offene Vertiefungen aufweist, die zusammen mit der Walzenmantelinnenfläche Kammern bilden, in die unter Druck stehendes Medium geleitet wird. Durchbiegungseinstellwalzen werden allgemein als Nipwalzen eingesetzt. Die bereits bekannten so genannten Schuhwalzen sind gewöhnlich hydraulisch durchbiegungsgeregelte zonengesteuerte Walzen, bei denen der Mantel von der feststehenden Walzenachse aus durch eine hydrostatische Belastungsanordnung, wie zum Beispiel durch eine Reihe Stützschuhe, gestützt und belastet wird. Die Schuhreihe ist gewöhnlich auch in Zonen unterteilt, wobei der Belastungsdruck quer zur Laufrichtung der Faserstoffbahn, d.h. quer zur MD-Richtung, also in CD-Richtung je nach Profilierungsbedarf gesteuert werden kann. Bei einer solchen zonengesteuerten Schuhwalze können die Zonen sogar aus je einem Einzelelement der Belastungsanordnung bestehen, wobei die Zonenzahl der Belastungsanordnung bis zu über 60 betragen kann – wofür als Beispiele die von der Anmelderin unter den Warenzeichen SymCDTM und SymCDSTM auf den Markt gebrachten Schuhwalzen angeführt werden können, oder aus Gruppen mit je einigen Elementen der Belastungsanordnung, wobei die Walze und die Belastungsanordnung normalerweise acht Zonen aufweisen – als Beispiele können die von der Anmelderin unter den Warenzeichen SymZTM, SymZSTM, SymZLTM und SymZLCTM auf den Markt gebrachten Schuhwalzen angeführt werden. In Durchbiegungseinstellwalzen hat man Walzenmäntel aus Gusseisen und als Gleitlagerwerkstoff der Schuhe Bleizinnbronze eingesetzt. Bei gewissen Anwendungen war es erforderlich, Mäntel aus Stahl einzusetzen. Die Bleizinnbronze-Gleitschuhe haben sich in Verbindung mit Stahlmänteln als problematisch erwiesen, denn diese Werkstoffe sind als Werkstoffpaar, das sich in gegenseitigem Kontakt befindet, nicht gut geeignet, und es kam mitunter zum Festfressen von Schuhen und damit zur Beschädigung der Mantelinnenfläche bis zu deren Unbrauchbarkeit. Der Gleitlagerwerkstoff muss verschleißfest, sich an der Gegenfläche nicht festfressend, von ausreichender Festigkeit, ermüdungsfest und,

damit er den Kantendrücken standhält und harte Partikel in ihn eindringen können, in gewissem Grade verformbar sein. Um diese Forderungen zu erfüllen, hat man die Gleitfläche mitunter mit Polymerwerkstoff beschichtet.

Ein weiterer in Faserstoffbahn-Herstellungsmaschinen verwendeter Walzentyp mit Stützelement, d.h. Schuh, ist die Schuh- oder Breitnipwalze, die ein Achsenteil, das einen stationären Pressschuh stützt, und zwei Stirnscheiben, die rotierbar am Achsenteil gelagert sind, sowie einen das Achsenteil umgebenden elastischen Mantel umfasst, dessen Randpartien mit Hilfe von Befestigungselementen so an den Stirnscheiben befestigt sind, dass der Mantel zusammen mit den Stirnscheiben rotiert, wobei die einzelnen Mantelzonen nacheinander über die Oberfläche des Pressschuhs gleiten. Breitnipwalzen werden u.a. in der Pressenpartie der Papiermaschine und beim Kalandern eingesetzt. In der Presszone der Breitnippresse oder des Breitnipkalanders wird der elastische Mantel der Breitnipwalze mit Hilfe der Gegenwalze in Gleitkontakt mit dem Pressschuh gezwungen. Ein Problem bei Breitnippressen bilden die aus verschiedenen Stoffansammlungen resultierenden Bandschäden. Bei Auftreten solcher Ansammlungen wird der zwischen Band und Schuh befindliche Schmiermittelfilm zerstört, wobei dann auf das Band eine starke Scherspannung wirkt und das Band einen Riss bekommt, von dem ausgehend eine Delaminierung des Bandes einsetzt und u.U. auch die Gegenwalze beschädigt wird. In einer solchen Situation kommt es oft zu einer Beschädigung des Schuhs, der dann in seiner Gesamtheit ausgewechselt werden muss. Aus diesem Grunde muss die Reibung zwischen Schuh und Band (Mantel) gering gehalten werden, damit der Schuh auch in Grenzsituationen der oben beschriebenen Art funktioniert.

Vom Stand der Technik her ist eine Anordnung bekannt, bei der die vorgenannten Probleme zu lösen versucht wurden, indem man auf die Schuhe an der Nipstelle eine Leistenkonstruktion aufbrachte, die aus einer über die gesamte Querrichtung, d.h. Niplänge reichenden Leiste bestimmter Dicke besteht. Ein Mangel dabei ist jedoch, dass es sich um eine stufige Konstruktion handelt, sodass sie sich nicht für alle in Faserstoffbahn-Herstellungsmaschinen in Verbindung mit Walzen eingesetzten Schuhe, wie zum Beispiel in Verbindung mit Breitnipwalzen, eignet. Eine derartige Anordnung ist zum Beispiel in der US-Patentschrift 6,045,492 beschrieben.

Weiter hat man Probleme auch durch Beschichten der Mantelinnenfläche mit einem passenden Werkstoff zu lösen versucht, was jedoch u.U. aus fertigungstechnischen Gründen schwierig sein kann und sich auch nicht für alle in Faserstoffbahn-Herstellungsmaschinen in Verbindung mit Walzen eingesetzten Schuhe, wie zum Beispiel in Verbindung mit Breitnipwalzen, eignet. Ein solches Konzept ist in der US-Patentschrift 5,785,636 beschrieben.

In der EP-Offenlegungsschrift 1 394 424 ist eine Anordnung beschrieben, bei der das gesamte Oberteil des Schuhs zwischen der Stützkonstruktion und der Gegenfläche oder das Schuhoberteil einschließlich Stützkonstruktion aus Kunststoff gefertigt ist. Dies ist jedoch eine ziemlich kostspielige Anordnung, die außerdem bei Anwendungen, die eine hohe Steifigkeit verlangen, dieser Forderung möglicherweise nicht entspricht.

Hauptaufgabe der vorliegenden Erfindung ist die Bereitstellung einer für Faserstoffbahn-Herstellungsmaschinen bestimmten Walze, bei der die oben genannten Probleme eliminiert oder zumindest wesentlich reduziert sind.

Erreicht werden die oben genannten und die aus dem folgenden Text hervorgehenden Aufgabe hauptsächlich mit den im kennzeichnenden Teil von Patentanspruch 1 aufgeführten charakteristischen Merkmalen der erfindungemäßen Walze.

Mit der Erfindung wird also ein auswechselbares Verschleißteil bereitgestellt, bei dem das sich abnutzende Teil des Stützelements/Schuhs entweder in seiner Gesamtheit oder in Teilen ausgewechselt werden kann.

Gemäß einer bevorzugten Ausführungsform der Erfindung ist die Rahmenkonstruktion des Schuhs/Stützelements mit einem bei Auftreten eines Schadens leicht auswechselbaren Verschleißteil ausgestattet.

Bei der Erfindung wird als Gleitlagerwerkstoff des Schuhs der Walze der Faserstoffbahn-Herstellungsmaschine ein hochentwickelter Thermoplast (Advanced Engineering Plastic), zum Beispiel Polyetherketon (PEEK) Polyamidimid (PAI) oder Polyimid (PI), der zur Verbesserung der Gleiteigenschaften bevorzugt mit einer geringen Menge Polytetrafluorethen (PTFE) und/oder Graphit dotiert ist, eingesetzt. Die neuen hochentwickelten Thermoplaste haben eine gute Verschleißfestigkeit, fressen sich nicht an der Stahlfläche fest und sind in gewissem Grade verformbar, sodass sie den Randdrücken des Schuhs gut standhalten und außerdem eventuelle Partikel in sie

eindringen können. Sie haben jedoch keine besonders gute Steifigkeit, weshalb die Konstruktion denn auch bevorzugt ein starres, zum Beispiel aus Stahl gefertigtes Stützteil enthält. Das erfindungsgemäße auswechselbare Verschleißteil ist somit ein als Gleitlagermaterial funktionierendes Teil, das einschließlich seiner eventuellen Versteifung mittels der Düsen der Stützelemente auswechselbar an der übrigen Schuhkonstruktion befestigt ist. Diese Anordnung hat gleichzeitig den Vorteil, dass teurer Kunststoff lediglich für das Gleitlagerteil benötigt wird, während das Versteifungsteil aus kostengünstigerem Werkstoff, zum Beispiel Metall, bevorzugt Gusseisen oder Stahl, oder aus faserverstärktem Polymerverbundstoff gefertigt wird. Die Versteifung und das Gleitlagerteil sind zum Beispiel durch Schrauben, Klebstoff oder Niete aneinander befestigt. Und natürlich sind die erfindungsgemäßen Schuh-Verschleißteile mit den für den Ölfluss erforderlichen Kanälen versehen.

Bei der Erfindung besteht das gegen das Band zu liegen kommende Teil des Schuhs aus irgendeinem Kunststoff, dessen Reibung mit dem Band bei Schmierungs-Grenzfällen wesentlich geringer ist als die des gegenwärtig benutzten Stahls oder sonstigen Metallwerkstoffs. Das Kunststoffteil kann sich in einem Stück über die gesamte Schuhlänge (d.h. in CD-Richtung) erstrecken oder aus Sektionen gefertigt sein, wobei dann im Fall einer Beschädigung lediglich die beschädigte Sektion ausgewechselt zu werden braucht. Befestigt wird das Teil am Rahmen bevorzugt durch Schwalbenschwanzverbindung, Schrauben oder auf sonstige passende Weise. Das Teil hat eine Dicke von wenigstens 5 mm.

Das auswechselbare Teil erstreckt sich an der Schuhoberfläche vom Anfang des Kontakts wenigstens bis in den druckbeaufschlagten Bereich, jedoch kann sich das auswechselbare Verschleißteil auch über den gesamten Oberflächenbereich erstrecken.

Ein weiterer Vorteil besteht darin, dass Kunststoff im Vergleich zu Stahl in Schadensfällen, in denen der Schuh an der Gegenwalze reibt, geringere Beschädigungen der Gegenwalze verursacht. Auch wirkt der Kunststoff wärmedämmend und verhindert so, dass Reibungswärme auf den Metallrahmen des Schuhs übergeht, wodurch temperaturbedingtes Verziehen des Schuhs, das ja zu Profilproblemen führen könnte, vermieden wird.

In seinen übrigen Teilen besteht das Stützelement/der Schuh typischerweise aus Metall, wie Aluminium, Stahl oder Aluminiumbronze.

Im Folgenden wird die Erfindung an Hand einiger für vorteilhaft befundener Ausführungsformen und unter Bezugnahme auf die beigefügten Zeichnungen, auf deren Details die Erfindung jedoch in keiner Weise eng beschränkt werden soll, im Einzelnen beschrieben. Es zeigen:

1 in schematischer Darstellung eine dem Stand der Technik entsprechende Breitnippresse;

2 in schematischer Darstellung eine dem Stand der Technik entsprechende Durchbiegungseinstellwalze;

3A–3B in schematischer Darstellung eine Ausführungsform der Erfindung in Verbindung mit einer Breitnipwalze;

4A–4C in schematischer Darstellung eine Ausführungsform der Erfindung für eine Durchbiegungseinstellwalze.

Einander entsprechenden Teilen wurden in den Zeichnungen, falls nicht anders angegeben, jeweils die gleichen Bezugszeichen zugeordnet.

1 zeigt in schematischer Darstellung eine dem Stand der Technik entsprechende Breitnippresse, die eine Breitnipwalze 1 und eine Gegenwalze 2 umfasst, die zusammen einen verbreiterten Pressnip N bilden, durch den die Papier- bzw. Kartonbahn, von einem (nicht dargestellten) Pressfilz getragen, geführt wird. Die Breitnipwalze 1 hat ein stationäres Achsenteil 3, das in der Zeichnung nur teilweise dargestellt ist. An diesem Teil abgestützt sind der Pressschuh 5 und die Stützelemente 4, mit denen der Pressschuh 5, um den gewünschten Pressdruck zu erzielen, gegen die Gegenwalze 2 gedrückt wird. Das Achsenteil 3 ist von einem elastischen schlauchartigen Mantel 10 umgeben, der an den (nur angedeuteten) beiden Stirnscheiben 11 der Walze befestigt ist. Die Stirnscheiben 11 sind rotierbar um das Achsenteil 3 gelagert. Beim Rotieren des Mantels 10 um das Achsenteil 3 gleiten die Zonen des Mantels nacheinander über die Oberfläche des Pressschuhs 5.

2 zeigt eine dem Stand der Technik entsprechende Durchbiegungseinstellwalze mit

einem um eine stationäre Achse 3 rotierbaren Mantel 10, der zusammen mit der Oberfläche der Gegenwalze 2 einen Nip N bildet, wo die Niplast eine Deformation am Mantel 10 zu bewirken trachtet. Zwischen der stationären Achse 3 und dem Walzenmantel 10 ist eine Belastungsanordnung eingefügt, die eine in Maschinenquerrichtung, d.h. CD-Richtung verlaufende Reihe hydraulischer Belastungskolben 4 zum Kompensieren der Walzendurchbiegung und zum Drücken des Walzenmantels gegen die Gegenwalze aufweist. Die Walze kann mehrere Dutzend solcher Belastungskolben 4 aufweisen. An der stationären Achse 3 ist für jeden Belastungskolben 4 eine hydraulische Belastungskammer 4' ausgebildet, in die über den Versorgungskanal 15 ein unter Druck stehendes Medium, bevorzugt Hydrauliköl, geleitet wird. Jedem Belastungskolben 4 kann ein eigener Versorgungskanal 15 zugeordnet sein. In die Walze geführt werden kann das Druckmedium zum Beispiel über die Zentralbohrung 15' der stationären Achse 3. Über den Versorgungskanal 15 wird das Druckmedium, um das Stützelement 20 radial zur Achse 3 zu bewegen, in die Belastungskammer 4' geleitet. Das Stützelement 20 besteht aus einem Belastungskolben 4 und einem oder mehreren im Wesentlichen fest daran gefügten Gleitelementen 5. Mit dem Druck, der mit dem Hydraulikmedium in der Belastungskammer 4' bewirkt wird, kann das Stützelement 20 gegen die Innenfläche des Mantels 10 belastet/gedrückt werden, damit die Gleitfläche des Gleitelements 5 gegen die besagte Innenfläche des Mantels 10 zu liegen kommt. Zwischen die Gleitfläche und die Innenfläche des Mantels 10 wird durch Einleiten von Druckmedium durch die Kapillaren 15" des Stützelements 20 hindurch in die als Schmierkammern fungierenden, an der Gleitfläche ausgebildeten Vertiefungen 22 ein Schmiermittelfilm gelegt. Die Schmierkammern 22 sind durch „Stege" 16 voneinander getrennt und können in Maschinenquerrichtung (CD-Richtung) zu mehreren hintereinander angeordnet sein.

In 3A–3B ist eine Ausführungsform der Erfindung in Verbindung mit einer Breitnipwalze dargestellt. 3A zeigt den von der Breitnipwalze und ihrer Gegenwalze 2 gebildeten verbreiterten Nip N. Der Schuh der Breitnipwalze wird, um den gewünschten Nipdruck P innerhalb des elastischen Mantels 10 oder Bandes 10 zu bewirken, gegen die Gegenwalze 2 gedrückt. Über den am Schuh 5 ausgebildeten Kanal 15 wird zur Schmierung des Nips N Schmiermittel in die an der Oberfläche des Schuhs 5 ausgebildete Vertiefung 22 geleitet. Wie in 3A–3B gezeigt, hat der Schuh 5 ein auswechselbares Verschleißteil 30. Dieses Verschleißteil 30 ist in eine am Schuh 5 ausgebildete Ausnehmung eingesetzt und so angeordnet, dass es an der Oberfläche des Schuhs 5, die gegen die Innenfläche des elastischen Mantels 10 gerichtet ist, sich wenigstens über jenen Bereich erstreckt, in dem der Nipdruck wirkt. Das an der Innenfläche des Bandes 10 anliegende Verschleißteil 30 ist bevorzugt aus Kunststoff gefertigt, dessen Reibung mit dem Band 10 in Schmierungs-Grenzfällen wesentlich geringer ist als die des gegenwärtig benutzten Stahls oder sonstigen Metallwerkstoffs. Das Verschleißteil 30 kann sich in einem Stück über die gesamte Länge des Schuhs 5 (in CD-Richtung) erstrecken oder aus Sektionen gefertigt sein, wobei dann im Fall einer Beschädigung lediglich die beschädigte Sektion ausgewechselt zu werden braucht. Befestigt wird das Verschleißteil am Rahmen des Schuhs 5 bevorzugt durch Schwalbenschwanzverbindung, Schrauben oder auf sonstige passende, ein Auswechseln ermöglichende Weise. Das Verschleißteil 30 hat eine Dicke von wenigstens 5 mm. Als Rahmenwerkstoff des Schuhs 5 dient zum Beispiel Metall, wie Aluminium, Stahl oder Aluminiumbronze. Wie aus 3A ersichtlich, reicht das auswechselbare Verschleißteil 30 an der Oberfläche des Schuhs 5 beginnend vom Kontaktanfang wenigstens bis zum Ende des druckbeaufschlagten Bereichs P, kann sich aber auch über den gesamten Oberflächenbereich erstrecken.

In 4A–4C ist eine erfindungsgemäße Ausführungsform für eine Durchbiegungseinstellwalze anschaulich dargestellt. Das Stützelement 20 umfasst ein Oberflächenteil 32, d.h. ein Gleitlagerteil, und ein Stützteil 31. Befestigt ist das Stützelement 20 am Belastungskolben 4 über die Düsen 17, in denen die Mediumkanäle, d.h. die Kapillaren 15" verlaufen. Das Oberflächenteil 30 des Stützelements 20 fungiert als Gleitlager. Als Werkstoff für das Oberflächenteil dient bevorzugt hochentwickelter Thermoplast, zum Beispiel Polyetherketon (PEEK) Polyamidimid (PAI) oder Polyimid (PI), der zur Verbesserung der Gleiteigenschaften bevorzugt mit einer geringen Menge Polytetrafluorethen (PTFE) und/oder Graphit dotiert ist. Zur Erhöhung der Steifigkeit hat das auswechselbare Verschleißteil bei dieser Ausführungsform ein starres, aus Metall, zum Beispiel Stahl, oder aus Verbundstoff hergestelltes Stützteil 31. Das auswechselbare Verschleißteil 30 besteht somit aus dem als Gleitlagerwerkstoff fungierenden Teil 32, das einschließlich seines Stützteils 31 zum Beispiel mittels der Düsen 17 demontierbar an der übrigen Schuhkonstruktion befestigt ist. Das Stützteil 31 und das Gleitlagerteil 32 des auswechselbaren Verschleißteils 32 sind zum Beispiel durch Schrauben, Klebstoff oder Niete aneinander befestigt.

Die Erfindung wurde vorangehend lediglich an Hand einiger bevorzugter

Ausführungsformen beschrieben, auf deren Details die Erfindung jedoch in keiner Weise eng begrenzt werden soll.

Claims

Number of Claims: 12

ENGLISH CLAIMS:

Roller for a fibrous material course manufacture machine, the one supporting element in form of a shoe (5;) exhibits 20, whereby the roller (1) together with its Gegenwalze (2) a Nip (N) forms and the Nipdruck (P) in this Nip by one in connection with the shoe (5; 20) arranged load piston (4) caused, **by the fact it is marked** that the shoe (5; , that has 20) of the roller a replaceable wearing part (30) to the Nip (N) arranged surface of the shoe (5; 20) arranged is and itself at least over that range to the Nip (N) arranged surface of the shoe (5; 20) extends, in which the Nipdruck (P) works.

Roller according to requirement 1, by the fact characterized that replaceable wearing part (30) of the shoe (5; 20) of the roller from plastic is manufactured.

Roller according to requirement 1 or 2, by the fact characterized that the plastic of the replaceable wearing part (30) of the shoe (5; 20) of the roller a highly developed thermoplastic, for example Polyetherketon (PEEK) PP imide (PAI) or Polyimid (pi) is.

Roller after any of the requirements 1 to 3, by the fact characterized that the plastic of the replaceable wearing part (30) of the shoe (5; 20) of the roller is endowed with a small quantity of Polytetrafluorethen (ptfe) and/or graphite.

Roller after any of the requirements 1 to 4, by the fact characterized that replaceable wearing part (30) of the shoe (5; 20) of the roller by dove tail joint at the framework of the shoe (5; 20) is fastened.

Roller after any of the requirements 1 to 5, by the fact characterized that replaceable wearing part (30) of the shoe (5; 20) of the roller in CD direction of the fibrous material course manufacture machine uniformly, i.e. in a piece is arranged.

Roller after any of the requirements 1 to 6, by the fact characterized that replaceable wearing part (30) of the shoe (5; 20) in CD direction of the fibrous material course manufacture machine is compound for the roller from several sections, which are separately replaceable.

Roller according to requirement 1, by the fact characterized that replaceable wearing part (30) of the shoe (5; 20) of the roller a surface part of 32 from plastic and a supporting piece (31) made of metal covers.

Roller after any of the requirements 1 to 8, by the fact characterized that replaceable wearing part (30) of the shoe (5; 20) of the roller over nozzles (17) is fastened to the remaining shoe construction.

Roller after any of the requirements 1 to 9, by the fact characterized that the surface part (32) and the supporting piece (31) of the replaceable wearing part (30) of the shoe (5; 20) of the roller by screws, adhesive or rivets is together fastened.

Roller according to requirement 1, by the fact characterized that the roller is a Breitnipwalze (1)-rolls

1, by the fact characterized according to requirement that the roller is a deflection attitude roller (2).

GERMAN CLAIMS:

Walze füreine Faserstoffbahn-Herstellungsmaschine, die ein Stützelementin Form eines Schuhs (5; 20) aufweist, wobei dieWalze (1) zusammen mit ihrer Gegenwalze (2) einenNip (N) bildet und der Nipdruck (P) in diesem Nip durch einen in Verbindungmit dem Schuh (5; 20) angeordneten Belastungskolben(4) bewirkt wird, **dadurch gekennzeichnet**, dass derSchuh (5; 20) der Walze ein auswechselbares Verschleißteil (30)hat, das an der zum Nip (N) hin gerichteten Fläche des Schuhs (5; 20)angeordnet ist und sich wenigstens über jenen Bereich der zum Nip(N) hin gerichteten Flächedes Schuhs (5; 20) erstreckt, in welchem der Nipdruck(P) wirkt.

Walze nach Anspruch 1, dadurch gekennzeichnet, dassdas auswechselbare Verschleißteil (30)des Schuhs (5; 20) der Walze aus Kunststoff gefertigtist.

Walze nach Anspruch 1 oder 2, dadurch gekennzeichnet,dass der Kunststoff des auswechselbaren Verschleißteils (30)des Schuhs (5; 20) der Walze ein hochentwickelterThermoplast, zum Beispiel Polyetherketon (PEEK) Polyamidimid (PAI) oder Polyimid (PI) ist.

Walze nach irgendeinem der Ansprüche 1 bis 3, dadurch gekennzeichnet,dass der Kunststoff des auswechselbaren Verschleißteils (30)des Schuhs (5; 20) der Walze mit einer geringenMenge Polytetrafluorethen (PTFE) und/oder Graphit dotiert ist.

Walze nach irgendeinem der Ansprüche 1 bis 4, dadurch gekennzeichnet,dass das auswechselbare Verschleißteil (30) des Schuhs(5; 20) der Walze durch Schwalbenschwanzverbindungam Rahmen des Schuhs (5; 20) befestigt ist.

Walze nach irgendeinem der Ansprüche 1 bis 5, dadurch gekennzeichnet,dass das auswechselbare Verschleißteil (30) des Schuhs(5; 20) der Walze in CD-Richtung der Faserstoffbahn-Herstellungsmaschineeinheitlich, d.h. in einem Stückgestaltet ist.

Walze nach irgendeinem der Ansprüche 1 bis 6, dadurch gekennzeichnet,dass das auswechselbare Verschleißteil (30) des Schuhs(5; 20) der Walze in CD-Richtung der Faserstoffbahn-Herstellungsmaschineaus mehreren Sektionen zusammengesetzt ist, die einzeln auswechselbarsind.

Walze nach Anspruch 1, dadurch gekennzeichnet, dassdas auswechselbare Verschleißteil (30)des Schuhs (5; 20) der Walze ein Oberflächenteil 32 ausKunststoff und ein Stützteil(31) aus Metall umfasst.

Walze nach irgendeinem der Ansprüche 1 bis 8, dadurch gekennzeichnet,dass das auswechselbare Verschleißteil (30) des Schuhs(5; 20) der Walze über Düsen (17) an der übrigen Schuhkonstruktion befestigtist.

Walze nach irgendeinem der Ansprüche 1 bis 9, dadurch gekennzeichnet,dass das Oberflächenteil (32)und das Stützteil(31) des auswechselbaren Verschleißteils (30) des Schuhs(5; 20) der Walze durch Schrauben, Klebstoff oderNiete aneinander befestigt sind.

Walze nach Anspruch 1, dadurch gekennzeichnet, dassdie Walze eine Breitnipwalze ist (1).

Walze nach Anspruch 1, dadurch gekennzeichnet, dassdie Walze eine Durchbiegungseinstellwalze ist (2).

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(74) Vertreter:
Lorenz und Kollegen, 89522 Heidenheim

(71) Anmelder:
Metso Paper, Inc., Helsinki, FI

(72) Erfinder:
Korolainen, Tommi, Jyväskylä, FI; Snellman, Jorma, Jyväskylä, FI

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Walze für eine Faserstoffbahn-Herstellungsmaschine**

(57) Zusammenfassung: Walze für eine Faserstoffbahn-Herstellungsmaschine, die ein Stützelement in Form eines Schuhs (5; 20) aufweist, wobei diese Walze zusammen mit ihrer Gegenwalze (2) einen Nip (N) bildet und der Nipdruck (P) in diesem Nip durch einen in Verbindung mit dem Schuh (5; 20) angeordneten Belastungskolben (4) bewirkt wird. Der Schuh (5; 20) der Walze hat ein auswechselbares Verschleißteil (30), das an der zum Nip (N) hin gerichteten Fläche des Schuhs (5; 20) angeordnet ist und sich wenigstens über jenen Bereich der zum Nip (N) hin gerichteten Fläche des Schuhs (5; 20) erstreckt, in welchem der Nipdruck (P) wirkt.

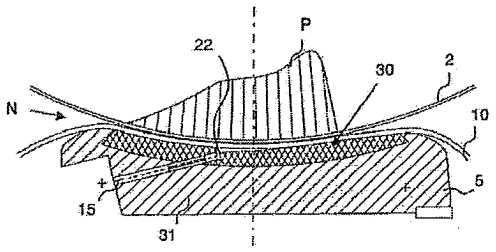


Exhibit 1002
FLS v. Metso

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Beschreibung

[0001] Die vorliegende Erfindung betrifft Walzen für Faserstoffbahn-Herstellungsmaschinen, wie Papier- und Kartonmaschinen. Genauer gesagt ist die für eine Faserstoffbahn-Herstellungsmaschine bestimmte Walze nach dem Oberbegriff von Patentanspruch 1 Gegenstand dieser Erfindung.

[0002] Ein in Faserstoffbahn-Herstellungsmaschinen eingesetzter Walzentyp, bei dem Stützelemente, d.h. Stützschuhe benutzt werden, ist die Durchbiegungseinstellwalze, die eine stationäre Walzenachse mit einem Belastungshohlraum für ein unter Druck stehendes Medium und eine Belastungsanordnung, wie einen Stützschuh, und einen um die Walzenachse rotierbaren Walzenmantel aufweist, der durch eine innere Belastungsanordnung belastet wird, die in dem Belastungshohlraum radial gegen die Walzenmantelinnenfläche belastet/gedrückt wird, wobei die Belastungsanordnung zur Walzenmantelinnenfläche hin offene Vertiefungen aufweist, die zusammen mit der Walzenmantelinnenfläche Kammern bilden, in die unter Druck stehendes Medium geleitet wird. Durchbiegungseinstellwalzen werden allgemein als Nipwalzen eingesetzt. Die bereits bekannten so genannten Schuhwalzen sind gewöhnlich hydraulisch durchbiegungsgeregelte zonengesteuerte Walzen, bei denen der Mantel von der feststehenden Walzenachse aus durch eine hydrostatische Belastungsanordnung, wie zum Beispiel durch eine Reihe Stützschuhe, gestützt und belastet wird. Die Schuhreihe ist gewöhnlich auch in Zonen unterteilt, wobei der Belastungsdruck quer zur Laufrichtung der Faserstoffbahn, d.h. quer zur MD-Richtung, also in CD-Richtung je nach Profilierungsbedarf gesteuert werden kann. Bei einer solchen zonengesteuerten Schuhwalze können die Zonen sogar aus je einem Einzelelement der Belastungsanordnung bestehen, wobei die Zonenzahl der Belastungsanordnung bis zu über 60 betragen kann – wofür als Beispiele die von der Anmelderin unter den Warenzeichen SymCD™ und SymCDS™ auf den Markt gebrachten Schuhwalzen angeführt werden können, oder aus Gruppen mit je einigen Elementen der Belastungsanordnung, wobei die Walze und die Belastungsanordnung normalerweise acht Zonen aufweisen – als Beispiele können die von der Anmelderin unter den Warenzeichen SymZ™, SymZS™, SymZL™ und SymZLC™ auf den Markt gebrachten Schuhwalzen angeführt werden. In Durchbiegungseinstellwalzen hat man Walzenmäntel aus Gusseisen und als Gleitlagerwerkstoff der Schuhe Bleizinnbronze eingesetzt. Bei gewissen Anwendungen war es erforderlich, Mäntel aus Stahl einzusetzen. Die Bleizinnbronze-Gleitschuhe haben sich in Verbindung mit Stahlmänteln als problematisch erwiesen, denn diese Werkstoffe sind als Werkstoffpaar, das sich in gegenseitigem Kontakt befindet, nicht gut geeignet, und es kam mitunter zum Festfressen von Schuhen und damit zur Beschädigung der Mantelinnenfläche bis zu deren Unbrauchbarkeit. Der Gleitlagerwerkstoff muss verschleißfest, sich an der Gegenfläche nicht festfressend, von ausreichender Festigkeit, ermüdungsfest und, damit er den Kantendrücken standhält und harte Partikel in ihn eindringen können, in gewissem Grade verformbar sein. Um diese Forderungen zu erfüllen, hat man die Gleitfläche mitunter mit Polymerwerkstoff beschichtet.

[0003] Ein weiterer in Faserstoffbahn-Herstellungsmaschinen verwendeter Walzentyp mit Stützelement, d.h. Schuh, ist die Schuh- oder Breitnipwalze, die ein Achsenteil, das einen stationären Pressschuh stützt, und zwei Stirnscheiben, die rotierbar am Achsenteil gelagert sind, sowie einen das Achsenteil umgebenden elastischen Mantel umfasst, dessen Randpartien mit Hilfe von Befestigungselementen so an den Stirnscheiben befestigt sind, dass der Mantel zusammen mit den Stirnscheiben rotiert, wobei die einzelnen Mantelzonen nacheinander über die Oberfläche des Pressschuhs gleiten. Breitnipwalzen werden u.a. in der Pressenpartie der Papiermaschine und beim Kalandern eingesetzt. In der Presszone der Breitnippresse oder des Breitnipkalanders wird der elastische Mantel der Breitnipwalze mit Hilfe der Gegenwalze in Gleitkontakt mit dem Pressschuh gezwungen. Ein Problem bei Breitnippressen bilden die aus verschiedenen Stoffansammlungen resultierenden Bandschäden. Bei Auftreten solcher Ansammlungen wird der zwischen Band und Schuh befindliche Schmiermittelfilm zerstört, wobei dann auf das Band eine starke Scherspannung wirkt und das Band einen Riss bekommt, von dem ausgehend eine Delaminierung des Bandes einsetzt und u.U. auch die Gegenwalze beschädigt wird. In einer solchen Situation kommt es oft zu einer Beschädigung des Schuhs, der dann in seiner Gesamtheit ausgewechselt werden muss. Aus diesem Grunde muss die Reibung zwischen Schuh und Band (Mantel) gering gehalten werden, damit der Schuh auch in Grenzsituationen der oben beschriebenen Art funktioniert.

[0004] Vom Stand der Technik her ist eine Anordnung bekannt, bei der die vorgenannten Probleme zu lösen versucht wurden, indem man auf die Schuhe an der Nipstelle eine Leistenkonstruktion aufbrachte, die aus einer über die gesamte Querrichtung, d.h. Niplänge reichenden Leiste bestimmter Dicke besteht. Ein Mangel dabei ist jedoch, dass es sich um eine stufige Konstruktion handelt, sodass sie sich nicht für alle in Faserstoffbahn-Herstellungsmaschinen in Verbindung mit Walzen eingesetzten Schuhe, wie zum Beispiel in Verbindung mit Breitnipwalzen, eignet. Eine derartige Anordnung ist zum Beispiel in der US-Patentschrift 6,045,492 beschrieben.

[0005] Weiter hat man Probleme auch durch Beschichten der Mantelinnenfläche mit einem passenden Werkstoff zu lösen versucht, was jedoch u.U. aus fertigungstechnischen Gründen schwierig sein kann

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und sich auch nicht für alle in Faserstoffbahn-Herstellungsmaschinen in Verbindung mit Walzen eingesetzten Schuhe, wie zum Beispiel in Verbindung mit Breitnipwalzen, eignet. Ein solches Konzept ist in der US-Patentschrift 5,785,636 beschrieben.

[0006] In der EP-Offenlegungsschrift 1 394 424 ist eine Anordnung beschrieben, bei der das gesamte Oberteil des Schuhs zwischen der Stützkonstruktion und der Gegenfläche oder das Schuhoberteil einschließlich Stützkonstruktion aus Kunststoff gefertigt ist. Dies ist jedoch eine ziemlich kostspielige Anordnung, die außerdem bei Anwendungen, die eine hohe Steifigkeit verlangen, dieser Forderung möglicherweise nicht entspricht.

[0007] Hauptaufgabe der vorliegenden Erfindung ist die Bereitstellung einer für Faserstoffbahn-Herstellungsmaschinen bestimmten Walze, bei der die oben genannten Probleme eliminiert oder zumindest wesentlich reduziert sind.

[0008] Erreicht werden die oben genannten und die aus dem folgenden Text hervorgehenden Aufgabe hauptsächlich mit den im kennzeichnenden Teil von Patentanspruch 1 aufgeführten charakteristischen Merkmalen der erfindungemäßen Walze.

[0009] Mit der Erfindung wird also ein auswechselbares Verschleißteil bereitgestellt, bei dem das sich abnutzende Teil des Stützelements/Schuhs entweder in seiner Gesamtheit oder in Teilen ausgewechselt werden kann.

[0010] Gemäß einer bevorzugten Ausführungsform der Erfindung ist die Rahmenkonstruktion des Schuhs/Stützelements mit einem bei Auftreten eines Schadens leicht auswechselbaren Verschleißteil ausgestattet.

[0011] Bei der Erfindung wird als Gleitlagerwerkstoff des Schuhs der Walze der Faserstoffbahn-Herstellungsmaschine ein hochentwickelter Thermoplast (Advanced Engineering Plastic), zum Beispiel Polyetherketon (PEEK) Polyamidimid (PAI) oder Polyimid (PI), der zur Verbesserung der Gleiteigenschaften bevorzugt mit einer geringen Menge Polytetrafluorethen (PTFE) und/oder Graphit dotiert ist, eingesetzt. Die neuen hochentwickelten Thermoplaste haben eine gute Verschleißfestigkeit, fressen sich nicht an der Stahlfläche fest und sind in gewissem Grade verformbar, sodass sie den Randdrücken des Schuhs gut standhalten und außerdem eventuelle Partikel in sie eindringen können. Sie haben jedoch keine besonders gute Steifigkeit, weshalb die Konstruktion denn auch bevorzugt ein starres, zum Beispiel aus Stahl gefertigtes Stützteil enthält. Das erfindungsgemäße auswechselbare Verschleißteil ist somit ein als Gleitlagermaterial funktionierendes Teil, das einschließlich seiner eventuellen Versteifung mittels der Düsen der Stützelemente auswechselbar an der übrigen Schuhkonstruktion befestigt ist. Diese Anordnung hat gleichzeitig den Vorteil, dass teurer Kunststoff lediglich für das Gleitlagerteil benötigt wird, während das Versteifungsteil aus kostengünstigerem Werkstoff, zum Beispiel Metall, bevorzugt Gusseisen oder Stahl, oder aus faserverstärktem Polymerverbundstoff gefertigt wird. Die Versteifung und das Gleitlagerteil sind zum Beispiel durch Schrauben, Klebstoff oder Niete aneinander befestigt. Und natürlich sind die erfindungsgemäßen Schuh-Verschleißteile mit den für den Ölfluss erforderlichen Kanälen versehen.

[0012] Bei der Erfindung besteht das gegen das Band zu liegen kommende Teil des Schuhs aus irgendeinem Kunststoff, dessen Reibung mit dem Band bei Schmierungs-Grenzfällen wesentlich geringer ist als die des gegenwärtig benutzten Stahls oder sonstigen Metallwerkstoffs. Das Kunststoffteil kann sich in einem Stück über die gesamte Schuhlänge (d.h. in CD-Richtung) erstrecken oder aus Sektionen gefertigt sein, wobei dann im Fall einer Beschädigung lediglich die beschädigte Sektion ausgewechselt zu werden braucht. Befestigt wird das Teil am Rahmen bevorzugt durch Schwalbenschwanzverbindung, Schrauben oder auf sonstige passende Weise. Das Teil hat eine Dicke von wenigstens 5 mm.

[0013] Das auswechselbare Teil erstreckt sich an der Schuhoberfläche vom Anfang des Kontakts wenigstens bis in den druckbeaufschlagten Bereich, jedoch kann sich das auswechselbare Verschleißteil auch über den gesamten Oberflächenbereich erstrecken.

[0014] Ein weiterer Vorteil besteht darin, dass Kunststoff im Vergleich zu Stahl in Schadensfällen, in denen der Schuh an der Gegenwalze reibt, geringere Beschädigungen der Gegenwalze verursacht. Auch wirkt der Kunststoff wärmedämmend und verhindert so, dass Reibungswärme auf den Metallrahmen des Schuhs übergeht, wodurch temperaturbedingtes Verziehen des Schuhs, das ja zu Profilproblemen führen könnte, vermieden wird.

[0015] In seinen übrigen Teilen besteht das Stützelement/der Schuh typischerweise aus Metall, wie Aluminium, Stahl oder Aluminiumbronze.

[0016] Im Folgenden wird die Erfindung an Hand einiger für vorteilhaft befundener Ausführungsformen und unter Bezugnahme auf die beigefügten Zeichnungen, auf deren Details die Erfindung jedoch in keiner Weise eng beschränkt werden soll, im Einzelnen beschrieben. Es zeigen:

[0017] Fig. 1 in schematischer Darstellung eine dem Stand der Technik entsprechende Breitnippresse;

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[0018] Fig. 2 in schematischer Darstellung eine dem Stand der Technik entsprechende Durchbiegungseinstellwalze;

[0019] Fig. 3A–Fig. 3B in schematischer Darstellung eine Ausführungsform der Erfindung in Verbindung mit einer Breitnipwalze;

[0020] Fig. 4A–Fig. 4C in schematischer Darstellung eine Ausführungsform der Erfindung für eine Durchbiegungseinstellwalze.

[0021] Einander entsprechenden Teilen wurden in den Zeichnungen, falls nicht anders angegeben, jeweils die gleichen Bezugszeichen zugeordnet.

[0022] Fig. 1 zeigt in schematischer Darstellung eine dem Stand der Technik entsprechende Breitnippresse, die eine Breitnipwalze **1** und eine Gegenwalze **2** umfasst, die zusammen einen verbreiterten Pressnip N bilden, durch den die Papier- bzw. Kartonbahn, von einem (nicht dargestellten) Pressfilz getragen, geführt wird. Die Breitnipwalze **1** hat ein stationäres Achsenteil **3**, das in der Zeichnung nur teilweise dargestellt ist. An diesem Teil abgestützt sind der Pressschuh **5** und die Stützelemente **4**, mit denen der Pressschuh **5**, um den gewünschten Pressdruck zu erzielen, gegen die Gegenwalze **2** gedrückt wird. Das Achsenteil **3** ist von einem elastischen schlauchartigen Mantel **10** umgeben, der an den (nur angedeuteten) beiden Stirnscheiben **11** der Walze befestigt ist. Die Stirnscheiben **11** sind rotierbar um das Achsenteil **3** gelagert. Beim Rotieren des Mantels **10** um das Achsenteil **3** gleiten die Zonen des Mantels nacheinander über die Oberfläche des Pressschuhs **5**.

[0023] Fig. 2 zeigt eine dem Stand der Technik entsprechende Durchbiegungseinstellwalze mit einem um eine stationäre Achse **3** rotierbaren Mantel **10**, der zusammen mit der Oberfläche der Gegenwalze **2** einen Nip N bildet, wo die Niplast eine Deformation am Mantel **10** zu bewirken trachtet. Zwischen der stationären Achse **3** und dem Walzenmantel **10** ist eine Belastungsanordnung eingefügt, die eine in Maschinenquerrichtung, d.h. CD-Richtung verlaufende Reihe hydraulischer Belastungskolben **4** zum Kompensieren der Walzendurchbiegung und zum Drücken des Walzenmantels gegen die Gegenwalze aufweist. Die Walze kann mehrere Dutzend solcher Belastungskolben **4** aufweisen. An der stationären Achse **3** ist für jeden Belastungskolben **4** eine hydraulische Belastungskammer **4'** ausgebildet, in die über den Versorgungskanal **15** ein unter Druck stehendes Medium, bevorzugt Hydrauliköl, geleitet wird. Jedem Belastungskolben **4** kann ein eigener Versorgungskanal **15** zugeordnet sein. In die Walze geführt werden kann das Druckmedium zum Beispiel über die Zentralbohrung **15'** der stationären Achse **3**. Über den Versorgungskanal **15** wird das Druckmedium, um das Stützelement **20** radial zur Achse **3** zu bewegen, in die Belastungskammer **4'** geleitet. Das Stützelement **20** besteht aus einem Belastungskolben **4** und einem oder mehreren im Wesentlichen fest daran gefügten Gleitelementen **5**. Mit dem Druck, der mit dem Hydraulikmedium in der Belastungskammer **4'** bewirkt wird, kann das Stützelement **20** gegen die Innenfläche des Mantels **10** belastet/gedrückt werden, damit die Gleitfläche des Gleitelements **5** gegen die besagte Innenfläche des Mantels **10** zu liegen kommt. Zwischen die Gleitfläche und die Innenfläche des Mantels **10** wird durch Einleiten von Druckmedium durch die Kapillaren **15"** des Stützelements **20** hindurch in die als Schmierkammern fungierenden, an der Gleitfläche ausgebildeten Vertiefungen **22** ein Schmiermittelfilm gelegt. Die Schmierkammern **22** sind durch „Stege" **16** voneinander getrennt und können in Maschinenquerrichtung (CD-Richtung) zu mehreren hintereinander angeordnet sein.

[0024] In Fig. 3A–Fig. 3B ist eine Ausführungsform der Erfindung in Verbindung mit einer Breitnipwalze dargestellt. Fig. 3A zeigt den von der Breitnipwalze und ihrer Gegenwalze **2** gebildeten verbreiterten Nip N. Der Schuh der Breitnipwalze wird, um den gewünschten Nipdruck P innerhalb des elastischen Mantels **10** oder Bandes **10** zu bewirken, gegen die Gegenwalze **2** gedrückt. Über den am Schuh **5** ausgebildeten Kanal **15** wird zur Schmierung des Nips N Schmiermittel in die an der Oberfläche des Schuhs **5** ausgebildete Vertiefung **22** geleitet. Wie in Fig. 3A–Fig. 3B gezeigt, hat der Schuh **5** ein auswechselbares Verschleißteil **30**. Dieses Verschleißteil **30** ist in eine am Schuh **5** ausgebildete Ausnehmung eingesetzt und so angeordnet, dass es an der Oberfläche des Schuhs **5**, die gegen die Innenfläche des elastischen Mantels **10** gerichtet ist, sich wenigstens über jenen Bereich erstreckt, in dem der Nipdruck wirkt. Das an der Innenfläche des Bandes **10** anliegende Verschleißteil **30** ist bevorzugt aus Kunststoff gefertigt, dessen Reibung mit dem Band **10** in Schmierungs-Grenzfällen wesentlich geringer ist als die des gegenwärtig benutzten Stahls oder sonstigen Metallwerkstoffs. Das Verschleißteil **30** kann sich in einem Stück über die gesamte Länge des Schuhs **5** (in CD-Richtung) erstrecken oder aus Sektionen gefertigt sein, wobei dann im Fall einer Beschädigung lediglich die beschädigte Sektion ausgewechselt zu werden braucht. Befestigt wird das Verschleißteil am Rahmen des Schuhs **5** bevorzugt durch Schwalbenschwanzverbindung, Schrauben oder auf sonstige passende, ein Auswechseln ermöglichende Weise. Das Verschleißteil **30** hat eine Dicke von wenigstens 5 mm. Als Rahmenwerkstoff des Schuhs **5** dient zum Beispiel Metall, wie Aluminium, Stahl oder Aluminiumbronze. Wie aus Fig. 3A ersichtlich, reicht das auswechselbare Verschleißteil **30** an der Oberfläche des Schuhs **5** beginnend vom Kontaktanfang wenigstens bis zum Ende des druckbeaufschlagten Bereichs P, kann sich aber auch über den gesamten Oberflächenbereich erstrecken.

[0025] In Fig. 4A–Fig. 4C ist eine erfindungsgemäße Ausführungsform für eine Durchbiegungseinstellwalze anschaulich dargestellt. Das Stützelement **20** umfasst ein Oberflächenteil **32**, d.h. ein Gleitlagerteil, und ein Stützteil **31**. Befestigt ist das Stützelement **20** am Belastungskolben **4** über die Düsen **17**, in denen die Mediumkanäle, d.h. die Kapillaren **15"** verlaufen. Das Oberflächenteil **30** des Stützelements **20** fungiert als Gleitlager. Als Werkstoff für das Oberflächenteil dient bevorzugt hochentwickelter Thermoplast, zum Beispiel Polyetherketon (PEEK) Polyamidimid (PAI) oder Polyimid (PI), der zur Verbesserung der Gleiteigenschaften bevorzugt mit einer geringen Menge Polytetrafluorethen (PTFE) und/oder Graphit dotiert ist. Zur Erhöhung der Steifigkeit hat das auswechselbare Verschleißteil bei dieser Ausführungsform ein starres, aus Metall, zum Beispiel Stahl, oder aus Verbundstoff hergestelltes Stützteil **31**. Das auswechselbare Verschleißteil **30** besteht somit aus dem als Gleitlagerwerkstoff fungierenden Teil **32**, das einschließlich seines Stützteils **31** zum Beispiel mittels der Düsen **17** demontierbar an der übrigen Schuhkonstruktion befestigt ist. Das Stützteil **31** und das Gleitlagerteil **32** des auswechselbaren Verschleißteils **32** sind zum Beispiel durch Schrauben, Klebstoff oder Niete aneinander befestigt.

[0026] Die Erfindung wurde vorangehend lediglich an Hand einiger bevorzugter Ausführungsformen beschrieben, auf deren Details die Erfindung jedoch in keiner Weise eng begrenzt werden soll.

Patentansprüche

1. Walze für eine Faserstoffbahn-Herstellungsmaschine, die ein Stützelement in Form eines Schuhs (**5**; **20**) aufweist, wobei die Walze (**1**) zusammen mit ihrer Gegenwalze (**2**) einen Nip (N) bildet und der Nipdruck (P) in diesem Nip durch einen in Verbindung mit dem Schuh (**5**; **20**) angeordneten Belastungskolben (**4**) bewirkt wird, **dadurch gekennzeichnet**, dass der Schuh (**5**; **20**) der Walze ein auswechselbares Verschleißteil (**30**) hat, das an der zum Nip (N) hin gerichteten Fläche des Schuhs (**5**; **20**) angeordnet ist und sich wenigstens über jenen Bereich der zum Nip (N) hin gerichteten Fläche des Schuhs (**5**; **20**) erstreckt, in welchem der Nipdruck (P) wirkt.

2. Walze nach Anspruch 1, dadurch gekennzeichnet, dass das auswechselbare Verschleißteil (**30**) des Schuhs (**5**; **20**) der Walze aus Kunststoff gefertigt ist.

3. Walze nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass der Kunststoff des auswechselbaren Verschleißteils (**30**) des Schuhs (**5**; **20**) der Walze ein hochentwickelter Thermoplast, zum Beispiel Polyetherketon (PEEK) Polyamidimid (PAI) oder Polyimid (PI) ist.

4. Walze nach irgendeinem der Ansprüche 1 bis 3, dadurch gekennzeichnet, dass der Kunststoff des auswechselbaren Verschleißteils (**30**) des Schuhs (**5**; **20**) der Walze mit einer geringen Menge Polytetrafluorethen (PTFE) und/oder Graphit dotiert ist.

5. Walze nach irgendeinem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass das auswechselbare Verschleißteil (**30**) des Schuhs (**5**; **20**) der Walze durch Schwalbenschwanzverbindung am Rahmen des Schuhs (**5**; **20**) befestigt ist.

6. Walze nach irgendeinem der Ansprüche 1 bis 5, dadurch gekennzeichnet, dass das auswechselbare Verschleißteil (**30**) des Schuhs (**5**; **20**) der Walze in CD-Richtung der Faserstoffbahn-Herstellungsmaschine einheitlich, d.h. in einem Stück gestaltet ist.

7. Walze nach irgendeinem der Ansprüche 1 bis 6, dadurch gekennzeichnet, dass das auswechselbare Verschleißteil (**30**) des Schuhs (**5**; **20**) der Walze in CD-Richtung der Faserstoffbahn-Herstellungsmaschine aus mehreren Sektionen zusammengesetzt ist, die einzeln auswechselbar sind.

8. Walze nach Anspruch 1, dadurch gekennzeichnet, dass das auswechselbare Verschleißteil (**30**) des Schuhs (**5**; **20**) der Walze ein Oberflächenteil **32** aus Kunststoff und ein Stützteil (**31**) aus Metall umfasst.

9. Walze nach irgendeinem der Ansprüche 1 bis 8, dadurch gekennzeichnet, dass das auswechselbare Verschleißteil (**30**) des Schuhs (**5**; **20**) der Walze über Düsen (**17**) an der übrigen Schuhkonstruktion befestigt ist.

10. Walze nach irgendeinem der Ansprüche 1 bis 9, dadurch gekennzeichnet, dass das Oberflächenteil (**32**) und das Stützteil (**31**) des auswechselbaren Verschleißteils (**30**) des Schuhs (**5**; **20**) der Walze durch Schrauben, Klebstoff oder Niete aneinander befestigt sind.

11. Walze nach Anspruch 1, dadurch gekennzeichnet, dass die Walze eine Breitnipwalze ist (Fig. 1).

12. Walze nach Anspruch 1, dadurch gekennzeichnet, dass die Walze eine Durchbiegungseinstellwalze ist (Fig. 2).

Es folgen 3 Blatt Zeichnungen

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Anhängende Zeichnungen

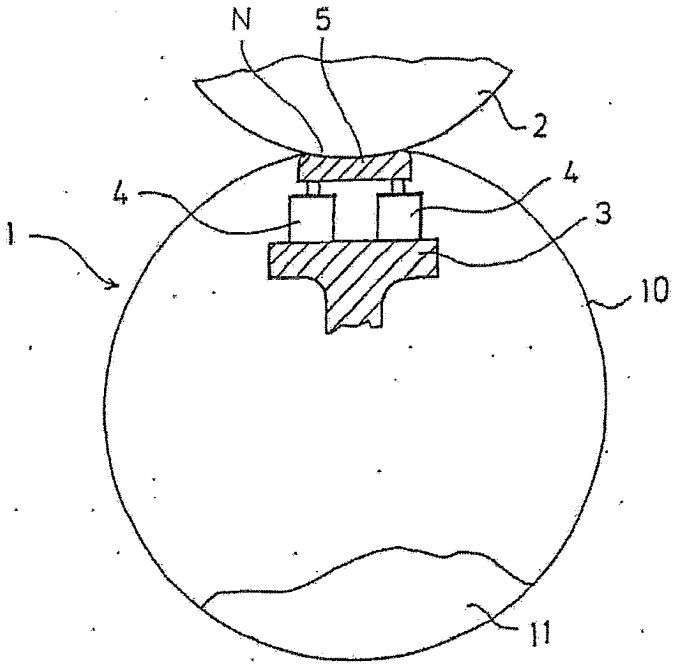


FIG. 1

Stand der Technik

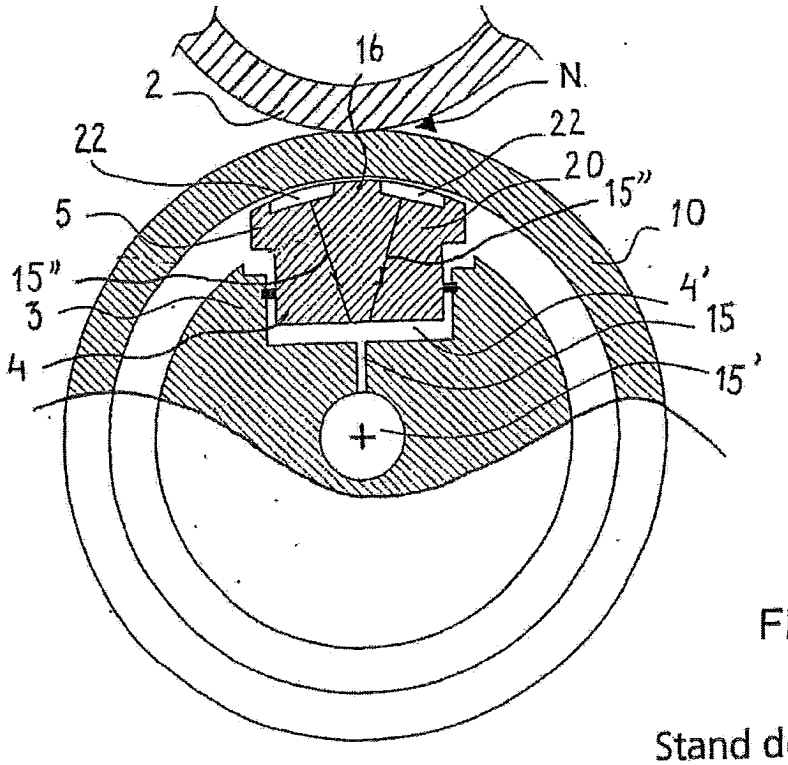


FIG. 2

Stand der Technik

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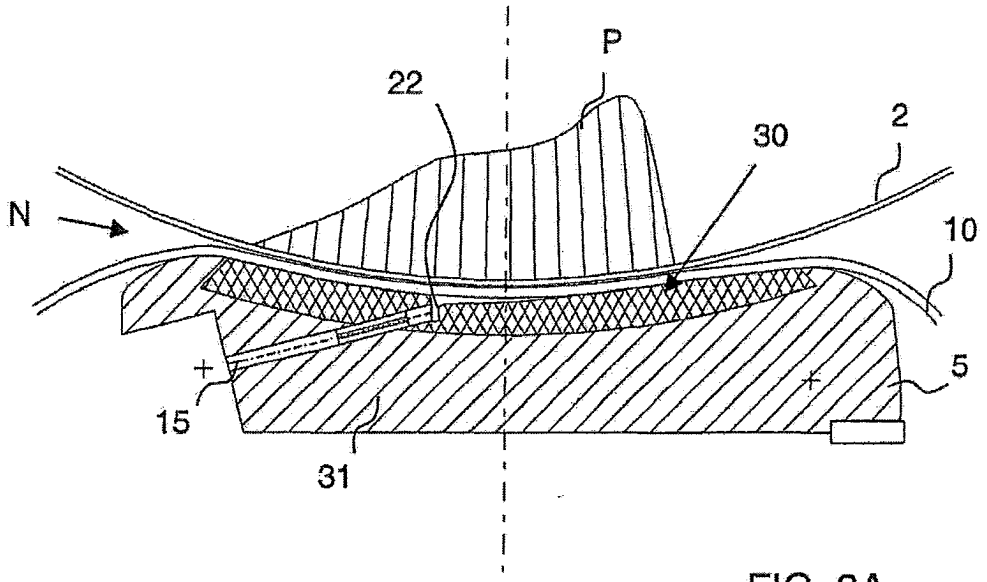


FIG. 3A

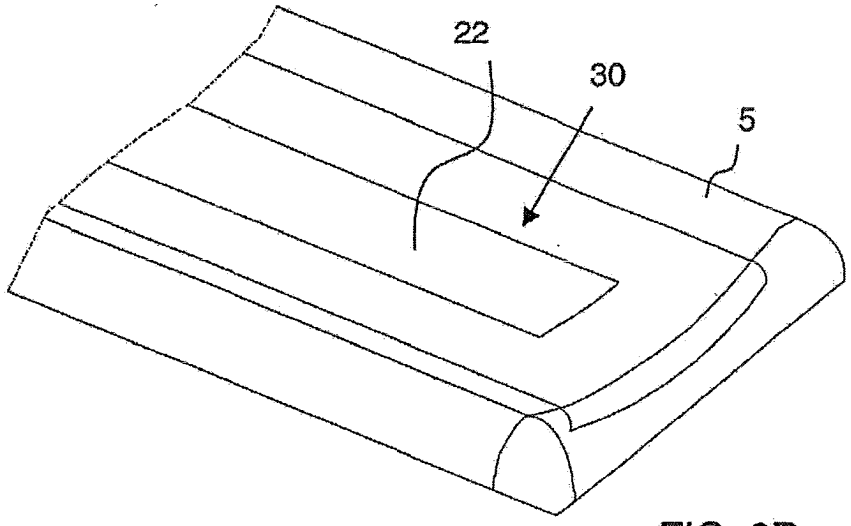


FIG. 3B

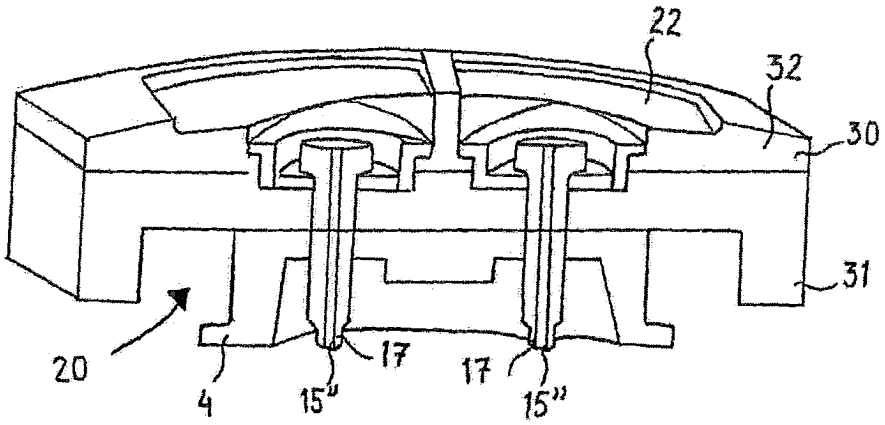


FIG. 4A

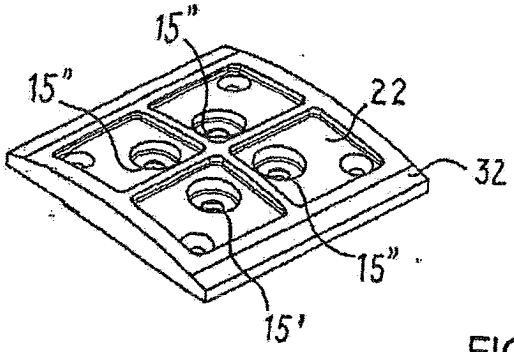


FIG. 4B

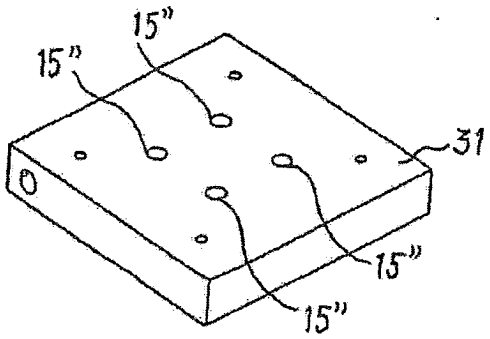


FIG. 4C

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(71) Applicant *(for all designated States except US)*: **US SYNTHETIC CORPORATION** [US/US]; 1260 South 1600 West, Orem, UT 84058 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **COOLEY, Craig, H.** [US/US]; 363 Marina Circle, Saratoga Springs, UT 84045 (US). **SEXTON, Timothy, N.** [US/US]; 624 North 350 East, Genola, UT 84655 (US).

(74) Agents: **SIMON, Marcus, S.** et al.; Workman Nydegger, 60 East South Temple, 1000 Eagle Gate Tower, Salt Lake City, UT 84111 (US).

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(54) **Title**: TILTING PAD BEARING ASSEMBLIES AND APPARATUSES, AND MOTOR ASSEMBLIES USING THE SAME

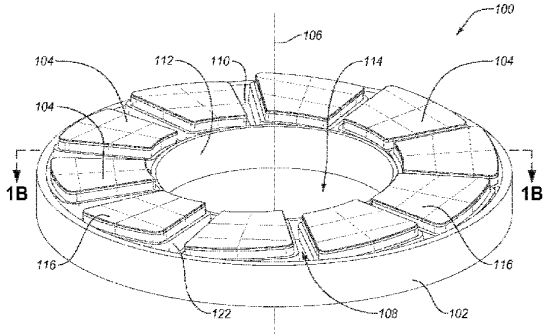


Fig. 1A

(57) **Abstract**: Embodiments of the invention relate to tilting pad bearing assemblies (100) and apparatuses. The disclosed tilting pad bearing assemblies and apparatuses may be employed in downhole motors of a subterranean drilling system or other mechanical systems. In an embodiment, a bearing assembly or apparatus includes a support ring (102) and a plurality of tilting pads (104). Each tilting pad (104) is tilted and/or tiltably secured relative to the support ring (102). In some embodiments, one or more of the tilting pads (104) include a plurality of superhard bearing segments (126) assembled to form a superhard bearing surface (116). One or more seams (136) are positioned between adjacent superhard bearing segments (126) of the superhard bearing segments (126). In other embodiments, one or more of the tilting pads (104) may include at least one or only one superhard bearing segment (126), such as a polycrystalline diamond bearing segment.

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TILTING PAD BEARING ASSEMBLIES AND APPARATUSES, AND MOTOR ASSEMBLIES USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Patent Application No. 13/089,725 filed on 19 April 2011, the contents of which are incorporated herein, in their entirety, by this reference.

BACKGROUND

[0002] Wear-resistant, superhard compacts are utilized in a variety of mechanical applications. For example, polycrystalline diamond compacts ("PDCs") are used in drilling tools (*e.g.*, cutting elements, gage trimmers, etc.), machining equipment, bearing apparatuses, wire-drawing machinery, and in other mechanical apparatuses.

[0003] PDCs have found particular utility as superhard bearing elements in fixed-position thrust bearings within subterranean drilling systems. A PDC bearing element typically includes a superhard diamond layer commonly referred to as a diamond table. The diamond table is formed and bonded to a substrate using a high-pressure/high-temperature ("HPHT") process.

[0004] A fixed-position thrust-bearing apparatus includes a number of PDC bearing elements affixed to a support ring. The PDC bearing elements bear against PDC bearing elements of an adjacent bearing assembly during use. PDC bearing elements are typically brazed directly into a preformed recess formed in a support ring of a fixed-position thrust bearing.

SUMMARY

[0005] Embodiments of the invention relate to bearing assemblies and apparatuses, which may be operated hydrodynamically. The disclosed bearing assemblies and apparatuses may be employed in bearing apparatuses for use in downhole motors of a subterranean drilling system or other mechanical systems.

[0006] In one or more embodiments, a bearing assembly includes a support ring and a plurality of tilting pads. Each tilting pad is tilted and/or tiltably secured relative to the support ring. In some embodiments, one or more of the tilting pads include a plurality of superhard bearing segments assembled to form a superhard bearing surface. One or more seams may be formed and positioned between adjacent superhard bearing segments of the superhard bearing segments. In other embodiments, one or more of the tilting pads may

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include at least one or only one superhard bearing segment, such as a polycrystalline diamond ("PCD") bearing segment.

[0007] In an embodiment, a bearing apparatus includes a rotor and a stator. The rotor or stator may include any of the bearing assembly embodiments disclosed herein.

[0008] Other embodiments are directed to motor assemblies including any of the bearing assembly and apparatus embodiments disclosed herein.

[0009] Features from any of the disclosed embodiments may be used in combination with one another, without limitation. In addition, other features and advantages of the present disclosure will become apparent to those of ordinary skill in the art through consideration of the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The drawings illustrate several embodiments of the present disclosure, wherein identical reference numerals refer to identical or similar elements or features in different views or embodiments shown in the drawings.

[0011] **FIG. 1A** is an isometric view of a hydrodynamic tilting pad thrust-bearing assembly according to an embodiment.

[0012] **FIG. 1B** is an isometric partial cross-sectional view taken along line **1B – 1B** of the hydrodynamic tilting pad thrust-bearing assembly shown in **FIG. 1A**.

[0013] **FIG. 1C** is an isometric view of one of the tilting pads shown in **FIGS. 1A** and **1B**, the tilting pad being segmented into multiple segments having substantially planar adjoining ends according to an embodiment.

[0014] **FIG. 1D** is a cross-sectional view taken along line **1D – 1D** of the bearing tilting pad shown in **FIG. 1C**.

[0015] **FIG. 2A** is an isometric view of three adjacent superhard bearing segments of a tilting pad, the superhard bearing segments having slotted ends forming a set of seams between the three superhard bearing segments according to an embodiment.

[0016] **FIG. 2B** is a top plan view of the tilting pad of **FIG. 2A**, the tilting pad being fully assembled and including six superhard bearing segments defining seams therebetween.

[0017] **FIG. 3** is a top plan view of a tilting pad comprising multiple segments having serrated ends that form seams between the multiple segments according to another embodiment.

[0018] **FIG. 4** is an isometric view of a tilting pad comprising a unitary superhard bearing element according to another embodiment.

[0019] **FIG. 5A** is an isometric cutaway view of a hydrodynamic tilting pad thrust-bearing apparatus that may employ any of the disclosed hydrodynamic tilting pad thrust-bearing assemblies according to one embodiment, with a housing shown in cross-section.

[0020] **FIG. 5B** is an isometric cross-sectional view of the hydrodynamic tilting pad thrust-bearing apparatus taken along line **5B – 5B** of **FIG. 5A** showing a fluid film that develops between tilting pads of a stator and a substantially continuous a superhard bearing element of a rotor.

[0021] **FIG. 6A** is an isometric view of a runner of a hydrodynamic tilting pad thrust-bearing assembly according to one embodiment.

[0022] **FIG. 6B** is an isometric partial cross-sectional view taken along the line **6B – 6B** of **FIG. 6A**.

[0023] **FIG. 7A** is an exploded isometric view of a hydrodynamic tilting pad radial bearing apparatus that may use teachings of any of the disclosed hydrodynamic tilting pad thrust-bearing assemblies according to an embodiment.

[0024] **FIG. 7B** is an isometric partial cross-sectional view of radial tilting pad stator of the hydrodynamic tilting pad radial bearing apparatus of **FIG. 7A** according to an embodiment.

[0025] **FIG. 7C** is an isometric partial cross-sectional view of a rotor of the hydrodynamic tilting pad radial bearing apparatus of **FIG. 7A** according to an embodiment.

[0026] **FIG. 8** is a schematic isometric cutaway view of a subterranean drilling system including one of the disclosed hydrodynamic tilting pad thrust-bearing apparatuses according to an embodiment.

DETAILED DESCRIPTION

[0027] Embodiments of the invention relate to tilting pad bearing assemblies and apparatuses, which may be operated hydrodynamically. The disclosed tilting pad bearing assemblies and apparatuses may be employed in downhole motors of a subterranean drilling system or other mechanical systems. Motor assemblies including at least one of such bearing assemblies or apparatus are also disclosed, as well as methods of fabricating such bearing assemblies and apparatuses utilizing superhard compacts.

[0028] While the description herein provides examples relative to a subterranean drilling and motor assembly, the tilting pad bearing assembly and apparatus embodiments disclosed herein may be used in any number of applications. For instance, tilting pad bearing assemblies and apparatuses may be used in pumps, motors, compressors, turbines, generators, gearboxes, and other systems and apparatuses, or in any combination of the foregoing. Furthermore, while the embodiments disclosed herein are described as being operated hydrodynamically, the tilting pad bearing assemblies and apparatuses may also be operated partially hydrodynamically or not hydrodynamically, if desired or needed.

[0029] **FIGS. 1A** and **1B** are isometric and isometric partial cross-sectional views, respectively, of a hydrodynamic tilting pad thrust-bearing assembly 100 according to an embodiment. The bearing assembly 100 includes a support ring 102 that carries a plurality of circumferentially spaced tilting pads 104. The tilting pads 104 may include, for instance, fixed tilting pads, adjustable tilting pads, self-establishing tilting pads, other bearing pads or elements, or combinations of the foregoing.

[0030] The tilting pads 104 of the illustrated embodiment generally have a truncated pie-shaped geometry or a generally trapezoidal geometry, and may be distributed about a thrust axis 106, along which a thrust force may be generally directed during use. Each tilting pad 104 may be located circumferentially adjacent to another tilting pad 104, with a gap 108 or other offset therebetween. For instance, the gap 108 may separate adjacent tilting pads 104 by a distance of about 2.0 mm to about 20.0 mm, or more particularly a distance of about 3.5 mm to about 15 mm, although the separation distance may be greater or smaller. For instance, as the size of the hydrodynamic tilting pad bearing assembly 100 increases, the size of the tilting pads 104 and/or the size of the gaps 108 may also increase. Each tilting pad 104 includes a discrete superhard bearing surface

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116, such that the tilting pads 104 collectively provide a non-continuous superhard bearing surface. The term "superhard," as used herein, means a material having a hardness at least equal to a hardness of tungsten carbide.

[0031] To support the tilting pads 104 of the bearing assembly 100, the support ring 102 may define a channel 110 and the tilting pads 104 may be placed within the channel 110. In other embodiments, the support ring 102 may define multiple pockets or otherwise define locations for the tilting pads 104. The tilting pads 104 may then be supported or secured within the support ring 102 in any suitable manner. For instance, as discussed hereafter, a pivotal connection may be used to secure the tilting pads 104 within the support ring 102, although any other suitable securement or attachment mechanism may also be utilized. The support ring 102 may also include an inner, peripheral surface defining an aperture 114. The aperture 114 may be generally centered about the thrust axis 106, and may be adapted to receive a shaft (*e.g.*, a downhole drilling motor shaft).

[0032] As best shown in **FIG. 1B**, each tilting pad 104 may include a plurality of superhard bearing segments having a plurality of materials, layers, segments, or other elements, or any combination of the foregoing. For instance, as discussed in greater detail herein, the tilting pads 104 may be composed of multiple superhard bearing segments. In such an embodiment, multiple individual segments may be arranged relative to each other to collectively define a hydrodynamic superhard bearing surface 116 for each tilting pad 104.

[0033] Each tilting pad 104 optionally includes multiple layers or other components. For instance, each segment of the tilting pad 104 may be a superhard compact that includes a superhard table 118 bonded to a substrate 120. The superhard table 118 may be at least partially made from a number of different superhard materials. Suitable materials for use in the superhard table 118 include natural diamond, sintered PCD, polycrystalline cubic boron nitride, diamond grains bonded together with silicon carbide, or combinations of the foregoing. In an embodiment, the superhard table 118 is a PCD table that includes a plurality of directly bonded-together diamond grains exhibiting diamond-to-diamond bonding therebetween (*e.g.*, sp^3 bonding), which define a plurality of interstitial regions. A portion of, or substantially all of, the interstitial regions of such a superhard table 118 may include a metal-solvent catalyst or a metallic infiltrant disposed therein that is infiltrated from the substrate 120 or from another source. For example, the metal-solvent catalyst or metallic infiltrant may be selected from iron, nickel, cobalt, and

alloys of the foregoing. The superhard table 118 may further include thermally-stable diamond in which the metal-solvent catalyst or metallic infiltrant has been partially or substantially completely depleted from a selected surface or volume of the superhard table 118 using, for example, an acid leaching process.

[0034] For example, appropriately configured PDCs may be used as the tilting pads 104, which may be formed in an HPHT processes. For example, diamond particles may be disposed adjacent to the substrate 120, and subjected to an HPHT process to sinter the diamond particles to form a PCD table that bonds to the substrate thereby forming the PDC. The temperature of the HPHT process may be at least about 1000 °C (*e.g.*, about 1200 °C to about 1600 °C) and the cell pressure of the HPHT process may be at least 4.0 GPa (*e.g.*, about 5.0 GPa to about 12 GPa or about 7.5 GPa to about 11 GPa) for a time sufficient to sinter the diamond particles.

[0035] The diamond particles may exhibit an average particle size of about 50 μm or less, such as about 30 μm or less, about 20 μm or less, about 10 μm to about 18 μm, or about 15 μm to about 18 μm. In some embodiments, the average particle size of the diamond particles may be about 10 μm or less, such as about 2 μm to about 5 μm or submicron. In some embodiments, the diamond particles may comprise a relatively larger size and at least one relatively smaller size. As used herein, the phrases "relatively larger" and "relatively smaller" refer to particle sizes (by any suitable method) that differ by at least a factor of two (*e.g.*, 30 μm and 15 μm). According to various embodiments, the mass of diamond particles may include a portion exhibiting a relatively larger size (*e.g.*, 30 μm, 20 μm, 15 μm, 12 μm, 10 μm, 8 μm) and another portion exhibiting at least one relatively smaller size (*e.g.*, 6 μm, 5 μm, 4 μm, 3 μm, 2 μm, 1 μm, 0.5 μm, less than 0.5 μm, 0.1 μm, less than 0.1 μm). In one embodiment, the diamond particles may include a portion exhibiting a relatively larger size between about 10 μm and about 40 μm and another portion exhibiting a relatively smaller size between about 1 μm and 4 μm. In some embodiments, the diamond particles may comprise three or more different sizes (*e.g.*, one relatively larger size and two or more relatively smaller sizes), without limitation. The PCD table so-formed after sintering may exhibit an average diamond grain size that is the same or similar to any of the foregoing diamond particle sizes and distributions.

[0036] In some embodiments, one or more sp^2-carbon-containing additives may be mixed with the diamond particles. For example, the one or more sp^2-carbon-containing

additives may be present in a mixture with the diamond particles in an amount of about 1 weight percent ("wt %") to about 15 wt %, such as 3 wt % to about 12 wt %, about 4.5 wt % to about 6.5 wt %, about 4.5 wt % to about 5.5 wt, or about 5 wt % of the mixture. The one or more sp^2-carbon-containing additives may be chosen from graphite, graphene, fullerenes, ultra-dispersed diamond particles, or combinations of the foregoing.

[0037] In an embodiment, the superhard table 118 may be integrally formed with the substrate 120. For example, the superhard table 118 may be a sintered PCD table that is integrally formed with the substrate 120. In such an embodiment, the infiltrated metal-solvent catalyst may be used to catalyze formation of diamond-to-diamond bonding between diamond grains of the superhard table 118 from diamond powder during HPHT processing. In another embodiment, the superhard table 118 may be a pre-sintered superhard table that has been HPHT bonded to the substrate 120 in a second HPHT process after being initially formed in a first HPHT process. For example, the superhard table 118 may be a pre-sintered PCD table that has been leached to substantially completely remove metal-solvent catalyst used in the manufacture thereof and subsequently HPHT bonded or brazed to the substrate 120 in a separate process.

[0038] In some embodiments, the superhard table 118 may be leached to deplete a metal-solvent catalyst or a metallic infiltrant therefrom in order to enhance the thermal stability of the superhard table 118. For example, where the superhard table 118 is a PCD table, the superhard table 118 may be leached to remove at least a portion of the metal-solvent catalyst from a working region thereof to a selected depth that was used to initially sinter the diamond grains to form a leached thermally-stable region. The leached thermally-stable region may extend inwardly from the superhard bearing surface 116 to a selected depth. In one example, the depth of the thermally-stable region may be about 10 μm to about 500 μm. More specifically, in some embodiments, the selected depth is about 50 μm to about 100 μm or about 200 μm to about 350 μm. The leaching may be performed in a suitable acid, such as aqua regia, nitric acid, hydrofluoric acid, or mixtures of the foregoing.

[0039] The substrate 120 may similarly be formed from any number of different materials, and may be integrally formed with, or otherwise bonded or connected to, the superhard table 118. Materials suitable for the substrate 120 may include, without limitation, cemented carbides, such as tungsten carbide, titanium carbide, chromium carbide, niobium carbide, tantalum carbide, vanadium carbide, or combinations thereof

cemented with iron, nickel, cobalt, or alloys thereof. For example, in an embodiment, the substrate 120 comprises cobalt-cemented tungsten carbide. However, in certain embodiments, the superhard tables 118 may be omitted, and each superhard bearing segment may be made from a superhard material, such as cemented tungsten carbide. In other embodiments, the substrate 120 may be omitted and the superhard bearing segment may be a superhard material, such as a polycrystalline diamond body that has been leached to deplete metal-solvent catalyst therefrom or may be an un-leached PCD body.

[0040] In the embodiment illustrated in **FIGS. 1A** and **1B**, the superhard tables 118 of mating superhard bearing segments may collectively define a substantially continuous superhard bearing surface 116 of a respective tilting pad 104. More particularly, the tilting pads 104 may be used in connection with a runner or other superhard bearing element. In general, the hydrodynamic tilting pad bearing assembly 100 may rotate relative to a runner or other superhard bearing element while a lubricant or other fluid floods the hydrodynamic tilting pad bearing assembly 100 and the runner. As the bearing assembly 100 is rotated relative to a runner, a fluid film separating the runner from the superhard bearing surfaces 116 may develop. For favorable use of the hydrodynamic forces within the lubricant, the tilting pads 104 may tilt which may result in a higher lubricant film thickness existing at a leading edge (*i.e.*, an edge of a tilting pad 104 that would be traversed first by any line on the runner while the assembly 100 moves in the direction of rotation of the assembly 100), than at a trailing edge (*i.e.*, an edge of a tilting pad 104 over which a line of the superhard bearing element is second to pass in the direction of rotation of the assembly 100), at which a minimum film thickness may develop.

[0041] In the illustrated embodiment, the set of superhard bearing segments collectively defining at least a portion of the tilting pad 104 are secured to a support plate 122. The support plate 122 may, for instance, be formed of a metal, an alloy, a cemented carbide material, other material, or any combination thereof. The substrate 120 of the superhard bearing segments may be secured to the support plate 122 by brazing, welding, or other method. In some embodiments, the support plate 122 may define a pocket into which the superhard bearing segments may be assembled and/or positioned. In at least one embodiment, the support plate 122 has an integral construction such that a single segment may form substantially the full support plate 122, while multiple superhard bearing segments may be used to form the superhard bearing surface 116. In other

embodiments, multiple segments of one or more materials may be used to form or define the support plate 122.

[0042] The degree to which the tilting pads 104 rotate or tilt may be varied in any suitable manner. For instance, in an embodiment, the tilting pads 104 may be tilted about respective radial axes that extend radially from the thrust axis 106 and through each respective tilting pad 104. In **FIG. 1B**, the support plate 122 may be attached to a pin 124. The pin 124 may be allowed to at least partially rotate, or may otherwise define or correspond to a tilt axis 125. For instance, in accordance with some embodiments, the pin 124 is journaled or otherwise secured within the support ring 102 in a manner that allows the pin 124 to rotate relative to the support ring 102. The pin 124 may be fixed to the support plate 122 such that as the pin 124 rotates relative to the support ring 102, the support plate 122 may also rotate or tilt relative to the axis 125 of the pin 124. The pin 124 and support plate 122 may rotate or tilt between zero and twenty degrees in some embodiments, such that the superhard bearing surfaces 116 of the respective tilting pads 104 may also tilt between about zero and about twenty degrees relative to the pin 124 or other horizontal axis. In other embodiments, the pin 124 and/or the superhard bearing surface 116 may rotate between about zero and about fifteen degrees, such as a positive or negative angle (θ) of about 0.5 to about 3 degrees (*e.g.*, about 0.5 to about 1 degree or less than 1 degree) relative to the axis 125 of the pin 124. In some cases, the support ring 102 may be configured for bidirectional rotation. In such a case, the pin 124 may be allowed to rotate in clockwise and counter-clockwise directions. In such an embodiment, the superhard bearing surface 116 may thus tilt in either direction relative to the axis of the pin 124 and/or the support ring 102. For instance, the superhard bearing surface 116 may be rotated to a position anywhere between a positive or negative angle of about twenty degrees relative to a axis of the pin 124, such as a positive or negative angle (θ) of about 0.5 to about 3 degrees (*e.g.*, about 0.5 to about 1 degree or less than 1 degree) relative to the axis 125 of the pin 124.

[0043] The pin 124 may be used to allow the tilting pads 104 to selectively rotate. For instance, the tilting pads 104 may be self-establishing such that based on the lubricant used, the axial forces applied along the thrust axis, the rotational speed of the runner or hydrodynamic tilting pad bearing assembly 100, other factors, or combinations of the foregoing, the tilting pads 104 may automatically or otherwise adjust to a desired tilt or other orientation. In still other embodiments, the tilting pads 104 may be fixed at a

particular tilt, or may be manually set to a particular tilt with or without being self-establishing.

[0044] Further, the pin 124 represents a single mechanism for facilitating rotation, translation, or other positioning of the tilting pads 104 so as to provide tilting pad superhard bearing surfaces 116. In other embodiments, other mechanisms may be used. By way of illustration, leveling links, pivotal rockers, spherical pivots, other elements, or any combination of the foregoing may also be used to facilitate positioning of the tilting pads 104 in a tilted configuration. In an embodiment, the support plate 122 may be used to facilitate rotation of a respective tilting pad 104. The support plate 122 may, for instance, be machined or otherwise formed to include a receptacle, an opening, or other structure into which the pin 124 may be at least partially received or secured. In embodiments in which the pin 124 is excluded, the support plate 122 may be machined or otherwise formed to include other components, such as spherical pivot, pivotal rocker, or leveling link interface. The support plate 122 may be formed of any suitable material, such as steel or other alloy; however, in some embodiments the support plate 122 is formed of a material that is relatively softer than the substrate 120, such that the support plate 122 may be relatively easily machined or formed into a desired shape or form. In other embodiments, the support plate 122 can be eliminated and the substrate 120 may be directly machined or formed to facilitate tilting of the tilting pad 104.

[0045] In some embodiments, the tilt axis of the tilting pads 104 is centered relative to the tilting pads 104. For instance, where the support ring 102 may be configured for bi-directional rotation, the tilt axis of the tilting pads 104 may be centered due to either of opposing edges of the tilting pads 104 being the leading or trailing edge, based on a particular direction of rotation. In other embodiments, the tilt axis of a tilting pad 104 may be offset relative to a center of the tilting pads 104. For instance, where the support ring 102 is part of a rotor configured for only unidirectional rotation, the axis of rotation of the tilting pad 104 may be offset such that the axis of rotation is closer to one of the leading edge or the trailing edge of the tilting pad 104. In other embodiments, a tilt axis may be offset from center despite a rotor being configured for bidirectional rotation, or a tilt axis may be centered despite a rotor being configured for unidirectional rotation.

[0046] The use of superhard materials such as those contemplated in the present disclosure may provide wear resistance, frictional, or other properties that extend the useful life and/or utility of the corresponding bearing, motor, or other assemblies

described herein. For instance, in some applications, hardened steel bearing tilting pads may wear at a rate that is between five and twenty times greater than bearing pads made of superhard materials. Thus, in at least some applications, use of superhard materials in a tilting pad bearing assembly may significantly increase the potential useful life of a bearing assembly.

[0047] While superhard materials may thus provide desirable wear characteristics, use of some superhard materials may be limited in various regards. For instance, certain types of superhard materials may be manufacturable in limited quantities, or may be available with certain size restrictions. Such limitations may be the result of technological, quality, or economic constraints. For instance, in some cases, the technology to produce large pieces of a superhard material may not exist, or developing machinery that may produce large pieces may be cost prohibitive, or result in low quality components. PDCs are a superhard article including at least one such material that is considered to have production size constraints. For instance, as described herein, PDCs may be produced using an HPHT sintering and/or bonding process. To maintain the temperature and pressure requirements over a large surface area, and thereby produce large segments of PDCs, can consume large amounts of power and require large, powerful, and sophisticated machinery. If such pressure and temperature tolerances are not maintained, the PDCs may include defects that reduce desirable wear resistance and/or frictional characteristics of the PDCs. Moreover, the temperature and/or pressure requirements for production of a high quality and large PDC may exceed the capabilities of currently available HPHT presses. Consequently, PDCs are currently produced under size restrictions. For example, PDCs are available in limited sizes that typically range up to about 25 mm to about 75 mm (*e.g.*, about 25 mm to about 30 mm) in diameter for cylindrical PDCs and up to about 3.0 mm in diamond table thickness.

[0048] Where the hydrodynamic tilting pad bearing assembly of **FIGS. 1A** and **1B**, includes superhard bearing segments formed from PDCs or other polycrystalline diamond material, use of a unitary PDC for an entire molding element may currently be available primarily where the tilting pad 104 is very small (*e.g.*, having size dimensions limited to a maximum dimension of about 25 mm to about 30 mm). Tilting pad bearing assemblies, however, often require or use tilting pads that far exceed the size of a typical PDC. For instance, in a turbine application, it may not be uncommon for tilting pad bearing assemblies to utilize tilting pads having length and/or width dimensions measuring 30

mm or more. For instance, tilting pads may be used in bearing systems where tilting pads measure between about 30 mm and about 1500 mm. More particularly, in some embodiments, a length and/or width of a tilting pad may measure between about 50 mm and about 1000 mm, although larger or smaller tilting pads may be utilized. Because of the significant wear resistive properties that PDCs or other superhard materials provide, it is nonetheless desirable to use superhard materials for large tilting pads or other superhard bearing segments, even when the tilting pads exceed the size of available superhard materials.

[0049] According to some embodiments, superhard materials such as polycrystalline diamond or PDCs including polycrystalline diamond may be formed as multiple independent superhard bearing segments that may be joined and/or assembled together to collectively define a superhard bearing element and/or superhard bearing surface. **FIGS. 1C** and **1D** illustrate in greater detail such an embodiment in which multiple segments are combined to define a superhard bearing element in the form of a tilting pad.

[0050] In particular, **FIGS. 1C** and **1D** are isometric and cross-sectional views, respectively, of a single tilting pad 104 that may be used in connection with the hydrodynamic tilting pad bearing assembly described above. The tilting pad 104 includes multiple superhard bearing segments 126a-f that collectively define the bearing pad 126, including a substantially continuous superhard bearing surface 116. Each superhard bearing segment 126a-f may include a superhard table 118 bonded to a substrate 120, and each segment 126a-f may further be secured within the support plate 122 by brazing, press-fitting, fastening with fasteners, or other suitable attachment mechanism. In the illustrated embodiment, the support plate 122 may facilitate attachment of the segments 126a-f to the support plate 122 by including an interior surface 128 that defines an interior pocket 130. The pocket 130 may be sized to generally correspond to a size of the collective, assembled set of segments 126a-f. The superhard bearing segments 126a-f may be assembled within the pocket 130 and secured to the support plate 122 by brazing the segments 126a-f to the support plate 122, press-fitting the segments 126a-f to the support plate 122 and/or against each other, attaching each of the superhard bearing segments 126a-f to the support plate 122 using a mechanical fastener, or using another suitable technique, or any combination of the foregoing. It is noted that the support plate 122 merely represents one embodiment for a support plate and other configurations may be used. For example, according to another embodiment, a support plate may lack a

pocket or other receptacle. In still another embodiment, the support plate may be eliminated. For instance, the segments 126a-f may be directly connected together and the substrates 120 may directly engage the support ring 102 (**FIGS. 1A** and **1B**) and/or a tilt mechanism.

[0051] The illustrated embodiment shows an example structure of the superhard bearing segments 126a-f, and an example of how the superhard bearing segments 126a-f may be assembled together. In this embodiment, six superhard bearing segments 126a-f collectively define a pie-shaped bearing pad 126 and a substantially continuous superhard bearing surface 116, although more or fewer than six segments may be provided. Generally, more than one bearing segment may be provided to collectively form a tilting pad. Each superhard bearing segment 126a-f may include at least one outer edge region 132 and at least one interior edge region 134. In the illustrated embodiment, each outer edge region 132 defines a portion of a periphery of the superhard bearing surface 116. Each interior edge region 134 may be configured to correspond with, and in some embodiments may mesh with, corresponding interior edge regions of one or more of other of the superhard bearing segments 126a-f. In **FIG. 1C**, for instance, each of the superhard bearing segments 126a-f is configured to be arranged such that the interior edge region 134 mates with corresponding interior edge regions of at least two and sometimes three adjacent segments 126a-f.

[0052] In the illustrated embodiment, the superhard bearing surface 116 is substantially planar, although such embodiment is merely illustrative. In other embodiments, the superhard bearing surface 116 may be curved, or have another contour or topography. Moreover, the outer edges of the superhard bearing surface 116 optionally include a chamfer 140. The chamfer 140 may be formed by placing a chamfer on the individual outer edge regions 132 of each of the superhard bearing segments 126a-f. The superhard bearing surface 116 may also take a number of other forms. For instance, in **FIG. 1C**, the superhard bearing surface 116 is substantially pie shaped with a curved and chamfered outer edge 142 and curved and chamfered interior edge 144. Chamfered side edges 146, 148 may be substantially straight and taper inward from the outer edge 142 to the interior edge 144. In other embodiments, the edges of a superhard bearing surface 116 may define other shapes, including radiused, arcuate, circular, elliptical, trapezoidal, or other shaped surfaces, or may form a sharp edge.

[0053] The superhard bearing segments 126a-f may also be arranged to each have any desired individual shape. By way of illustration, a set of seams 136 may be at least partially formed between separate superhard bearing segments 126a-f and each superhard bearing segment 126a-f may have a different size and/or shape. The superhard bearing segments 126a-f and/or seams 136 may be non-symmetrical. In other embodiments, however, the seams 136 and/or the superhard bearing segments 126a-f may define the superhard bearing surface 116 in a substantially symmetrical fashion.

[0054] Any number of superhard bearing segments may be used to form a superhard bearing surface 116. For instance, as noted above, a bearing tilting pad may be sized many times larger than a largest available size of a PDC or other material used to form a portion of the bearing tilting pad, or may be small enough to be formed of a single PDC. In **FIG. 1C**, six superhard bearing segments 126a-f may be used to define the full size of the superhard bearing surface 116. In other embodiments, however, more or less than six superhard bearing segments may be used. By way of illustration, a bearing tilting pad measuring 75 mm in circumferential width and 100 mm in radial length, may include ten or more individual segments. In some embodiments, some individual segments include only interior edges of the corresponding superhard bearing surface, such as where a segment is bounded in all directions by other of the superhard bearing segments. Thus, it is not necessary that a superhard bearing segment have a portion thereof corresponding to an outer edge of the superhard bearing surface 116.

[0055] The interior edge regions 134 of the superhard bearing segments 126a-f may be configured to limit fluid from being able to leak through the seams 136 formed between adjacent superhard bearing segments 126a-f. By way of illustration, the seams 136 may be interconnected and defined by interfaces between the interior edge regions 134. Depending upon the tolerances of the superhard bearing segments 126a-f, all or a portion of the seams 136 may comprise a relatively small gap 138. For example, the gap 138 may have a width of about 0.001 mm to about 3.5 mm, more particularly a width of about 0.0025 mm to about 2.5 mm, and more particularly a width of about 0.125 mm to about 1.25 mm. More particularly still, the gap 138 may have a width from about 0.025 mm up to about 1.0 mm. In another embodiment, the gap 138 may have a width from about 0.005 mm up to about 0.50 mm. As the gaps 138 decrease in size, it may become more difficult for fluid to flow radially between the gaps 138 and leak from the superhard bearing surface 116 of the superhard bearing element 104. However, it should be noted

that in at least some operational conditions, entrained fluid in the gaps 138 may assist with formation of a hydrodynamic film on the superhard bearing surface 116.

[0056] The interior edge regions 134 of the superhard bearing segments 126a-f in **FIGS. 1C** and **1D** may be substantially straight or planar and may create substantially planar seams 136 between the various segments 126a-f. In other embodiments, one or more segments may exhibit other configurations or geometry that depart from the illustrated embodiment in **FIGS. 1A – 1D**. For example, **FIGS. 2A** and **2B** illustrate isometric and top plan views, respectively, of a tilting pad 204 according to another embodiment. The tilting pad 204 includes multiple superhard bearing segments 226a-f, each of which may include a superhard table 218 bonded to a substrate 220. The substrate 220 and/or superhard table 218 may further be bonded to a support plate 222 using a brazing, fastening, or other process such as those described herein. The tilting pad 204 may also be configured to pivot or otherwise tilt. For instance, a pin 224 may be attached to the support plate 222. The pin 224 may have a central axis 235 about which it tilts, thereby allowing the superhard bearing surface 216 to also pivot, rotate, tilt, or otherwise move about the central axis 235.

[0057] The superhard bearing segments 226a-f of the illustrated embodiment each include interior edge regions 234 configured to correspond to and/or mate with interior edge regions 234 of two or three adjacent superhard bearing segments 226a-f. Each of the superhard bearing segments 226a-f may further include an outer edge region 232 defining at least a portion of the periphery of the superhard bearing surface 216. As discussed herein, the foregoing is merely an example. In other embodiments, there may be one or more superhard bearing segments that do not include an outer edge region, include an interior edge region corresponding to, or mating with, only one or more than three adjacent superhard bearing segments, or superhard bearing segments may have still other configurations.

[0058] In the illustrated embodiment, the superhard bearing segments 226a-f may include, at their respective interior edge regions 234, generally rectangular-shaped slots 250 and rectangular-shaped ridges 252. The slots 250 and ridges 252 may be configured to correspond to and potentially mesh with corresponding ridges 252 and slots 250 of adjoining segments 226a-f. Consequently, the superhard bearing segments 226a-f may at least partially interlock along respective interior edge regions 234.

[0059] Each superhard bearing segment 226a-f may thus be positioned radially, circumferentially, or otherwise adjacent to another of the superhard bearing segments 226a-f, with one of the seams 236 formed therebetween. In some embodiments, interlocked superhard bearing segments 226a-f may act to limit fluid leakage at the superhard bearing surface 216. For instance, the seams 236 may define a tortuous path to limit fluid leakage through the seams 236. If present, gaps located between adjacent superhard bearing segments 226a-f may further be filled with a sealant material to help limit leakage of fluid through the seams 236. For example, gaps between interior edge regions 234 may be substantially filled with a sealant material. Examples of sealant materials may include a ceramic material, metallic material, polymeric material, or another suitable material, or any combination of the foregoing. In an embodiment, the sealant material may exhibit abrasion and/or erosion resistance to commonly used drilling fluids (also known as drilling mud). For example, a sealant material may comprise chemically-vapor-deposited ("CVD") diamond or a CVD-deposited carbide material (*e.g.,* binderless tungsten carbide). Specifically, one example of a commercially available CVD binderless tungsten carbide material (currently marketed under the trademark HARDIDE®) is currently available from Hardide Layers Inc. of Houston, Texas.

[0060] In other embodiments, a binderless tungsten carbide material may be formed by physical vapor deposition ("PVD"), variants of PVD, high-velocity oxygen fuel ("HVOF") thermal spray processes, supersonic transfer ("SST"), or any other suitable process, without limitation. In still other embodiments, the braze alloy used to braze the superhard bearing segments 226a-f to the support plate 222 may infiltrate the seams 236 and substantially fill all or a portion of the gaps at the seams 236, which may exist at the interfaces of the interior edge regions 234 of mating superhard bearing segments 226a-f. For example, suitable abrasion resistant braze alloys include, but are not limited to, silver-copper based braze alloys commercially known as braze 505 and braze 516 and are available from Handy & Harmon of Canada Limited. In another embodiment, a sealant material may comprise a hardfacing material (*e.g.,* a nickel or cobalt alloy) applied at least within the gaps by thermal spraying. In yet a further embodiment, a sealant material may comprise polyurethane, or another suitable polymeric, metal, alloy, or other material. In another embodiment, a substantially continuous superhard bearing surface 216 may be at least partially formed by depositing a layer of diamond onto the surface 216 and into gaps between the segments 226a-f.

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[0061] **FIGS. 3** and **4** illustrate top plan and isometric views, respectively, of different embodiments of tilting pads that may be employed in a hydrodynamic tilting pad bearing assembly according to an embodiment. In particular, **FIG. 3** illustrates a tilting pad 304 that may include a plurality of superhard bearing segments 326a-d, each of which includes a superhard table 318 with a superhard bearing surface 316 bonded to a substrate (not shown). The superhard table 318 and substrate (not shown) is optionally bonded or otherwise connected to a support plate 322.

[0062] The superhard bearing segments 326a-d each may include an outer edge region 332 and an interior edge region 334. The superhard bearing segments 326a-d may be configured with a serrated geometry at the interior edge regions 334. Such a configuration may allow adjacent superhard bearing segments 326a-d to mate and at least partially interlock, while also defining seams 336 of a geometry that limits fluid leakage radially through the gaps between adjoining superhard bearing segments 326a-d.

[0063] The illustrated and described seams between adjacent superhard bearing segments are merely illustrative, and seams between superhard bearing segments and/or configurations of interior edge regions of superhard bearing segments may have any number of configurations. For, instance, a set of interconnecting superhard bearing segments may have substantially straight, serrated, saw-toothed, sinusoidal-like, curved, or otherwise shaped interior edge regions, or any combination of the foregoing. Moreover, some portions of an interior edge region may have one configuration of shape while another portion of an interior edge region on the same superhard bearing segment may have a different configuration or shape. Accordingly, different superhard bearing segments may also include different mating geometry or other configurations.

[0064] As discussed herein, a tilting pad bearing assembly may be utilized where certain conditions are met, or in any number of other circumstances or industries. For instance, an application may be identified where it would benefit to use a superhard bearing element including a superhard material; however, the superhard material may have associated production limits (*e.g.*, size, availability, etc.). Where the superhard bearing element has a size, shape, or other feature(s) exceeding such production limits, the superhard bearing element may be fashioned out of multiple individual segments that collectively define a superhard bearing surface of the superhard bearing element. In other cases, however, the type of material used in the superhard bearing element may not have the same production limits as PDCs or other superhard materials, or the superhard bearing

element may be sized small enough to allow a single superhard or other material to be used to form the superhard bearing surface. **FIG. 4** illustrates an embodiment in which a tilting pad 404 may have a size and/or comprise a material configured such that a single segment may form a substantially continuous superhard bearing surface 416. In particular, the tilting pad 404 may include a superhard table 418 bonded to a substrate 420. The substrate may in turn be bonded to a support plate 422. Optionally, the support plate 422 is oversized relative to the substrate 420; however, the support plate 422 may also be about the same size or smaller than the substrate 420. In this embodiment, a single segment 426 may define substantially the entire superhard bearing surface 416. For instance, the segment 426 may exhibit a length and/or width that may measure approximately 15 mm by 10 mm, such that a single superhard table 418 made from polycrystalline diamond or other materials may be fashioned into the desired shape, even in the absence of providing multiple interlocking, adjoining, or adjacent segments. In other embodiments, the segment 426 may have other sizes and may even exceed a maximum size available for PCDs. For instance, other superhard materials (*e.g.*, tungsten carbide) may be used to form the superhard bearing surface 116 using a single, integral segment.

[0065] Any of the above-described hydrodynamic tilting pad bearing assembly embodiments may be employed in a hydrodynamic tilting pad bearing apparatus. **FIGS. 5A** and **5B** are isometric cutaway and isometric partial cross-sectional views, respectively, of a hydrodynamic tilting pad thrust-bearing apparatus 500 according to an embodiment. The hydrodynamic tilting pad thrust-bearing apparatus 500 may include a rotor 554 and a stator 556. The stator 556 may be configured as any of the described embodiments of hydrodynamic tilting pad bearing assemblies, or may include any of the described embodiments of superhard bearing elements or tilting pads. The stator 556 may include a support ring 502 and a plurality of tilting pads 504 mounted or otherwise attached to the support ring 502, with each of the tilting pads 504 having a superhard bearing surface 516. The tilting pads 504 may be tilted and/or tilt relative to a rotational axis 505 of the hydrodynamic tilting pad apparatus 500 and/or one or more surfaces of the support ring 502. The tilting pads 504 may be fixed at a particular tilt, may be manually adjusted to exhibit a particular tilt, may self-establish at a particular tilt, or may be otherwise configured. The terms "rotor" and "stator" refer to rotating and stationary components of the tilting pad bearing apparatus 500, respectively, although the rotating

and stationary status of the illustrated embodiments may also be reversed. For instance, the support ring 502 and tilting pads 504 may remain stationary while a support ring 558 rotates.

[0066] The rotor 554 may be configured in any suitable manner, including in accordance with embodiments described herein. The rotor 554 may include a support ring 558 connected to one or more superhard bearing segments 562. The rotor 554 may include a substantially continuous superhard bearing surface which is generally adjacent the superhard bearing surfaces 516 of the stator 556. A fluid film may be formed between the substantially continuous superhard bearing surface of the rotor 554 and the superhard bearing surfaces 516 of the stator 556. In some embodiments, the superhard bearing surface of the rotor 554 may be formed of a single material and may be formed of a same or different material relative to materials used to form the tilting pad superhard bearing elements 504. In other embodiments, such as shown in **FIGS. 6A** and **6B**, the superhard bearing surface of the rotor 554 may be defined at least partially by a plurality of circumferentially-adjacent superhard bearing segments 562 (*e.g.*, a plurality of superhard compacts), each of which includes an outer superhard bearing surface 560 defining at least a portion of the substantially continuous superhard bearing surface of the rotor 554. The superhard bearing segments 562 may be mounted or otherwise attached to a support ring 558 by brazing, a press-fit, mechanical fasteners, or in another manner.

[0067] As shown in **FIG. 5A**, a shaft 564 may be coupled to the support ring 558 and operably coupled to an apparatus capable of rotating the shaft section 564 in a direction R (or in an opposite direction). An apparatus capable of providing such rotation may include a downhole motor. For example, the shaft 564 may extend through and may be secured to the support ring 558 of the rotor 554 by press-fitting or a threaded connection that couples the shaft 564 to the support ring 502, or by using another suitable technique. A housing 566 may be secured to the support ring 502 of the stator 556 by, for example, press-fitting or threadly coupling the housing 566 to the support ring 502, and may extend circumferentially about the shaft 564, the stator 556, and the rotor 554.

[0068] The operation of the hydrodynamic tilting pad bearing apparatus 500 is discussed in more detail with reference to **FIG. 5B**. **FIG. 5B** is an isometric partial cross-sectional view in which the shaft 510 and housing 511 are not shown for clarity. In operation, drilling fluid, mud, or some other fluid may be pumped between the shaft 510 and the housing 511, and between the tilting pads 504 of the stator 556 and the superhard

bearing segments 562 of the rotor 554. More particularly, rotation of the rotor 554 at a sufficient rotational speed may sweep the fluid onto superhard bearing surfaces 516 of the stator 556 and may allow a fluid film 568 to develop between the superhard bearing surfaces 560 of the rotor 554 and the superhard bearing surfaces 516 of the stator 556. The fluid film 568 may develop under certain operational conditions in which the rotational speed of the rotor 556 is sufficiently great and the thrust load is sufficiently low.

[0069] The stator 556 may include tilting pads 504 that are optionally made of multiple segments 526. Moreover, in at least some embodiments, the tilting pads 504 may be configured to tilt as described herein. In such an embodiment, the tilting pads 504 may be positioned at a fixed tilt angle or at a configurable or self-establishing tilt angle. The tilting pads 504 of the stator 556 may have a leading edge 570 at a different position than a trailing edge 572 relative to the rotor 554. For instance, in **FIG. 5B**, the tilting pads 504 may be tilted such that a greater separation exists between the tilting pads 504 and the superhard bearing segments 562 at the leading edge 570 than at the trailing edge 572. Under such circumstances, the lubricant film 568 may have a variable thickness across the tilting pad 504. In this particular embodiment, a higher lubricant film thickness may exist at the leading edge 570 than at the trailing edge 572.

[0070] Under certain operational conditions, the pressure of the fluid film 568 may be sufficient to substantially prevent contact between the superhard bearing surfaces 560 of the rotor 554 and the superhard bearing surfaces 516 of the stator 556 and may thus substantially reduce wear of the superhard bearing segments 562 and the tilting pads 504. When the thrust loads exceed a certain value and/or the rotational speed of the rotor 554 is reduced, the pressure of the fluid film 568 may not be sufficient to substantially prevent the superhard bearing surfaces 560 of the rotor 554 and the superhard bearing surfaces 516 of the stator 556 from contacting each other. Under such operational conditions, the hydrodynamic tilting pad bearing apparatus 500 is not operated as a hydrodynamic bearing. Thus, under certain operational conditions, the hydrodynamic tilting pad bearing apparatus 500 may be operated as a hydrodynamic bearing apparatus and under other conditions the hydrodynamic tilting pad bear apparatus 500 may be operated so that the superhard bearing surfaces 516, 560 contact each other during use or a partially developed fluid film is present between the superhard bearing surfaces 516, 560. However, the tilting pads 504 and superhard bearing segments 562 may comprise

superhard materials that are sufficiently wear-resistant to accommodate repetitive contact with each other, such as during start-up and shut-down of a subterranean drilling or other system employing the hydrodynamic tilting pad bearing apparatus 500 or other operational conditions not favorable for forming the fluid film 568. In still other embodiments, a backup roller or other bearing (not shown) may also be included for use during certain operational conditions, such as during start-up, or as the fluid film 558 develops.

[0071] **FIGS. 6A** and **6B** illustrate top isometric views and isometric partial cross-sectional views, respectively, of the rotor 554 and illustrate an embodiment of a configuration of multiple superhard bearing segments 562a, 562b in more detail. In particular, in the illustrated embodiment, the superhard bearing segments 562a, 562b may be a superhard compact (*e.g.*, a PDC) that includes a superhard table 574 bonded to a substrate 576. Each superhard table 574 may include a superhard bearing surface 560. The superhard bearing surfaces 560 of the superhard tables 574 may collectively form a substantially continuous superhard bearing surface of the stator 556.

[0072] An example manner in which the superhard bearing segments 562a, 562b may be assembled together is illustrated in **FIGS. 6A** and **6B**; however, in other embodiments, multiple segments may be assembled together in other manners, using differing geometries, or using a single material rather than a set of multiple segments. In the illustrated embodiment, the superhard bearing segments 562a, 562b may extend circumferentially in a generally circular manner, and may be secured to the support ring 558 using a brazing, press-fit, fastener, or other attachment mechanism. There may be a plurality of outer segments 562a and a plurality of inner segments 562b. The outer segments 562a may include, in some embodiments, an outer edge section 586 and at least one interior edge section 588. The outer edge sections 586 of the collective set of outer segments 562 may define all or a portion of the outermost edge of the superhard bearing surface 560. Similarly, the inner segments 562b may include, in some embodiments, an inner edge section 588 and at least one outer edge section 586. The outer edge sections 588 of the collective set of inner segments 562b may define all or a portion of the innermost edge of the superhard bearing surface 560. For instance, the innermost edge of the superhard bearing surface 560 may bear against a shaft (*see* **FIG. 5A**).

[0073] The interior edge sections 584 of the superhard bearing segments 562a, 562b may interconnect with, or otherwise correspond to, other of the multiple superhard

bearing segments 562a, 562b. For instance, in the illustrated embodiment, each outer superhard bearing segment 562a may connect at opposing ends to other outer superhard bearing segments 562a that extend circumferentially relative thereto. Each outer superhard bearing segment 562a may also interface or mesh with one or more inner superhard bearing segment 562b which extend radially inward relative to the outer superhard bearing segment 562a. Such an arrangement is, however, merely exemplary. In other embodiments, there may be more than two superhard bearing segments extending radially to form the substantially continuous superhard bearing surface, any number of different segments extending circumferentially to form the substantially continuous superhard bearing surface, or a superhard bearing segment may interface with a segment extending at least partially in both circumferential and radial directions with respect thereto. Accordingly, a substantially continuous superhard bearing surface may be formed by a collective set of superhard bearing segments 562a, 562b each having a respective superhard bearing surfaces 560, and such superhard bearing segments 562a, 562b may be arranged, connected, or shaped in any suitable manner.

[0074] In **FIGS. 6A** and **6B**, each of the interior edge sections 584 may have an alternating slot-and-ridge pattern, although such a configuration is merely illustrative. In other embodiments, the interior edge sections 584 may exhibit any of the previously described geometries, such as a serrated, straight, curved, or other geometry. Such geometries may enable mating adjacent superhard bearing segments together and/or limiting of fluid leakage through seams between adjacent superhard bearing segments.

[0075] Accordingly regardless of the particular arrangement, multiple segments form the substantially continuous superhard bearing surface of the stator 556, a set of seams 582 may form between adjoining segments 562a, 562b. The seams 582 may provide a tortuous or winding path that limits fluid leakage radially through the seams 582. The seams 582 may correspond to a relatively small gap 580 existing between the segments 562a, 562b. Although not necessary, the size of the gaps 580 may be the same or similar to those described previously with respect to exemplary tilting pad superhard bearing elements. For instance, the gaps 580 may have a width of about 0.001 mm to about 3.5 mm, more particularly a width of about 0.0025 mm to about 2.5 mm, and more particularly a width of about 0.125 mm to about 1.25 mm. More particularly still, the gaps 580 may have a width from about 0.005 mm up to about 1.0 mm. The gaps 580 are optionally filled with a sealant material as described herein.

[0076] The concepts used in the hydrodynamic tilting pad bearing assemblies and apparatuses described herein may also be employed in tilting pad radial bearing assemblies and apparatuses. **FIGS. 7A** to **7C** are isometric, exploded, and isometric partial cross-sectional views, respectively, of a hydrodynamic tilting pad radial bearing apparatus 600 according to yet another embodiment. The hydrodynamic tilting pad radial bearing apparatus 600 may include an inner race 654 (*e.g.*, a runner or rotor) that may have an interior surface 667 defining an opening 655 for receiving a shaft or other component. The inner race 654 may also include a plurality of circumferentially and/or longitudinally adjacent superhard bearing segments 662 (*e.g.*, a plurality of superhard compacts) at or near an exterior surface 669 of the inner race 654, each of which may include a convexly-curved superhard bearing surface 660.

[0077] The hydrodynamic tilting pad radial bearing apparatus 600 may further include an outer race 656 (*e.g.*, a stator) configured to extend about and/or receive the inner race 654. The outer race 656 may include a plurality of circumferentially-spaced tilting pads 604, each of which may include a superhard bearing surface 616. The superhard bearing surface 616 may be substantially planar, although in other embodiments the superhard bearing surface 616 may be a concavely-curved superhard bearing surface to generally correspond to shapes of convexly-curved superhard bearing surfaces of the inner race 654. The terms "rotor" and "stator" refer to rotating and stationary components of the radial bearing system 600, respectively. Thus, if the inner race 654 is configured to remain stationary, the inner race 654 may be referred to as the stator and the outer race 656 may be referred to as the rotor.

[0078] The hydrodynamic tilting pad radial bearing apparatus 600 may be employed in a variety of mechanical applications. For example, rotary drill bits may benefit from a radial bearing apparatus disclosed herein. More specifically, the inner race 654 may be mounted or affixed to a spindle of a rotary drill bit and the outer race 656 may be affixed to an inner bore such that an outer race 656 and inner race 654 may be assembled to form the radial bearing system 600.

[0079] With continued reference to **FIG. 7A**, rotation of a shaft (not shown) secured to the inner race 654 may effect rotation of the inner race 654 relative to the outer race 656. Drilling fluid or other fluid or lubricant may be pumped between the superhard bearing surfaces 616 of the inner race 654 and the superhard bearing surfaces 660 of the outer race 656. When the inner race 654 rotates, the leading edge sections 670 of the

tilting pads 604 may sweep lubricant (*e.g.*, drilling fluid or other lubricant) onto the superhard bearing surfaces 660 of the outer race 656. As previously described with respect to the hydrodynamic tilting pad bearing apparatus 500, at sufficient rotational speeds for the inner race 654, a fluid film may develop between the superhard bearing surfaces 616, 660 of the tilting pads 604 and the superhard bearing segments 662, and may develop sufficient pressure to maintain the superhard bearing surfaces 616 and the superhard bearing surfaces 660 apart from each other. Accordingly, wear on the tilting pads 604 and superhard bearing segments 662 may be reduced compared to when direct contact between the tilting pads 604 and superhard bearing segments 662 occurs.

[0080] As further illustrated in **FIGS. 7A** and **7B**, the outer race 656 includes a support ring 602 extending about an axis 606. The support ring 602 may include an interior channel 603 configured to receive a set of tilting pad superhard bearing elements 604 distributed circumferentially about the axis 606. Each tilting pad 604 may comprise a superhard table 618 including a superhard bearing surface 616. The superhard bearing surface 616 may be curved (*e.g.*, concavely-curved) or substantially planar and, in some embodiments, may include a peripheral chamfer. In other embodiments, the superhard bearing surface 616 may be otherwise curved, lack a chamfered edge, may have another contour or configuration, or any combination of the foregoing. Each superhard table 618 may be bonded to a corresponding substrate 620. Further, each superhard bearing surface 616 may be tilted circumferentially relative to an imaginary cylindrical surface. The superhard tables 618 and substrates 620 may be fabricated from the same materials described above for the tilting pads 104 shown in **FIGS. 1A** and **1B**.

[0081] Each superhard bearing surface 616 of a corresponding tilting pad 604 may be tilted in a manner that facilities sweeping in of a lubricant or other fluid to form a fluid film between the inner race 654 and the outer race 656. Each tilting pad 604 may be tilted and/or tilt about an axis that is generally parallel to the central axis 606. As a result, each tilting pad 604 may be tilted at an angle relative to the inner and outer surfaces of the ring 602 and in a circumferential fashion such that the leading edges 670 of the tilting pads 604 are about parallel to the central axis 606. The leading edge 670 may help to sweep lubricant or another fluid onto the superhard bearing surfaces 616 of the stator 656 to form a fluid film in a manner similar to the tilting pads 504 shown in **FIGS. 5A** and **5B**. More particularly, when the inner race 654 is concentrically positioned relative to the outer race 656, the leading edges 670 may be offset relative to the outer edge 669 of the

outer race 656, and by a distance that is larger than a distance between the outer race 656 and a trailing edge of the superhard bearing elements 604. It should be noted that in other embodiments, the radial bearing apparatus 600 may be configured as a journal bearing. In such an embodiment, the inner race 654 may be positioned eccentrically relative to the outer race 656.

[0082] In some embodiments, the tilting pad 604 may be formed from a plurality of superhard bearing segments 626 that collectively define a respective tilting pad 604 and/or superhard bearing surface 616. Each superhard bearing segment 626 may be substantially identical, or the superhard bearing segments 626 may be different relative to other of the superhard bearing segments 626. In some embodiments, the superhard bearing segments 626 each include a superhard table 618 bonded to a substrate 620 as described herein. Optionally, the substrate 620 may be connected or supported relative to a support plate 622, the support ring 602, or other material or component. The support plate 622 may be a single component or segment and used to facilitate assembly of the multiple segments 626 into the superhard bearing element 604, although in other embodiments the support plate 622 may also include multiple assembled segments.

[0083] With continued reference to **FIGS. 7A** and **7B**, the seams 636 may be formed between circumferentially and/or longitudinally adjacent to the superhard bearing elements 604. As with the hydrodynamic tilting pad bearing assembly 100 described above, the edges of the superhard bearing segments 626 may have any number of configurations or shapes, and may correspond to or interlock with adjoining edges in any number of different manners. Further, sealant materials may be disposed within a gap (not shown) that may be formed between adjacent superhard bearing segments 662 to help further prevent fluid leakage through the seams 636.

[0084] As further illustrated in **FIGS. 7A** and 7**C**, the inner race 654 of the radial bearing apparatus 600 is shown with a support ring 658 connected to a plurality of circumferentially and longitudinally-adjacent superhard bearing segments 662 assembled together to form a substantially continuous superhard bearing element 626 and substantially continuous superhard bearing surface. In other embodiments, an outer race of a radial bearing system may include a plurality superhard bearing segments that are only circumferentially spaced around the inner race 654, or a plurality of superhard bearing segments that are only longitudinally spaced with respect to the inner race 654. In still other embodiments, the inner race 654 may define a superhard bearing surface that

is formed from only a single segment, such that there are not multiple segments assembled together. For instance, a single segment may be used where the size of the inner race 654 is sufficiently small that the material forming the superhard bearing surface 660 may be formed as a single material. Under some conditions, such as where a material forming the superhard bearing surface has limited production constraints, the superhard bearing surface 660 may be formed from multiple segments.

[0085] As noted previously, the plurality of superhard bearing segments 662 may be distributed circumferentially and/or longitudinally relative to the axis 606. Where the superhard bearing segments 662 include a superhard table 674 and/or a substrate 676, the superhard tables 674 and substrates 676 may be fabricated from the same materials described above for the superhard bearing segments 104 shown in **FIGS. 1A** to **1D**. One or more seams 682 may be formed between adjacent superhard bearing segments 662. As with the tilting pad bearing assembly 100 described above, the seams may follow slot-and-ridge, serrated, straight, curved or other edge geometries. Further, if desired, any of the previously described sealant materials may be disposed within a gap (not shown) that may be formed between adjacent superhard bearing segments 662 to help further prevent fluid leakage through the seams 682.

[0086] The support ring 658 of the inner race 654 may include a circumferentially extending recess configured to receive the plurality of superhard bearing segments 662. The superhard bearing segments 662 may be secured within the recess or otherwise secured to the support ring 658 by brazing, press-fitting, using fasteners, or another suitable technique. The support ring 658 may also define an interior surface 667 defining an opening 655 that is capable of receiving, for example, a shaft of a motor from a downhole motor assembly or other apparatus.

[0087] Any of the embodiments for bearing apparatuses discussed above may be used in a subterranean drilling system. **FIG. 8** is a schematic isometric cutaway view of a subterranean drilling system 700 according to an embodiment, which uses a hydrodynamic tilting pad bearing apparatus 701. The subterranean drilling system 700 may include a housing 702 enclosing a downhole drilling motor 724 (*e.g.*, a motor, turbine, or any other device capable of rotating an output shaft) that is operably connected to an output shaft 706. A hydrodynamic tilting pad bearing apparatus 701 may be operably coupled to the downhole drilling motor 724. The hydrodynamic tilting pad bearing apparatus 701 may be configured as any of the previously described

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hydrodynamic tilting pad bearing apparatus or radial bearing apparatus embodiments. A rotary drill bit 712 may be configured to engage a subterranean formation and drill a borehole and may be connected to the output shaft 706. The rotary drill bit 712 is depicted as a roller cone bit including a plurality of roller cones 714. However, other embodiments may utilize different types of rotary drill bits, such as fixed cutter bits, core bits, eccentric bits, bi-center bits, reamers, reamer wings, or any other downhole tool. As the borehole is drilled, pipe sections may be connected to the subterranean drilling system 700 to form a drill string capable of progressively drilling the borehole to a greater depth within an earthen formation.

[0088] The tilting pad bearing apparatus 701 may include a stator 756 that does not rotate and a rotor 754 that may be attached to the output shaft 706 and may rotate with the output shaft 706. The rotor 754 optionally includes a plurality of adjacent superhard bearing segments (not shown) assembled together to form a substantially continuous superhard bearing element, as previously described such as in the stator 654 shown in **FIGS. 7A** and **7C**. The stator 756 may include a plurality of superhard bearing elements 704 circumferentially spaced around the stator 756. The superhard bearing elements 704 may in some embodiments include tilting pads or other superhard bearing elements, such as tilting pads 104, 204, 304, 404, 504, or 604 as described previously herein.

[0089] In operation, drilling or other fluid may be circulated through the downhole drilling motor 724 to generate torque and effect rotation of the output shaft 706 and the rotary drill bit 712 attached thereto so that a borehole may be drilled. A portion of the fluid may also be used to lubricate opposing superhard bearing surfaces of the stator 756 and rotor 754. When the rotor 754 is rotated at a sufficient rotational speed, the fluid may be swept onto the superhard bearing surfaces of the stator 756 and a fluid film having sufficient pressure may develop that maintains the superhard bearing surfaces of the stator 756 and the superhard bearing surfaces of the rotor 754 apart, as previously discussed. In embodiments in which the superhard bearing surfaces of the stator 756 are tilted such as in the case of example tilting pad bearing assemblies, the tilted superhard bearing surfaces may facilitate formation of a film thickness having different thicknesses at leading and trailing edges of the superhard bearing elements 704.

[0090] Although the bearing assemblies and apparatuses described above have been discussed in the context of subterranean drilling systems and applications, in other embodiments, the bearing assemblies and apparatuses disclosed herein are not limited to

such use and may be used for many different applications, if desired, without limitation. Thus, such bearing assemblies and apparatuses are not limited for use with subterranean drilling systems and may be used with various other mechanical systems, without limitation.

[0091] While various aspects and embodiments have been disclosed herein, other aspects and embodiments are contemplated. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting. Additionally, the words "including," "having," and variants thereof (*e.g.*, "includes" and "has") as used herein, including the claims, shall be open ended and have the same meaning as the word "comprising" and variants thereof (*e.g.*, "comprise" and "comprises").

CLAIMS

1. A bearing assembly, comprising:

a support ring; and

a plurality of tilting pads each of which is tilted and/or tiltably secured relative to the support ring, each of the plurality of tilting pads including:

a plurality of superhard bearing segments assembled to form a superhard bearing surface, one or more seams positioned between adjacent superhard bearing segments of the plurality of superhard bearing segments.

2. The bearing assembly of claim 1 wherein the plurality of superhard bearing segments of one of the tilting pads are at least partially interlocked with each other.

3. The bearing assembly of claim 1 wherein the superhard bearing surface of one of the tilting pads comprises a substantially planar geometry or a substantially non-planar geometry.

4. The bearing assembly of claim 1 wherein at least some of the plurality of superhard bearing segments are arranged radially adjacent to each other.

5. The bearing assembly of claim 1 wherein at least some of the plurality of superhard bearing segments are arranged circumferentially adjacent to each other.

6. The bearing assembly of claim 1 wherein each of the plurality of superhard bearing segments comprises:

a substrate; and

a superhard table.

7. The bearing assembly of claim 1 wherein at least one of the plurality of seams comprises a gap of about 0.005 mm to about 1.0 mm.

8. The bearing assembly of claim 1 wherein each of the plurality of tilting pads comprises a support plate on which the plurality of superhard bearing segments thereof are mounted.

9. The bearing assembly of claim 8 wherein each of the plurality of tilting pads is tiltable about a respective tilt axis of the support plate.

10. The bearing assembly of claim 1 wherein each of the tilting pads comprises a fixed tilting pad, an adjustable tilting pad, or a self-establishing tilting pad.

11. The bearing assembly of claim 1 wherein the plurality of tilting pads are distributed around a rotation axis.

12. The bearing assembly of claim 1 wherein the bearing assembly is configured as a thrust-bearing assembly or a radial bearing assembly.

13. A bearing apparatus, comprising:

a rotor;

a stator;

wherein at least one of the stator or the rotor is configured as any one of the bearing assemblies of claims 1-12.

14. A motor assembly, comprising:

a motor operable to apply torque to a rotary drill bit, the motor operably coupled to a bearing apparatus, the bearing apparatus including a rotor and a stator; and

wherein at least one of the stator or the rotor is configured as any one of the bearing assemblies of claims 1-12.

15. A method of operating a bearing apparatus, comprising:

rotating a first bearing assembly relative to a second bearing assembly, wherein at least one of the first or second bearing assembly includes:

a support ring; and

a plurality of tilting pads tilted and/or tiltably secured relative to the support ring, each of the plurality of tilting pads including a plurality of superhard bearing segments assembled to form a superhard bearing surface, one or more seams positioned between adjacent superhard bearing segments of the plurality of superhard bearing segments.

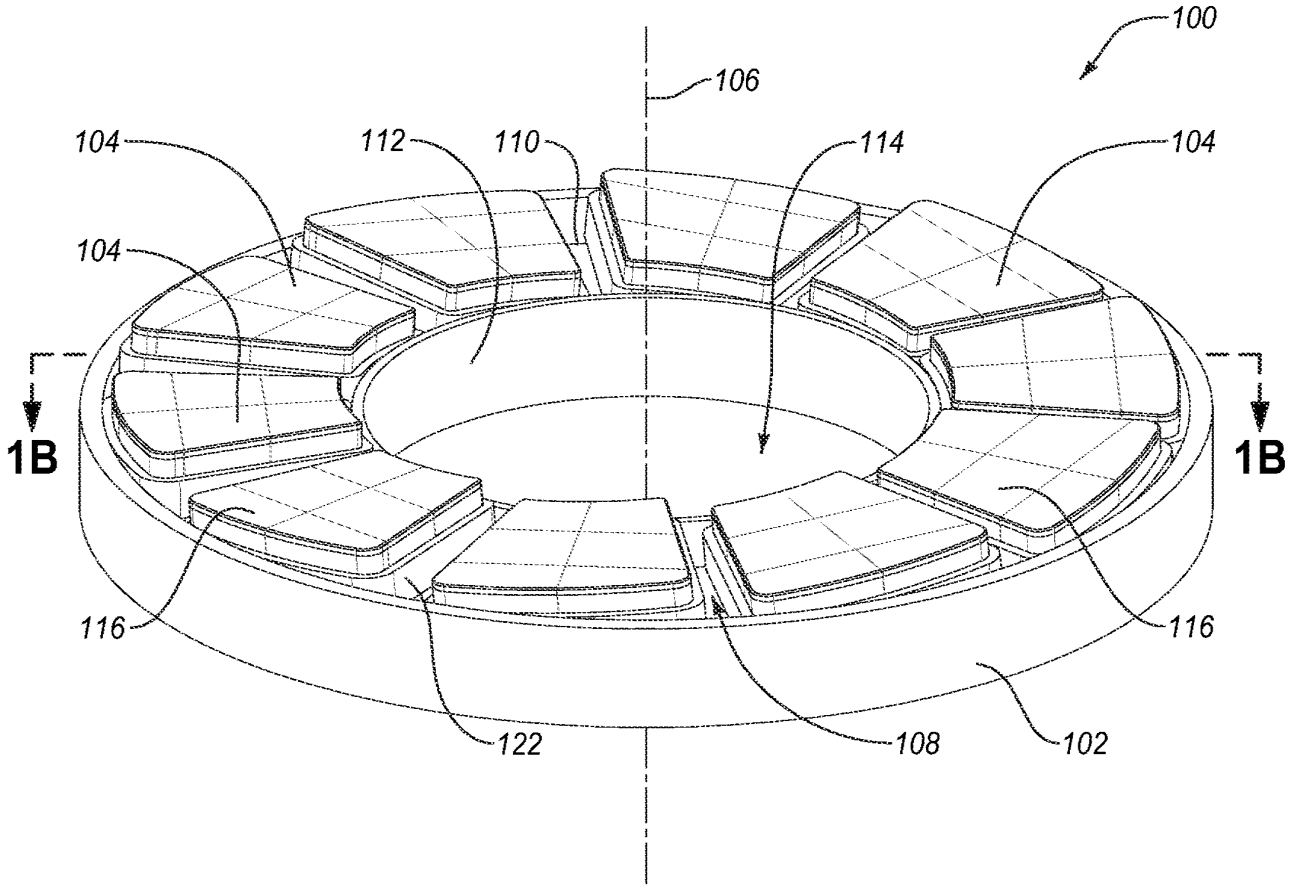

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Fig. 1A

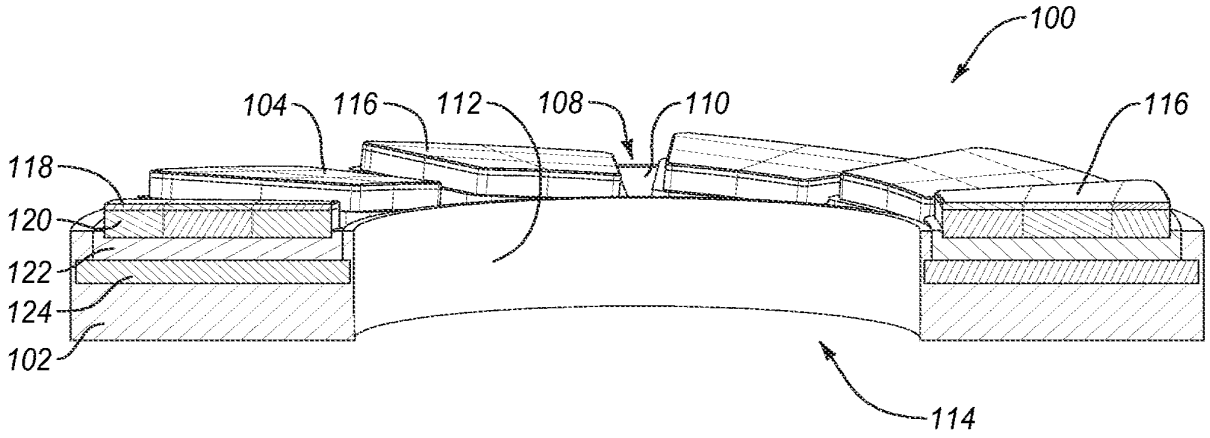

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Fig. 1B

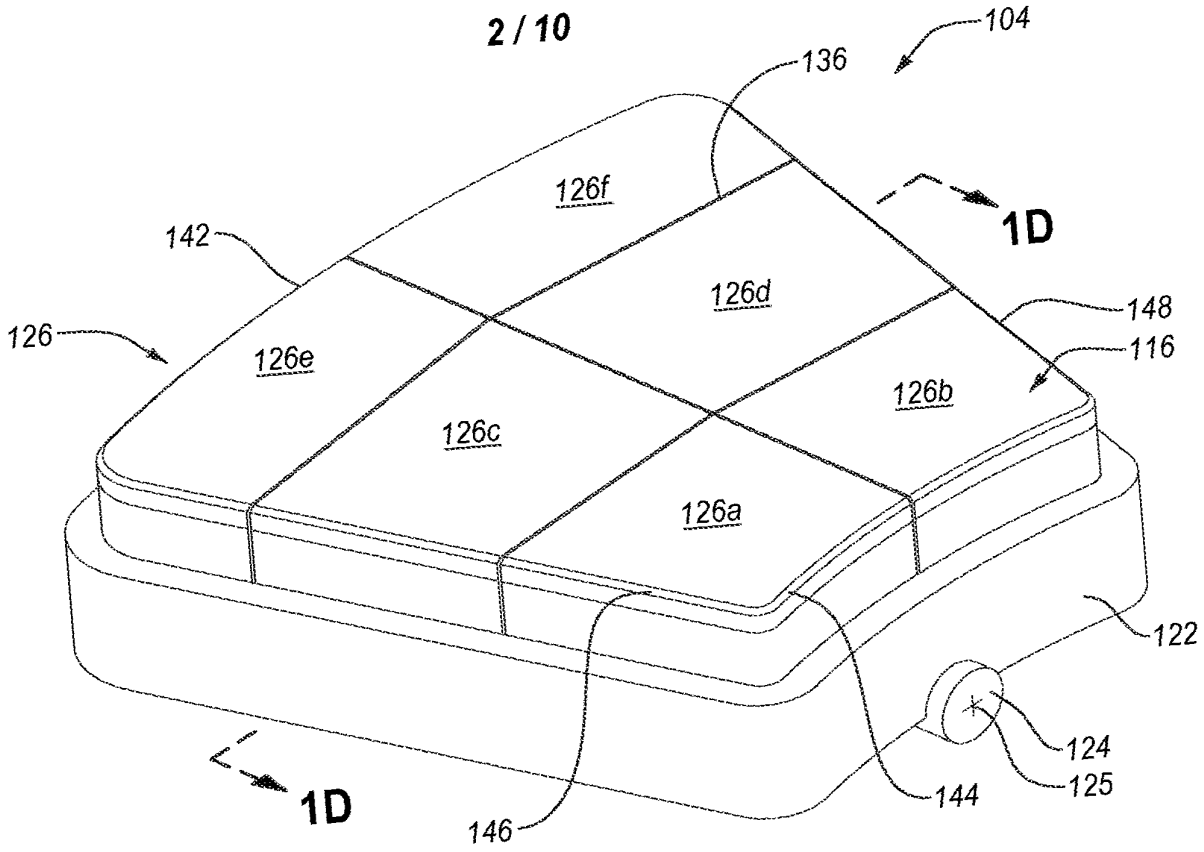

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126f
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Fig. 1C

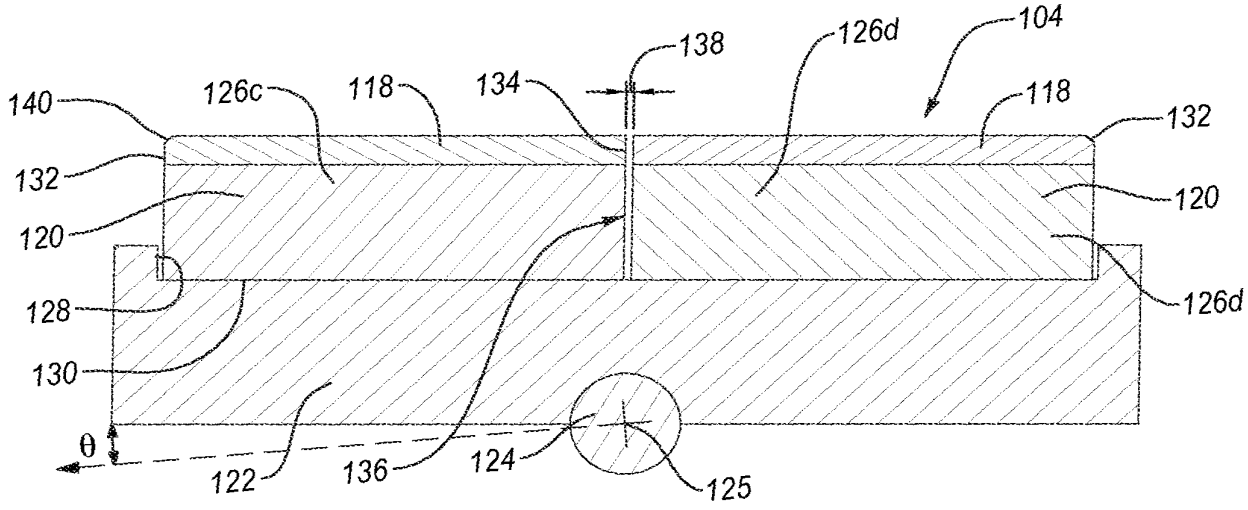

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Fig. 1D

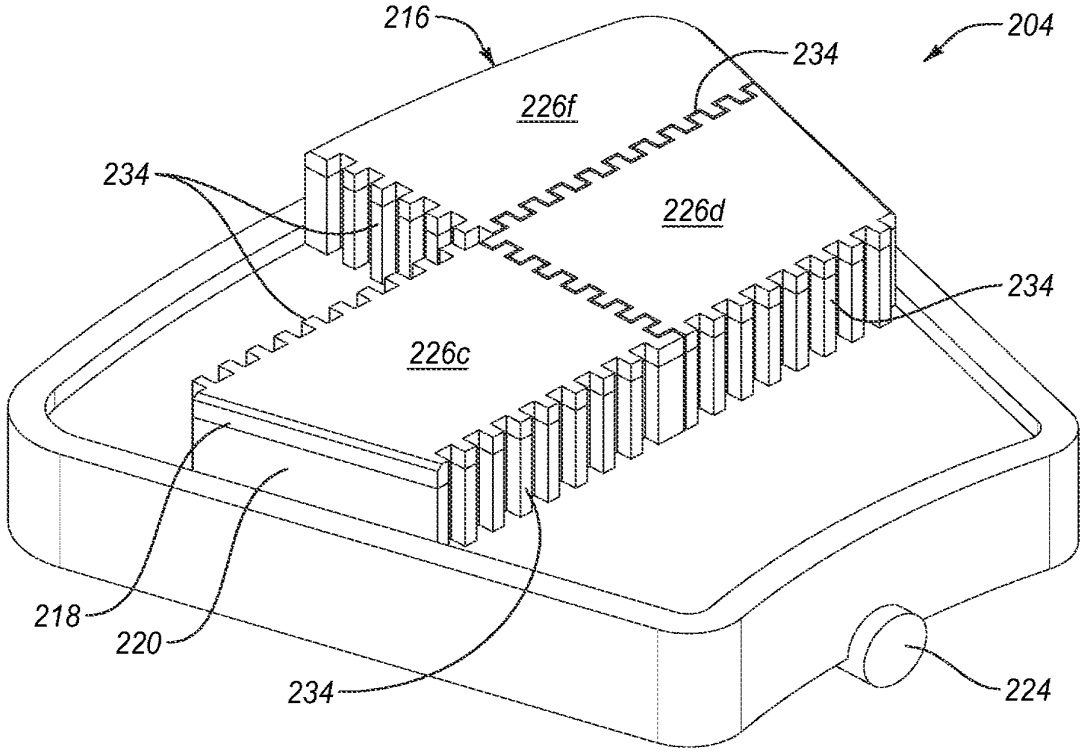

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Fig. 2A

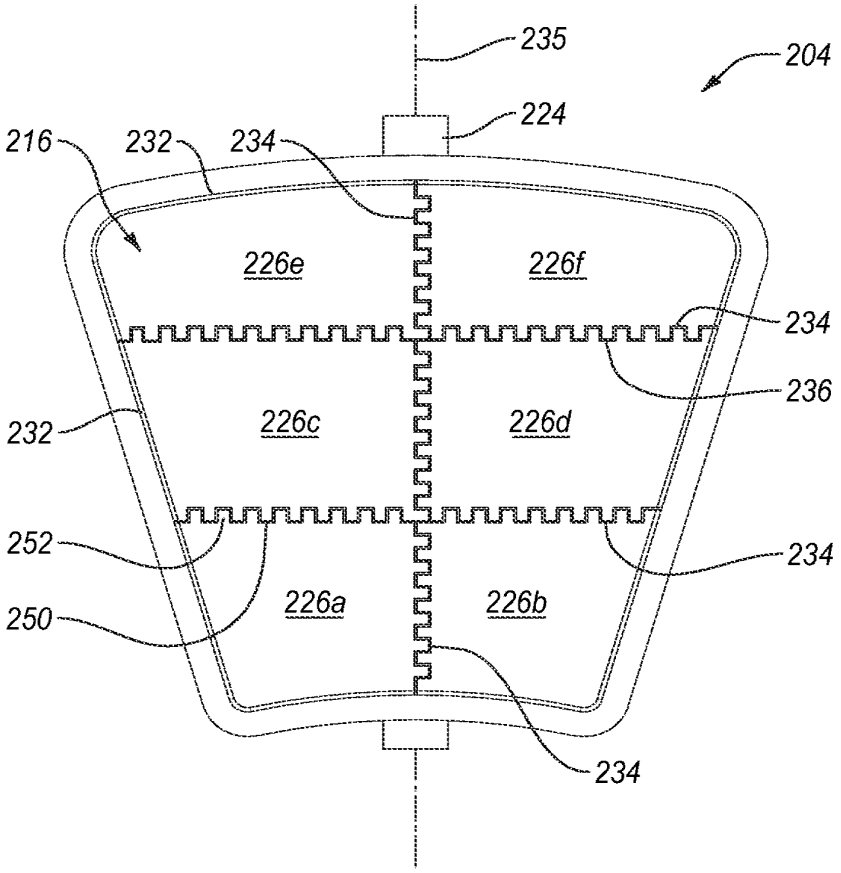

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Fig. 2B

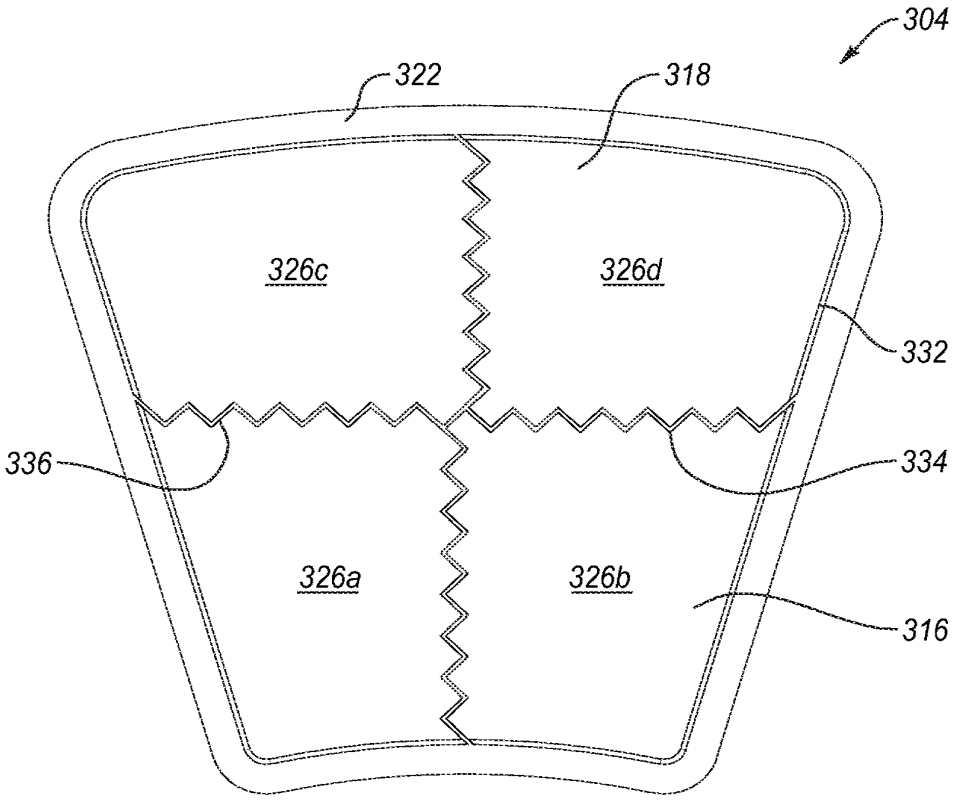

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Fig. 3

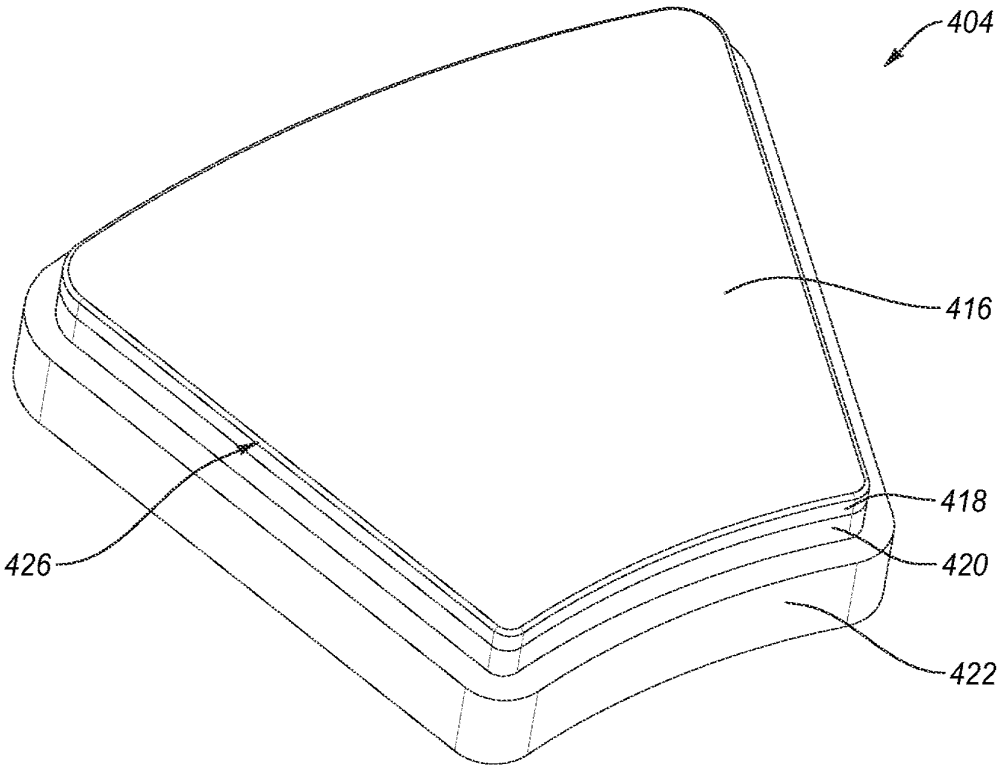

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Fig. 4

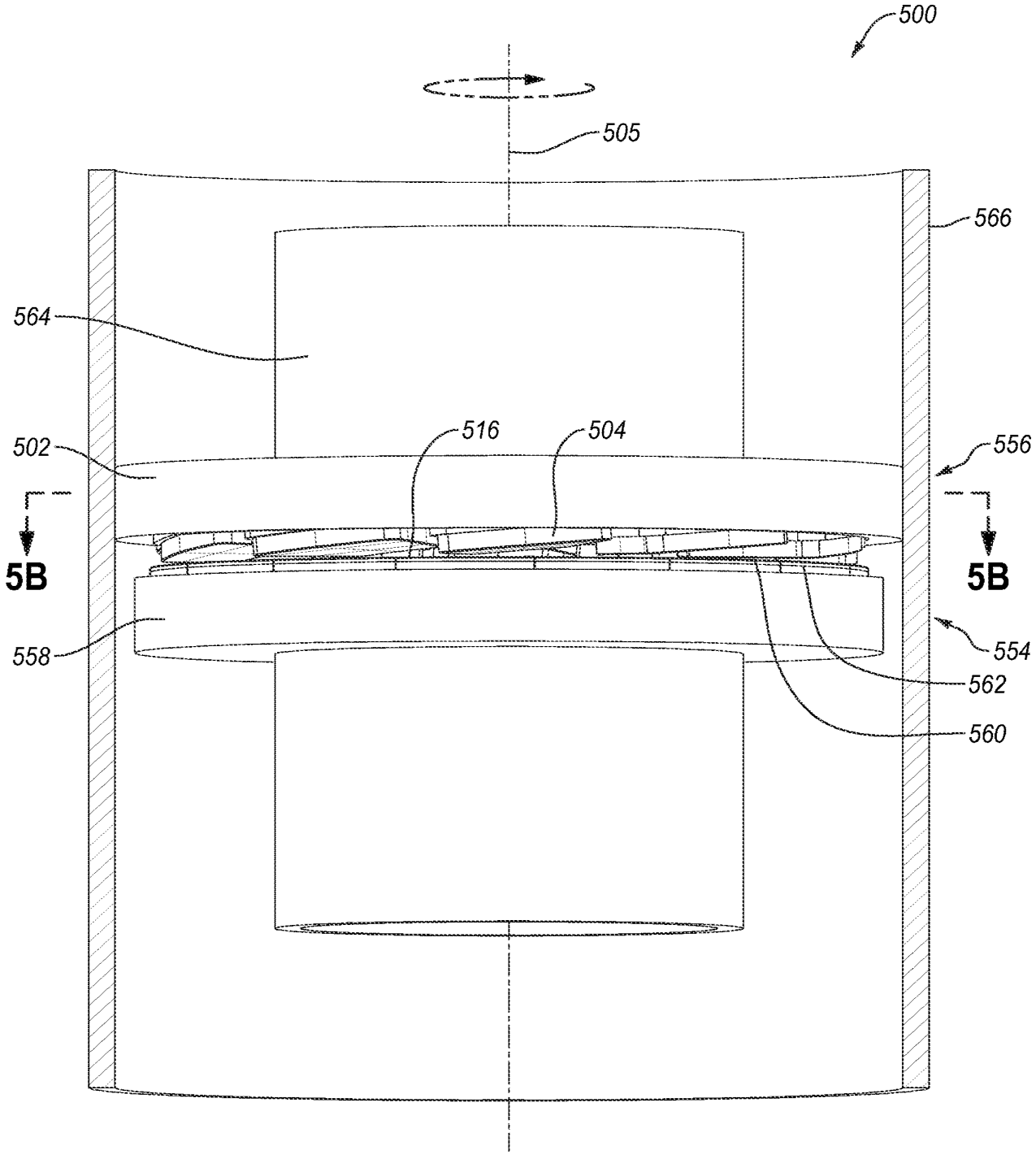


Fig. 5A

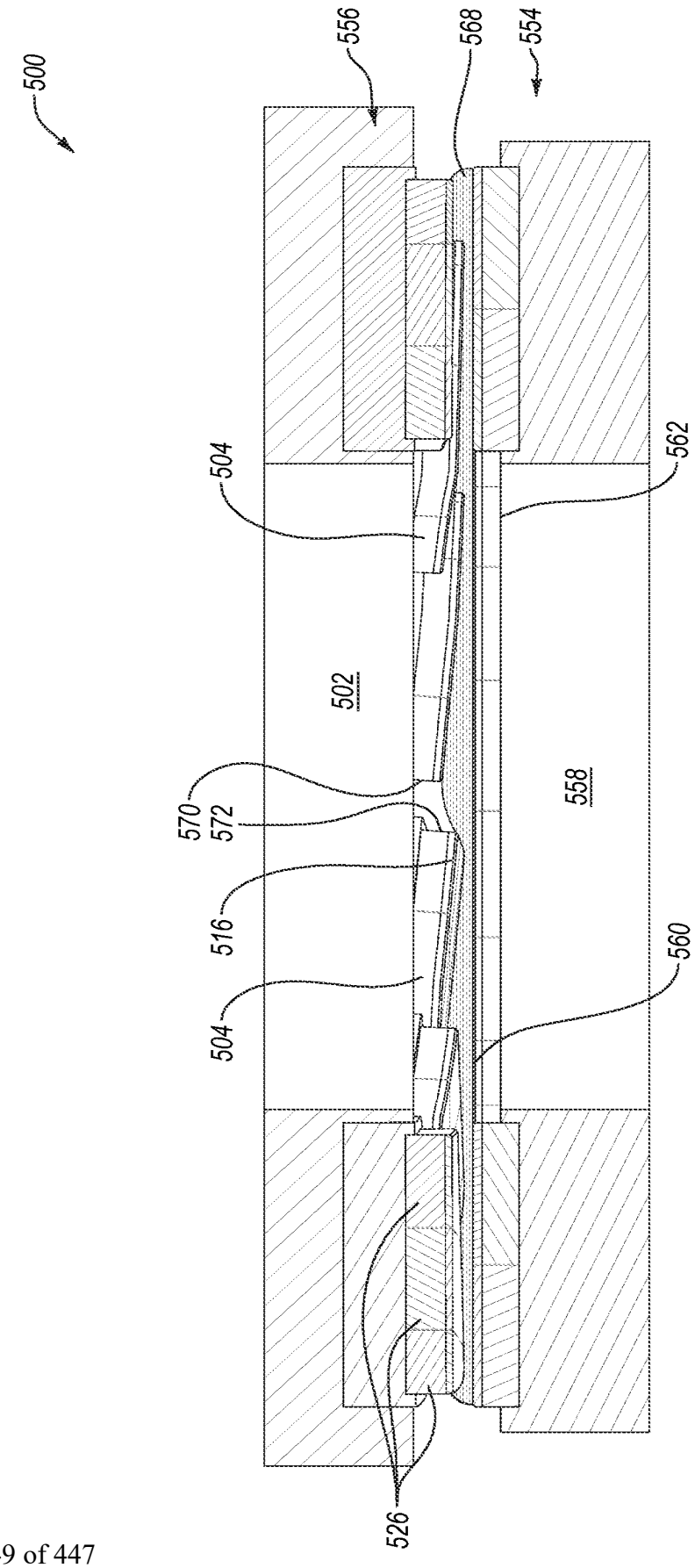


Fig. 5B

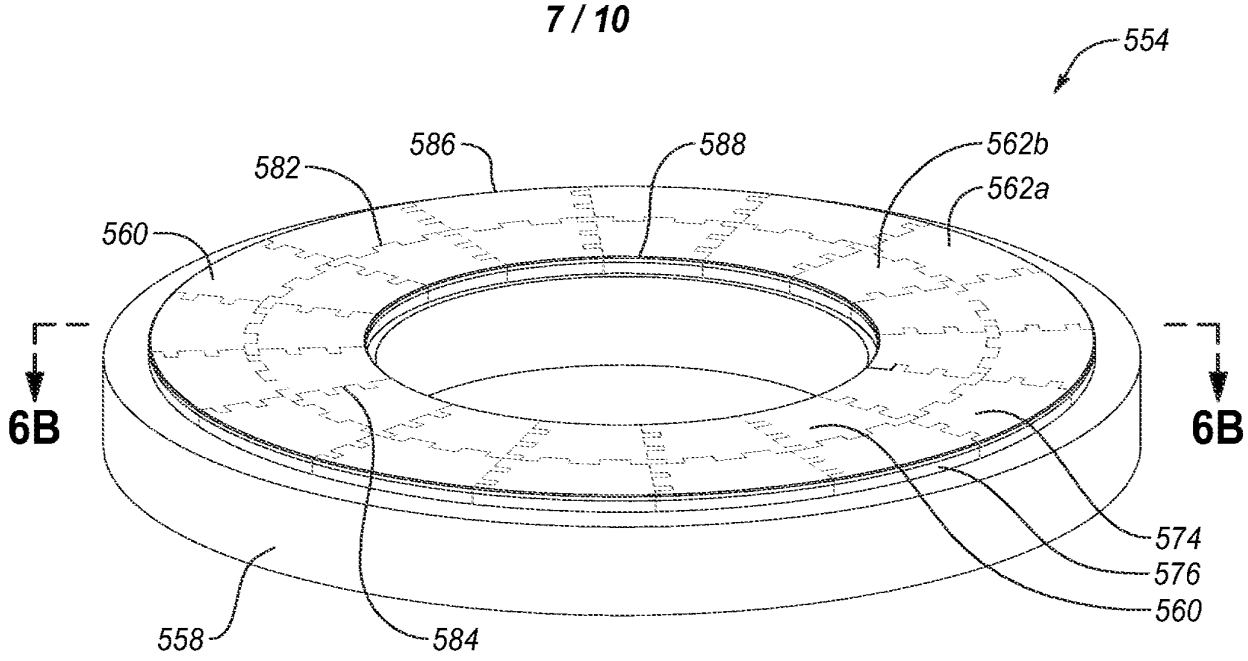

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Fig. 6A

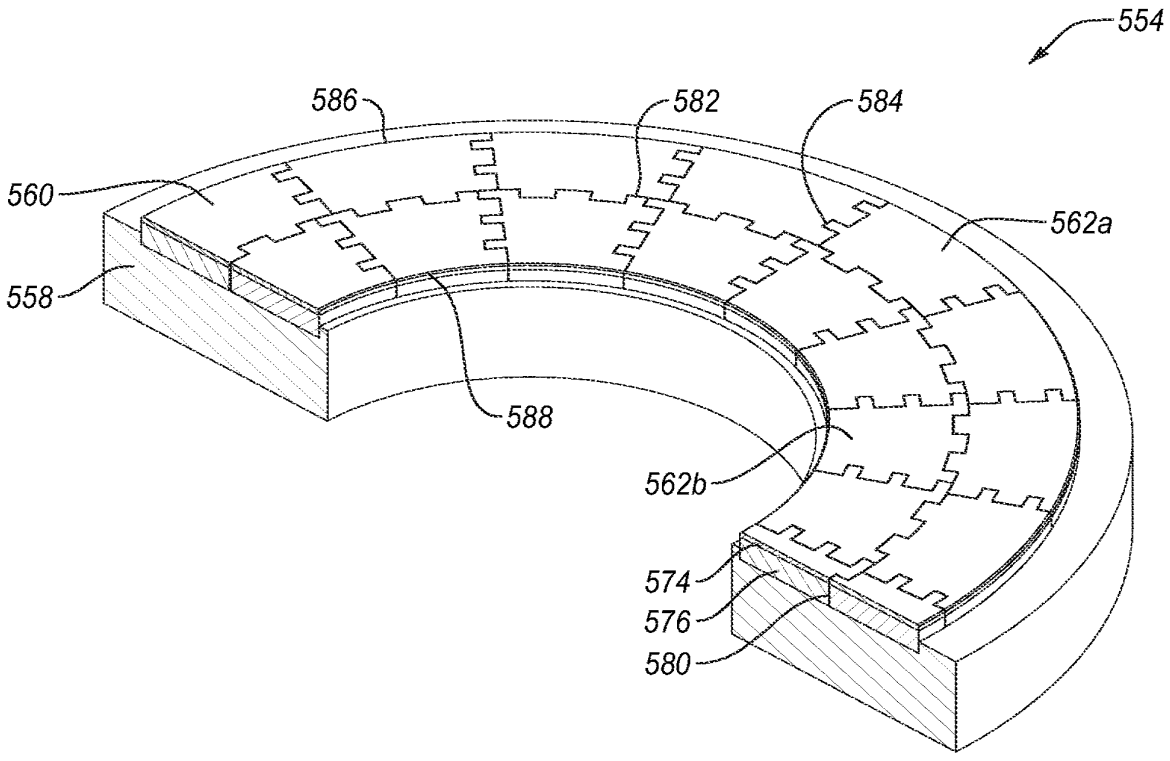

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Fig. 6B

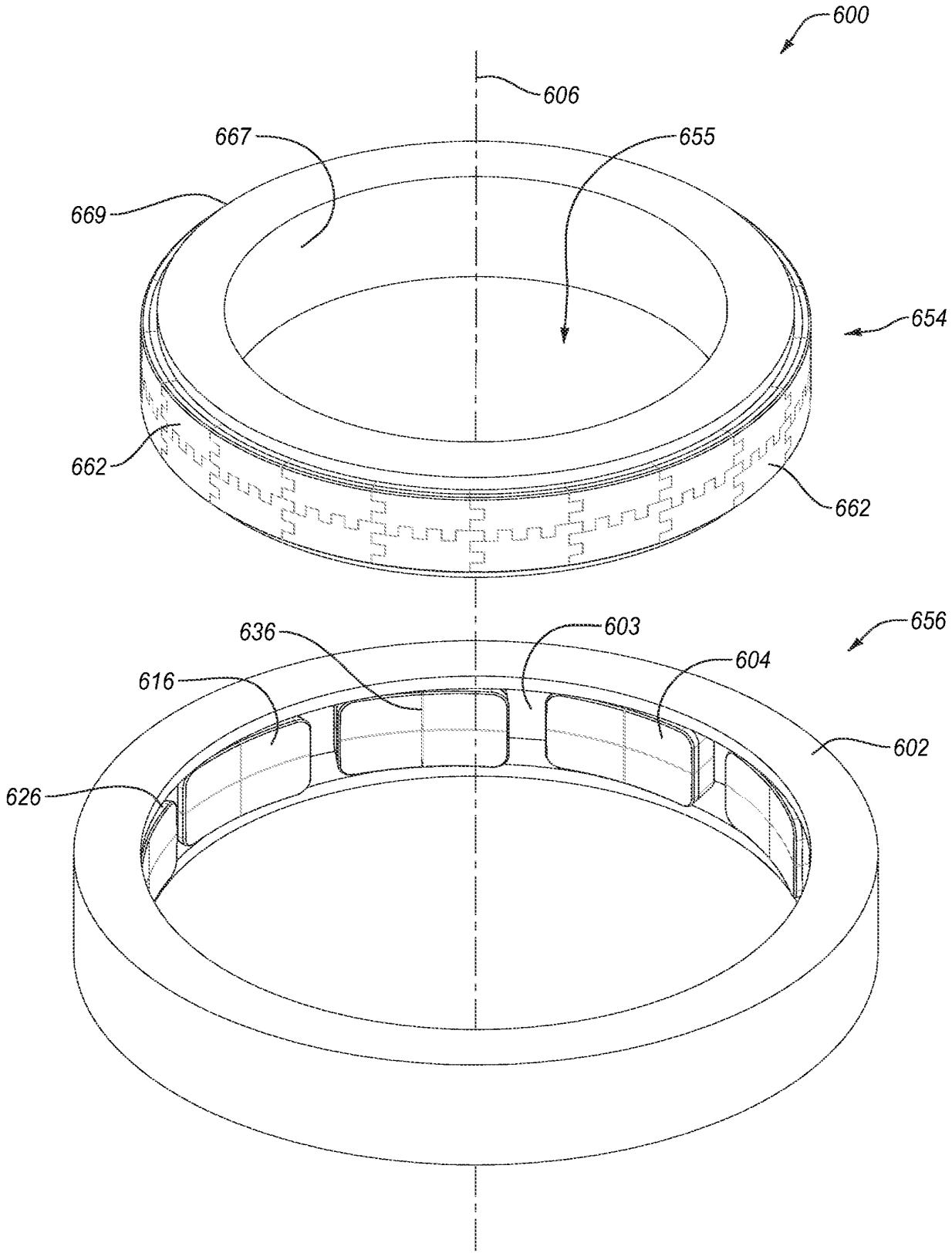


Fig. 7A

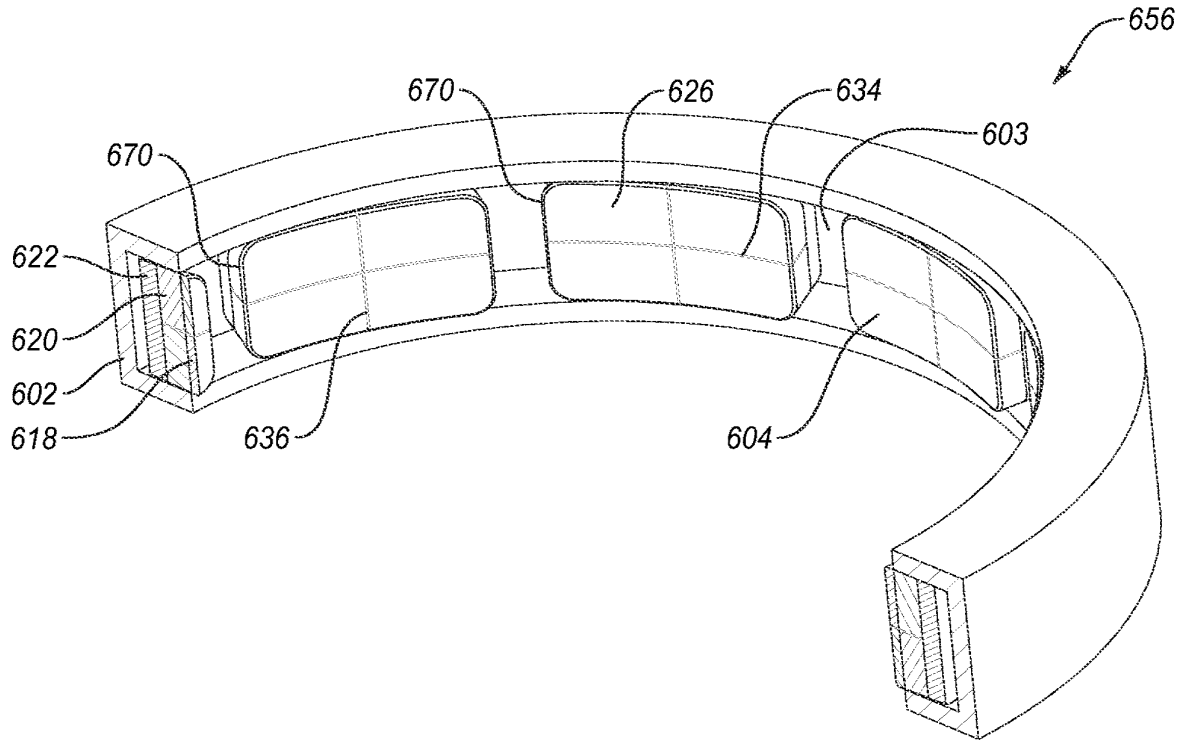

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Fig. 7B

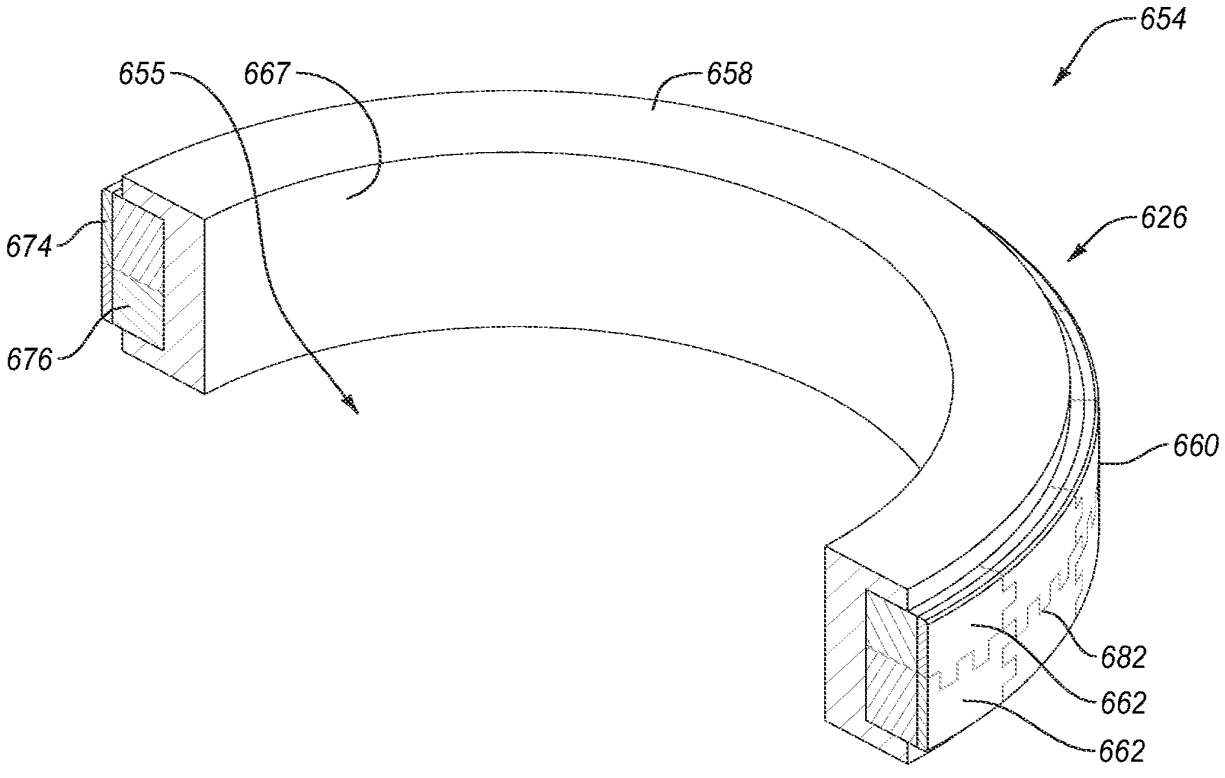

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Fig. 7C

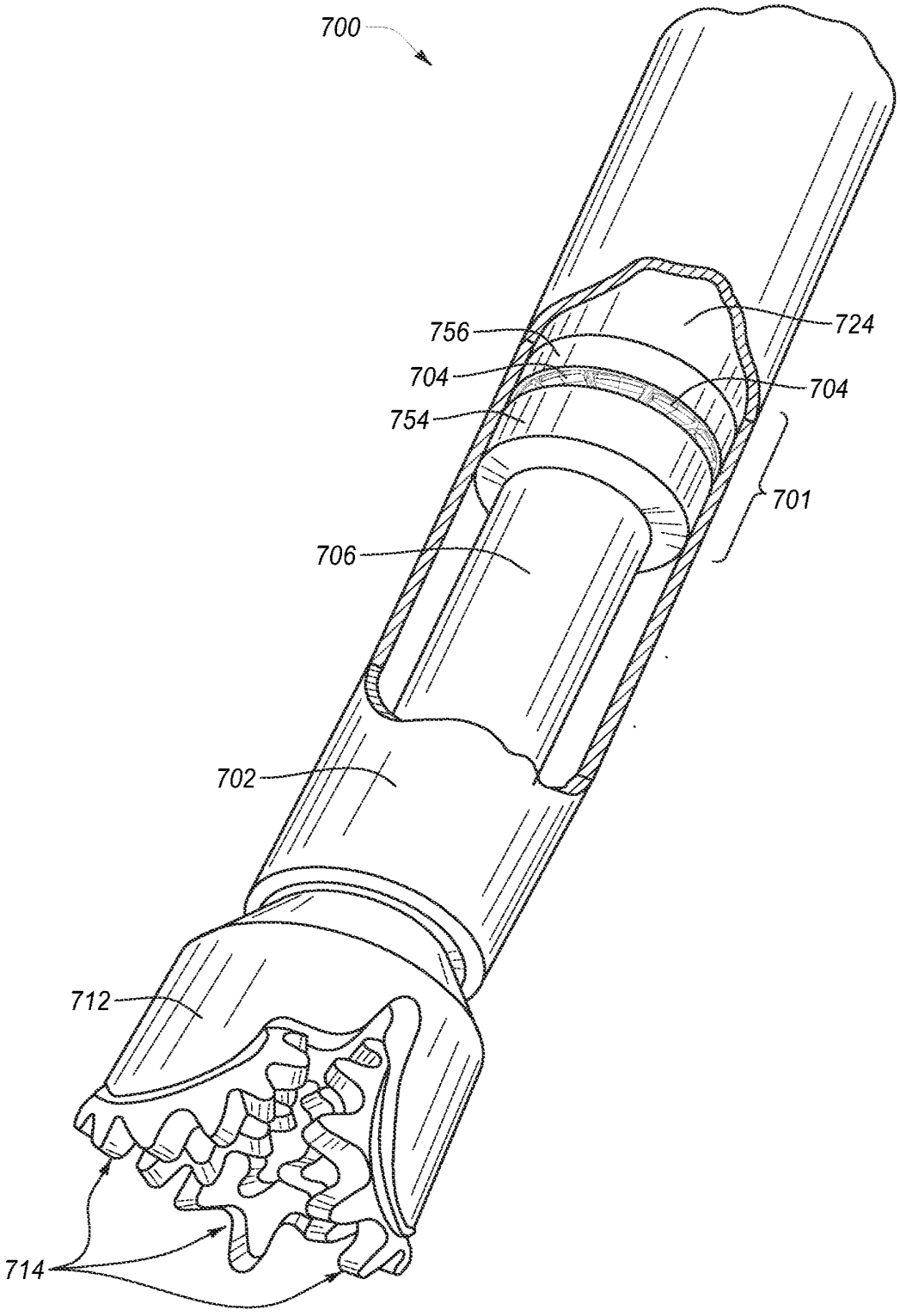


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/033206

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16C17/03 F16C17/06 F16C33/04 F16C33/26
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)
F16C

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 4 927 275 A (LAWSON JAMES L [US]) 22 May 1990 (1990-05-22) column 4, line 17 - column 5, line 20; figures 1,3	1-3,5,6, 8-13,15 14
Y	US 2004/190804 A1 (JOHN HENDRIK [DE] ET AL) 30 September 2004 (2004-09-30) paragraphs [0027] - [0029], [0038], [0040]; figures 2A,2B,1,13	1-15
Y	US 5 393 145 A (IDE RUSSELL D [US]) 28 February 1995 (1995-02-28) column 36, line 29 - line 43; figures 16A,16B column 9, line 39 - line 53 column 6, line 10 - line 26	1-15

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 July 2012	19/07/2012

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	Schlossarek, M

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010/288558 A1 (SEXTON TIMOTHY N [US]) 18 November 2010 (2010-11-18) abstract; figure 1 -----	14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/033206

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4927275 A	22-05-1990	NONE	
US 2004190804 A1	30-09-2004	US 2004190804 A1	30-09-2004
		US 2006140524 A1	29-06-2006
US 5393145 A	28-02-1995	NONE	
US 2010288558 A1	18-11-2010	CA 2758730 A1	18-11-2010
		EP 2430324 A1	21-03-2012
		US 2010288558 A1	18-11-2010
		WO 2010132182 A1	18-11-2010

Form PCT/ISA/210 (patent family annex) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/055305

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16C32/06
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)
F16C

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, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2007 039364 A1 (METSO PAPER INC [FI]) 6 March 2008 (2008-03-06)	1-4,6-9, 12-16, 18, 25-32, 36,38
Y	page 4, right-hand column, line 27 - line 30 paragraph [0025]; figures 3A-4C	5,10,11, 17, 19-24, 33-35, 39-52

Y	WO 90/12216 A1 (VICKERS PLC [GB]) 18 October 1990 (1990-10-18)	10,20, 22-24, 39-42, 44,46, 48-52
	page 9, line 20 - line 36; claims 1-3,9-14; figures	

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 October 2013	30/10/2013

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	Martin, Christophe

Form PCT/ISA/210 (second sheet) (April 2005)

Exhibit 1002
FLS v. Metso

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2006 009968 A (OILES INDUSTRY CO LTD) 12 January 2006 (2006-01-12) paragraph [0027] - paragraph [0028]; figures 1-3	5,17,19, 43,45
Y,P	WO 2012/145217 A1 (US SYNTHETIC CORP [US]; COOLEY CRAIG H [US]; SEXTON TIMOTHY N [US]) 26 October 2012 (2012-10-26) page 2, line 19 - page 3, line 3; figures 1c-3	11,21, 33-35,47

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2013/055305

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6, 9, 10, 12-20, 24-28, 30-33, 40, 43-46, 49, 50, 52

   Bearing pad, bearing and method characterized by mounting means.

   ---

2. claims: 7-10, 20, 24, 25, 29, 30, 33, 35-38, 40-42, 46, 52

   Bearing pad, bearing and method characterized by a chamfer.

   ---

3. claims: 9-11, 20, 21, 24, 25, 30, 33, 34, 40, 46, 47, 52

   Bearing pad, bearing and method characterized by lateral connecting portions.

   ---

4. claims: 9, 10, 20, 22-25, 30, 33, 39, 40, 46, 48, 51, 52

   Bearing pad, bearing and method characterized by first and second surfaces of the bearing base.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2013/055305

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102007039364 A1	06-03-2008	AT 504091 A2	15-03-2008
		DE 102007039364 A1	06-03-2008
		FI 20065532 A	29-02-2008
WO 9012216 A1	18-10-1990	AU 5419590 A	05-11-1990
		EP 0466762 A1	22-01-1992
		GB 2230305 A	17-10-1990
		WO 9012216 A1	18-10-1990
JP 2006009968 A	12-01-2006	JP 4483430 B2	16-06-2010
		JP 2006009968 A	12-01-2006
WO 2012145217 A1	26-10-2012	US 8545103 B1	01-10-2013
		US 2013192899 A1	01-08-2013
		WO 2012145217 A1	26-10-2012

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of
Daniel BRAITHWAITE et al.

Application No:

Filed:

For: IMPROVEMENTS IN FLUID BEARINGS

Confirmation No:

Art Unit:

Examiner:

Docket: SHEL.3143

PRELIMINARY AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Sir:

Please make the following amendments to this application prior to examination thereof.

Please charge any underpayment of fees required to accept or take action on this filing, or credit any overpayment, to Deposit Account No. 03-1550. This authorization does not apply to fees under 37 CFR 1.16 (h), (i) or (j) or 37 CFR 1.492(d), (e) or (f), unless necessary to prevent abandonment of the application.

SPECIFICATION AMENDMENTS

Please amend the specification in the following manners. The following instructions describe placement of amendments as *in the line following* a specific line on a page, meaning that an additional line should be added following the mentioned line, wherein the amendment should be made.

Replace "TITLE OF INVENTION" with "(a) TITLE OF THE INVENTION." on page 1, line 1.

Insert the following paragraph in the line following (a):

"(b) CROSS-REFERENCE TO RELATED APPLICATIONS. This is a national stage application filed under 35 USC 371 based on International Application No. PCT/IB2013/055305, filed June 28, 2013 and claims priority under 35 USC 119 of Australian Patent Application No. 2012902770 filed June 28, 2012."

Insert "(c) STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT. Not Applicable." in the line following (b).

Insert "(d) THE NAMES OF THE PARTIES TO A JOINT RESEARCH AGREEMENT. Not Applicable." in the line following (c).

Insert "(e) INCORPORATION-BY-REFERENCE OF MATERIAL SUBMITTED ON A COMPACT DISC OR AS A TEXT FILE VIA THE OFFICE ELECTRONIC FILING SYSTEM (EFS-WEB). Not Applicable." in the line following (d).

Insert "(f) STATEMENT REGARDING PRIOR DISCLOSURES BY THE INVENTOR OR A JOINT INVENTOR. Not Applicable." in the line following (e).

Replace "Background of the Invention" on page 1, with

"(g) BACKGROUND OF THE INVENTION.

Replace "SUMMARY OF INVENTION" on page 3, with "(h) BRIEF SUMMARY OF THE INVENTION."

Replace "Brief Description of the Drawings" on page 11 with "(i) BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS."

Replace "Preferred Embodiments of the Invention" on page 14 with "(j) DETAILED DESCRIPTION OF THE INVENTION."

Replace "CLAIMS" on page 29, with "(k) CLAIMS."

Replace "Abstract" with "(l) ABSTRACT OF THE DISCLOSURE" after (k).

Insert a new page with the heading "(m) SEQUENCE LISTING. Not Applicable". After (l).

CLAIM AMENDMENTS

Please amend the claims as follows:

1. – 52. (canceled)

53. (new) A bearing assembly for supporting a journal of a grinding mill body, comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a polymer bearing pad mounted to a base, said polymer bearing pad comprising an outer surface, at least one recess for receiving lubricating fluid from at least one passage of said base and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad to said base, said base also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage, wherein said base is mounted to said frame so that said fluid bearings self adjust to changes in the angular position of the journal during operation of said grinding mill body.

54. (new) A bearing assembly for supporting a journal of a grinding mill body, comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a polymer bearing pad mounted to a base, said polymer bearing pad comprising an outer surface, at least one recess for receiving lubricating fluid from at least one passage of said base and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad to said base, said base also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage, wherein said base is fixedly mounted to said frame.

55. (new) The bearing assembly of claim 53, wherein said mounting means comprises a mounting portion extending from said polymer bearing pad, said mounting portion comprising a protrusion from a mounting surface opposite to said outer surface for engaging a flange of said base, said flange being located at an outer edge of said base.

56 (new) The bearing assembly of claim 53, wherein said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base; said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess and said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess.

57. (new) The bearing assembly of claim 53, wherein said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base, said bearing assembly further comprising a locking element for retaining said at least one fastener within said at least one recess.

58. (new) The bearing assembly of claim 53, wherein said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

59. (new) The bearing assembly of claim 53, further comprising a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal, wherein said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer pad.

60. (new) The bearing assembly of claim 53, said at least one recess of said polymer bearing pad comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage of said base.

61. (new) The bearing assembly of claim 53, further comprising a plurality of said polymer bearing pads, wherein said respective outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal, wherein each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

62. (new) The bearing assembly of claim 53, wherein said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

wherein there is a plurality of said polymer bearing pads, a first of said polymer bearing pads being mountable to said first surface and a second of said polymer bearing pads being mountable to said second surface,

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wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface,

wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

63. (new) A multidirectional fluid bearing for a journal, comprising:

a base having a first surface orthogonal to a second surface, one or more lubricating fluid supply ports and a plurality of passages in fluid communication with said lubricating fluid supply ports, said first surface and said second surface,

a first polymer bearing pad mountable to said first surface, said polymer bearing pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer bearing pad mountable to said second surface, said second polymer bearing pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

64. (new) The multidirectional fluid bearing of claim 63, said first polymer bearing pad substantially covers said first surface and said second polymer bearing pad substantially covers said second surface to respectively create fluid seals between said first and second polymer bearing pads and said base.

65. (new) The multidirectional fluid bearing of claim 63, wherein at least one of said first and second polymer bearing pads comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal, wherein said chamfer has an outer edge that is displaced from a journal when said journal engages said at least one polymer bearing pad.

66. (new) The multidirectional fluid bearing of claim 63, wherein there is a plurality of at least one of said first and second polymer bearing pads, wherein said respective outer surfaces of said plurality of at least one of said first and second polymer pads form a substantially uniform bearing surface for said journal, wherein each of said plurality of at least one of said first and second polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

67. (new) The multidirectional fluid bearing of claim 63, wherein at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base, wherein said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess, said head portion being tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab, and wherein said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess, said at least one fastener being partially received in said at least one passage.

68. (new) The multidirectional fluid bearing of claim 63, wherein base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base, said flange being located at an outer edge of said base.

69. (new) The multidirectional fluid bearing of claim 63, wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

70. (new) The bearing assembly of claim 54, wherein said mounting means comprises a mounting portion extending from said polymer bearing pad, said mounting portion comprising a protrusion from a mounting surface opposite to said outer surface for engaging a flange located at an outer edge of said base.

71. (new) The bearing assembly of claim 54, wherein said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base; said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at

least one recess and said at least one fastener comprising a bore for conveying lubricating fluid from said at least one passage to said at least one recess.

72. (new) The bearing assembly of claim 54, wherein said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base, said bearing assembly further comprising a locking element for retaining said at least one fastener within said at least one recess.

73. (new) The bearing assembly of claim 54, wherein said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

74. (new) The bearing assembly of claim 54, further comprising a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal, said chamfer having an outer edge that is displaced from a journal when said journal engages said polymer pad.

75. (new) The bearing assembly of claim 54, said at least one recess of said polymer bearing pad comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage of said base.

76. (new) The bearing assembly of claim 54, further comprising a plurality of said polymer bearing pads, wherein said respective outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal, wherein each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

77 (new). The bearing assembly of claim 54, wherein said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

wherein there is a plurality of said polymer bearing pads, a first of said polymer bearing pads being mountable to said first surface and a second of said polymer bearing pads being mountable to said second surface,

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface,

wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

REMARKS

The above amendments are presented in order to place this application in better condition for examination.

Specification amendments are submitted herewith. No new matter has been added to the specification.

Cancellation or amendment of claims effected above is in order to expedite examination and is without the intention to abandon subject matter that is claimed in the application as originally filed. Applicant reserves the right to reinstate claims of scope corresponding to that of claims that are canceled or amended by this preliminary amendment.

Respectfully submitted,

/Susan D. Pitchford/
Susan D. Pitchford
Reg. No. 50,945

Chernoff, Vilhauer, McClung & Stenzel, LLP
601 SW Second Avenue, Suite 1600
Portland, OR 97204
Tel. (503) 278-3334
Fax (503) 228-4373

598702

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SHEL.3143
	Application Number	
Title of Invention	IMPROVEMENTS IN FLUID BEARINGS	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Daniel		BRAITHWAITE	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Innaloo	Country of Residence i	AU

Mailing Address of Inventor:

Address 1	5/17 Hertha Road		
Address 2			
City	Innaloo, Western Australia	State/Province	
Postal Code	6018	Country i	AU

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Jeffrey	Victor	BELKE	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Mt Pleasant	Country of Residence i	AU

Mailing Address of Inventor:

Address 1	11 Cowrie Cresent		
Address 2			
City	Mt Pleasant, Western Australia	State/Province	
Postal Code	6153	Country i	AU

Inventor 3 Remove

Legal Name

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Prefix	Given Name	Middle Name	Family Name	Suffix
	Nicholas	John	GREEN	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Rivervale	Country of Residence i	AU

Mailing Address of Inventor:

Address 1	98a Toorak Road		
Address 2			
City	Rivervale, Western Australia	State/Province	
Postal Code	6103	Country i	AU

Inventor 4 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Chris		TATE	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Iluka	Country of Residence i	AU

Mailing Address of Inventor:

Address 1	187 Delgado Parade		
Address 2			
City	Iluka, Western Australia	State/Province	
Postal Code	6028	Country i	AU

Inventor 5 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Oscar		HARRISON	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Balcatta	Country of Residence i	AU

Mailing Address of Inventor:

Address 1	35 Campsbourne Street		
Address 2			
City	Balcatta, Western Australia	State/Province	
Postal Code	6021	Country i	AU

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SHEL.3143
	Application Number	
Title of Invention	IMPROVEMENTS IN FLUID BEARINGS	

Inventor 6 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Knut		VAAGE	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Oslo	Country of Residence i	NO

Mailing Address of Inventor:

Address 1	Middlethunsgate 23		
Address 2			
City	Oslo	**State/Province**	
Postal Code	0368	**Country** i	NO

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	00152		
Email Address	SDP.docket@chernofflaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	IMPROVEMENTS IN FLUID BEARINGS		
Attorney Docket Number	SHEL.3143	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	13	**Suggested Figure for Publication (if any)**	

Filing By Reference :

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country i

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SHEL.3143
	Application Number	
Title of Invention	IMPROVEMENTS IN FLUID BEARINGS	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	00152		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/IB2013/055305	2013-06-28

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) [i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country [i]	Filing Date (YYYY-MM-DD)	Access Code [i] (if applicable)
2012902770	AU	2012-06-28	

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SHEL.3143
	Application Number	
Title of Invention	IMPROVEMENTS IN FLUID BEARINGS	

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SHEL.3143
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Title of Invention	IMPROVEMENTS IN FLUID BEARINGS	

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

○ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
◉ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Outotec (Finland) Oy

Mailing Address Information:

Address 1	Rauhalanpuisto 9		
Address 2			
City	Espoo	**State/Province**	
Country [i]	FI	Postal Code	02230
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

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	Application Number	
Title of Invention	IMPROVEMENTS IN FLUID BEARINGS	

Organization Name	Outotec (Finland) Oy

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	Rauhalanpuisto 9		
Address 2			
City	Espoo	**State/Province**	
Country i	FI	Postal Code	02230
Phone Number		Fax Number	
Email Address			

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Exhibit 1002
FLS v. Metso

Improvements in fluid bearings

Field of the Invention

[0001] The present invention relates to a fluid bearing and in a particular a hydrostatic polymeric bearing for use in a mill. The invention has been developed primarily for use as a hydrostatic polymeric bearing in grinding mills and will be described hereinafter by reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use, but also extends to other types of fluid bearings such as hydrodynamic bearings and hybrid bearings (i.e. bearings that use a combination of hydrodynamic and continuous hydrostatic flow for lubrication).

Background of the Invention

[0002] The following discussion of the prior art is intended to present the invention in an appropriate technical context and allow its advantages to be properly appreciated. Unless clearly indicated to the contrary, however, reference to any prior art in this specification should not be construed as an express or implied admission that such art is widely known or forms part of common general knowledge in the field.

[0003] A grinding mill has a mill chamber and two journal shafts, the journals being mounted upon supports for rotation. Typical bearings have two main components; a steel base for mounting to the support and a bearing pad or surface for contact with the mill journal. These mill bearings are installed between the mill journals and the supports so that the mill journals rotate on the bearing pads during operation of the grinding mill.

[0004] The applicant developed a hydrostatic pad bearing system for grinding mills that is currently in use. In this hydrostatic pad bearing system, an external oil supply system pumps high-pressure oil to recesses machined into the bearing so that the oil forms a thin film on the bearing pad surface. The resultant hydraulic pressure is sufficient to completely lift the mill journal off the hydrostatic pads and separate the sliding surfaces. Thus, mill actually "floats" on a film of oil between journal and bearing. As such the bearing will operate under both static and dynamic conditions. Since the surfaces are completely separated and the bearing is self aligning there is no metal-to-metal contact between the bearing surface and the mill journal due to the oil film, thus resulting in only low friction. Consequently, maintaining the oil film between the surfaces means that there is virtually no wear in the bearing.

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[0005] Despite the advantages conferred by this hydrostatic bearing system, a loss of oil pressure (and thus a reduction in the oil film thickness) can cause failure of the bearings, leading to damage to the bearing pad and/or the mill journal. For example, it can take a few seconds for a grinding mill to stop turning in the event of a power failure, and when this happens there is a high risk of damage to the mill bearing pads or journal surfaces due to a loss of oil reducing the oil film thickness, thereby bringing the journal and bearings into direct metal to metal contact. The consequential downtime for replacement of any damaged bearings and/or journals severely impairs operation of the mill, reducing its efficiency.

[0006] To prevent this type of damage, grinding mill lubrication systems usually have pressure accumulator systems that are typically used to store and deliver high pressure oil to the bearing in the event of a power failure and the oil supply system fails. These pressure accumulators are expensive, require frequent maintenance to ensure that they are at the appropriate pressure level and can interfere with control systems in the mill. Thus, there are increased operational and maintenance costs of the mill.

[0007] Typically, to manufacture hydrostatic bearings, the recesses are machined into the steel base and then the oil supply ports for delivering high pressure oil to the recesses are then drilled into the base. Bronze is spray welded or cast onto the relevant parts of the steel base to form the bearing pad or lining. Spray welding enables the bronze metal to form a seal with the base. White metal may be used instead of bronze, but is cast onto the base. Due to this manufacturing process, the repair and/or refurbishment of these bearings involves initially cleaning the damaged bearing surface, machining any parts of the steel base and either spray welding the bronze or re-casting the bronze/white metal. This repair process cannot be performed on-site but requires the bearing to be returned to the manufacturer. Consequently, mills must keep a sufficient stock of spare bearings to account for the absence of damaged bearings being repaired. This adds to the maintenance costs of the mill.

[0008] It is an object of the present invention to overcome or substantially ameliorate one or more of the disadvantages of prior art, or at least to provide a useful alternative.

[0009] It is an object of the invention in at least one preferred form to provide improved fluid bearings for mills that are more tolerant to the loss of oil film, distortions in the journal, require less strict manufacturing tolerances, can be easily repaired, minimise waste and reduce or eliminate the need for pressure accumulators, and a method for making such fluid bearings.

[0010] Summary of the Invention

[0011] According to a first aspect of the invention, there is provided a bearing assembly for supporting a journal of a grinding mill body, comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a polymer bearing pad mounted to a base,

said polymer bearing pad comprising an outer surface, at least one recess for receiving lubricating fluid from at least one passage of said base and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad to said base, said base also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage, wherein said base is mounted to said frame so that said fluid bearings self adjust to changes in the angular position of the journal during operation of said grinding mill body~~a polymer bearing pad for a fluid bearing, comprising an outer surface, at least one recess for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface and a mounting means for securely mounting said polymer bearing pad to said base~~.

[0012] A second aspect of the present invention provides a bearing assembly for supporting a journal of a grinding mill body, comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a polymer bearing pad mounted to a base, said polymer bearing pad comprising an outer surface, at least one recess for receiving lubricating fluid from at least one passage of said base and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad to said base, said base also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage, wherein said base is fixedly mounted to said frame.

[0013] Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising", and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

[0014] As used herein, unless otherwise specified the use of the ordinal adjectives "first", "second", "third", etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0015] Preferably, said mounting means comprises a mounting portion extending from said polymer bearing pad. More preferably, said mounting portion comprises a protrusion from a mounting surface opposite to said outer surface for engaging a flange of said base. In one preferred form, said mounting surface comprises an inner surface of said polymer bearing pad. In another preferred form, said inner surface is the underside of said polymer bearing pad.

[0016] Alternatively or additionally, said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer bearing pad to said base. More

preferably, said at least one recess has a locking tab for retaining a head portion of said fastener within said at least one recess.

[0017] Preferably, said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

[0018] Preferably, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said base.

[0019] Preferably, said outer surface is partially curved. Alternatively, said outer surface is substantially planar.

[0020] Preferably, said polymer bearing pad comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said polymer bearing pad comprises two chamfers at opposing outer edges. In one preferred form, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In a particularly preferred form, said chamfer is inclined approximately 8° from said tangent.

[0021] Preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer bearing pad.

[0022] Preferably, said polymer bearing pad comprises at least one complementary connecting portion for connecting said polymer bearing pad to an adjacent polymer bearing pad. In a particularly preferred form, said polymer pad has at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of said adjacent polymer bearing pad.

[0023] Preferably, said polymer bearing pad is made from any suitable polymer, including, but not limited to, polyetheretherketone (PEEK), PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the polymer pad is made of PEEK.

~~[0024] According to a second aspect of the invention, there is provided a fluid bearing for a journal, comprising:~~

~~a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port, and~~

~~the polymer bearing pad of the first aspect of the present invention mountable to said base.~~

~~[0025]~~[0024] Preferably, ~~said polymer bearing pad has the preferred features of the abovementioned first aspect of the invention. In this second aspect,~~ said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage.

~~[0026]~~[0025] Preferably, said base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base. More preferably,

said at least one flange is located at an outer edge of said base. In one preferred form, said base comprises two of said flanges located at opposing outer edges of said base.

~~[0027]~~[0026] Preferably, said fluid bearing comprises at least one fastener for mounting said polymer bearing pad to said base. More preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said bore conveys lubricating fluid from said at least one passage to said interconnecting passage.

~~[0028]~~[0027] Preferably, said fluid bearing is a hydrostatic bearing. More preferably, said outer surface is partially curved such that said fluid bearing acts as a radial hydrostatic bearing. In one preferred form, said fluid bearing is a self-aligning radial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted radial hydrostatic bearing. In a further preferred form, said fluid bearing is a hydrostatic slipper bearing.

~~[0029]~~[0028] Alternatively, said outer surface is substantially planar such that said fluid bearing acts as an axial bearing. In one preferred form, said fluid bearing is a self-aligning axial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted axial hydrostatic bearing.

~~[0030]~~[0029] Preferably, said at least one fastener is partially received in said at least one passage. Preferably, said at least one fastener comprises a head portion for engagement with said at least one recess. More preferably, said at least one recess has a locking tab for retaining said head portion within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

~~[0031]~~[0030] Alternatively, said fluid bearing comprises a plug for engagement with said head portion and said at least one recess to retain said at least one fastener. In one preferred form, said at least one fastener is countersunk into said at least one recess.

~~[0032]~~[0031] Preferably, said at least one fastener is substantially retained within said at least one recess by a locking element. More preferably, said locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

~~[0033]~~[0032] Preferably, the fluid bearing comprises a plurality of said polymer pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

~~[0034]~~[0033] Preferably, said polymer pads are connected together. More preferably, each of said polymer pads has at least one complementary connecting portion for connecting said polymer pad to an adjacent polymer pad. In one preferred form, each of said polymer pads has at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

~~[0035]~~[0034] Preferably, said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

a first of said polymer bearing pads is mountable to said first surface and a second of said polymer bearing pads is mountable to said second surface,

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

~~[0036]~~[0035] Preferably, said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer bearing pad acts as a self-aligning radial hydrostatic bearing.

~~[0037]~~[0036] Preferably, said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing. In one preferred form, said second polymer bearing pad acts as a fixedly mounted axial hydrostatic bearing.

~~[0038]~~[0037] Preferably, said first surface is orthogonal to said second surface. In one preferred form, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

~~[0039]~~[0038] ~~According to a third aspect of the invention, t~~There is ~~provid~~disclosed a method of making a polymer bearing pad for a fluid bearing, comprising forming a polymer pad having an outer surface, forming at least one recess in said polymer pad for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface, and forming a mounting means on said polymer pad for securely mounting said polymer pad to said base.

~~[0040]~~[0039] Preferably, said mounting means forming step comprises forming a mounting portion to extend from said polymer pad. More preferably, said mounting portion forming step comprises machining said polymer pad to form said mounting portion. Alternatively, said mounting portion forming step comprises placing said polymer pad in a mould to form said mounting portion. Alternatively or additionally, said mounting means forming step comprises forming an opening in said at least one recess for receiving at least one fastener. More preferably, said opening is drilled, punched, cut or machined into said at least one recess.

~~[0041]~~[0040] Preferably, said at least one recess forming step comprises machining said at least one recess in said polymer pad. More preferably, said at least one recess forming step comprises machining at least one interconnecting passage to interconnect said at least one recess to said base.

~~[0042]~~[0041] Preferably, said method further comprises chamfering an outer edge of said polymer pad. In one preferred form, said chamfering step comprises chamfering two opposing outer edges of said polymer pad.

~~[0043]~~[0042] ~~According to a fourth aspect of the invention, there is provided~~Also disclosed is a method of making a fluid bearing for a journal, comprising the steps of:

providing a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port;

forming a polymer pad having an outer surface and at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to said outer surface, and

mounting said polymer bearing pad to said base.

~~[0044]~~[0043] Preferably, said method comprises each of the preferred steps in the abovementioned third aspect of the invention. In this aspect, said forming step further comprises machining at least one interconnecting passage to interconnect said at least one recess to said passage.

~~[0045]~~[0044] Preferably, said mounting step comprising mechanically fastening said polymer bearing pad to said base. More preferably, the method further comprises the steps of using a fastener to mechanically fasten said polymer bearing pad to said base and forming a bore in said at least one fastener for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said mounting step comprises bolting said polymer pads to said base.

~~[0046]~~[0045] Preferably, where there are a plurality of said polymer pads, said method further comprises the step of connecting said polymer bearing pads such that said outer surfaces of said polymer bearing pads form a substantially uniform bearing surface for said journal. More preferably, said forming step further comprises the step of forming at least one connecting portion in each said polymer bearing pad for connecting said polymer pad to an adjacent polymer bearing pad. In one preferred form, said forming step comprises forming at least one lateral connecting portion in each said polymer bearing pad for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0047][0046] Preferably, said method further comprises selecting one or more polymer bearing pads for mounting at the outer edges of said base and chamfering an outer edge of each selected polymer bearing pad.

[0048][0047] Where said fluid bearing is a radial hydrostatic bearing, each of said polymer pads have curved outer surfaces such that said outer surfaces define a substantially curved uniform bearing surface.

[0049][0048] Also further disclosed is ~~ccording to a fifth aspect of the invention, there is provided~~ a fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a polymer bearing pad having at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to an outer surface of said bearing pad,

said polymer bearing pad being mountable to said base and further comprising a chamfer at an outer edge for retaining said lubricating fluid thereon and transferring said lubricating fluid to said journal.

[0050][0049] Preferably, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In one preferred form, said chamfer is inclined approximately 8° from a tangent of an edge of said outer surface.

[0051][0050] Preferably, said chamfer has an outer edge that is displaced from said journal when said journal engages said polymer bearing pad.

[0052][0051] Preferably, the polymer bearing pad is composed of a polymer material that includes, but is not limited to, PEEK, PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the bearing pad is composed of polyetheretherketone (PEEK).

[0053][0052] Preferably, said fluid bearing is a hydrostatic bearing.

[0054][0053] According to a third ~~sixth~~ aspect of the invention, there is provided a multidirectional fluid bearing for a journal, comprising:

a base having a first surface orthogonal to~~,~~ a second surface, at least one lubricating fluid supply port and a plurality of passages in fluid communication with said at least one lubricating fluid supply port, said first surface and said second surface,

a first polymer pad mountable to said first surface, said polymer pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer pad mountable to said second surface, said polymer pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

~~[0055]~~[0054] Preferably, said first polymer bearing pad substantially covers said first ~~outer~~ surface and said second polymer bearing pad substantially covers said second ~~outer~~ surface to respectively create fluid seals between said first and second polymer bearing pads and said base.

~~[0056]~~[0055] Preferably, at least one of said first and second polymer bearing pads comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said at least one polymer bearing pad.

~~[0057]~~[0056] Preferably, at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base. More preferably, said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

~~[0058]~~[0057] Preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess, said at least one fastener being partially received in said at least one passage.

~~[0059]~~[0058] Preferably, at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base. Preferably, said at least one polymer bearing pad comprises a locking element for retaining said at least one fastener within said at least one recess.

~~[0060]~~[0059] Preferably, ~~least one of said first and second polymer bearing pads comprises~~ there is a plurality of at least one of said first and second polymer bearing pads, wherein said respective outer surfaces of said plurality of at least one of said first and second polymer pads form a substantially uniform bearing surface for said journal. More preferably, each of said plurality of at least one of said first and second polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

~~[0061]~~[0060] Preferably, said first outer surface is partially curved such that said first polymer pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer pad acts as a self-aligning radial hydrostatic bearing.

~~[0062]~~[0061] Preferably, said second outer surface is substantially planar such that said second polymer pad acts as an axial bearing. In one preferred form, said second polymer pad acts as a fixedly mounted axial hydrostatic bearing.

[0063][0062] Preferably, ~~said first surface is orthogonal to said second surface. In one preferred form~~, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0064][0063] Preferably, said first polymer bearing pad and said second polymer bearing pad have the preferred features of the abovementioned aspects of the invention.

[0065][0064] Preferably, said lubricating fluid includes oil or water.

Brief Description of the Drawings

[0066][0065] Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0067][0066] Figure 1 is a cross-sectional side view of a grinding mill for receiving a hydrostatic bearing according to a first embodiment of the invention;

[0068][0067] Figure 2 is a perspective view of a bearing assembly in the mill of Figure 1;

[0069][0068] Figure 3 is a front view of the bearing assembly of Figure 2;

[0070][0069] Figure 4 is a schematic plan view of a radial hydrostatic bearing for the bearing assembly of Figure 3;

[0071][0070] Figure 5 is a cross-sectional view of the radial hydrostatic bearing along section A-A of Figure 4;

[0072][0071] Figure 5A is a expanded partial cross-sectional view of the chamfer of the radial hydrostatic bearing of Figure 4;

[0073][0072] Figure 6 is a cross-sectional view of the radial hydrostatic bearing taken along section B-B of Figure 4;

[0074][0073] Figure 7 is a schematic plan view of the base of the radial hydrostatic bearing of Figure 4;

[0075][0074] Figure 8 is a schematic cross-sectional view of the base of Figure 7;

[0076][0075] Figure 9 is a schematic cross-sectional view of an axial hydrostatic bearing for the bearing assembly of Figure 3;

[0077][0076] Figure 10 is a schematic plan view of the axial hydrostatic bearing of Figure 9;

[0078][0077] Figures 11 and 11A are schematic partial views of a fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0079][0078] Figure 12 and 12A are schematic partial views of an alternative fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0080][0079] Figure 13 is a schematic partial view of the chamfer of Figure 5A;

[0081][0080] Figure 14 is a schematic cross-sectional view of a prior art hydrostatic bearing;

[0082][0081] Figure 15 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with another embodiment of the invention;

[0083][0082] Figures 16 and 16A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0084][0083] Figures 17 and 17A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0085][0084] Figures 18 and 18A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0086][0085] Figure 19 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0087][0086] Figure 20 is a schematic partial cross-sectional view of an axial hydrostatic bearing according to a further embodiment of the invention;

[0088][0087] Figure 21 is a schematic partial expanded view of the axial hydrostatic bearing of Figure 20;

[0089][0088] Figure 22 is a schematic side view of the axial hydrostatic bearing of Figure 20;

[0090][0089] Figure 23 is a schematic plan view of a hydrostatic bearing in accordance with a further embodiment of the invention;

[0091][0090] Figure 24 is a schematic end view of the hydrostatic bearing of Figure 23;

[0092][0091] Figure 25 is a schematic side view of the hydrostatic bearing of Figure 23, and

[0093][0092] Figure 26 is a schematic perspective view of a hydrostatic bearing in accordance with a further embodiment of the invention.

Preferred Embodiments of the Invention

[0094][0093] Referring to Figure 1, a typical grinding mill 1 comprises a milling chamber or body 2 rotatably mounted on supports 3 via journal shafts 4 and bearing assemblies 5. The mill body 2 has an inlet 6 for introducing a charge for grinding and a discharge outlet 7 for removing the processed charge from the mill 1.

[0095][0094] As best shown in Figures 2 and 3, each bearing assembly 5 has a frame 10 and a plurality of fluid bearings in the form of radial hydrostatic bearings 11 and axial hydrostatic bearings 12, which are designed to transport a lubricating fluid in the form of a high pressure oil to an outer surface 13A, 13B of each bearing 11, 12.

~~[0096]~~[0095] Referring to Figures 4 to 8, where corresponding features have been given the same reference numerals, each radial hydrostatic bearing 11 comprise a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. The hydrostatic bearings 11, 12 are self-aligning in that the hydrostatic bearings self-adjust to any changes in the angular position of the journals 4 during operation of the mill 1. This is typically achieved by having the base 14 mounted on a spherical seat (not shown) to permit self-adjustment to any angular movement of the journals 4. The base 14 is composed of cast iron, but can be made of any other suitable metal or material.

~~[0097]~~[0096] A polymer pad 17 is mountable to the base 14 of each radial hydrostatic bearing 11 via a mounting portion 8 extending from the polymer pad. In this embodiment, the mounting portion 8 is a protrusion extending from a mounting surface opposite the outer surface 13A to engage flanges 9 located at respective outer edges or sides of the base 14. Generally, the mounting surface will be an inner surface or the underside of the polymer pad 17, but in other embodiments can be located elsewhere. Likewise, the flanges 9 need not be located at opposing outer edges of the base 14, but can be arranged in any manner that would act to hold captive the bearing pad 17, such as the flanges 9 being located closer to the centre of the base 14 rather than at the outer edges or the flanges 9 being opposed herringbone flanges positioned on the base 14 between which the mounting portions 8 are constrained.

~~[0098]~~[0097] The polymer bearing pad 17 has at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13A to act as a lubricating fluid between the radial hydrostatic bearing 11 and the journal shafts 4. In the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19. Also, the radial hydrostatic bearings 11 have a plurality of oil supply ports 15, oil galleries 16, recesses 18 and interconnecting passages 19.

~~[0099]~~[0098] The outer surface 13A of the polymer pad 17 of the radial hydrostatic bearings 11, 12 is curved to receive the curved bearing surface 20 of the journal 4, as best shown in Figures 1, 9, 11 and 11A. Thus, the outer surface 13A of the polymer pad 17 forms a bearing surface, and hence the polymer pad is a bearing pad for the bearings 11 when assembled with the base 14.

~~[00100]~~[0099] Referring to Figures 9 and 10, where corresponding features have been given the same reference numerals, each of the axial hydrostatic bearings 12 also comprises a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. A polymer pad 17 is mountable to the base 14 of each axial hydrostatic bearing 12, the polymer pad 17 having at least one recess 18 for receiving oil from the oil

gallery 16 and distributing it to the outer surface 13B to act as a lubricating fluid between the axial hydrostatic bearings 12 and the journal shafts 4. Again, in the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19 in the polymer pad 17. In addition, the axial hydrostatic bearings 12 have a plurality of oil galleries 16 in the base 14, and recesses 18 and interconnecting passages 19 in the polymer pad 17.

~~[00101]~~[00100] Also, the outer surface 13B of the axial hydrostatic bearing 12 is substantially planar as it receives the substantially planar end surface 21 of the journal 4, as best shown in Figure 1. Similarly to outer surface 13A, the outer surface 13B of the polymer pad 17 also forms a bearing surface, and hence the polymer pad is a bearing pad for the bearings 12 when assembled with the base 14.

~~[00102]~~[00101] In both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 substantially covers the entire outer surface 22 of the base 14 to form a substantially fluid impermeable seal between the base and the polymer pad. Also, the polymer pad 17 is mounted to the base 14 using at least one fastener in the form of bolts 23, as best shown in Figures 5 and 9. The fastening system for both the radial hydrostatic bearing 11 and the axial hydrostatic bearing 12 is described in more detail below.

~~[00103]~~[00102] The fastening system for mounting the polymer pad 17 to the bases 14 of the radial and axial hydrostatic bearings 11, 12 is illustrated in more detail in Figures 11 and 11A, where corresponding features have been given the same reference numerals. The fastening system comprises one of more bolts 23 that are inserted into corresponding openings 18A that are in fluid communication with the oil galleries 16. Each bolt 23 has a bore in the form of through bore 24 for conveying oil from the oil galleries 16 to the recesses 18 via a discharge port 25, as best shown in Figure 11. Thus, there is no need to provide separate oil passages between the oil galleries 16 in the base 14 and the recesses 18 in the polymer pad 17, unlike conventional bronze/white metal hydrostatic bearings. This reduces the complexity and cost in the manufacture of the hydrostatic polymer bearings. It will be appreciated that not all the bolts necessarily will have a bore as sometimes more fasteners are required to mount the polymer bearing pad 17 than the number of oil passages to connect the oil galleries 16 to the recesses 18.

~~[00104]~~[00103] The bolt 23 is inserted into the oil gallery 16 via the opening 18A and has a head portion 26 for engagement with a seat 27 of the recess 18, as best shown in Figure 11A. The bolt 23 engages the recess 18 to ensure that, in the event of the bolt becoming loose, it is held captive within the recess 18. This prevents any loose bolts 23 coming into contact with and damaging the journal 4. A locking tab 28 is also provided for retaining the head portion 26 within the recess 18. In addition, the head portion 26 has a

tapered portion 29 to facilitate retention of the bolt 23 within the recess 18 by the locking tab 28.

~~[00105]~~[00104] Also, the mounting portion 8 of the polymer pad 17 engages the flanges 9 of the base 14 to help lock the polymer pad in place. This ensures that frictional loads generated during the rotation of the journal 4 do not forcibly remove or "wipe" the polymer pad 17 from the base 14, even where the bolts 23 become loose, such that the mounting portion 8 and flanges 9 in effect replace the restraint of the bolts 23 against frictional related lateral loads. This makes for a very simple but reliable arrangement, with a level of redundancy to ensure correct operation even if the bolts 23 become loose.

~~[00106]~~[00105] Moreover, hydrostatic pressure acts between the journal 4 and the polymer bearing pad 17, while there is atmospheric pressure between the polymer bearing pad and the base 14. This pressure difference during operation of the fluid bearing 11, 12, together with the engagement of the mounting portion 8 and the flange or shoulder 9, acts to hold the polymer bearing pad 17 in place. In practice, the fastening system primarily assists in the initial installation of the polymer bearing pad 17 since there is no pressure between polymer bearing pad and the journal 4. This means that in the event bolts 23 are loose the polymer bearing pad 17 would be free to move or "float" until the hydrostatic pressure at the journal 4 is greater than the atmospheric pressure between polymer bearing pad and the base 14.

~~[00107]~~[00106] An alternative fastening arrangement is illustrated in Figure 12, where corresponding features have been given the same reference numerals. The fastener takes the form of a countersunk screw 30 having a tapered head portion 31 for engagement with a seat 27 recessed in the polymer pad 17. Due to the screw 30 being countersunk into the base 14 and the polymer pad 17, the head portion 31 is tapered in the reverse direction to the taper of the head portion 26 of the bolt 23. To prevent any screw 30 becoming loose and coming into contact with the journal 4, a plug 32 is used to engage the head portion 31 and a locking tab 28 is used to retain the plug 32, and thus the screw 30, within the seat 27. Oil is delivered to the outer surface 13 through a separate recess in the form of a hole 33 that is connected to a bore 34 located over the same position as the oil gallery 16 in the base 14 below, as best shown in Figure 12A.

~~[00108]~~[00107] In either fastening arrangement, separate O-rings 36 are fitted to the base 14 to provide a fluid seal preventing oil leaking in between the polymer pad 17 and the base, as best shown in Figures 9, 11, 11A and 12A. The thread into which the bolts 23 also assists in forming a fluid seal between the polymer bearing pad 17 and the base 14. The threads 35 act as plugs to close off holes that are required for machining the oil galleries 16 that direct lubricating fluid into the corner pockets from the central pocket.

~~[00109]~~[00108] In operation, the radial and axial hydrostatic bearings 11, 12 are installed in the bearing assembly 5 in the positions generally shown in Figure 3 in a manner readily understood by a person skilled in the art. The mill body 2 is then mounted on the bearing assembly 5 via the journals 4. An oil supply system is fluidly connected to the oil supply ports 15 in the base 14 of each radial and axial hydrostatic bearing 11, 12. Typically, the oil is positively pumped to the oil supply ports 15. However, in some variants, the oil need not be supplied by positive displacement pump. In either case, high pressure oil is conveyed from the oil supply ports 15 through the passages 16, bores 23 and interconnecting passages 19 to the recesses 18 and discharge ports 25 and up to the outer surfaces 13A, 13B, as best shown by arrow 39 in Figure 11. The oil collects on the outer surfaces 13A, 13B to create an oil film and lubricate the bearing surfaces 20, 21 of the journals 4.

~~[00110]~~[00109] Where there is a loss of oil due to a failure in the oil supply system, the polymer pad 17 absorbs most, if not all, of the detrimental effects so any damage is limited to the polymer pad 17 rather than the bearing surfaces 20, 21 of the journal 4 or the base 14. Thus, the base 14 (and its oil galleries 16 and oil supply ports 15) are protected from damage and any damage is suffered by the polymer pad 17. Thus, by having the polymer pad 17 provided with recesses 18 for distributing oil to the outer surface 13, rather than the base 14, the polymer pad can be easily replaced in the event of damage without having to repair the entire bearing. In addition, this advantage is further facilitated by using mechanical fasteners described above to mount the polymer pad 17. Thus, a damaged polymer pad 17 can be removed simply by removing the fasteners 23, 30, enabling easy replacement of the polymer pads 17. Thus, maintenance and operational costs of the mill 1 are reduced, increasing the efficiency of the mill.

~~[00111]~~[00110] It has also been discovered that providing a polymer pad for the hydrostatic bearings 11, 12 confer numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads, as follows:

(1) It has been discovered that the polymer pad 17 behaves similar to white metal/bronze pads, but is able to self-mould to the journal 4. That is, the polymer pad 17 is able to modify its outer surface 13A, 13B to accommodate circumferential surface imperfections on the bearing surfaces 20, 21 of the journal 4. This reduces or eliminates the need for tight machining tolerances required for bronze bearings, and can subsequently reduce the associated machining costs. Hence, there is a reduced manufacturing cost for the hydrostatic bearings by using a polymer pad.

(2) The polymer bearing pads 17 enable reduced lubrication rates to be used over traditional bronze bearing pads due to the running in characteristics of polymer material, thus conserving lubricating fluid. However, where necessary or desirable, the polymer pads 17 operate equally well at the same lubrication rates used for conventional bronze/white metal bearing pads.

(3) The hydrostatic polymer bearing pads 17 have a lower modulus of elasticity, and thus are able to create a "hovercraft" type cushion around the perimeter of the polymer pad. This acts to accommodate journal imperfections whilst maintaining pressure, much like the cushioning effect produced when a hovercraft moves over bumpy ground.

(4) The hydrostatic polymer bearing pads 17 are much more tolerant than traditional materials to a loss of oil to the bearing 11,12, to contact between journal 4 and outer surface 13A, 13B, and to deformations in the journal bearing surfaces 20, 21. Thus, a loss of oil film due to oil viscosity being too low (from such causes as a high temperature or oil degradation) can be more tolerably managed by the polymer pad 17.

(5) The polymer is elastic, unlike bronze, and is significantly softer than bronze. Thus, the elastic nature of the polymer pads 17 dampen excessive forces that are applied to the hydrostatic bearings 11, 12. For example, where there is a loss of oil through a shock load placed on the hydrostatic bearing 11, 12 there is little or no risk of damage to the metal journal 4 because the polymer pad 17 dampens the shock to some extent and any damage sustained is suffered by the polymer pad rather than the journal. By way of contrast, with white metal/bronze bearings there is a significant risk of damage to metal journals, resulting in on-site machining and costly stoppages. This advantage of the elasticity of the polymer bearing pads also extends to white metal bearing pads, which are brittle and so are more easily damaged when subjected to typical shock loads.

(6) Any contaminants in the oil that would normally damage the bearing surfaces of the journal 4 or a standard bearing pad tend to be embedded into the polymer pad 17 without adversely affecting operation of the hydrostatic bearing 11, 12.

(7) The self-moulding property of the polymer pads 17 means that the outer surfaces 13A, 13B of the polymer pads tend to conform to the profile of the bearing surface 21 of the journal 4 that it is running against. As a consequence, the polymer pads 17 (and hence bearing 11) do not necessarily require a self-alignment mechanism (such as a

spherical seat) within certain limits, unlike conventional bearings. It is also contemplated that the self-moulding property also permits the design and installation of hydrostatic bearings that ordinarily would be outside of the capacity of conventional bearings, since the polymer pad 17 can provide some degree of self-alignment in addition to a conventional self-alignment mechanism.

~~[00112]~~[00111] These advantages of the polymer pad 17 means that the hydrostatic bearings can be operated at lower oil film thicknesses. This has a flow on effect, permitting the use of smaller and cheaper lubrication systems, reducing power consumption and conserving the use of oil. Also, in the event of operational problems damage to the journals 4 and polymer bearing pads 17 is significantly reduced, increasing product life and reducing the frequency of maintenance and repair. Furthermore, any damage is limited to the polymer bearing pads 17 and does not adversely affect operation of the journal 4. Finally, the complex and expensive accumulator systems can be removed, saving installation costs and eliminating their associated maintenance costs.

~~[00113]~~[00112] Referring now to Figures 5A, 9 and 13, another aspect of the invention is described, where corresponding features have been given the same reference numerals. In this aspect of the invention, a chamfer is provided at an outer edge of a bearing pad for retaining lubricating fluid on the chamfer, thus enabling recycling of lubricating fluid in the bearing. In applying this aspect of the invention to both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 has a chamfer 37 at both outer edges 38 for retaining oil on the chamfer, as best shown in Figures 5A, 9 and 13. The chamfer 37 creates a lead-in and lead-out for the oil, especially when residual oil on the outer surfaces 13A, 13B must be relied upon for lubrication in the event of an unexpected loss of normal oil supply to the bearings 11, 12. The chamfer 37 inhibits or prevents oil being wiped off the journal 4, as would occur with a bearing having a sharp straight edge. Thus, the chamfer 37 helps to ensure that there is a residual amount of oil between the polymer pad 17 and the metal journal 4.

~~[00114]~~[00113] In a conventional bearing, the straight edge would wipe off oil from the journal and thus increase the loss of oil from the bearing. By way of contrast, in this aspect of the invention, the chamfer 37 provides a capture point for the oil that may be lost during operation. As the journal 4 rotates on the hydrostatic bearing 11, 12 the "lead-in" chamfer 37 enables the bearing surface 20 of the journal 4 to capture oil from the chamfer 37 and thus is lubricated before coming into contact with the outer surface 13A, 13B of the hydrostatic bearing. The inventors believe that the oil held by the "lead-in" chamfer 37 is recaptured by the journal 4 due to a hydrodynamic effect produced by its rotation. When the bearing surface 20 of the journal 4 leaves the outer surface 13A, 13B of the hydrostatic bearing, the

"lead-out" chamfer 37 on the other side of the hydrostatic bearing 11, 12 feeds any discharging oil from the outer surface 13A, 13B onto the journal to provide a consistent oil thickness over the journal, thus maintaining its lubrication. The provision of chamfers 37 at each outer edge 38 enables the mill journal 4 to be operated in either rotational direction. As a consequence, the use of the chamfers 37 minimises the loss of oil and effectively removes the need to provide oil pressure accumulators with their associated high maintenance and installation costs. Therefore, the chamfers 37 provide the radial and axial hydrostatic bearings 11, 12 provide a cost effective solution and safety measure for the hydrostatic bearings.

~~[00115]~~[00114] The chamfer 37 is inclined approximately at an angle α to the outer surface 13A, 13B. In the case of the radial hydrostatic bearing 11, the angle α is defined relative to a tangent 39 from the curved outer surface 13A, as best shown in Figure 13. In the case of the axial hydrostatic bearing 12, the angle α is defined relative to the horizontal plane of the planar outer surface 13B. In either case, the angle α is in the range of 0.01° to 89°, and is preferably 8°.

~~[00116]~~[00115] In addition, the chamfer 37 has an outer edge 40 that is displaced from the journal 4 when the journal engages the polymer pad 17. In both the radial and axial hydrostatic bearings 11, 12 the outer edge 40 of the chamfer 27 is displaced approximately 0.5mm to 1.5 mm from the journal 4. The displacement β is preferably displaced by approximately 0.85 mm from the journal 4.

~~[00117]~~[00116] It will be appreciated by a person skilled in the art that the chamfer 37 could also be applied to existing bronze/white metal hydrostatic bearings and is not limited to hydrostatic bearings having a polymer pad.

~~[00118]~~[00117] Referring now to Figures 14 to 19, various methods of making the polymer pads 17 and the hydrostatic bearings 11, 12 of Figures 4 to 10 are illustrated, where corresponding features have been given the same reference numerals. As best shown in Figure 14, manufacturing the curved surface for a radial hydrostatic bearing involves removing the hatched area 41 from the material. This waste material can be a significant, especially on larger bearings, and contributes to unnecessary additional manufacturing costs. Furthermore, the manufacturing process is not environmentally sustainable.

~~[00119]~~[00118] With the hydrostatic bearings of Figures 4 to 10, polymer material can be purchased "off the shelf" in sheet form and subsequently formed to produce the polymer pads 17. One method involves heating the polymer material to a holding temperature which does not melt the material, but the polymer retains some structural integrity while having some malleability or pliability to be able to be formed. There are various procedures that can be used to heat and form the polymer readily understood by the person skilled in the art.

~~[00120]~~[00119] In one example, the polymer can be placed in a shaped former or mould and lightly clamped. The former or mould is then heated to an intermediate temperature, removed from oven, fully clamped and returned to the oven. After heating to a holding temperature, the former is held for a set period of time, removed from oven and allowed to cool.

~~[00121]~~[00120] In another example, the polymer is placed in a shaped former and clamped using springs or a dead weight. The former is heated to the holding temperature and kept at this temperature for a set period of time. After being allowed to cool, the polymer is removed from the former.

~~[00122]~~[00121] In a further example, the polymer sheet is heated to the holding temperature for set period of time to ensure uniform heating of material. The polymer is then removed from the heat, immediately placed in cold former and pressed to profile. In the case of a radial hydrostatic bearing 11, the former also creates the curved outer surface 13A. After being allowed to cool, the polymer pad 17 is removed from the former.

~~[00123]~~[00122] After assuming the required shape for the hydrostatic bearing 11, 12, the recesses 18 and interconnecting passages 19 are machined into the outer surface 13A, 13B of the polymer pad 17. Also, the chamfer 37 is machined at the same time. The mounting portion 8 is machined, either before or after machining of the recesses 18, interconnecting passages 19 and the chamfer 37. Alternatively, the mounting portion 8 is formed during the initial moulding of the polymer sheet. The openings 18A can also be formed either during the initial moulding or by drilling, punching, cutting or machining the polymer pad 17. The machined polymer pad 17 is then mechanically mounted to the base 14 using the fastener systems described above to complete assembly of the hydrostatic bearing 11, 12.

~~[00124]~~[00123] Referring now to Figures 15 to 16, another method of making the hydrostatic bearings is illustrated, where corresponding features have been given the same reference numerals. This method involves making a plurality of polymer pads in the form of slats 50 each having outer surfaces 51 that form a substantially uniform bearing surface 52 for the journal 4, as best shown in Figure 15. The slats 50 are produced using the same heating and forming method described above, and then fastened to the base 14 using either of the fastener systems as described in relation to Figures 4 to 10. As best shown in Figure 15, the resultant amount of removed material indicated by hatched area 53 is considerably less than the amount of material removed in a conventional bearing indicated by hatched area 41.

~~[00125]~~[00124] Also, the polymer pad 17 can be divided into any number of smaller polymer pads or slats 50 of any shape and/or size, as required. For example, there could be six polymeric slats 50 that are rectangular and uniform in shape but have differently shaped

recesses, as best shown in Figures 16, 16A, 17 and 17A. Similarly, the polymeric slats 50 could be larger in size, as best shown in Figures 18 and 18A.

~~[00126]~~[00125] In a further variation to this method, the polymeric slats 55 each have complementary connecting portions 56 to connect with an adjacent polymer pad 55, as best shown in Figure 19. The complementary connecting portions in this variation take the form of teeth 56 that are splayed together so that the slats 55 form a complete polymer pad 17. The polymer pads 55 are then mounted to the base 14 using either of the fastener systems as described in relation to Figures 4 to 10. Once in position, glue may be applied at adjacent surfaces of the polymer slats and their teeth 56 to enhance sealing. Then, the polymer slats 55 are clamped and heated to cure the adhesive joint. The joint formed by the connecting teeth 56 is such that the weight of mill journal 4 on the polymeric slats 55 works to ensure the joint is always in compression. It has been found by testing such bearings that they are strong enough as a bearing surface for the journal 4. It will be appreciated that other profiles for the connecting portions 56 can be used, such as tabs and detents of any polygonal shape.

~~[00127]~~[00126] The inventors believe that segmenting the surface area of the polymer pad 17 into individual polymer pads or slats 50reduces the amount of wastage involved with machining standard bearings, as indicated in area 41 of Figure 14, and provides a suitable supplementary option to heating and forming the entire polymer pad 17 as described above.

~~[00128]~~[00127] While the hydrostatic bearings 11, 12 have been described in the context of self-aligning hydrostatic bearings, it will be appreciated that the various aspects of the invention are also equally applicable to fixedly mounted hydrostatic bearings. Referring now to Figures 20 to 22, one example of a fixedly mounted hydrostatic bearing 60 is illustrated, where corresponding features have been given the same reference numerals. In this embodiment, the fixedly mounted hydrostatic bearing is an axial hydrostatic bearing 60 comprises a polymer pad 17 mounted on a base 14, which is fixedly mounted to mounting plate 61 via fasteners 62. Due to the polymeric nature of the polymer bearing pad 17, the outer surface 13B of the polymer pad will conform to the profile of the bearing surface 21 of the journal 4 that it is running against. This means that the axial hydrostatic bearing can provide some degree of self-alignment, if necessary, which is not possible in a conventional axial hydrostatic bearing. Aside from the manner of its mounting, the axial hydrostatic bearing 60 operates in substantially same manner as the self-aligning axial hydrostatic bearing 12 described above. Furthermore, while this embodiment concerns as axial hydrostatic bearing, it is also applicable to a fixedly mounted radial hydrostatic bearing.

~~[00129]~~[00128] Referring now to Figures 23 to 25, a fluid bearing 70 according to another aspect of the invention is illustrated, where corresponding features have been given the same reference numerals. The fluid bearing 70 is a hydrostatic bearing that is a

combination of the radial and axial hydrostatic bearings 11, 12, 60 described above. The base 71 has been adapted to receive both a polymer pad 17A having a radial or curved outer surface 13A mounted on its outer surface 72 and two polymer pads 17B having a substantially planar outer surface 13B mounted on opposing side surfaces 73 that are orthogonal to the outer surface 72. Thus, the combination hydrostatic bearing 70 acts as a self-aligning radial hydrostatic bearing 11 in one direction and as two fixedly mounted axial hydrostatic bearings 60 in two other directions, as best shown in Figure 25. Again, due to the polymer's characteristics the outer surfaces 13B of the polymer pads 17B with conform to the profile of the bearing surface 21 of the journal 4 that it is running against. Thus, there is no need for a separate base for the axial hydrostatic bearings. The inventors contemplate that this combination hydrostatic bearing 70 avoids the need to install three separate hydrostatic bearings and thus allows for ease of installation in the mill 1. Due to the easy replacement of the polymer pads 17A, 17B, there is no need to remove the base 71 in the event one or more of the polymer pads 17A, 17B are damaged during operation of the mill 1. Thus, the combination hydrostatic bearing 70 creates cost savings in installation and repair.

~~[00130]~~[00129] The inventors also contemplate that the combination bearing 70 can be modified so as to minimise or eliminate the "axial float". Axial float is the difference between the distance between axial bearing pads and the distance between axial journal faces. Axial float is generally required so that the axial hydrostatic bearings are not tightly fitted with the mill journal 4. Typically, this axial float is set to around 0.5 to 1mm, meaning that the mill journal is able to freely float in the axial direction by this 0.5 to 1mm. A potential advantage of this combination bearing 70 is that the amount of axial float can be reduced or eliminated, since one of the axial bearings on the combination bearing 70 can be configured to move axially on a piston which is supplied by pressurised oil. This effectively ensures that axial float is minimised or removed.

~~[00131]~~[00130] In other embodiments, the hydrostatic bearing takes the form of a slipper bearing 80, as best shown in Figure 26. Due to the larger size of the bearing pad for a slipper bearing and its 120° curvature, it could be difficult to mould a single polymer pad 17. Thus, segmenting the bearing pad surface into multiple polymer pads or slats 81 having curved outer surfaces and laterally connected together enables the invention to be used for a slipper bearing. The lateral connections can be formed as described in relation to Figure 19. Thus, the advantages of the polymer pad 17 can be extended to a slipper bearing.

~~[00132]~~[00131] In the preferred embodiments of the invention, the polymer pad 17 is made of polyetheretherketone (PEEK). However, it will be appreciated that other polymer materials are also suitable for the hydrostatic bearings 11, 12, such as PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. Also,

while the preferred embodiments of the invention have been described as employing oil as the lubricating fluid, other lubricating fluids can be used such as water.

~~[00133]~~[00132] It will be appreciated by a person skilled in the art that the hydrostatic bearings of the preferred embodiments of the invention can be readily retrofitted into existing bearing assemblies, and thus do not require the replacement of each bearing in a milling apparatus.

~~[00134]~~[00133] While the preferred embodiments of the invention have been described using one of two possible fastener arrangements as illustrated in Figures 11, 11A, 12 and 12A, it will be appreciated that other fastener type arrangements may be used to implement the invention. For example, in one preferred form the fasteners are substantially retained within the recesses 18 by a locking element. The locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

~~[00135]~~[00134] In another embodiment, the outer (bearing) surface of the polymer bearing pad comprises two co-planar surfaces at 45° to each other. In this embodiment, the polymer bearing pad acts as both a linear and axial bearing pad simultaneously, similar to a lathe bed bearing.

~~[00136]~~[00135] It will further be appreciated that any of the features in the preferred embodiments of the invention can be combined together and are not necessarily applied in isolation from each other. For example, the chamfer 37 could be readily applied to the outermost polymer slats 81 in the slipper bearing to provide the advantages of reducing oil loss and elimination of oil pressure accumulators.

~~[00137]~~[00136] Also, while the preferred embodiment of the invention have been described in relation to hydrostatic bearings in general, it will be appreciated that each of the aspects of the invention and the corresponding preferred features are also applicable to other types of fluid bearings, such as hydrodynamic bearings and hybrid bearings that use a combination of hydrodynamic and a continuous hydrostatic flow for lubrication.

~~[00138]~~[00137] By providing a polymer bearing pad for a hydrostatic bearing in a bearing assembly, the invention confers numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads. The polymer bearing pads 17 reduces or eliminates damage to the journal and the base of the hydrostatic bearing, thus increasing product life and reducing the frequency of maintenance and repair. Moreover, the polymer pads 17 are easily replaceable, enabling easy installation and removal for repair. This advantage is facilitated by the use of the mounting portion 8, flange 9 and a mechanical fastening system to mount the polymer pad 17 to the base 14.

~~[00139]~~[00138] Also, the polymer pads 17 do not require tight machining tolerances, can conform to the profile of the journal, have reduced lubrication rates enabling the use of

less oil, resistant to damage caused by the loss of oil or contaminants, and dampen any excessive shock forces, protecting the journal bearing surface. These advantages permits the operation of the hydrostatic bearings of the preferred embodiments of the invention at lower oil film thicknesses, thus reducing oil consumption, permitting the use of smaller and cheaper lubrication systems and more efficient power consumption and conserving the use of oil.

~~[00140]~~[00139] Also, the use of chamfer in hydrostatic bearings in general obviates the need for expensive accumulator systems that are difficult to operate and maintain. Furthermore, the chamfer conserves the use of oil and thus reduces oil consumption. Furthermore, since the base is of a standard design, the hydrostatic bearings of the invention can be readily retrofitted to existing mills. In all these respects, the invention represents a practical and commercially significant improvement over the prior art.

~~[00141]~~[00140] Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

Abstract

The present invention provides improvements to a fluid bearing (11, 12) for a journal (4), one being a polymer bearing pad (17) comprising an outer surface (13), at least one recess (18) for receiving lubricating fluid from a base (14) of said fluid bearing and distributing said lubricating fluid to said outer surface and a mounting means (8, 18A) for securely mounting said polymer bearing pad to said base. Other improvements include a fluid bearing (11, 12) comprising the polymer bearing pad (17), methods of making the polymer bearing pad and fluid bearing, a fluid bearing comprising a polymer bearing pad (17) having a chamfer (37) and a multidirectional fluid bearing (70).

Improvements in fluid bearings

Field of the Invention

[0001] The present invention relates to a fluid bearing and in a particular a hydrostatic polymeric bearing for use in a mill. The invention has been developed primarily for use as a hydrostatic polymeric bearing in grinding mills and will be described hereinafter by reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use, but also extends to other types of fluid bearings such as hydrodynamic bearings and hybrid bearings (i.e. bearings that use a combination of hydrodynamic and continuous hydrostatic flow for lubrication).

Background of the Invention

[0002] The following discussion of the prior art is intended to present the invention in an appropriate technical context and allow its advantages to be properly appreciated. Unless clearly indicated to the contrary, however, reference to any prior art in this specification should not be construed as an express or implied admission that such art is widely known or forms part of common general knowledge in the field.

[0003] A grinding mill has a mill chamber and two journal shafts, the journals being mounted upon supports for rotation. Typical bearings have two main components; a steel base for mounting to the support and a bearing pad or surface for contact with the mill journal. These mill bearings are installed between the mill journals and the supports so that the mill journals rotate on the bearing pads during operation of the grinding mill.

[0004] The applicant developed a hydrostatic pad bearing system for grinding mills that is currently in use. In this hydrostatic pad bearing system, an external oil supply system pumps high-pressure oil to recesses machined into the bearing so that the oil forms a thin film on the bearing pad surface. The resultant hydraulic pressure is sufficient to completely lift the mill journal off the hydrostatic pads and separate the sliding surfaces. Thus, mill actually "floats" on a film of oil between journal and bearing. As such the bearing will operate under both static and dynamic conditions. Since the surfaces are completely separated and the bearing is self aligning there is no metal-to-metal contact between the bearing surface and the mill journal due to the oil film, thus resulting in only low friction. Consequently, maintaining the oil film between the surfaces means that there is virtually no wear in the bearing.

[0005] Despite the advantages conferred by this hydrostatic bearing system, a loss of oil pressure (and thus a reduction in the oil film thickness) can cause failure of the bearings, leading to damage to the bearing pad and/or the mill journal. For example, it can take a few seconds for a grinding mill to stop turning in the event of a power failure, and when this happens there is a high risk of damage to the mill bearing pads or journal surfaces due to a loss of oil reducing the oil film thickness, thereby bringing the journal and bearings into direct metal to metal contact. The consequential downtime for replacement of any damaged bearings and/or journals severely impairs operation of the mill, reducing its efficiency.

[0006] To prevent this type of damage, grinding mill lubrication systems usually have pressure accumulator systems that are typically used to store and deliver high pressure oil to the bearing in the event of a power failure and the oil supply system fails. These pressure accumulators are expensive, require frequent maintenance to ensure that they are at the appropriate pressure level and can interfere with control systems in the mill. Thus, there are increased operational and maintenance costs of the mill.

[0007] Typically, to manufacture hydrostatic bearings, the recesses are machined into the steel base and then the oil supply ports for delivering high pressure oil to the recesses are then drilled into the base. Bronze is spray welded or cast onto the relevant parts of the steel base to form the bearing pad or lining. Spray welding enables the bronze metal to form a seal with the base. White metal may be used instead of bronze, but is cast onto the base. Due to this manufacturing process, the repair and/or refurbishment of these bearings involves initially cleaning the damaged bearing surface, machining any parts of the steel base and either spray welding the bronze or re-casting the bronze/white metal. This repair process cannot be performed on-site but requires the bearing to be returned to the manufacturer. Consequently, mills must keep a sufficient stock of spare bearings to account for the absence of damaged bearings being repaired. This adds to the maintenance costs of the mill.

[0008] It is an object of the present invention to overcome or substantially ameliorate one or more of the disadvantages of prior art, or at least to provide a useful alternative.

[0009] It is an object of the invention in at least one preferred form to provide improved fluid bearings for mills that are more tolerant to the loss of oil film, distortions in the journal, require less strict manufacturing tolerances, can be easily repaired, minimise waste and reduce or eliminate the need for pressure accumulators, and a method for making such fluid bearings.

[0010] Summary of the Invention

[0011] According to a first aspect of the invention, there is provided a bearing assembly for supporting a journal of a grinding mill body, comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a polymer bearing pad mounted to a base,

said polymer bearing pad comprising an outer surface, at least one recess for receiving lubricating fluid from at least one passage of said base and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad to said base, said base also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage, wherein said base is mounted to said frame so that said fluid bearings self adjust to changes in the angular position of the journal during operation of said grinding mill body.

[0012] A second aspect of the present invention provides a bearing assembly for supporting a journal of a grinding mill body, comprising a frame and a plurality of fluid bearings, said fluid bearings each comprising a polymer bearing pad mounted to a base, said polymer bearing pad comprising an outer surface, at least one recess for receiving lubricating fluid from at least one passage of said base and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad to said base, said base also comprising at least one lubricating fluid supply port in fluid communication with said at least one passage, wherein said base is fixedly mounted to said frame.

[0013] Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising", and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

[0014] As used herein, unless otherwise specified the use of the ordinal adjectives "first", "second", "third", etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0015] Preferably, said mounting means comprises a mounting portion extending from said polymer bearing pad. More preferably, said mounting portion comprises a protrusion from a mounting surface opposite to said outer surface for engaging a flange of said base. In one preferred form, said mounting surface comprises an inner surface of said polymer bearing pad. In another preferred form, said inner surface is the underside of said polymer bearing pad.

[0016] Alternatively or additionally, said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer bearing pad to said base. More preferably, said at least one recess has a locking tab for retaining a head portion of said fastener within said at least one recess.

[0017] Preferably, said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

[0018] Preferably, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said base.

[0019] Preferably, said outer surface is partially curved. Alternatively, said outer surface is substantially planar.

[0020] Preferably, said polymer bearing pad comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said polymer bearing pad comprises two chamfers at opposing outer edges. In one preferred form, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In a particularly preferred form, said chamfer is inclined approximately 8° from said tangent.

[0021] Preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer bearing pad.

[0022] Preferably, said polymer bearing pad comprises at least one complementary connecting portion for connecting said polymer bearing pad to an adjacent polymer bearing pad. In a particularly preferred form, said polymer pad has at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of said adjacent polymer bearing pad.

[0023] Preferably, said polymer bearing pad is made from any suitable polymer, including, but not limited to, polyetheretherketone (PEEK), PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the polymer pad is made of PEEK.

[0024] Preferably, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage.

[0025] Preferably, said base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base. More preferably, said at least one flange is located at an outer edge of said base. In one preferred form, said base comprises two of said flanges located at opposing outer edges of said base.

[0026] Preferably, said fluid bearing comprises at least one fastener for mounting said polymer bearing pad to said base. More preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said bore conveys lubricating fluid from said at least one passage to said interconnecting passage.

[0027] Preferably, said fluid bearing is a hydrostatic bearing. More preferably, said outer surface is partially curved such that said fluid bearing acts as a radial hydrostatic bearing. In one preferred form, said fluid bearing is a self-aligning radial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted radial hydrostatic bearing. In a further preferred form, said fluid bearing is a hydrostatic slipper bearing.

[0028] Alternatively, said outer surface is substantially planar such that said fluid bearing acts as an axial bearing. In one preferred form, said fluid bearing is a self-aligning axial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted axial hydrostatic bearing.

[0029] Preferably, said at least one fastener is partially received in said at least one passage. Preferably, said at least one fastener comprises a head portion for engagement with said at least one recess. More preferably, said at least one recess has a locking tab for retaining said head portion within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

[0030] Alternatively, said fluid bearing comprises a plug for engagement with said head portion and said at least one recess to retain said at least one fastener. In one preferred form, said at least one fastener is countersunk into said at least one recess.

[0031] Preferably, said at least one fastener is substantially retained within said at least one recess by a locking element. More preferably, said locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

[0032] Preferably, the fluid bearing comprises a plurality of said polymer pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

[0033] Preferably, said polymer pads are connected together. More preferably, each of said polymer pads has at least one complementary connecting portion for connecting said polymer pad to an adjacent polymer pad. In one preferred form, each of said polymer pads has at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0034] Preferably, said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

a first of said polymer bearing pads is mountable to said first surface and a second of said polymer bearing pads is mountable to said second surface,

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

[0035] Preferably, said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer bearing pad acts as a self-aligning radial hydrostatic bearing.

[0036] Preferably, said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing. In one preferred form, said second polymer bearing pad acts as a fixedly mounted axial hydrostatic bearing.

[0037] Preferably, said first surface is orthogonal to said second surface. In one preferred form, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0038] There is disclosed a method of making a polymer bearing pad for a fluid bearing, comprising forming a polymer pad having an outer surface, forming at least one recess in said polymer pad for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface, and forming a mounting means on said polymer pad for securely mounting said polymer pad to said base.

[0039] Preferably, said mounting means forming step comprises forming a mounting portion to extend from said polymer pad. More preferably, said mounting portion forming step comprises machining said polymer pad to form said mounting portion. Alternatively, said mounting portion forming step comprises placing said polymer pad in a mould to form said mounting portion. Alternatively or additionally, said mounting means forming step comprises forming an opening in said at least one recess for receiving at least one fastener. More preferably, said opening is drilled, punched, cut or machined into said at least one recess.

[0040] Preferably, said at least one recess forming step comprises machining said at least one recess in said polymer pad. More preferably, said at least one recess forming step comprises machining at least one interconnecting passage to interconnect said at least one recess to said base.

[0041] Preferably, said method further comprises chamfering an outer edge of said polymer pad. In one preferred form, said chamfering step comprises chamfering two opposing outer edges of said polymer pad.

[0042] Also disclosed is a method of making a fluid bearing for a journal, comprising the steps of:

providing a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port;

forming a polymer pad having an outer surface and at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to said outer surface, and

mounting said polymer bearing pad to said base.

[0043] Preferably, said method comprises each of the preferred steps in the abovementioned third aspect of the invention. In this aspect, said forming step further comprises machining at least one interconnecting passage to interconnect said at least one recess to said passage.

[0044] Preferably, said mounting step comprising mechanically fastening said polymer bearing pad to said base. More preferably, the method further comprises the steps of using a fastener to mechanically fasten said polymer bearing pad to said base and forming a bore in said at least one fastener for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said mounting step comprises bolting said polymer pads to said base.

[0045] Preferably, where there are a plurality of said polymer pads, said method further comprises the step of connecting said polymer bearing pads such that said outer surfaces of said polymer bearing pads form a substantially uniform bearing surface for said journal. More preferably, said forming step further comprises the step of forming at least one connecting portion in each said polymer bearing pad for connecting said polymer pad to an adjacent polymer bearing pad. In one preferred form, said forming step comprises forming at least one lateral connecting portion in each said polymer bearing pad for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0046] Preferably, said method further comprises selecting one or more polymer bearing pads for mounting at the outer edges of said base and chamfering an outer edge of each selected polymer bearing pad.

[0047] Where said fluid bearing is a radial hydrostatic bearing, each of said polymer pads have curved outer surfaces such that said outer surfaces define a substantially curved uniform bearing surface.

[0048] Also further disclosed is a fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a polymer bearing pad having at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to an outer surface of said bearing pad,

said polymer bearing pad being mountable to said base and further comprising a chamfer at an outer edge for retaining said lubricating fluid thereon and transferring said lubricating fluid to said journal.

[0049] Preferably, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In one preferred form, said chamfer is inclined approximately 8° from a tangent of an edge of said outer surface.

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[0050] Preferably, said chamfer has an outer edge that is displaced from said journal when said journal engages said polymer bearing pad.

[0051] Preferably, the polymer bearing pad is composed of a polymer material that includes, but is not limited to, PEEK, PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the bearing pad is composed of polyetheretherketone (PEEK).

[0052] Preferably, said fluid bearing is a hydrostatic bearing.

[0053] According to a third aspect of the invention, there is provided a multidirectional fluid bearing for a journal, comprising:

a base having a first surface orthogonal to a second surface, at least one lubricating fluid supply port and a plurality of passages in fluid communication with said at least one lubricating fluid supply port, said first surface and said second surface,

a first polymer pad mountable to said first surface, said polymer pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer pad mountable to said second surface, said polymer pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

[0054] Preferably, said first polymer bearing pad substantially covers said first surface and said second polymer bearing pad substantially covers said second surface to respectively create fluid seals between said first and second polymer bearing pads and said base.

[0055] Preferably, at least one of said first and second polymer bearing pads comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said at least one polymer bearing pad.

[0056] Preferably, at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base. More preferably, said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

[0057] Preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess, said at least one fastener being partially received in said at least one passage.

[0058] Preferably, at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one

polymer bearing pad to said base. Preferably, said at least one polymer bearing pad comprises a locking element for retaining said at least one fastener within said at least one recess.

[0059] Preferably, there is a plurality of at least one of said first and second polymer bearing pads, wherein said respective outer surfaces of said plurality of at least one of said first and second polymer pads form a substantially uniform bearing surface for said journal. More preferably, each of said plurality of at least one of said first and second polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0060] Preferably, said first outer surface is partially curved such that said first polymer pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer pad acts as a self-aligning radial hydrostatic bearing.

[0061] Preferably, said second outer surface is substantially planar such that said second polymer pad acts as an axial bearing. In one preferred form, said second polymer pad acts as a fixedly mounted axial hydrostatic bearing.

[0062] Preferably,, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0063] Preferably, said first polymer bearing pad and said second polymer bearing pad have the preferred features of the abovementioned aspects of the invention.

[0064] Preferably, said lubricating fluid includes oil or water.

Brief Description of the Drawings

[0065] Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0066] Figure 1 is a cross-sectional side view of a grinding mill for receiving a hydrostatic bearing according to a first embodiment of the invention;

[0067] Figure 2 is a perspective view of a bearing assembly in the mill of Figure 1;

[0068] Figure 3 is a front view of the bearing assembly of Figure 2;

[0069] Figure 4 is a schematic plan view of a radial hydrostatic bearing for the bearing assembly of Figure 3;

[0070] Figure 5 is a cross-sectional view of the radial hydrostatic bearing along section A-A of Figure 4;

[0071] Figure 5A is a expanded partial cross-sectional view of the chamfer of the radial hydrostatic bearing of Figure 4;

[0072] Figure 6 is a cross-sectional view of the radial hydrostatic bearing taken along section B-B of Figure 4;

[0073] Figure 7 is a schematic plan view of the base of the radial hydrostatic bearing of Figure 4;

[0074] Figure 8 is a schematic cross-sectional view of the base of Figure 7;

[0075] Figure 9 is a schematic cross-sectional view of an axial hydrostatic bearing for the bearing assembly of Figure 3;

[0076] Figure 10 is a schematic plan view of the axial hydrostatic bearing of Figure 9;

[0077] Figures 11 and 11A are schematic partial views of a fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0078] Figure 12 and 12A are schematic partial views of an alternative fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0079] Figure 13 is a schematic partial view of the chamfer of Figure 5A;

[0080] Figure 14 is a schematic cross-sectional view of a prior art hydrostatic bearing;

[0081] Figure 15 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with another embodiment of the invention;

[0082] Figures 16 and 16A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0083] Figures 17 and 17A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0084] Figures 18 and 18A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0085] Figure 19 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0086] Figure 20 is a schematic partial cross-sectional view of an axial hydrostatic bearing according to a further embodiment of the invention;

[0087] Figure 21 is a schematic partial expanded view of the axial hydrostatic bearing of Figure 20;

[0088] Figure 22 is a schematic side view of the axial hydrostatic bearing of Figure 20;

[0089] Figure 23 is a schematic plan view of a hydrostatic bearing in accordance with a further embodiment of the invention;

[0090] Figure 24 is a schematic end view of the hydrostatic bearing of Figure 23;

[0091] Figure 25 is a schematic side view of the hydrostatic bearing of Figure 23, and

[0092] Figure 26 is a schematic perspective view of a hydrostatic bearing in accordance with a further embodiment of the invention.

Preferred Embodiments of the Invention

[0093] Referring to Figure 1, a typical grinding mill 1 comprises a milling chamber or body 2 rotatably mounted on supports 3 via journal shafts 4 and bearing assemblies 5. The mill body 2 has an inlet 6 for introducing a charge for grinding and a discharge outlet 7 for removing the processed charge from the mill 1.

[0094] As best shown in Figures 2 and 3, each bearing assembly 5 has a frame 10 and a plurality of fluid bearings in the form of radial hydrostatic bearings 11 and axial hydrostatic bearings 12, which are designed to transport a lubricating fluid in the form of a high pressure oil to an outer surface 13A, 13B of each bearing 11, 12.

[0095] Referring to Figures 4 to 8, where corresponding features have been given the same reference numerals, each radial hydrostatic bearing 11 comprise a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. The hydrostatic bearings 11, 12 are self-aligning in that the hydrostatic bearings self-adjust to any changes in the angular position of the journals 4 during operation of the mill 1. This is typically achieved by having the base 14 mounted on a spherical seat (not shown) to permit self-adjustment to any angular movement of the journals 4. The base 14 is composed of cast iron, but can be made of any other suitable metal or material.

[0096] A polymer pad 17 is mountable to the base 14 of each radial hydrostatic bearing 11 via a mounting portion 8 extending from the polymer pad. In this embodiment, the mounting portion 8 is a protrusion extending from a mounting surface opposite the outer surface 13A to engage flanges 9 located at respective outer edges or sides of the base 14. Generally, the mounting surface will be an inner surface or the underside of the polymer pad 17, but in other embodiments can be located elsewhere. Likewise, the flanges 9 need not be located at opposing outer edges of the base 14, but can be arranged in any manner that would act to hold captive the bearing pad 17, such as the flanges 9 being located closer to the centre of the base 14 rather than at the outer edges or the flanges 9 being opposed herringbone flanges positioned on the base 14 between which the mounting portions 8 are constrained.

[0097] The polymer bearing pad 17 has at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13A to act as a lubricating fluid between the radial hydrostatic bearing 11 and the journal shafts 4. In the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19. Also, the radial hydrostatic bearings 11 have a plurality of oil supply ports 15, oil galleries 16, recesses 18 and interconnecting passages 19.

[0098] The outer surface 13A of the polymer pad 17 of the radial hydrostatic bearings 11, 12 is curved to receive the curved bearing surface 20 of the journal 4, as best shown in Figures 1, 9, 11 and 11A. Thus, the outer surface 13A of the polymer pad 17 forms a bearing surface, and hence the polymer pad is a bearing pad for the bearings 11 when assembled with the base 14.

[0099] Referring to Figures 9 and 10, where corresponding features have been given the same reference numerals, each of the axial hydrostatic bearings 12 also comprises a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. A polymer pad 17 is mountable to the base 14 of each axial hydrostatic bearing 12, the polymer pad 17 having at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13B to act as a lubricating fluid between the axial hydrostatic bearings 12 and the journal shafts 4. Again, in the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19 in the polymer pad 17. In addition, the axial hydrostatic bearings 12 have a plurality of oil galleries 16 in the base 14, and recesses 18 and interconnecting passages 19 in the polymer pad 17.

[00100] Also, the outer surface 13B of the axial hydrostatic bearing 12 is substantially planar as it receives the substantially planar end surface 21 of the journal 4, as best shown in Figure 1. Similarly to outer surface 13A, the outer surface 13B of the polymer pad 17 also forms a bearing surface, and hence the polymer pad is a bearing pad for the bearings 12 when assembled with the base 14.

[00101] In both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 substantially covers the entire outer surface 22 of the base 14 to form a substantially fluid impermeable seal between the base and the polymer pad. Also, the polymer pad 17 is mounted to the base 14 using at least one fastener in the form of bolts 23, as best shown in Figures 5 and 9. The fastening system for both the radial hydrostatic bearing 11 and the axial hydrostatic bearing 12 is described in more detail below.

[00102] The fastening system for mounting the polymer pad 17 to the bases 14 of the radial and axial hydrostatic bearings 11, 12 is illustrated in more detail in Figures 11 and 11A, where corresponding features have been given the same reference numerals. The fastening system comprises one of more bolts 23 that are inserted into corresponding openings 18A that are in fluid communication with the oil galleries 16. Each bolt 23 has a bore in the form of through bore 24 for conveying oil from the oil galleries 16 to the recesses 18 via a discharge port 25, as best shown in Figure 11. Thus, there is no need to provide separate oil passages between the oil galleries 16 in the base 14 and the recesses 18 in the polymer pad 17, unlike conventional bronze/white metal hydrostatic bearings. This reduces the complexity and cost in the manufacture of the hydrostatic polymer bearings. It will be

appreciated that not all the bolts necessarily will have a bore as sometimes more fasteners are required to mount the polymer bearing pad 17 than the number of oil passages to connect the oil galleries 16 to the recesses 18.

[00103] The bolt 23 is inserted into the oil gallery 16 via the opening 18A and has a head portion 26 for engagement with a seat 27 of the recess 18, as best shown in Figure 11A. The bolt 23 engages the recess 18 to ensure that, in the event of the bolt becoming loose, it is held captive within the recess 18. This prevents any loose bolts 23 coming into contact with and damaging the journal 4. A locking tab 28 is also provided for retaining the head portion 26 within the recess 18. In addition, the head portion 26 has a tapered portion 29 to facilitate retention of the bolt 23 within the recess 18 by the locking tab 28.

[00104] Also, the mounting portion 8 of the polymer pad 17 engages the flanges 9 of the base 14 to help lock the polymer pad in place. This ensures that frictional loads generated during the rotation of the journal 4 do not forcibly remove or "wipe" the polymer pad 17 from the base 14, even where the bolts 23 become loose, such that the mounting portion 8 and flanges 9 in effect replace the restraint of the bolts 23 against frictional related lateral loads. This makes for a very simple but reliable arrangement, with a level of redundancy to ensure correct operation even if the bolts 23 become loose.

[00105] Moreover, hydrostatic pressure acts between the journal 4 and the polymer bearing pad 17, while there is atmospheric pressure between the polymer bearing pad and the base 14. This pressure difference during operation of the fluid bearing 11, 12, together with the engagement of the mounting portion 8 and the flange or shoulder 9, acts to hold the polymer bearing pad 17 in place. In practice, the fastening system primarily assists in the initial installation of the polymer bearing pad 17 since there is no pressure between polymer bearing pad and the journal 4. This means that in the event bolts 23 are loose the polymer bearing pad 17 would be free to move or "float" until the hydrostatic pressure at the journal 4 is greater than the atmospheric pressure between polymer bearing pad and the base 14.

[00106] An alternative fastening arrangement is illustrated in Figure 12, where corresponding features have been given the same reference numerals. The fastener takes the form of a countersunk screw 30 having a tapered head portion 31 for engagement with a seat 27 recessed in the polymer pad 17. Due to the screw 30 being countersunk into the base 14 and the polymer pad 17, the head portion 31 is tapered in the reverse direction to the taper of the head portion 26 of the bolt 23. To prevent any screw 30 becoming loose and coming into contact with the journal 4, a plug 32 is used to engage the head portion 31 and a locking tab 28 is used to retain the plug 32, and thus the screw 30, within the seat 27. Oil is delivered to the outer surface 13 through a separate recess in the form of a hole 33 that is connected to a bore 34 located over the same position as the oil gallery 16 in the base 14 below, as best shown in Figure 12A.

[00107] In either fastening arrangement, separate O-rings 36 are fitted to the base 14 to provide a fluid seal preventing oil leaking in between the polymer pad 17 and the base, as best shown in Figures 9, 11, 11A and 12A. The thread into which the bolts 23 also assists in forming a fluid seal between the polymer bearing pad 17 and the base 14. The threads 35 act as plugs to close off holes that are required for machining the oil galleries 16 that direct lubricating fluid into the corner pockets from the central pocket.

[00108] In operation, the radial and axial hydrostatic bearings 11, 12 are installed in the bearing assembly 5 in the positions generally shown in Figure 3 in a manner readily understood by a person skilled in the art. The mill body 2 is then mounted on the bearing assembly 5 via the journals 4. An oil supply system is fluidly connected to the oil supply ports 15 in the base 14 of each radial and axial hydrostatic bearing 11, 12. Typically, the oil is positively pumped to the oil supply ports 15. However, in some variants, the oil need not be supplied by positive displacement pump. In either case, high pressure oil is conveyed from the oil supply ports 15 through the passages 16, bores 23 and interconnecting passages 19 to the recesses 18 and discharge ports 25 and up to the outer surfaces 13A, 13B, as best shown by arrow 39 in Figure 11. The oil collects on the outer surfaces 13A, 13B to create an oil film and lubricate the bearing surfaces 20, 21 of the journals 4.

[00109] Where there is a loss of oil due to a failure in the oil supply system, the polymer pad 17 absorbs most, if not all, of the detrimental effects so any damage is limited to the polymer pad 17 rather than the bearing surfaces 20, 21 of the journal 4 or the base 14. Thus, the base 14 (and its oil galleries 16 and oil supply ports 15) are protected from damage and any damage is suffered by the polymer pad 17. Thus, by having the polymer pad 17 provided with recesses 18 for distributing oil to the outer surface 13, rather than the base 14, the polymer pad can be easily replaced in the event of damage without having to repair the entire bearing. In addition, this advantage is further facilitated by using mechanical fasteners described above to mount the polymer pad 17. Thus, a damaged polymer pad 17 can be removed simply by removing the fasteners 23, 30, enabling easy replacement of the polymer pads 17. Thus, maintenance and operational costs of the mill 1 are reduced, increasing the efficiency of the mill.

[00110] It has also been discovered that providing a polymer pad for the hydrostatic bearings 11, 12 confer numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads, as follows:

(1) It has been discovered that the polymer pad 17 behaves similar to white metal/bronze pads, but is able to self-mould to the journal 4. That is, the polymer pad 17 is able to modify its outer surface 13A, 13B to accommodate circumferential surface imperfections on the bearing surfaces 20, 21 of the journal 4. This reduces or

eliminates the need for tight machining tolerances required for bronze bearings, and can subsequently reduce the associated machining costs. Hence, there is a reduced manufacturing cost for the hydrostatic bearings by using a polymer pad.

(2) The polymer bearing pads 17 enable reduced lubrication rates to be used over traditional bronze bearing pads due to the running in characteristics of polymer material, thus conserving lubricating fluid. However, where necessary or desirable, the polymer pads 17 operate equally well at the same lubrication rates used for conventional bronze/white metal bearing pads.

(3) The hydrostatic polymer bearing pads 17 have a lower modulus of elasticity, and thus are able to create a "hovercraft" type cushion around the perimeter of the polymer pad. This acts to accommodate journal imperfections whilst maintaining pressure, much like the cushioning effect produced when a hovercraft moves over bumpy ground.

(4) The hydrostatic polymer bearing pads 17 are much more tolerant than traditional materials to a loss of oil to the bearing 11,12, to contact between journal 4 and outer surface 13A, 13B, and to deformations in the journal bearing surfaces 20, 21. Thus, a loss of oil film due to oil viscosity being too low (from such causes as a high temperature or oil degradation) can be more tolerably managed by the polymer pad 17.

(5) The polymer is elastic, unlike bronze, and is significantly softer than bronze. Thus, the elastic nature of the polymer pads 17 dampen excessive forces that are applied to the hydrostatic bearings 11, 12. For example, where there is a loss of oil through a shock load placed on the hydrostatic bearing 11, 12 there is little or no risk of damage to the metal journal 4 because the polymer pad 17 dampens the shock to some extent and any damage sustained is suffered by the polymer pad rather than the journal. By way of contrast, with white metal/bronze bearings there is a significant risk of damage to metal journals, resulting in on-site machining and costly stoppages. This advantage of the elasticity of the polymer bearing pads also extends to white metal bearing pads, which are brittle and so are more easily damaged when subjected to typical shock loads.

(6) Any contaminants in the oil that would normally damage the bearing surfaces of the journal 4 or a standard bearing pad tend to be embedded into the polymer pad 17 without adversely affecting operation of the hydrostatic bearing 11, 12.

(7) The self-moulding property of the polymer pads 17 means that the outer surfaces 13A, 13B of the polymer pads tend to conform to the profile of the bearing surface 21 of the journal 4 that it is running against. As a consequence, the polymer pads 17 (and hence bearing 11) do not necessarily require a self-alignment mechanism (such as a spherical seat) within certain limits, unlike conventional bearings. It is also contemplated that the self-moulding property also permits the design and installation of hydrostatic bearings that ordinarily would be outside of the capacity of conventional bearings, since the polymer pad 17 can provide some degree of self-alignment in addition to a conventional self-alignment mechanism.

[00111] These advantages of the polymer pad 17 means that the hydrostatic bearings can be operated at lower oil film thicknesses. This has a flow on effect, permitting the use of smaller and cheaper lubrication systems, reducing power consumption and conserving the use of oil. Also, in the event of operational problems damage to the journals 4 and polymer bearing pads 17 is significantly reduced, increasing product life and reducing the frequency of maintenance and repair. Furthermore, any damage is limited to the polymer bearing pads 17 and does not adversely affect operation of the journal 4. Finally, the complex and expensive accumulator systems can be removed, saving installation costs and eliminating their associated maintenance costs.

[00112] Referring now to Figures 5A, 9 and 13, another aspect of the invention is described, where corresponding features have been given the same reference numerals. In this aspect of the invention, a chamfer is provided at an outer edge of a bearing pad for retaining lubricating fluid on the chamfer, thus enabling recycling of lubricating fluid in the bearing. In applying this aspect of the invention to both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 has a chamfer 37 at both outer edges 38 for retaining oil on the chamfer, as best shown in Figures 5A, 9 and 13. The chamfer 37 creates a lead-in and lead-out for the oil, especially when residual oil on the outer surfaces 13A, 13B must be relied upon for lubrication in the event of an unexpected loss of normal oil supply to the bearings 11, 12. The chamfer 37 inhibits or prevents oil being wiped off the journal 4, as would occur with a bearing having a sharp straight edge. Thus, the chamfer 37 helps to ensure that there is a residual amount of oil between the polymer pad 17 and the metal journal 4.

[00113] In a conventional bearing, the straight edge would wipe off oil from the journal and thus increase the loss of oil from the bearing. By way of contrast, in this aspect of the invention, the chamfer 37 provides a capture point for the oil that may be lost during operation. As the journal 4 rotates on the hydrostatic bearing 11, 12 the "lead-in" chamfer 37 enables the bearing surface 20 of the journal 4 to capture oil from the chamfer 37 and thus is

lubricated before coming into contact with the outer surface 13A, 13B of the hydrostatic bearing. The inventors believe that the oil held by the "lead-in" chamfer 37 is recaptured by the journal 4 due to a hydrodynamic effect produced by its rotation. When the bearing surface 20 of the journal 4 leaves the outer surface 13A, 13B of the hydrostatic bearing, the "lead-out" chamfer 37 on the other side of the hydrostatic bearing 11, 12 feeds any discharging oil from the outer surface 13A, 13B onto the journal to provide a consistent oil thickness over the journal, thus maintaining its lubrication. The provision of chamfers 37 at each outer edge 38 enables the mill journal 4 to be operated in either rotational direction. As a consequence, the use of the chamfers 37 minimises the loss of oil and effectively removes the need to provide oil pressure accumulators with their associated high maintenance and installation costs. Therefore, the chamfers 37 provide the radial and axial hydrostatic bearings 11, 12 provide a cost effective solution and safety measure for the hydrostatic bearings.

[00114] The chamfer 37 is inclined approximately at an angle α to the outer surface 13A, 13B. In the case of the radial hydrostatic bearing 11, the angle α is defined relative to a tangent 39 from the curved outer surface 13A, as best shown in Figure 13. In the case of the axial hydrostatic bearing 12, the angle α is defined relative to the horizontal plane of the planar outer surface 13B. In either case, the angle α is in the range of 0.01° to 89°, and is preferably 8°.

[00115] In addition, the chamfer 37 has an outer edge 40 that is displaced from the journal 4 when the journal engages the polymer pad 17. In both the radial and axial hydrostatic bearings 11, 12 the outer edge 40 of the chamfer 27 is displaced approximately 0.5mm to 1.5 mm from the journal 4. The displacement β is preferably displaced by approximately 0.85 mm from the journal 4.

[00116] It will be appreciated by a person skilled in the art that the chamfer 37 could also be applied to existing bronze/white metal hydrostatic bearings and is not limited to hydrostatic bearings having a polymer pad.

[00117] Referring now to Figures 14 to 19, various methods of making the polymer pads 17 and the hydrostatic bearings 11, 12 of Figures 4 to 10 are illustrated, where corresponding features have been given the same reference numerals. As best shown in Figure 14, manufacturing the curved surface for a radial hydrostatic bearing involves removing the hatched area 41 from the material. This waste material can be a significant, especially on larger bearings, and contributes to unnecessary additional manufacturing costs. Furthermore, the manufacturing process is not environmentally sustainable.

[00118] With the hydrostatic bearings of Figures 4 to 10, polymer material can be purchased "off the shelf" in sheet form and subsequently formed to produce the polymer pads 17. One method involves heating the polymer material to a holding temperature which

does not melt the material, but the polymer retains some structural integrity while having some malleability or pliability to be able to be formed. There are various procedures that can be used to heat and form the polymer readily understood by the person skilled in the art.

[00119] In one example, the polymer can be placed in a shaped former or mould and lightly clamped. The former or mould is then heated to an intermediate temperature, removed from oven, fully clamped and returned to the oven. After heating to a holding temperature, the former is held for a set period of time, removed from oven and allowed to cool.

[00120] In another example, the polymer is placed in a shaped former and clamped using springs or a dead weight. The former is heated to the holding temperature and kept at this temperature for a set period of time. After being allowed to cool, the polymer is removed from the former.

[00121] In a further example, the polymer sheet is heated to the holding temperature for set period of time to ensure uniform heating of material. The polymer is then removed from the heat, immediately placed in cold former and pressed to profile. In the case of a radial hydrostatic bearing 11, the former also creates the curved outer surface 13A. After being allowed to cool, the polymer pad 17 is removed from the former.

[00122] After assuming the required shape for the hydrostatic bearing 11, 12, the recesses 18 and interconnecting passages 19 are machined into the outer surface 13A, 13B of the polymer pad 17. Also, the chamfer 37 is machined at the same time. The mounting portion 8 is machined, either before or after machining of the recesses 18, interconnecting passages 19 and the chamfer 37. Alternatively, the mounting portion 8 is formed during the initial moulding of the polymer sheet. The openings 18A can also be formed either during the initial moulding or by drilling, punching, cutting or machining the polymer pad 17. The machined polymer pad 17 is then mechanically mounted to the base 14 using the fastener systems described above to complete assembly of the hydrostatic bearing 11, 12.

[00123] Referring now to Figures 15 to 16, another method of making the hydrostatic bearings is illustrated, where corresponding features have been given the same reference numerals. This method involves making a plurality of polymer pads in the form of slats 50 each having outer surfaces 51 that form a substantially uniform bearing surface 52 for the journal 4, as best shown in Figure 15. The slats 50 are produced using the same heating and forming method described above, and then fastened to the base 14 using either of the fastener systems as described in relation to Figures 4 to 10. As best shown in Figure 15, the resultant amount of removed material indicated by hatched area 53 is considerably less than the amount of material removed in a conventional bearing indicated by hatched area 41.

[00124] Also, the polymer pad 17 can be divided into any number of smaller polymer pads or slats 50 of any shape and/or size, as required. For example, there could be six polymeric

slats 50 that are rectangular and uniform in shape but have differently shaped recesses, as best shown in Figures 16, 16A, 17 and 17A. Similarly, the polymeric slats 50 could be larger in size, as best shown in Figures 18 and 18A.

[00125] In a further variation to this method, the polymeric slats 55 each have complementary connecting portions 56 to connect with an adjacent polymer pad 55, as best shown in Figure 19. The complementary connecting portions in this variation take the form of teeth 56 that are splayed together so that the slats 55 form a complete polymer pad 17. The polymer pads 55 are then mounted to the base 14 using either of the fastener systems as described in relation to Figures 4 to 10. Once in position, glue may be applied at adjacent surfaces of the polymer slats and their teeth 56 to enhance sealing. Then, the polymer slats 55 are clamped and heated to cure the adhesive joint. The joint formed by the connecting teeth 56 is such that the weight of mill journal 4 on the polymeric slats 55 works to ensure the joint is always in compression. It has been found by testing such bearings that they are strong enough as a bearing surface for the journal 4. It will be appreciated that other profiles for the connecting portions 56 can be used, such as tabs and detents of any polygonal shape.

[00126] The inventors believe that segmenting the surface area of the polymer pad 17 into individual polymer pads or slats 50reduces the amount of wastage involved with machining standard bearings, as indicated in area 41 of Figure 14, and provides a suitable supplementary option to heating and forming the entire polymer pad 17 as described above.

[00127] While the hydrostatic bearings 11, 12 have been described in the context of self-aligning hydrostatic bearings, it will be appreciated that the various aspects of the invention are also equally applicable to fixedly mounted hydrostatic bearings. Referring now to Figures 20 to 22, one example of a fixedly mounted hydrostatic bearing 60 is illustrated, where corresponding features have been given the same reference numerals. In this embodiment, the fixedly mounted hydrostatic bearing is an axial hydrostatic bearing 60 comprises a polymer pad 17 mounted on a base 14, which is fixedly mounted to mounting plate 61 via fasteners 62. Due to the polymeric nature of the polymer bearing pad 17, the outer surface 13B of the polymer pad will conform to the profile of the bearing surface 21 of the journal 4 that it is running against. This means that the axial hydrostatic bearing can provide some degree of self-alignment, if necessary, which is not possible in a conventional axial hydrostatic bearing. Aside from the manner of its mounting, the axial hydrostatic bearing 60 operates in substantially same manner as the self-aligning axial hydrostatic bearing 12 described above. Furthermore, while this embodiment concerns as axial hydrostatic bearing, it is also applicable to a fixedly mounted radial hydrostatic bearing.

[00128] Referring now to Figures 23 to 25, a fluid bearing 70 according to another aspect of the invention is illustrated, where corresponding features have been given the same

reference numerals. The fluid bearing 70 is a hydrostatic bearing that is a combination of the radial and axial hydrostatic bearings 11, 12, 60 described above. The base 71 has been adapted to receive both a polymer pad 17A having a radial or curved outer surface 13A mounted on its outer surface 72 and two polymer pads 17B having a substantially planar outer surface 13B mounted on opposing side surfaces 73 that are orthogonal to the outer surface 72. Thus, the combination hydrostatic bearing 70 acts as a self-aligning radial hydrostatic bearing 11 in one direction and as two fixedly mounted axial hydrostatic bearings 60 in two other directions, as best shown in Figure 25. Again, due to the polymer's characteristics the outer surfaces 13B of the polymer pads 17B with conform to the profile of the bearing surface 21 of the journal 4 that it is running against. Thus, there is no need for a separate base for the axial hydrostatic bearings. The inventors contemplate that this combination hydrostatic bearing 70 avoids the need to install three separate hydrostatic bearings and thus allows for ease of installation in the mill 1. Due to the easy replacement of the polymer pads 17A, 17B, there is no need to remove the base 71 in the event one or more of the polymer pads 17A, 17B are damaged during operation of the mill 1. Thus, the combination hydrostatic bearing 70 creates cost savings in installation and repair.

[00129] The inventors also contemplate that the combination bearing 70 can be modified so as to minimise or eliminate the "axial float". Axial float is the difference between the distance between axial bearing pads and the distance between axial journal faces. Axial float is generally required so that the axial hydrostatic bearings are not tightly fitted with the mill journal 4. Typically, this axial float is set to around 0.5 to 1mm, meaning that the mill journal is able to freely float in the axial direction by this 0.5 to 1mm. A potential advantage of this combination bearing 70 is that the amount of axial float can be reduced or eliminated, since one of the axial bearings on the combination bearing 70 can be configured to move axially on a piston which is supplied by pressurised oil. This effectively ensures that axial float is minimised or removed.

[00130] In other embodiments, the hydrostatic bearing takes the form of a slipper bearing 80, as best shown in Figure 26. Due to the larger size of the bearing pad for a slipper bearing and its 120° curvature, it could be difficult to mould a single polymer pad 17. Thus, segmenting the bearing pad surface into multiple polymer pads or slats 81 having curved outer surfaces and laterally connected together enables the invention to be used for a slipper bearing. The lateral connections can be formed as described in relation to Figure 19. Thus, the advantages of the polymer pad 17 can be extended to a slipper bearing.

[00131] In the preferred embodiments of the invention, the polymer pad 17 is made of polyetheretherketone (PEEK). However, it will be appreciated that other polymer materials are also suitable for the hydrostatic bearings 11, 12, such as PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. Also, while the

preferred embodiments of the invention have been described as employing oil as the lubricating fluid, other lubricating fluids can be used such as water.

[00132] It will be appreciated by a person skilled in the art that the hydrostatic bearings of the preferred embodiments of the invention can be readily retrofitted into existing bearing assemblies, and thus do not require the replacement of each bearing in a milling apparatus.

[00133] While the preferred embodiments of the invention have been described using one of two possible fastener arrangements as illustrated in Figures 11, 11A, 12 and 12A, it will be appreciated that other fastener type arrangements may be used to implement the invention. For example, in one preferred form the fasteners are substantially retained within the recesses 18 by a locking element. The locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

[00134] In another embodiment, the outer (bearing) surface of the polymer bearing pad comprises two co-planar surfaces at 45° to each other. In this embodiment, the polymer bearing pad acts as both a linear and axial bearing pad simultaneously, similar to a lathe bed bearing.

[00135] It will further be appreciated that any of the features in the preferred embodiments of the invention can be combined together and are not necessarily applied in isolation from each other. For example, the chamfer 37 could be readily applied to the outermost polymer slats 81 in the slipper bearing to provide the advantages of reducing oil loss and elimination of oil pressure accumulators.

[00136] Also, while the preferred embodiment of the invention have been described in relation to hydrostatic bearings in general, it will be appreciated that each of the aspects of the invention and the corresponding preferred features are also applicable to other types of fluid bearings, such as hydrodynamic bearings and hybrid bearings that use a combination of hydrodynamic and a continuous hydrostatic flow for lubrication.

[00137] By providing a polymer bearing pad for a hydrostatic bearing in a bearing assembly, the invention confers numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads. The polymer bearing pads 17 reduces or eliminates damage to the journal and the base of the hydrostatic bearing, thus increasing product life and reducing the frequency of maintenance and repair. Moreover, the polymer pads 17 are easily replaceable, enabling easy installation and removal for repair. This advantage is facilitated by the use of the mounting portion 8, flange 9 and a mechanical fastening system to mount the polymer pad 17 to the base 14.

[00138] Also, the polymer pads 17 do not require tight machining tolerances, can conform to the profile of the journal, have reduced lubrication rates enabling the use of less oil, resistant to damage caused by the loss of oil or contaminants, and dampen any excessive

shock forces, protecting the journal bearing surface. These advantages permits the operation of the hydrostatic bearings of the preferred embodiments of the invention at lower oil film thicknesses, thus reducing oil consumption, permitting the use of smaller and cheaper lubrication systems and more efficient power consumption and conserving the use of oil.

[00139] Also, the use of chamfer in hydrostatic bearings in general obviates the need for expensive accumulator systems that are difficult to operate and maintain. Furthermore, the chamfer conserves the use of oil and thus reduces oil consumption. Furthermore, since the base is of a standard design, the hydrostatic bearings of the invention can be readily retrofitted to existing mills. In all these respects, the invention represents a practical and commercially significant improvement over the prior art.

[00140] Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

Abstract

The present invention provides improvements to a fluid bearing (11, 12) for a journal (4), one being a polymer bearing pad (17) comprising an outer surface (13), at least one recess (18) for receiving lubricating fluid from a base (14) of said fluid bearing and distributing said lubricating fluid to said outer surface and a mounting means (8, 18A) for securely mounting said polymer bearing pad to said base. Other improvements include a fluid bearing (11, 12) comprising the polymer bearing pad (17), methods of making the polymer bearing pad and fluid bearing, a fluid bearing comprising a polymer bearing pad (17) having a chamfer (37) and a multidirectional fluid bearing (70).

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SIGNATURE of Assignee of Record
The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	20 August 2014
Name	Marja Lahonen	Telephone	+358 (0) 20 529 2011
Title	Head of IPR management		

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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Daniel BRAITHWAITE et al.

Application No./Patent No.: Not yet assigned Filed/Issue Date: _____

Titled: IMPROVEMENTS IN FLUID BEARINGS

OUTOTEC OYJ, a Finnish company

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

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[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Susan D. Pitchford/	December 22, 2014
Signature	Date
Susan D. Pitchford	50,945
Printed or Typed Name	Title or Registration Number

[Page 2 of 2]

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Application No.: Unknown
Filing Date: Unknown

PATENT

ASSIGNMENT

WHEREAS, We, Daniel BRAITHWAITE, an Australian citizen, residing at 5/17 Hertha Road, Innaloo, Western Australia 6018, Australia; and Jeffrey Victor BELKE, an Australian citizen, residing at 11 Cowrie Cresent, Mt Pleasant, Western Australia 6153, Australia; Nicholas John GREEN, an Australian citizen, residing at 98a Toorak Road, Rivervale, Western Australia 6103, Australia; Chris TATE, an Australian citizen, residing at 187 Delgado Parade, Iluka, Western Australia 6028, Australia; Oscar HARRISON, an Australian citizen, residing at 35 Campsbourne Street, Balcatta, Western Australia 6021, Australia; and Knut VAAGE, a Norwegian citizen, residing at Middlethunsgate 23, 0368, Oslo, Norway, hereinafter referred to as "ASSIGNOR" (collectively if more than one inventor is listed above), have invented certain new and useful improvements in a IMPROVEMENTS IN FLUID BEARINGS for which we have filed an International Application for Letters Patent designating the United States through the Patent Cooperation Treaty (PCT) for which we have filed an International Application for Letters Patent designating the United States through the Patent Cooperation Treaty (PCT) which was filed on 28 June 2013 and assigned PCT Application No. PCT/IB2013/055305.

AND WHEREAS, Outotec Oyj, hereinafter referred to as "ASSIGNEE", a Finnish Corporation, with its principal place of business at Riihitontuntie 7, FI-02200 Espoo, Finland, desires to acquire the entire right, title, and interest in and to the said improvements and the said Application;

NOW, THEREFORE, in return for good and valuable consideration, the receipt of which is hereby acknowledged, ASSIGNOR hereby acknowledges that s(he) has sold, assigned, transferred and set over, and by these presents does hereby sell, assign, transfer and set over, unto the said ASSIGNEE, its successors, legal representatives and assigns, the entire right, title, and interest throughout the world in, to and under the said improvements, and the said application and all divisions, renewals and continuations thereof, and all Letters Patent of the United States which may be granted thereon and all reissues and extensions thereof, and all rights of priority under International Conventions and applications for Letters Patent which may hereafter be filed for said improvements in any country or countries foreign to the United States, and all Letters Patent which may be granted for said improvements in any country or countries foreign to the United States and all extensions, renewals and reissues thereof; ASSIGNOR hereby authorizes and requests the Commissioner of Patents of the United States, and any Official of any country or countries foreign to the United States, whose duty it is to issue patents on applications as aforesaid, to issue all Letters Patent for said improvements to the said ASSIGNEE, its successors, legal representatives and assigns, in accordance with the terms of this instrument.

AND ASSIGNOR covenants and agrees that s(he) will communicate to the said ASSIGNEE, its successors, legal representatives and assignees, any facts known to the said ASSIGNOR respecting said improvements, and testify in any legal proceeding, sign all lawful papers, execute all divisional, continuing and reissue applications, make all rightful oaths and generally do everything possible to aid the said ASSIGNEE, its successors, legal representatives and assigns, to obtain and enforce proper patent protection for said improvements in all countries.

IN TESTIMONY WHEREOF, ASSIGNOR intending to be legally bound has hereunto affixed its signature.

Dated this THIRTIETH day of AUGUST.

Daniel BRAITHWAITE

Witness: Joshua van der Kooy Date: 30/8/13

Witness: SIMON LEAN Date: 30/08/2013

Dated this [Date Change] 4th day of [Date Change] September.

Jeffrey Victor BELKE

Witness: ANDRES PAZ Date: 4/9/2013

Witness: MARK ELLINSTON Date: 4/9/2013

Dated this 3rd 4th. day of SEPTEMBER.

Nicholas John GREEN

Witness: ANDRES PAZ Date: 4/9/2013

Witness: MARK ELLINSTON Date: 4/9/2013

Dated this 9th day of SEPT.

Chris TATE

Witness: Andrew Lakos Date: 9/9/13

Witness: MARK EZRAHINSON Date: 9/9/2013

Dated this 9th day of SEPTEMBER.

Oscar HARRISON

Witness: MARK EZRAHINSON Date: 9/9/2013.

Witness: ANDRES PAZ Date: 9/9/2013

Dated this 20th day of September.

Knut VAAGE

Witness: BJORN HOLSHAGEN Date: 20/9/2013

Witness: SVERRE NAKKIM Date: 20/9/2013

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10 June 2014 (10.06.2014)

Applicant's or agent's file reference
74861WOP00

IMPORTANT NOTIFICATION

International application No.
PCT/IB2013/055305

International filing date *(day/month/year)*
28 June 2013 (28.06.2013)

1. The following indications appeared on record concerning:

☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address
OUTOTEC OYJ
Puolikkotie 10
FI-02230 Espoo
Finland

State of Nationality: FI
State of Residence: FI
Telephone No.: (358) 205 29211
Facsimile No.: (358) 205 292988
E-mail address:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person ☒ the name ☐ the address ☐ the nationality ☐ the residence

Name and Address
OUTOTEC (FINLAND) OY
Puolikkotie 10
FI-02230 Espoo
Finland

State of Nationality: FI
State of Residence: FI
Telephone No.: (358) 205 29211
Facsimile No.: (358) 205 292988
E-mail address:
☐ Notifications by e-mail authorized

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

☐ the receiving Office
☐ the International Searching Authority
☐ the Authority(ies) specified for supplementary search
☒ the International Preliminary Examining Authority
☐ the designated Offices concerned
☒ the elected Offices concerned
☐ other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 910 06 10

Authorized officer
Santiago Hortensia
e-mail ro.ib@wipo.int
Telephone No. +4122 338 9588

ADVANCE E-MAIL

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92*bis*.1 and Administrative Instructions, Section 422)

To:

SHELSTON IP
Shelston IP
Level 21, 60 Margaret Street
Sydney, New South Wales 2000
AUSTRALIE

Date of mailing *(day/month/year)*
10 September 2013 (10.09.2013)

Applicant's or agent's file reference
74861WOP00

IMPORTANT NOTIFICATION

International application No.
PCT/IB2013/055305

International filing date *(day/month/year)*
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OUTOTEC OYJ
Riihitontuntie 7
FI-02200 Espoo
Finland

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FIN-02230 Espoo
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34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 910 06 10

Authorized officer
Lambert Jean-Francois
e-mail ro.ib@wipo.int
Telephone No. +4122 338 8717

ADVANCE E-MAIL

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92*bis*.1 and Administrative Instructions, Section 422)

To:

SHELSTON IP
Shelston IP
Level 21, 60 Margaret Street
Sydney, New South Wales 2000
AUSTRALIE

Date of mailing *(day/month/year)* 16 October 2014 (16.10.2014)	
Applicant's or agent's file reference 74861WOP00	**IMPORTANT NOTIFICATION**
International application No. PCT/IB2013/055305	International filing date *(day/month/year)* 28 June 2013 (28.06.2013)

1. The following indications appeared on record concerning:

☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address	State of Nationality	State of Residence
OUTOTEC (FINLAND) OY Puolikkotie 10 FI-02230 Espoo Finland	FI	FI
	Telephone No. (358) 205 29211	
	Facsimile No. (358) 205 292988	
	E-mail address	

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☐ the person ☐ the name ☒ the address ☐ the nationality ☐ the residence

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OUTOTEC (FINLAND) OY Rauhalanpuisto 9 FI-02230 Espoo Finland	FI	FI
	Telephone No.	
	Facsimile No.	
	E-mail address ☐ Notifications by e-mail authorized	

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4. A copy of this notification has been sent to:

☐ the receiving Office
☐ the International Searching Authority
☐ the Authority(ies) specified for supplementary search
☒ the International Preliminary Examining Authority
☐ the designated Offices concerned
☒ the elected Offices concerned
☐ other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 910 06 10	Authorized officer Bellour Veronique e-mail ro.ib@wipo.int Telephone No. +4122 338 8602

Page 335 of 447
FLS v. Metso

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	IMPROVEMENTS IN FLUID BEARINGS
First Named Inventor/Applicant Name:	Daniel BRAITHWAITE
Filer:	Susan D. Pitchford/Jennifer Abernathy
Attorney Docket Number:	SHEL.3143

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
National Stage Fee	1631	1	280	280
Natl Stage Search Fee - Report provided	1642	1	480	480
National Stage Exam - all other cases	1633	1	720	720
Pages:				
Claims:				
Claims in excess of 20	1615	5	80	400
Miscellaneous-Filing:				
Petition:				

Exhibit 1002
FLS v. Metso

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1880**

Electronic Acknowledgement Receipt

EFS ID:	21033509
Application Number:	14410241
International Application Number:	PCT/IB2013/055305
Confirmation Number:	6897
Title of Invention:	IMPROVEMENTS IN FLUID BEARINGS
First Named Inventor/Applicant Name:	Daniel BRAITHWAITE
Customer Number:	152
Filer:	Susan D. Pitchford/Jennifer Abernathy
Filer Authorized By:	Susan D. Pitchford
Attorney Docket Number:	SHEL.3143
Receipt Date:	22-DEC-2014
Filing Date:	
Time Stamp:	13:55:59
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$1880
RAM confirmation Number	60
Deposit Account	031550
Authorized User	PITCHFORD, SUSAN D

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

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Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Exhibit 1002
FLS v. Metso

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	Form_PTO_1390.pdf	263669 13517437bd1853a0dba01fb7bd06d92c8f617428	no	4
Warnings:					
Information:					
2	Documents submitted with 371 Applications	WO2014002060_publication.pdf	2122305 10015c8c7f93697cb5014b5e1adf5b59d1de7ca9	no	55
Warnings:					
Information:					
3	Oath or Declaration filed	Declaration_fmPCT.pdf	120474 9ea2d87d8f8d3e46845930adf615100ca85181f4	no	2
Warnings:					
Information:					
4	Documents submitted with 371 Applications	IPRP_wArticle34_amendments.pdf	3149260 84c9bd63c99cd9406bbb84083f7f16cb94e7dfd9	no	44
Warnings:					
Information:					
5	Information Disclosure Statement (IDS) Form (SB08)	IDS_filed_w_application.pdf	611917 3fe48ce1ec4f1976e3fb8c05193397f6a7f5d866	no	4
Warnings:					
Information:					
6	Foreign Reference	GB1508384.pdf	340164 abca1bb0e6865f6b01c044f2ba78c80837063b83	no	5
Warnings:					
Information:					
7	Foreign Reference	WO9012216.pdf	718144 236c56c500803d3008586f7ae5571c144d6a0bc4	no	21
Warnings:					
Information:					

8	Foreign Reference	JP2006009968.pdf	1548867 9da1254f4c4b50299f6d6fe8cf572f8abb40349f	no	20
Warnings:					
Information:					
9	Foreign Reference	DE102007039364A1.pdf	1519927 72d8e508ff65bb1ecbcf84309650ed73f7e08983	no	18
Warnings:					
Information:					
10	Foreign Reference	WO2012145217.pdf	2234808 6ba5deb08e8f2cf9e84be67f217d6021b1ec7194	no	44
Warnings:					
Information:					
11	Non Patent Literature	intl_search_report.pdf	130513 1b573b64452db3227c3dc205a288e4c8a03b7106	no	5
Warnings:					
Information:					
12		preliminary_amendment.pdf	364178 9d4e11e6452d3c1f06a4c6124e26d4057f346b70	yes	10

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Preliminary Amendment	1	1
Specification	2	3
Claims	4	9
Applicant Arguments/Remarks Made in an Amendment	10	10

Warnings:					
Information:					
13	Application Data Sheet	Application_Data_Sheet.pdf	1565747 4023d789093d21de3d3b70189dc77de6b21f4d28	no	8
Warnings:					
Information:					
14	Specification	substitute_specification_redline.pdf	1461146 ba723491227bb63e7312d24965c4c31ec9cd54d0	no	24
Warnings:					

Information:					
15	Specification	substitute_specification_clean.pdf	1338468 19449a5576be5b8e51fc209b84a6aea4c3100101	no	23
Warnings:					
Information:					
16	Power of Attorney	power_of_attorney.pdf	57197 60ef6f84635b1795d3ba67085e3e81f6497c6c75	no	1
Warnings:					
Information:					
17	Assignee showing of ownership per 37 CFR 3.73.	373c_stmt_w_Assignment.pdf	306977 b08798d061ab87053ed62b873d875d2767c38bff	no	5
Warnings:					
Information:					
18	Documents submitted with 371 Applications	PCT_IB306_mailed10June2014.pdf	75458 cea5e4410f34523e513af58b12a39acdc2d45482	no	1
Warnings:					
Information:					
19	Documents submitted with 371 Applications	PCT_IB306_mailed10Sept2013.pdf	43549 344a49e1f9528e9973e2e2af2e57f283cb5227da	no	1
Warnings:					
Information:					
20	Documents submitted with 371 Applications	PCT_IB306_mailed16Oct2014.pdf	43133 ac80ddb3aa99c465753e18347f44ca0624127619	no	1
Warnings:					
Information:					
21	Fee Worksheet (SB06)	fee-info.pdf	37283 81ff524e44377a7e43f59528df5e9e8d72eca2a1	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	18053184	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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From the INTERNATIONAL BUREAU

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NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92*bis*.1 and Administrative Instructions, Section 422)

To:

SHELSTON IP
Shelston IP
Level 21, 60 Margaret Street
Sydney, New South Wales 2000
AUSTRALIE

Date of mailing *(day/month/year)*
26 September 2013 (26.09.2013)

Applicant's or agent's file reference
74861WOP00

IMPORTANT NOTIFICATION

International application No.
PCT/IB2013/055305

International filing date *(day/month/year)*
28 June 2013 (28.06.2013)

1. The following indications appeared on record concerning:

☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address
OUTOTEC OYJ
Puolikkotie 10
FIN-02230 Espoo
Finland

State of Nationality: FI
State of Residence: FI
Telephone No.: (358) 205 29211
Facsimile No.: (358) 205 292988
E-mail address:

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☐ the elected Offices concerned
☐ other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 916 0670

Authorized officer
Martinez Sandrine
e-mail ro.ib@wipo.int
Telephone No. +4122 338 9741

Form PCT/IB/306 (January 2009)

Exhibit 1002
FLS v. Metso

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AUSTRALIE

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10 September 2013 (10.09.2013)

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IMPORTANT NOTIFICATION

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PCT/IB2013/055305

International filing date *(day/month/year)*
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1211 Geneva 20, Switzerland

Facsimile No. +41 22 916 0670

Authorized officer
Lambert Jean-Francois
e-mail ro.ib@wipo.int
Telephone No. +4122 338 8717

Box No. VIII (ii) DECLARATION: ENTITLEMENT TO APPLY FOR AND BE GRANTED A PATENT

The declaration must conform to the standardized wording provided for in Section 212; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (ii). If this Box is not used, this sheet should not be included in the request.

Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent (Rules 4.17(ii) and 51*bis*.1(a)(ii)), in a case where the declaration under Rule 4.17(iv) is not appropriate:

In relation to international application No. PCT/IB2013/055305 Outotec Oyj is entitled to apply for and be granted a patent by virtue of the following:

(a) Outotec Pty Ltd is entitled as employer of the inventors, Daniel Braithwaite, Jeffrey Victor Belke, Nicholas John Green, Chris Tate and Oscar Harrison;

(b) there was a transfer of entitlement from Outotec Pty Ltd to Outotec Oyj by way of a standing agreement, dated 1 June 2005, and

(c) an assignment from the inventor Knut Vaage to Outotec Oyj, dated 12 January 2012 .

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (ii)".

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(PCT Rule 92*bis*.1 and Administrative Instructions, Section 422)

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AUSTRALIE

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Applicant's or agent's file reference
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IMPORTANT NOTIFICATION

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International filing date *(day/month/year)*
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FI-02230 Espoo
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☐ other:

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1211 Geneva 20, Switzerland

Facsimile No. +41 22 916 06 10

Authorized officer
Bellour Veronique
e-mail ro.ib@wipo.int
Telephone No. +4122 338 8602

PCT/IB2013/055305

Box No. VIII (iv) DECLARATION: INVENTORSHIP (only for the purposes of the designation of the United States of America)
The declaration must conform to the following standardized wording provided for in Section 214; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (iv). If this Box is not used, this sheet should not be included in the request.

Declaration of inventorship (Rules 4.17(iv) and 51 *bis*.1(a)(iv))
for the purposes of the designation of the United States of America:

I hereby declare that I believe I am the original inventor or an original joint inventor of a claimed invention in the application.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/IB2013/055305 (if furnishing declaration pursuant to Rule 26*ter*).

I hereby declare that the above-identified international application was made or authorized to be made by me.

I hereby acknowledge that any wilful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Name: Daniel BRAITHWAITE

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 5/17 Hertha Road, Innaloo, Western Australia 6018, Australia

Inventor's Signature: _____ Date: 30/8/2013
(The signature must be that of the inventor, not that of the agent)

Name: Jeffrey Victor BELKE

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 11 Cowne Cresent, Mt Pleasant, Western Australia 6153, Australia

Inventor's Signature: _____ Date: 30/8/13
(The signature must be that of the inventor, not that of the agent)

Name: Nicholas John GREEN

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 98a Toorak Road, Rivervale, Western Australia 6103, Australia

Inventor's Signature: _____ Date: 3/9/2013
(The signature must be that of the inventor, not that of the agent)

PCT/IB2013/055305

Name: Chris TATE

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 187 Delgado Parade, Iluka, Western Australia 6028, Australia

Inventor's Signature: _____ Date: 09/09/13
(The signature must be that of the inventor, not that of the agent)

Name: Oscar HARRISON

Residence: Western Australia, Australia
(city and either US state, if applicable, or country)

Mailing Address: 35 Campsbourne Street, Balcatta, Western Australia 6021, Australia

Inventor's Signature: Oscar Harrison Date: 9/9/2013
(The signature must be that of the inventor, not that of the agent)

Name: Knut VAAGE

Residence: Oslo, Norway
(city and either US state, if applicable, or country)

Mailing Address: Middlethunsgate 23, 0368, Oslo, Norway

Inventor's Signature: _____ Date: 20/9/2013
(The signature must be that of the inventor, not that of the agent)

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

IB13/55305

Australian Government

Patent Office
Canberra

I, ALITA CLARK, PATENT AND PLANT BREEDERS RIGHTS ADMINISTRATION (PPBRA) hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2012902770 for a patent by OUTOTEC OYJ as filed on 28 June 2012.

WITNESS my hand this
Second day of July 2013

A Clark
ALITA CLARK
PATENT AND PLANT BREEDERS
RIGHTS ADMINISTRATION (PPBRA)

2012902770 28 Jun 2012

AUSTRALIA

PATENTS ACT 1990

PROVISIONAL SPECIFICATION

FOR THE INVENTION ENTITLED:-

"Improvements in fluid bearings"

The invention is described in the following statement:-

Shelston IP Ref: 74861AUV00

2012902770 28 Jun 2012

Field of the Invention

[0001] The present invention relates to a fluid bearing and in a particular a hydrostatic polymeric bearing for use in a mill. The invention has been developed primarily for use as a hydrostatic polymeric bearing in grinding mills and will be described hereinafter by reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use, but also extends to other types of fluid bearings such as hydrodynamic bearings and hybrid bearings (i.e. bearings that use a combination of hydrodynamic and continuous hydrostatic flow for lubrication).

Background of the Invention

[0002] The following discussion of the prior art is intended to present the invention in an appropriate technical context and allow its advantages to be properly appreciated. Unless clearly indicated to the contrary, however, reference to any prior art in this specification should not be construed as an express or implied admission that such art is widely known or forms part of common general knowledge in the field.

[0003] A grinding mill has a mill chamber and two journal shafts, the journals being mounted upon supports for rotation. Typical bearings have two main components; a steel base for mounting to the support and a bearing pad or surface for contact with the mill journal. These mill bearings are installed between the mill journals and the supports so that the mill journals rotate on the bearing pads during operation of the grinding mill.

[0004] The applicant developed a hydrostatic pad bearing system for grinding mills that is currently in use. In this hydrostatic pad bearing system, an external oil supply system pumps high-pressure oil to recesses machined into the bearing so that the oil forms a thin film on the bearing pad surface. The resultant hydraulic pressure is sufficient to completely lift the mill journal off the hydrostatic pads and separate the sliding surfaces. Thus, mill actually "floats" on a film of oil between journal and bearing. As such the bearing will operate under both static and dynamic conditions. Since the surfaces are completely separated and the bearing is self aligning there is no metal-to-metal contact between the bearing surface and the mill journal due to the oil film, thus

Exhibit 1002
FLS v. Metso

2012902770 28 Jun 2012

resulting in only low friction. Consequently, maintaining the oil film between the surfaces means that there is virtually no wear in the bearing.

[0005] Despite the advantages conferred by this hydrostatic bearing system, a loss of oil pressure (and thus a reduction in the oil film thickness) can cause failure of the bearings, leading to damage to the bearing pad and/or the mill journal. For example, it can take a few seconds for a grinding mill to stop turning in the event of a power failure, and when this happens there is a high risk of damage to the mill bearing pads or journal surfaces due to a loss of oil reducing the oil film thickness, thereby bringing the journal and bearings into direct metal to metal contact. The consequential downtime for replacement of any damaged bearings and/or journals severely impairs operation of the mill, reducing its efficiency.

[0006] To prevent this type of damage, grinding mill lubrication systems usually have pressure accumulator systems that are typically used to store and deliver high pressure oil to the bearing in the event of a power failure and the oil supply system fails. These pressure accumulators are expensive, require frequent maintenance to ensure that they are at the appropriate pressure level and can interfere with control systems in the mill. Thus, there are increased operational and maintenance costs of the mill.

[0007] Typically, to manufacture hydrostatic bearings, the recesses are machined into the steel base and then the oil supply ports for delivering high pressure oil to the recesses are then drilled into the base. Bronze is spray welded or cast onto the relevant parts of the steel base to form the bearing pad or lining. Spray welding enables the bronze metal to form a seal with the base. White metal may be used instead of bronze, but is cast onto the base. Due to this manufacturing process, the repair and/or refurbishment of these bearings involves initially cleaning the damaged bearing surface, machining any parts of the steel base and either spray welding the bronze or re-casting the bronze/white metal. This repair process cannot be performed on-site but requires the bearing to be returned to the manufacturer. Consequently, mills must keep a sufficient stock of spare bearings to account for the absence of damaged bearings being repaired. This adds to the maintenance costs of the mill.

[0008] It is an object of the present invention to overcome or substantially ameliorate one or more of the disadvantages of prior art, or at least to provide a useful alternative.

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[0009] It is an object of the invention in at least one preferred form to provide improved fluid bearings for mills that are more tolerant to the loss of oil film, distortions in the journal, require less strict manufacturing tolerances, can be easily repaired, minimise waste and reduce or eliminate the need for pressure accumulators, and a method for making such fluid bearings.

Summary of the Invention

[0010] According to a first aspect of the invention, there is provided a polymer pad for a fluid bearing, comprising an outer surface and at least one recess for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface, wherein said polymer pad is mountable to said base.

[0011] Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising", and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

[0012] Preferably, said polymer pad substantially covers an outer surface of said base to create a fluid seal between said polymer pad and said base.

[0013] Preferably, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said base.

[0014] Preferably, said outer surface is partially curved. Alternatively, said outer surface is substantially planar.

[0015] Preferably, said polymer pad comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said polymer pad comprises two chamfers at opposing outer edges. In one preferred form, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In a particularly preferred form, said chamfer is inclined approximately 8° from said tangent.

[0016] Preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer pad.

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[0017] Preferably, said polymer pad comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base. More preferably, said at least one recess has a locking tab for retaining a head portion of said fastener within said at least one recess.

[0018] Preferably, said polymer pad comprises at least one complementary connecting portion for connecting said polymer pad to an adjacent polymer pad. In a particularly preferred form, each of said polymer pads has at least one lateral connecting portion.

[0019] Preferably, said polymer pad is made from any suitable polymer, including, but not limited to, polyetheretherketone (PEEK), PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the polymer pad is made of PEEK.

[0020] According to a second aspect of the invention, there is provided a fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a polymer pad mountable to said base, said polymer pad having an outer surface and at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to said outer surface.

[0021] Preferably, said polymer pad has the preferred features of the abovementioned first aspect of the invention. In this second aspect, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage.

[0022] Preferably, said fluid bearing comprises at least one fastener for mounting said polymer pad to said base. More preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said bore conveys lubricating fluid from said at least one passage to said interconnecting passage.

[0023] Preferably, said fluid bearing is a hydrostatic bearing. More preferably, said outer surface is partially curved such that said fluid bearing acts as a radial hydrostatic

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bearing. In one preferred form, said fluid bearing is a self-aligning radial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted radial hydrostatic bearing. In a further preferred form, said fluid bearing is a hydrostatic slipper bearing.

[0024] Alternatively, said outer surface is substantially planar such that said fluid bearing acts as an axial bearing. In one preferred form, said fluid bearing is a self-aligning axial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted axial hydrostatic bearing.

[0025] Preferably, said at least one fastener is partially received in said at least one passage. Preferably, said at least one fastener comprises a head portion for engagement with said at least one recess. More preferably, said at least one recess has a locking tab for retaining said head portion within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

[0026] Alternatively, said fluid bearing comprises a plug for engagement with said head portion and said at least one recess to retain said at least one fastener. In one preferred form, said at least one fastener is countersunk into said at least one recess.

[0027] Preferably, said at least one fastener is substantially retained within said recess by a locking element. More preferably, said locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

[0028] Preferably, the fluid bearing comprises a plurality of said polymer pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

[0029] Preferably, said polymer pads are connected together. More preferably, each of said polymer pads has at least one complementary connecting portion for connecting said polymer pad to an adjacent polymer pad. In one preferred form, each of said polymer pads has at least one lateral connecting portion.

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[0030] Preferably, said base further comprises a first surface, a second surface and a plurality of said passages in fluid communication with said at least one lubricating fluid supply port, said first surface and said second surface, and

said polymer pad comprises a first polymer pad mountable to said first surface and a second polymer pad mountable to said second surface,

wherein said first polymer pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

[0031] Preferably, said first outer surface is partially curved such that said first polymer pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer pad acts as a self-aligning radial hydrostatic bearing.

[0032] Preferably, said second outer surface is substantially planar such that said second polymer pad acts as an axial bearing. In one preferred form, said second polymer pad acts as a fixedly mounted axial hydrostatic bearing.

[0033] Preferably, said first surface is orthogonal to said second surface. In one preferred form, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0034] According to a third aspect of the invention, there is provided a method of making a polymer bearing pad for a fluid bearing, comprising the steps of forming a polymer pad having an outer surface and forming at least one recess in said polymer pad for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface.

[0035] Preferably, said at least one recess forming step comprises machining said at least one recess in said polymer pad. More preferably, said at least one recess forming step comprises machining at least one interconnecting passage to interconnect said at least one recess to said base.

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[0036] Preferably, said method further comprises chamfering an outer edge of said polymer pad. In one preferred form, said chamfering step comprises chamfering two opposing outer edges of said polymer pad.

[0037] According to a fourth aspect of the invention, there is provided a method of making a fluid bearing for a journal, comprising the steps of:

providing a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port;

forming a polymer pad having an outer surface and at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to said outer surface, and

mounting said polymer pad to said base.

[0038] Preferably, said method comprises each of the preferred steps in the abovementioned third aspect of the invention. In this aspect, said forming step further comprises machining at least one interconnecting passage to interconnect said at least one recess to said passage.

[0039] Preferably, said mounting step comprising mechanically fastening said polymer pad to said base. More preferably, the method further comprises the steps of using a fastener to mechanically fasten said polymer pad to said base and forming a bore in said at least one fastener for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said mounting step comprises bolting said polymer pads to said base.

[0040] Preferably, where there are a plurality of said polymer pads, said method further comprises the step of connecting said polymer pads such that said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal. More preferably, said forming step further comprises the step of forming at least one connecting portion in each said polymer pad for connecting said polymer pad to an adjacent polymer pad. In one preferred form, said forming step comprises forming at least one lateral connecting portion in each said polymer pad.

[0041] Preferably, said forming step further comprises the steps of selecting one or more polymer pads for mounting at the outer edges of said base and chamfering an outer edge of each selected polymer pad.

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[0042] Where said fluid bearing is a radial hydrostatic bearing, each of said polymer pads have curved outer surfaces such that said outer surfaces define a substantially curved uniform bearing surface.

[0043] According to a fifth aspect of the invention, there is provided a fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a bearing pad having at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to an outer surface of said bearing pad,

said bearing pad being mountable to said base and further comprising a chamfer at an outer edge for retaining said lubricating fluid thereon and transferring said lubricating fluid to said journal.

[0044] Preferably, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In one preferred form, said chamfer is inclined approximately 8° from a tangent of an edge of said outer surface.

[0045] Preferably, said chamfer has an outer edge that is displaced from said journal when said journal engages said polymer pad.

[0046] Preferably, the bearing pad is composed of a polymer material. More preferably, the polymer material includes, but is not limited to, PEEK, PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the bearing pad is composed of polyetheretherketone (PEEK).

[0047] Preferably, said fluid bearing is a hydrostatic bearing.

[0048] According to a sixth aspect of the invention, there is provided a multidirectional fluid bearing for a journal, comprising:

a base having a first surface, a second surface, at least one lubricating fluid supply port and a plurality of passages in fluid communication with said at least one lubricating fluid supply port, said first surface and said second surface,

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a first polymer pad mountable to said first surface, said polymer pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer pad mountable to said second surface, said polymer pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

[0049] Preferably, said first outer surface is partially curved such that said first polymer pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer pad acts as a self-aligning radial hydrostatic bearing.

[0050] Preferably, said second outer surface is substantially planar such that said second polymer pad acts as an axial bearing. In one preferred form, said second polymer pad acts as a fixedly mounted axial hydrostatic bearing.

[0051] Preferably, said first surface is orthogonal to said second surface. In one preferred form, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0052] Preferably, said first polymer pad and said second polymer pad have the preferred features of the abovementioned aspects of the invention.

[0053] Preferably, said lubricating fluid includes oil or water.

Brief Description of the Drawings

[0054] Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0055] Figure 1 is a cross-sectional side view of a grinding mill for receiving a hydrostatic bearing according to a first embodiment of the invention;

[0056] Figure 2 is a perspective view of a bearing assembly in the mill of Figure 1;

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[0057] Figure 3 is a front view of the bearing assembly of Figure 2;

[0058] Figure 4 is a schematic plan view of a radial hydrostatic bearing for the bearing assembly of Figure 3;

[0059] Figure 5 is a cross-sectional view of the radial hydrostatic bearing along section A-A of Figure 4;

[0060] Figure 5A is a expanded partial cross-sectional view of the chamfer of the radial hydrostatic bearing of Figure 4;

[0061] Figure 6 is a cross-sectional view of the radial hydrostatic bearing taken along section B-B of Figure 4;

[0062] Figure 7 is a schematic plan view of the base of the radial hydrostatic bearing of Figure 4;

[0063] Figure 8 is a schematic cross-sectional view of the base of Figure 7;

[0064] Figure 9 is a schematic cross-sectional view of an axial hydrostatic bearing for the bearing assembly of Figure 3;

[0065] Figure 10 is a schematic plan view of the axial hydrostatic bearing of Figure 9;

[0066] Figures 11 and 11A are schematic partial views of a fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0067] Figure 12 and 12A are schematic partial views of an alternative fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0068] Figure 13 is a schematic partial view of the chamfer of Figure 5A;

[0069] Figure 14 is a schematic cross-sectional view of a prior art hydrostatic bearing;

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[0070] Figure 15 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with another embodiment of the invention;

[0071] Figures 16 and 16A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0072] Figures 17 and 17A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0073] Figures 18 and 18A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0074] Figure 19 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0075] Figure 20 is a schematic partial cross-sectional view of an axial hydrostatic bearing according to a further embodiment of the invention;

[0076] Figure 21 is a schematic partial expanded view of the axial hydrostatic bearing of Figure 20;

[0077] Figure 22 is a schematic side view of the axial hydrostatic bearing of Figure 20;

[0078] Figure 23 is a schematic plan view of a hydrostatic bearing in accordance with a further embodiment of the invention;

[0079] Figure 24 is a schematic end view of the hydrostatic bearing of Figure 23;

[0080] Figure 25 is a schematic side view of the hydrostatic bearing of Figure 23, and

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[0081] Figure 26 is a schematic perspective view of a hydrostatic bearing in accordance with a further embodiment of the invention.

Preferred Embodiments of the Invention

[0082] Referring to Figure 1, a typical grinding mill 1 comprises a milling chamber or body 2 rotatably mounted on supports 3 via journal shafts 4 and bearing assemblies 5. The mill body 2 has an inlet 6 for introducing a charge for grinding and a discharge outlet 7 for removing the processed charge from the mill 1.

[0083] As best shown in Figures 2 and 3, each bearing assembly 5 has a frame 10 and a plurality of fluid bearings in the form of radial hydrostatic bearings 11 and axial hydrostatic bearings 12, which are designed to transport a lubricating fluid in the form of a high pressure oil to an outer surface 13A, 13B of each bearing 11, 12.

[0084] Referring to Figures 4 to 8, where corresponding features have been given the same reference numerals, each radial hydrostatic bearing 11 comprise a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. The hydrostatic bearings 11, 12 are self-aligning in that the hydrostatic bearings self-adjust to any changes in the angular position of the journals 4 during operation of the mill 1. This is typically achieved by having the base 14 mounted on a spherical seat (not shown) to permit self-adjustment to any angular movement of the journals 4. The base 14 is composed of cast iron, but can be made of any other suitable metal or material.

[0085] A polymer pad 17 is mountable to the base 14 of each radial hydrostatic bearing 11, the polymer pad 17 having at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13A to act as a lubricating fluid between the radial hydrostatic bearing 11 and the journal shafts 4. In the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19. Also, the radial hydrostatic bearings 11 have a plurality of oil supply ports 15, oil galleries 16, recesses 18 and interconnecting passages 19.

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[0086] The outer surface 13A of the polymer pad 17 of the radial hydrostatic bearings 11, 12 is curved to receive the curved bearing surface 20 of the journal 4, as best shown in Figures 1, 9, 11 and 11A.

[0087] Referring to Figures 9 and 10, where corresponding features have been given the same reference numerals, each of the axial hydrostatic bearings 12 also comprises a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. A polymer pad 17 is mountable to the base 14 of each axial hydrostatic bearing 12, the polymer pad 17 having at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13B to act as a lubricating fluid between the axial hydrostatic bearings 12 and the journal shafts 4. Again, in the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19 in the polymer pad 17. In addition, the axial hydrostatic bearings 12 have a plurality of oil galleries 16 in the base 14, and recesses 18 and interconnecting passages 19 in the polymer pad 17.

[0088] Also, the outer surface 13B of the axial hydrostatic bearing 12 is substantially planar as it receives the substantially planar end surface 21 of the journal 4, as best shown in Figure 1.

[0089] In both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 substantially covers the entire outer surface 22 of the base 14 to form a substantially fluid impermeable seal between the base and the polymer pad. Also, the polymer pad 17 is mounted to the base 14 using at least one fastener in the form of bolts 23, as best shown in Figures 5 and 9. The fastening system for both the radial hydrostatic bearing 11 and the axial hydrostatic bearing 12 is described in more detail below.

[0090] A bolt 23 used to mount the polymer pad 17 to the bases 14 of the radial and axial hydrostatic bearings 11, 12 is illustrated in more detail in Figures 11 and 11A, where corresponding features have been given the same reference numerals. The bolt 23 has a bore in the form of through bore 24 for conveying oil from the oil galleries 16 to the recesses 18 via a discharge port 25, as best shown in Figure 11. Thus, there is no need to provide separate oil passages between the oil galleries 16 in the base 14 and the recesses 18 in the polymer pad 17, unlike conventional bronze/white metal

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hydrostatic bearings. This reduces the complexity and cost in the manufacture of the hydrostatic polymer bearings.

[0091] The bolt 23 is inserted into the oil gallery 16 and has a head portion 26 for engagement with a seat 27 of the recess 18, as best shown in Figure 11A. The bolt 23 engages the recess 18 to ensure that, in the event of the bolt becoming loose, it is held captive within the recess 18. This prevents any loose bolts 23 coming into contact with and damaging the journal 4. A locking tab 28 is also provided for retaining the head portion 26 within the recess 18. In addition, the head portion 26 has a tapered portion 29 to facilitate retention of the bolt 23 within the recess 18 by the locking tab 28.

[0092] An alternative fastening arrangement is illustrated in Figure 12, where corresponding features have been given the same reference numerals. The fastener takes the form of a countersunk screw 30 having a tapered head portion 31 for engagement with a seat 27 recessed in the polymer pad 17. Due to the screw 30 being countersunk into the base 14 and the polymer pad 17, the head portion 31 is tapered in the reverse direction to the taper of the head portion 26 of the bolt 23. To prevent any screw 30 becoming loose and coming into contact with the journal 4, a plug 32 is used to engage the head portion 31 and a locking tab 28 is used to retain the plug 32, and thus the screw 30, within the seat 27. Oil is delivered to the outer surface 13 through a separate recess in the form of a hole 33 that is connected to a bore 34 located over the same position as the oil gallery 16 in the base 14 below, as best shown in Figure 12A.

[0093] In either fastening arrangement, separate sealing threads 35 and O-rings 36 are fitted to the base 14 to provide a fluid seal preventing oil leaking in between the polymer pad 17 and the base, as best shown in Figures 9, 11, 11A and 12A.

[0094] In operation, the radial and axial hydrostatic bearings 11, 12 are installed in the bearing assembly 5 in the positions generally shown in Figure 3 in a manner readily understood by a person skilled in the art. The mill body 2 is then mounted on the bearing assembly 5 via the journals 4. An oil supply system is fluidly connected to the oil supply ports 15 in the base 14 of each radial and axial hydrostatic bearing 11, 12. Typically, the oil is positively pumped to the oil supply ports 15. However, in some variants, the oil need not be supplied by positive displacement pump. For example, a pump could provide oil to two or more bearings 11, 12 in parallel using relief valves also in parallel, through which a flow of oil maintains a constant pressure to the bearing pads

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17. This arrangement tends to facilitate load sharing between the bearings 11, 12 and maintains a constant bearing pressure rather than a fairly constant lubricant film thickness. In either case, high pressure oil is conveyed from the oil supply ports 15 through the passages 16, bores 23 and interconnecting passages 19 to the recesses 18 and discharge ports 25 and up to the outer surfaces 13A, 13B, as best shown by arrow 39 in Figure 11. The oil collects on the outer surfaces 13A, 13B to create an oil film and lubricate the bearing surfaces 20, 21 of the journals 4.

[0095] Where there is a loss of oil due to a failure in the oil supply system, the polymer pad 17 absorbs most, if not all, of the shock and so any damage is limited to the polymer pad 17 rather than the bearing surfaces 20, 21 of the journal 4 or the base 14. Thus, the base 14 (and its oil galleries 16 and oil supply ports 15) are protected from damage and any damage is suffered by the polymer pad 17. Thus, by having the polymer pad 17 provided with recesses 18 for distributing oil to the outer surface 13, rather than the base 14, the polymer pad can be easily replaced in the event of damage without having to repair the entire bearing. In addition, this advantage is further facilitated by using mechanical fasteners described above to mount the polymer pad 17. Thus, a damaged polymer pad 17 can be removed simply by removing the fasteners 23, 30, enabling easy replacement of the polymer pads 17. Thus, maintenance and operational costs of the mill 1 are reduced, increasing the efficiency of the mill.

[0096] It has also been discovered that providing a polymer pad for the hydrostatic bearings 11, 12 confer numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads, as follows:

(1) It has been discovered that the polymer pad 17 behaves similar to white metal/bronze pads, but is able to self-mould to the journal 4. That is, the polymer pad 17 is able to modify its outer surface 13A, 13B to accommodate any surface imperfections on the bearing surfaces 20, 21 of the journal 4. This reduces or eliminates the need for tight machining tolerances required for bronze bearings, and can subsequently reduce the associated machining costs. Hence, there is a reduced manufacturing cost for the hydrostatic bearings by using a polymer pad.

(2) The polymer bearing pads 17 enable reduced lubrication rates to be used over traditional bronze bearing pads due to the running in characteristics of polymer material, thus conserving lubricating fluid. However, where necessary or

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desirable, the polymer pads 17 operate equally well at the same lubrication rates used for conventional bronze/white metal bearing pads.

(3) The hydrostatic polymer bearing pads 17 have a lower modulus of elasticity, and thus are able to create a "hovercraft" type cushion around the perimeter of the polymer pad. This acts to accommodate journal imperfections whilst maintaining pressure, much like the cushioning effect produced when a hovercraft moves over bumpy ground.

(4) The hydrostatic polymer bearing pads 17 are much more tolerant than traditional materials to a loss of oil to the bearing 11,12, to contact between journal 4 and outer surface 13A, 13B, and to deformations in the journal bearing surfaces 20, 21. Thus, a loss of oil film due to oil viscosity being too low (from such causes as a high temperature or oil degradation) can be more tolerably managed by the polymer pad 17.

(5) The polymer is elastic, unlike bronze, and is significantly softer than bronze. Thus, the elastic nature of the polymer pads 17 dampen any excessive forces that are applied to the hydrostatic bearings 11, 12. For example, where there is a loss of oil through a shock load placed on the hydrostatic bearing 11, 12 there is little or no risk of damage to the metal journal 4 because the polymer pad 17 dampens the shock to some extent and any damage sustained is suffered by the polymer pad rather than the journal. By way of contrast, with white metal/bronze bearings there is a significant risk of damage to metal journals, resulting in on-site machining and costly stoppages. This advantage of the elasticity of the polymer bearing pads also extends to white metal bearing pads, which are brittle and so are more easily damaged when subjected to typical shock loads.

(6) Any contaminants in the oil that would normally damage the bearing surfaces of the journal 4 or a standard bearing pad tend to be embedded into the polymer pad 17 without adversely affecting operation of the hydrostatic bearing 11, 12.

(7) The self-moulding property of the polymer pads 17 means that the outer surfaces 13A, 13B of the polymer pads tend to conform to the profile of the bearing surface 21 of the journal 4 that it is running against. As a consequence, the polymer pads 17 (and hence bearing 11) do not necessarily require a self-alignment mechanism

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(such as a spherical seat) within certain limits, unlike conventional bearings. It is also contemplated that the self-moulding property also permits the design and installation of hydrostatic bearings that ordinarily would be outside of the capacity of conventional bearings, since the polymer pad 17 can provide some degree of self-alignment in addition to a conventional self-alignment mechanism.

[0097] These advantages of the polymer pad 17 means that the hydrostatic bearings can be operated at lower oil film thicknesses. This has a flow on effect, permitting the use of smaller and cheaper lubrication systems, reducing power consumption and conserving the use of oil. Also the damage to the journals 4 and polymer bearing pads 17 is significantly reduced, increasing product life and reducing the frequency of maintenance and repair. Furthermore, any damage is limited to the polymer bearing pads 17 and does not adversely affect operation of the journal 4. Finally, the complex and expensive accumulator systems can be removed, saving installation costs and eliminating their associated maintenance costs.

[0098] Referring now to Figures 5A, 9 and 13, another aspect of the invention is described, where corresponding features have been given the same reference numerals. In this aspect of the invention, a chamfer is provided at an outer edge of a bearing pad for retaining lubricating fluid on the chamfer, thus enabling recycling of lubricating fluid in the bearing. In applying this aspect of the invention to both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 has a chamfer 37 at both outer edges 38 for retaining oil on the chamfer, as best shown in Figures 5A, 9 and 13. The chamfer 37 creates a lead-in and lead-out for the oil, especially when residual oil on the outer surfaces 13A, 13B must be relied upon for lubrication in the event of an unexpected loss of normal oil supply to the bearings 11, 12. The chamfer 37 inhibits or prevents oil being wiped off the journal 4, as would occur with a bearing having a sharp straight edge. Thus, the chamfer 37 helps to ensure that there is a residual amount of oil between the polymer pad 17 and the metal journal 4.

[0099] In a conventional bearing, the straight edge would wipe off oil from the journal and thus increase the loss of oil from the bearing. By way of contrast, in this aspect of the invention, the chamfer 37 provides a capture point for the oil that may be lost during operation. As the journal 4 rotates on the hydrostatic bearing 11, 12 the "lead-in" chamfer 37 enables the bearing surface 20 of the journal 4 to capture oil from the chamfer 37 and thus is lubricated before coming into contact with the outer surface 13A,

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13B of the hydrostatic bearing. The inventors believe that the oil held by the "lead-in" chamfer 37 is recaptured by the journal 4 due to a hydrodynamic effect produced by its rotation. When the bearing surface 20 of the journal 4 leaves the outer surface 13A, 13B of the hydrostatic bearing, the "lead-out" chamfer 37 on the other side of the hydrostatic bearing 11, 12 feeds any discharging oil from the outer surface 13A, 13B onto the journal to provide a consistent oil thickness over the journal, thus maintaining its lubrication. The provision of chamfers 37 at each outer edge 38 enables the mill journal 4 to be operated in either rotational direction. As a consequence, the use of the chamfers 37 minimises the loss of oil and effectively removes the need to provide oil pressure accumulators with their associated high maintenance and installation costs. Therefore, the chamfers 37 provide the radial and axial hydrostatic bearings 11, 12 provide a cost effective solution and safety measure for the hydrostatic bearings.

[0100] The chamfer 37 is inclined approximately at an angle α to the outer surface 13A, 13B. In the case of the radial hydrostatic bearing 11, the angle α is defined relative to a tangent 39 from the curved outer surface 13A, as best shown in Figure 13. In the case of the axial hydrostatic bearing 12, the angle α is defined relative to the horizontal plane of the planar outer surface 13B. In either case, the angle α is in the range of 0.01° to 89°, and is preferably 8°.

[0101] In addition, the chamfer 37 has an outer edge 40 that is displaced from the journal 4 when the journal engages the polymer pad 17. In both the radial and axial hydrostatic bearings 11, 12 the outer edge 40 of the chamfer 27 is displaced approximately 0.5mm to 1.5 mm from the journal 4. The displacement β is preferably displaced by approximately 0.85 mm from the journal 4.

[0102] It will be appreciated by a person skilled in the art that the chamfer 37 could also be applied to existing bronze/white metal hydrostatic bearings and is not limited to hydrostatic bearings having a polymer pad.

[0103] Referring now to Figures 14 to 19, various methods of making the polymer pads 17 and the hydrostatic bearings 11, 12 of Figures 4 to 10 are illustrated, where corresponding features have been given the same reference numerals. As best shown in Figure 14, manufacturing the curved surface for a radial hydrostatic bearing involves removing the hatched area 41 from the material. This waste material can be a significant, especially on larger bearings, and contributes to unnecessary additional

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manufacturing costs. Furthermore, the manufacturing process is not environmentally sustainable.

[0104] With the hydrostatic bearings of Figures 4 to 10, polymer material can be purchased "off the shelf" in sheet form and subsequently formed to produce the polymer pads 17. One method involves heating the polymer material to a holding temperature which does not melt the material, but the polymer retains some structural integrity while having some malleability or pliability to be able to be formed. There are various procedures that can be used to heat and form the polymer readily understood by the person skilled in the art.

[0105] In one example, the polymer can be placed in a shaped former or mould and lightly clamped. The former or mould is then heated to an intermediate temperature, removed from oven, fully clamped and returned to the oven. After heating to a holding temperature, the former is held for a set period of time, removed from oven and allowed to cool.

[0106] In another example, the polymer is placed in a shaped former and clamped using springs or a dead weight. The former is heated to the holding temperature and kept at this temperature for a set period of time. After being allowed to cool, the polymer is removed from the former.

[0107] In a further example, the polymer sheet is heated to the holding temperature for set period of time to ensure uniform heating of material. The polymer is then removed from the heat, immediately placed in cold former and pressed to profile. In the case of a radial hydrostatic bearing 11, the former also creates the curved outer surface 13A. After being allowed to cool, the polymer pad 17 is removed from the former.

[0108] After assuming the required shape for the hydrostatic bearing 11, 12, the recesses 18 and interconnecting passages 19 are machined into the outer surface 13A, 13B of the polymer pad 17. Also, the chamfer 37 is machined at the same time. The machined polymer pad 17 is then mechanically mounted to the base 14 using the fastener systems described above to complete assembly of the hydrostatic bearing 11, 12.

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[0109] Referring now to Figures 15 to 16, another method of making the hydrostatic bearings involves making a plurality of polymer pads in the form of slats 50 each having outer surfaces 51 that form a substantially uniform bearing surface 52 for the journal 4, as best shown in Figure 15. The slats 50 are produced using the same heating and forming method described above, and then fastened to the base 14 using either fastener system as described in relation to Figures 4 to 10. As best shown in Figure 15, the resultant amount of removed material indicated by hatched area 53 is considerably less than the amount of material removed in a conventional bearing indicated by hatched area 41.

[0110] Also, the polymer pad 17 can be divided into any number of smaller polymer pads or slats 50 of any shape and/or size, as required. For example, there could be six polymeric slats 50 that are rectangular and uniform in shape but have differently shaped recesses, as best shown in Figures 16, 16A, 17 and 17A. Similarly, the polymeric slats 50 could be larger in size, as best shown in Figures 18 and 18A.

[0111] In a further variation to this method, the polymeric slats 55 each have complementary connecting portions 56 to connect with an adjacent polymer pad 55, as best shown in Figure 19. The complementary connecting portions in this variation take the form of teeth 56 that are glued together so that the slats 55 to form a complete polymer pad 17. In this variation, each polymeric slat 55 is cleaned and their outer surfaces are roughened by way of cut-wire blasting to form the teeth 56. The polymer pads 55 are then mounted to the base 14 using either fastener system as described in relation to Figures 4 to 10. Once in position, glue is applied at adjacent surfaces of the polymer slats and their teeth 56. Then, the polymer slats 55 are clamped and heated to cure the adhesive joint. The joint formed by the connecting teeth 56 is such that the weight of mill journal 4 on the polymeric slats 55 works to ensure the joint is always in compression. It has been found by testing that such bearings are strong enough as a bearing surface for the journal 4. It will be appreciated that other profiles for the connecting portions 56 can be used, such as tabs and detents of any polygonal shape.

[0112] The inventors believe that by segmenting the surface area of the polymer pad 17 into individual polymer pads or slats 50, this reduces the amount of wastage involved with machining standard bearings, as indicated in area 41 of Figure 14, and provides a suitable supplementary option to heating and forming the entire polymer pad 17 as described above.

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[0113] While the hydrostatic bearings 11, 12 have been described in the context of self-aligning hydrostatic bearings, it will be appreciated that the various aspects of the invention are also equally applicable to fixedly mounted hydrostatic bearings. Referring now to Figures 20 to 22, one example of a fixedly mounted hydrostatic bearing 60 is illustrated, where corresponding features have been given the same reference numerals. In this embodiment, the fixedly mounted hydrostatic bearing is an axial hydrostatic bearing 60 comprises a polymer pad 17 mounted on a base 14, which is fixedly mounted to mounting plate 61 via fasteners 62. Due to the polymeric nature of the polymer bearing pad 17, the outer surface 13B of the polymer pad will conform to the profile of the bearing surface 21 of the journal 4 that it is running against. This means that the axial hydrostatic bearing can provide some degree of self-alignment, if necessary, which is not possible in a conventional axial hydrostatic bearing. Aside from the manner of its mounting, the axial hydrostatic bearing 60 operates in substantially same manner as the self-aligning axial hydrostatic bearing 12 described above. Furthermore, while this embodiment concerns as axial hydrostatic bearing, it is also applicable to a fixedly mounted radial hydrostatic bearing.

[0114] Referring now to Figures 23 to 25, a fluid bearing 70 according to another aspect of the invention is illustrated, where corresponding features have been given the same reference numerals. The fluid bearing 70 is a hydrostatic bearing that is a combination of the radial and axial hydrostatic bearings 11, 12, 60 described above. The base 71 has been adapted to receive both a polymer pad 17A having a radial or curved outer surface 13A mounted on its outer surface 72 and two polymer pads 17B having a substantially planar outer surface 13B mounted on opposing side surfaces 73 that are orthogonal to the outer surface 72. Thus, the combination hydrostatic bearing 70 acts as a self-aligning radial hydrostatic bearing 11 in one direction and as two fixedly mounted axial hydrostatic bearings 60 in two other directions, as best shown in Figure 25. Again, due to the polymer's characteristics the outer surfaces 13B of the polymer pads 17B with conform to the profile of the bearing surface 21 of the journal 4 that it is running against. Thus, there is no need for a separate base for the axial hydrostatic bearings. The inventors contemplate that this combination hydrostatic bearing 70 avoids the need to install three separate hydrostatic bearings and thus allows for ease of installation in the mill 1. Due to the easy replacement of the polymer pads 17A, 17B, there is no need to remove the base 71 in the event one or more of the

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polymer pads 17A, 17B are damaged during operation of the mill 1. Thus, the combination hydrostatic bearing 70 creates cost savings in installation and repair.

[0115] The inventors also contemplate that the combination bearing 70 can be modified so as to minimise or eliminate the "axial float". Axial float is the difference between the distance between axial bearing pads and the distance between axial journal faces. Axial float is generally required so that the axial hydrostatic bearings are not tightly fitted with the mill journal 4. Typically, this axial float is set to around 0.5 to 1mm, meaning that the mill journal is able to freely float in the axial direction by this 0.5 to 1mm. A potential advantage of this combination bearing 70 is that the amount of axial float can be reduced or eliminated, since one of the axial bearings on the combination bearing 70 can be configured to move axially on a piston which is supplied by pressurised oil. This effectively ensures that axial float is minimised or removed.

[0116] In other embodiments, the hydrostatic bearing takes the form of a slipper bearing 80, as best shown in Figure 26. Due to the larger size of the bearing pad for a slipper bearing and its 120° curvature, it could be difficult to mould a single polymer pad 17. Thus, segmenting the bearing pad surface into multiple polymer pads or slats 81 having curved outer surfaces and laterally connected together enables the invention to be used for a slipper bearing. The lateral connections can be formed as described in relation to Figure 19. Thus, the advantages of the polymer pad 17 can be extended to a slipper bearing.

[0117] In the preferred embodiments of the invention, the polymer pad 17 is made of polyetheretherketone (PEEK). However, it will be appreciated that other polymer materials are also suitable for the hydrostatic bearings 11, 12, such as PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. Also, while the preferred embodiments of the invention have been described as employing oil as the lubricating fluid, other lubricating fluids can be used such as water.

[0118] It will be appreciated by a person skilled in the art that the hydrostatic bearings of the preferred embodiments of the invention can be readily retrofitted into existing bearing assemblies, and thus do not require the replacement of each bearing in a milling apparatus.

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[0119] While the preferred embodiments of the invention have been described using one of two possible fastener arrangements as illustrated in Figures 11, 11A, 12 and 12A, it will be appreciated that other fastener type arrangements may be used to implement the invention. For example, in one preferred form the fasteners are substantially retained within the recesses 18 by a locking element. The locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

[0120] It will further be appreciated that any of the features in the preferred embodiments of the invention can be combined together and are not necessarily applied in isolation from each other. For example, the chamfer 37 could be readily applied to the outermost polymer slats 81 in the slipper bearing to provide the advantages of reducing oil loss and elimination of oil pressure accumulators.

[0121] Also, while the preferred embodiment of the invention have been described in relation to hydrostatic bearings in general, it will be appreciated that each of the aspects of the invention and the corresponding preferred features are also applicable to other types of fluid bearings, such as hydrodynamic bearings and hybrid bearings that use a combination of hydrodynamic and a continuous hydrostatic flow for lubrication.

[0122] By providing a polymer bearing pad for a hydrostatic bearing, the invention confers numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads. The polymer bearing pads 17 reduces or eliminates damage to the journal and the base of the hydrostatic bearing, thus increasing product life and reducing the frequency of maintenance and repair. Moreover, the polymer pads 17 are easily replaceable, enabling easy installation and removal for repair. This advantage is facilitated by the use of mechanical fasteners to mount the polymer pad 17 to the base 14.

[0123] Also, the polymer pads 17 do not require tight machining tolerances, can conform to the profile of the journal, have reduced lubrication rates enabling the use of less oil, resistant to damage caused by the loss of oil or contaminants, and dampen any excessive shock forces, protecting the journal bearing surface. These advantages permits the operation of the hydrostatic bearings of the preferred embodiments of the invention at lower oil film thicknesses, thus reducing oil consumption, permitting the use

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of smaller and cheaper lubrication systems and more efficient power consumption and conserving the use of oil.

[0124] Also, the use of chamfer in hydrostatic bearings in general obviates the need for expensive accumulator systems that are difficult to operate and maintain. Furthermore, the chamfer conserves the use of oil and thus reduces oil consumption. Furthermore, since the base is of a standard design, the hydrostatic bearings of the invention can be readily retrofitted to existing mills. In all these respects, the invention represents a practical and commercially significant improvement over the prior art.

[0125] Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

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Claims

1. A polymer pad for a fluid bearing, comprising an outer surface and at least one recess for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface, wherein said polymer pad is mountable to said base.

2. A fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a polymer pad mountable to said base, said polymer pad having an outer surface and at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to said outer surface.

3. A method of making a polymer bearing pad for a fluid bearing, comprising the steps of forming a polymer pad having an outer surface and forming at least one recess in said polymer pad for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface.

4. A method of making a fluid bearing for a journal, comprising:

providing a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port;

forming a polymer pad having an outer surface and at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to said outer surface, and

mounting said polymer pad to said base.

5. A fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a bearing pad having at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to an outer surface of said bearing pad,

said bearing pad being mountable to said base and further comprising a chamfer at an outer edge for retaining said lubricating fluid thereon and transferring said lubricating fluid to said journal.

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6. A multidirectional fluid bearing for a journal, comprising:

a base having a first surface, a second surface, at least one lubricating fluid supply port and a plurality of passages in fluid communication with said at least one lubricating fluid supply port, said first surface and said second surface,

a first polymer pad mountable to said first surface, said polymer pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer pad mountable to said second surface, said polymer pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

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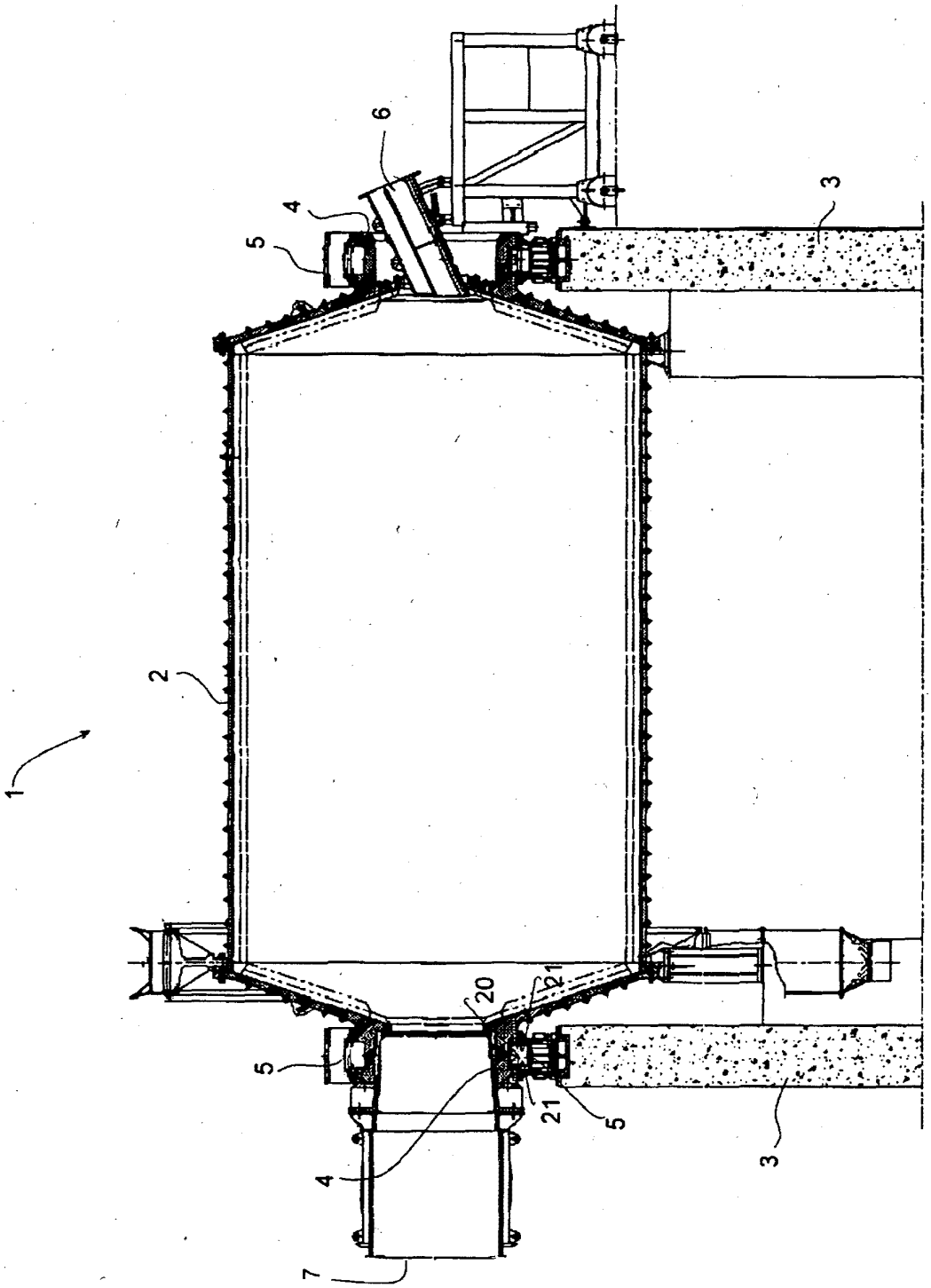


Fig. 1

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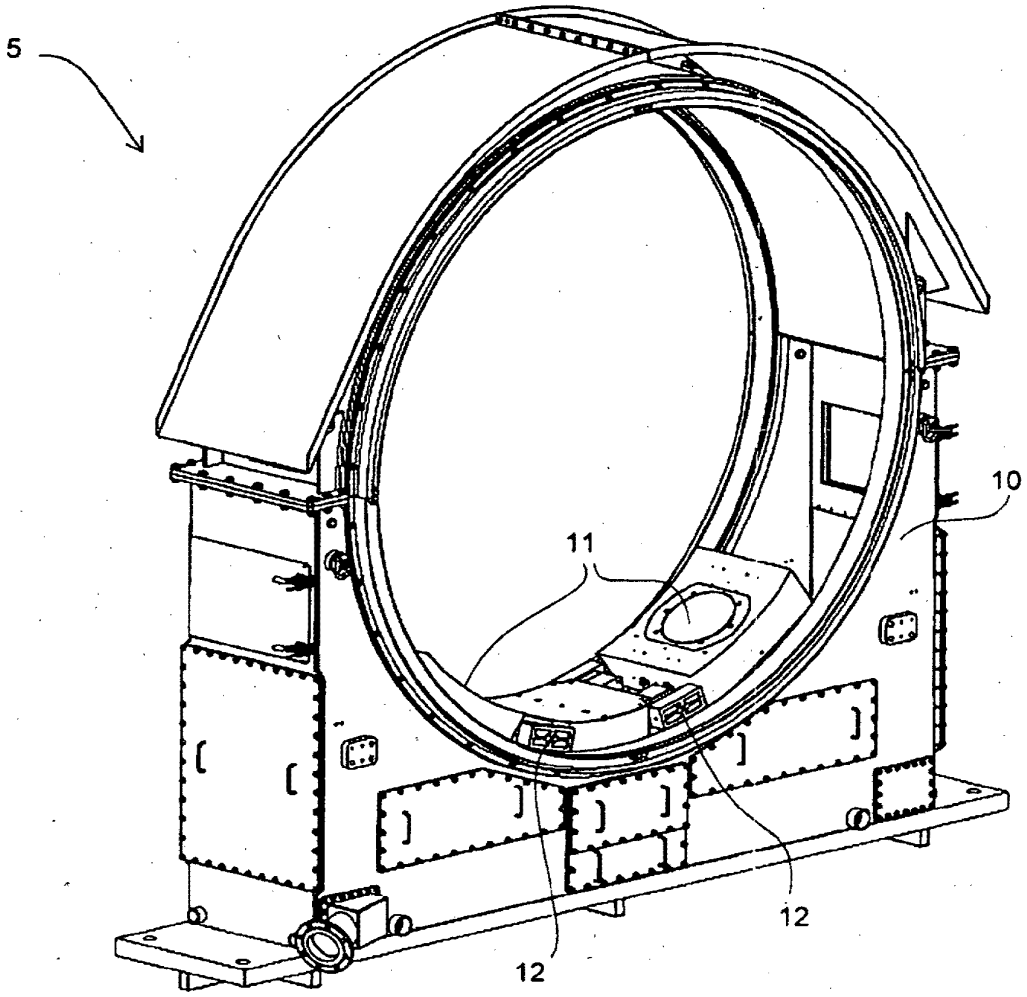


Fig. 2

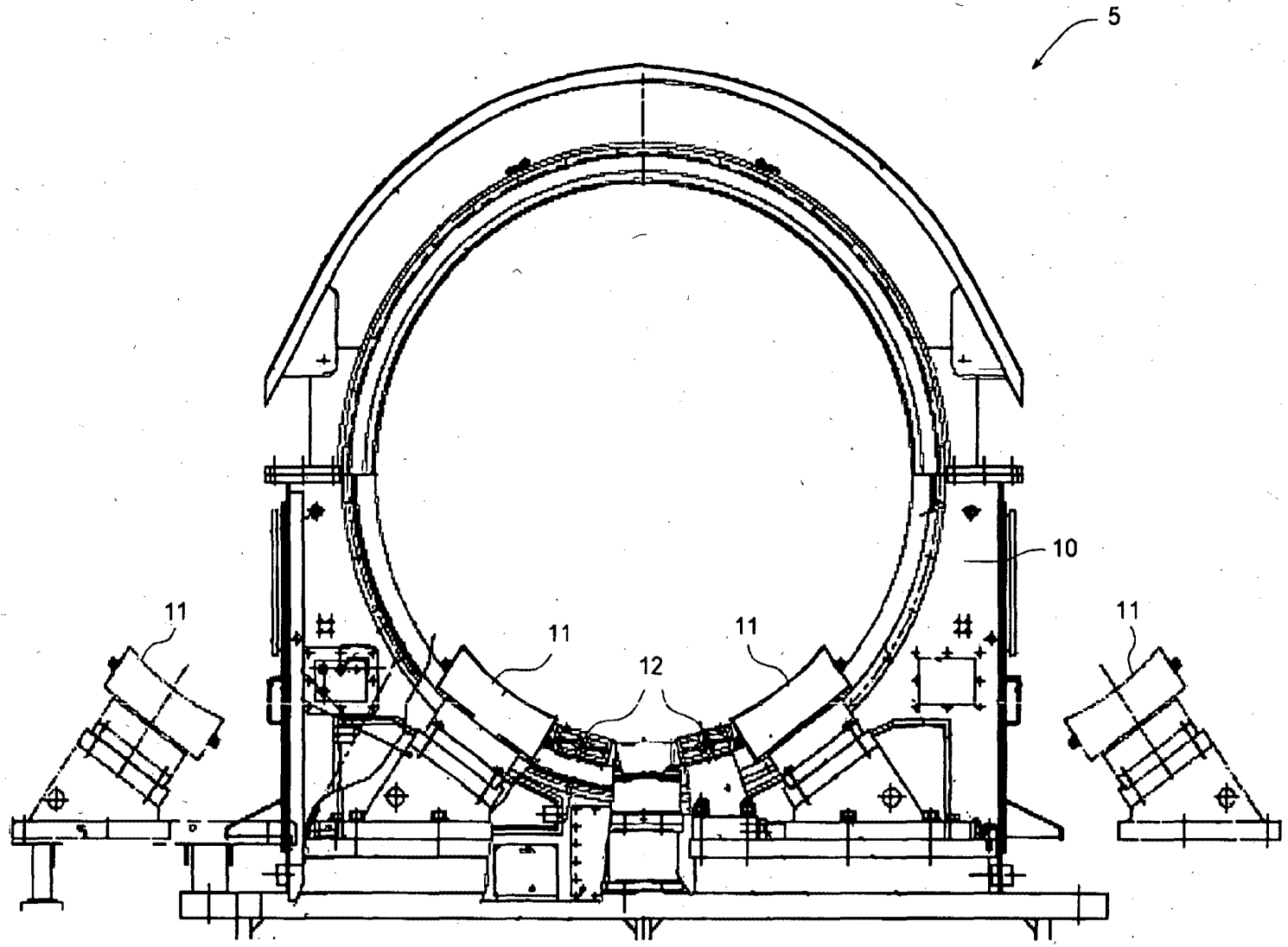


Fig. 3

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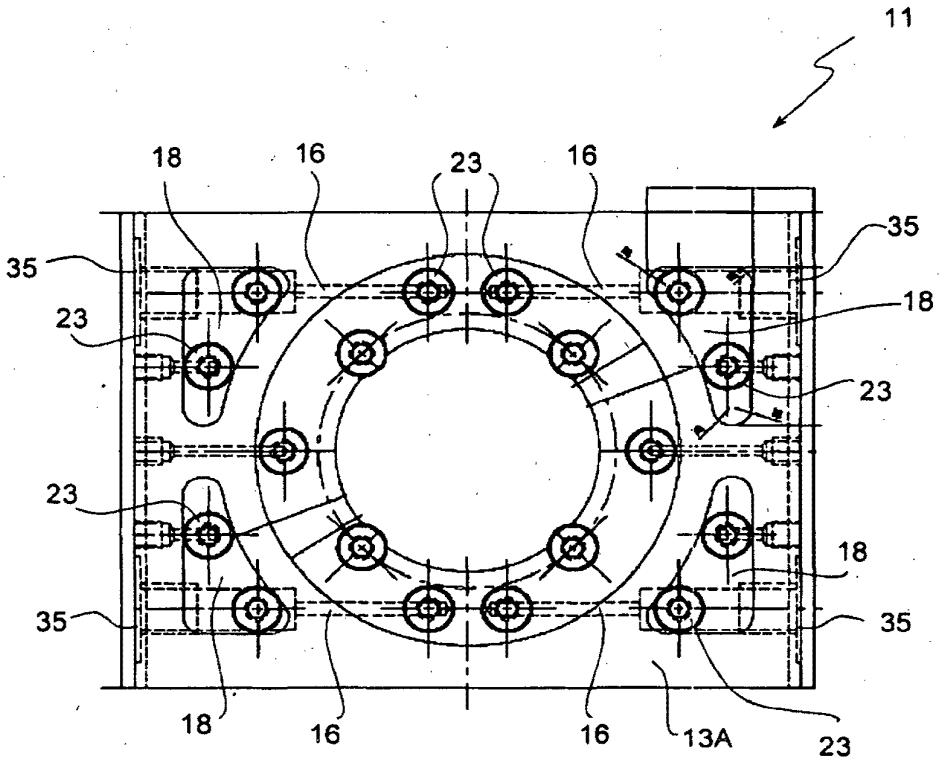


Fig. 4

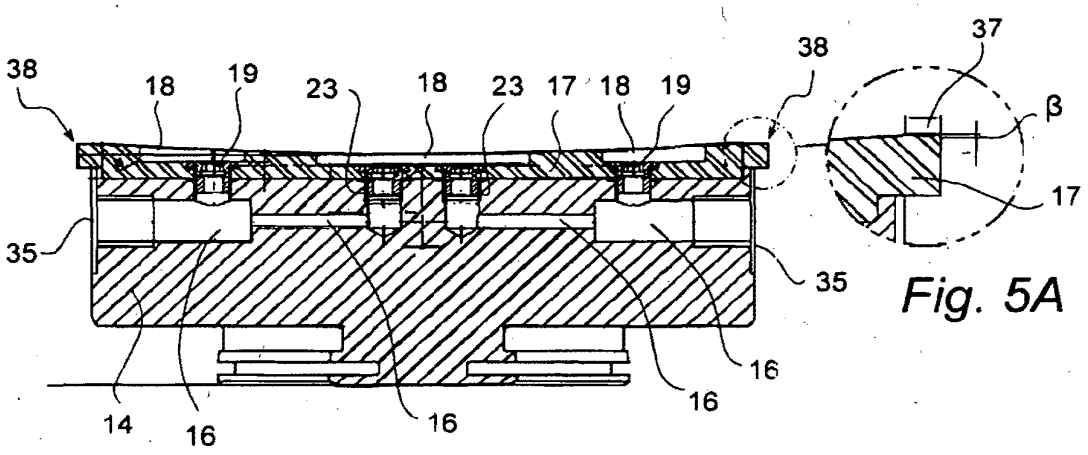


Fig. 5A

Fig. 5

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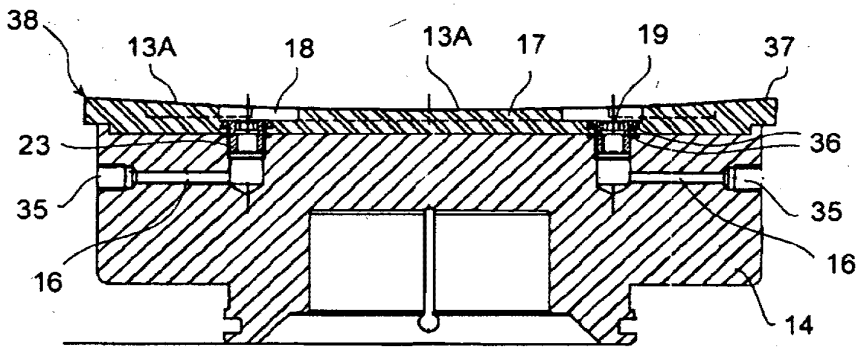


Fig. 6

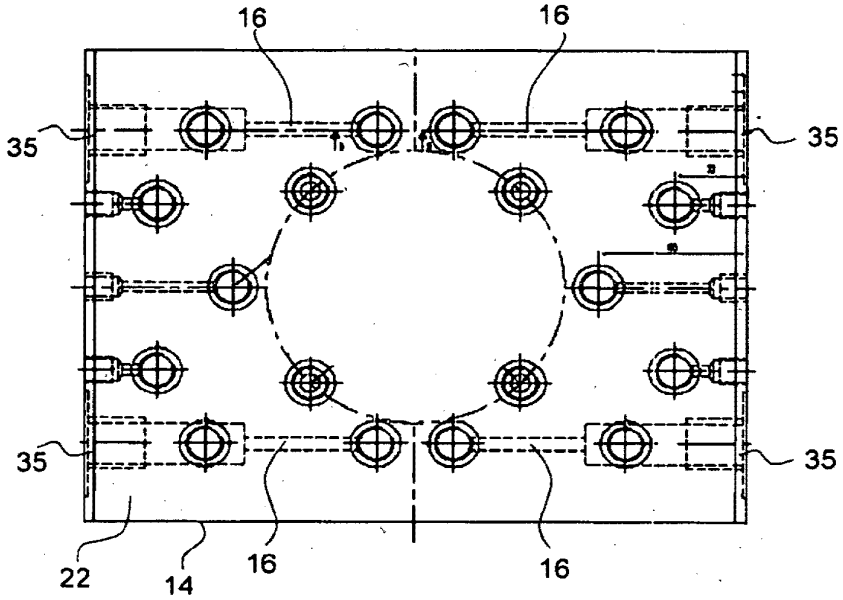


Fig. 7

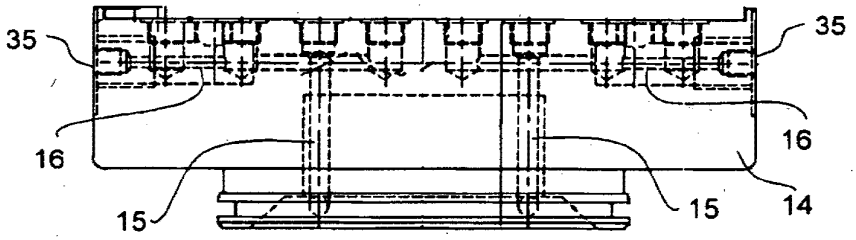


Fig. 8

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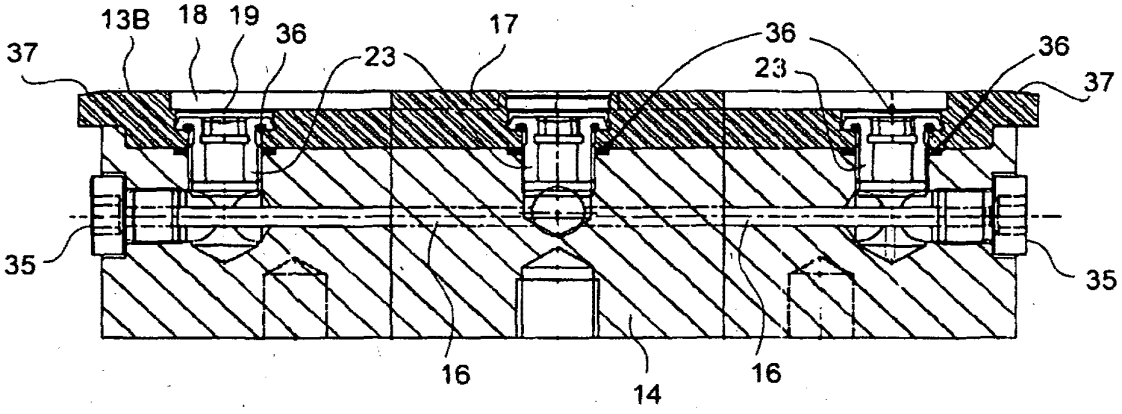


Fig. 9

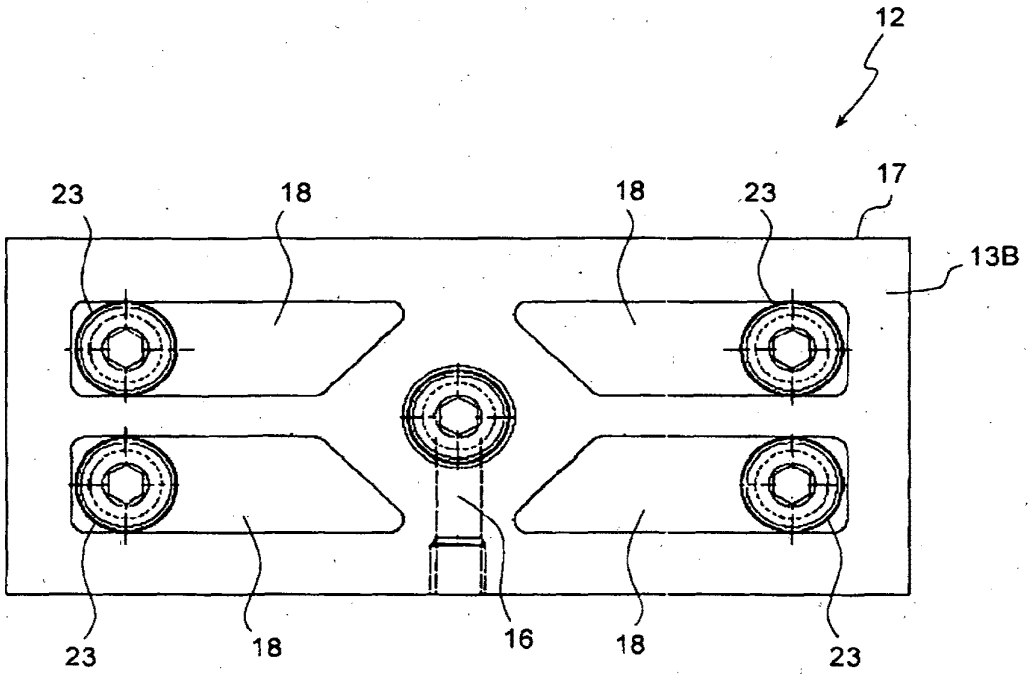


Fig. 10

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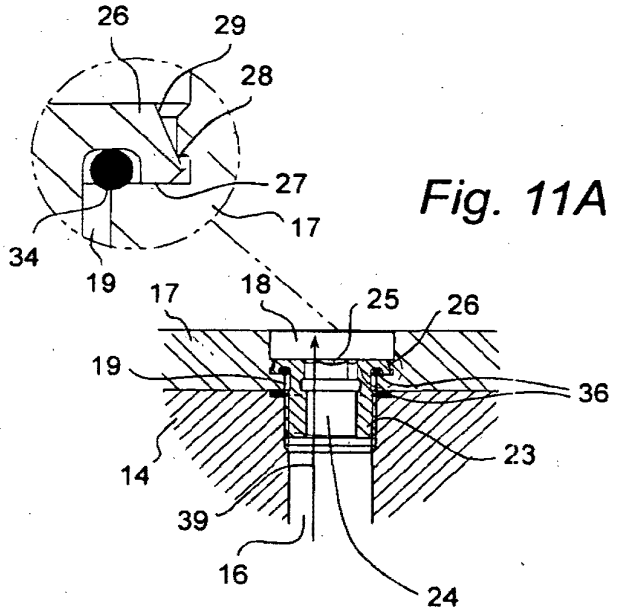


Fig. 11A

Fig. 11

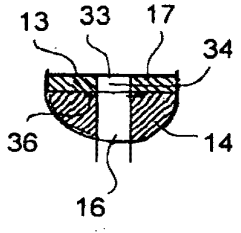


Fig. 12A

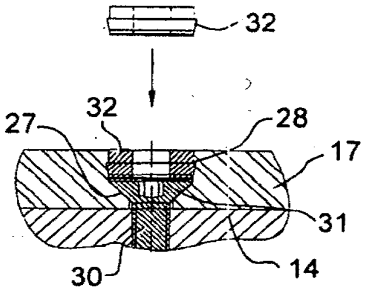


Fig. 12

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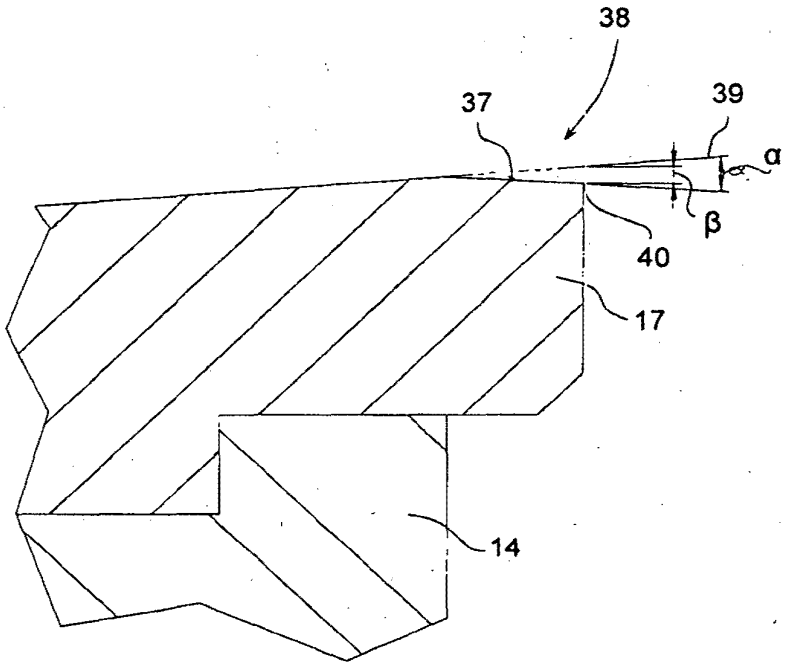


Fig. 13

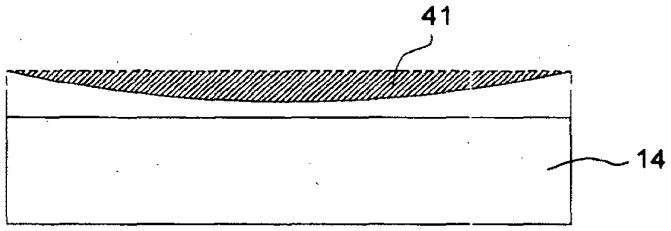


Fig. 14

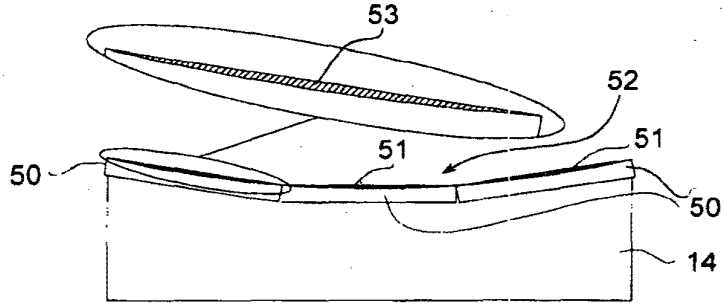


Fig. 15

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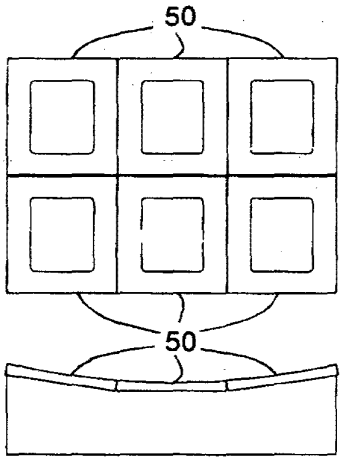


Fig.16

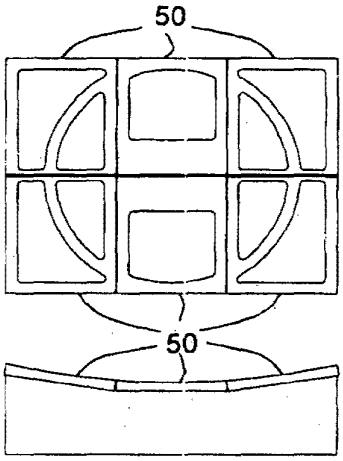


Fig.17

Fig.16A

Fig.17A

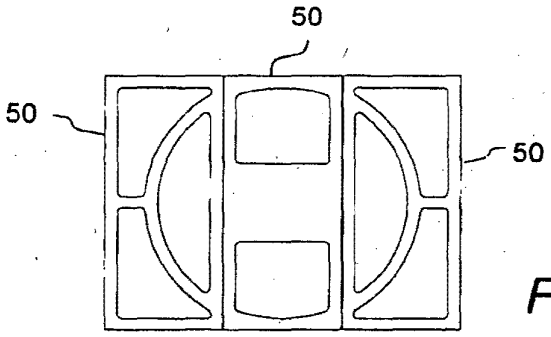


Fig. 18

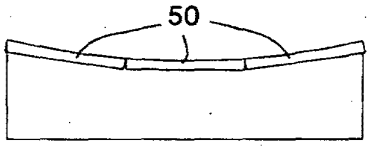


Fig. 18A

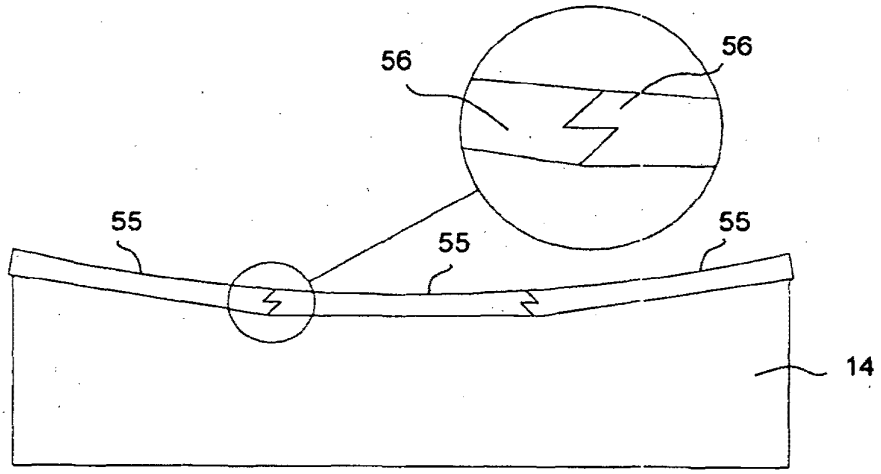


Fig. 19

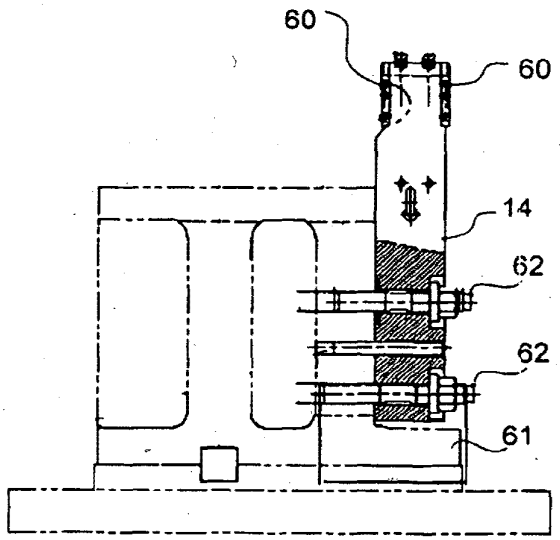


Fig. 22

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Fig. 21

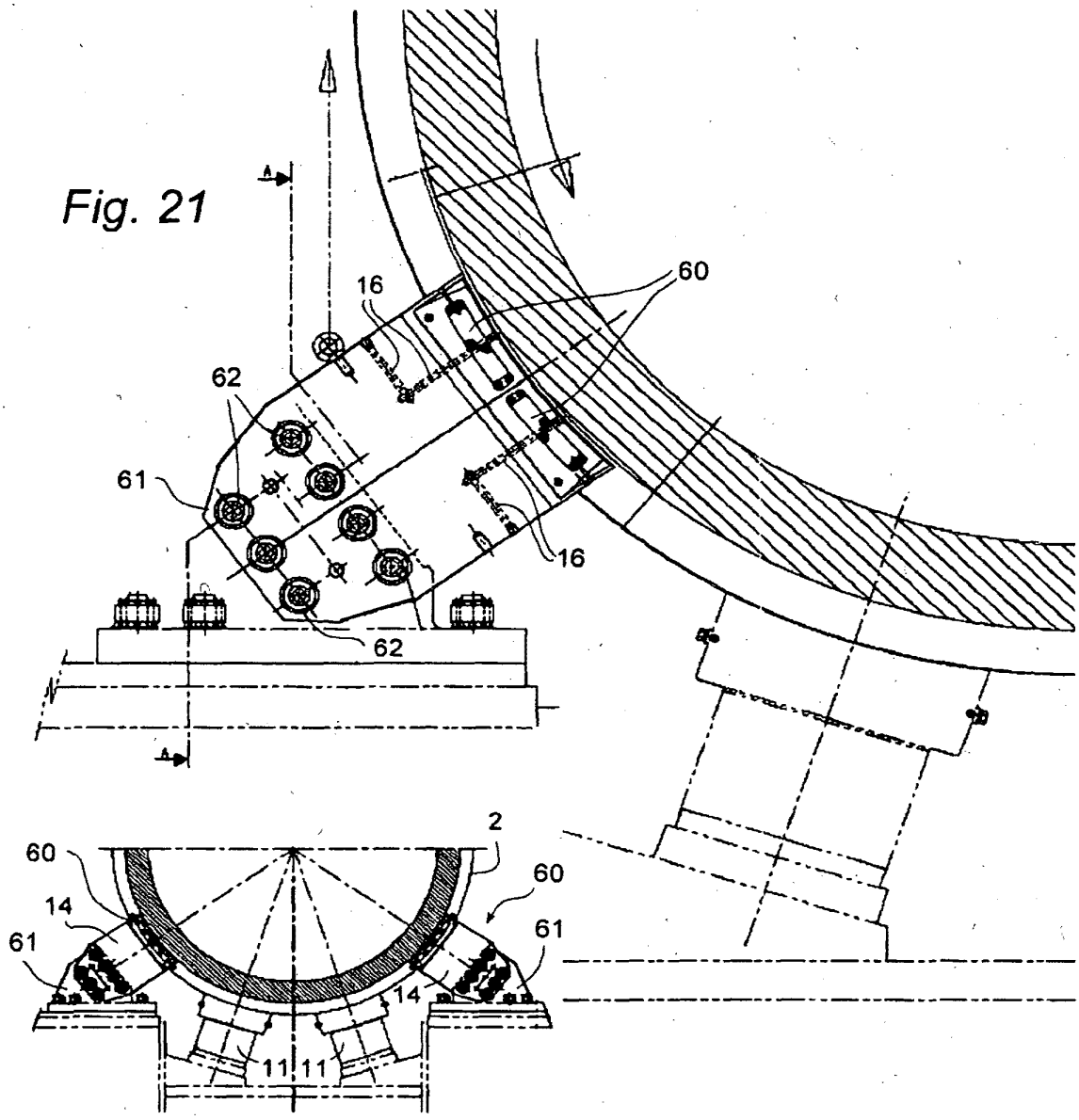


Fig. 20

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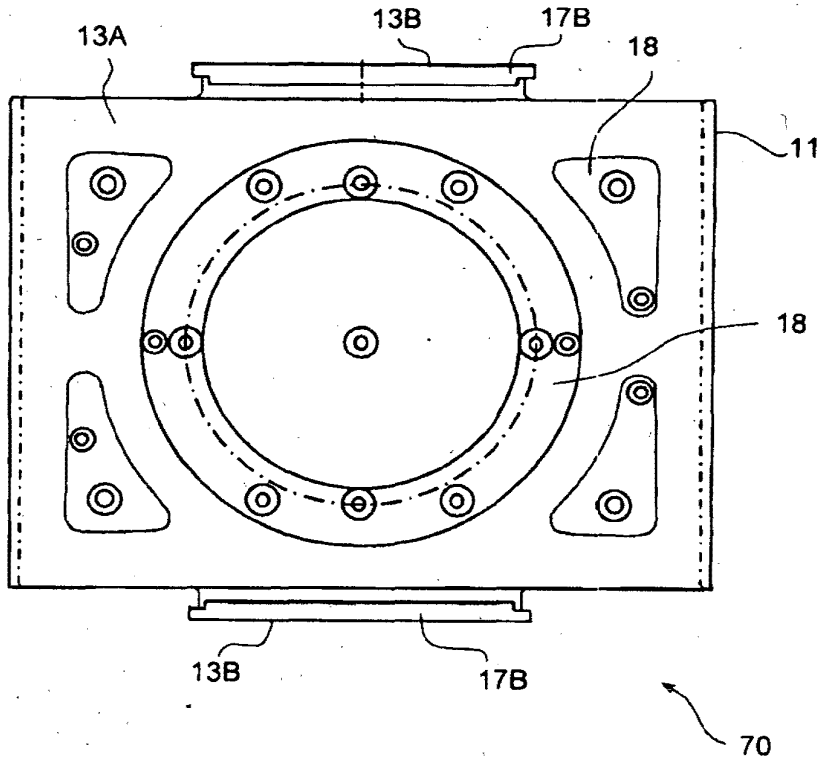


Fig. 23

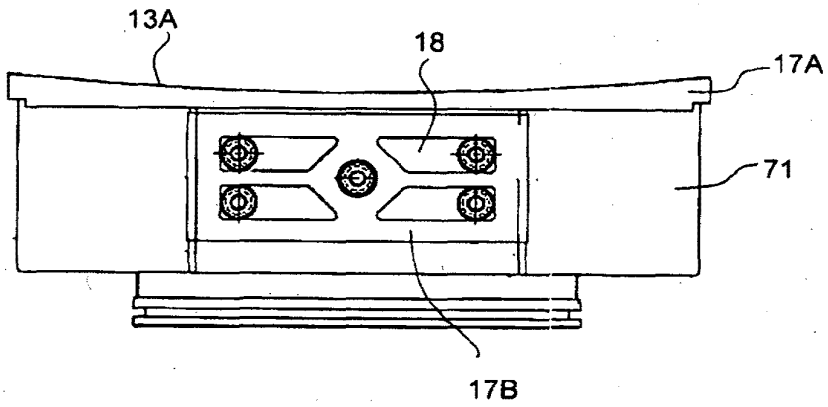


Fig. 24

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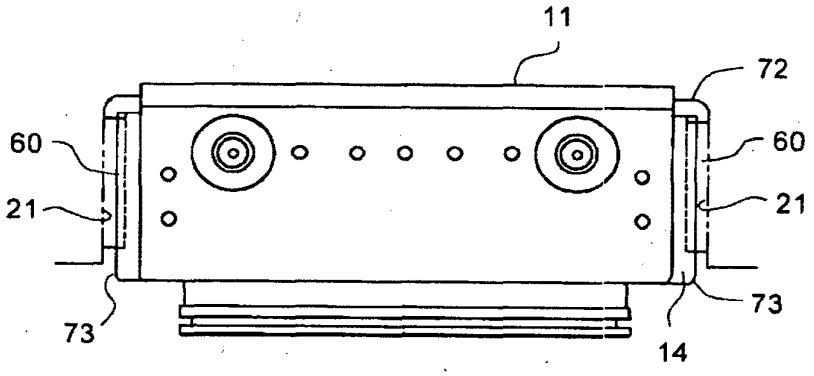


Fig. 25

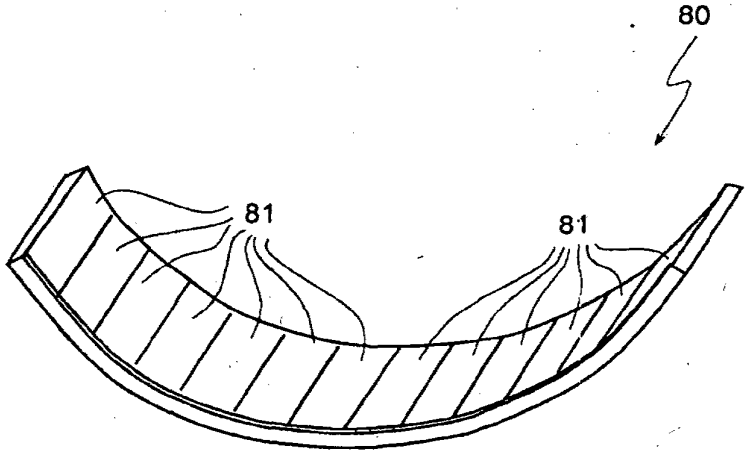


Fig. 26

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0-3	Name of receiving Office and "PCT International Application"	RO/IB

0-4	**Form PCT/RO/101 PCT Request**	
0-4-1	Prepared Using	PCT-SAFE Version 3.51.059.235 MT/FOP 20130401/0.20.5.21
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	International Bureau of the World Intellectual Property Organization (RO/IB)
0-7	**Applicant's or agent's file reference**	74861WOP00
I	**Title of Invention**	IMPROVEMENTS IN FLUID BEARINGS
II	**Applicant**	
II-1	This person is	Applicant only
II-2	Applicant for	All designated States
II-4	Name	OUTOTEC OYJ
II-5	Address	Riihitontuntie 7 FI-02200 Espoo Finland
II-6	State of nationality	FI
II-7	State of residence	FI
II-8	Telephone No.	(358) 205 29211
II-9	Facsimile No.	(358) 205 292988
III-1	**Applicant and/or inventor**	
III-1-1	This person is	Applicant and inventor
III-1-2	Applicant for	US
III-1-4	Name (LAST, First)	BRAITHWAITE, Daniel
III-1-5	Address	5/17 Hertha Road Innaloo, Western Australia 6018 Australia
III-1-6	State of nationality	AU
III-1-7	State of residence	AU

III-2	**Applicant and/or inventor**	
III-2-1	This person is	Applicant and inventor
III-2-2	Applicant for	US
III-2-4	Name (LAST, First)	BELKE, Jeffrey Victor
III-2-5	Address	11 Cowrie Cresent Mt Pleasant, Western Australia 6153 Australia
III-2-6	State of nationality	AU
III-2-7	State of residence	AU
III-3	**Applicant and/or inventor**	
III-3-1	This person is	Applicant and inventor
III-3-2	Applicant for	US
III-3-4	Name (LAST, First)	GREEN, Nicholas John
III-3-5	Address	98a Toorak Road Rivervale, Western Australia 6103 Australia
III-3-6	State of nationality	AU
III-3-7	State of residence	AU
III-4	**Applicant and/or inventor**	
III-4-1	This person is	Applicant and inventor
III-4-2	Applicant for	US
III-4-4	Name (LAST, First)	TATE, Chris
III-4-5	Address	187 Delgado Parade Iluka, Western Australia 6028 Australia
III-4-6	State of nationality	AU
III-4-7	State of residence	AU
III-5	**Applicant and/or inventor**	
III-5-1	This person is	Applicant and inventor
III-5-2	Applicant for	US
III-5-4	Name (LAST, First)	HARRISON, Oscar
III-5-5	Address	35 Campsbourne Street Balcatta, Western Australia 6021 Australia
III-5-6	State of nationality	AU
III-5-7	State of residence	AU

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III-6	**Applicant and/or inventor**	
III-6-1	This person is	Applicant and inventor
III-6-2	Applicant for	US
III-6-4	Name (LAST, First)	VAAGE, Knut
III-6-5	Address	Middlethunsgate 23 0368 Oslo Norway
III-6-6	State of nationality	NO
III-6-7	State of residence	NO
IV-1	**Agent or common representative; or address for correspondence**	
	The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	Agent
IV-1-1	Name	SHELSTON IP
IV-1-2	Address	SHELSTON IP Level 21, 60 Margaret Street Sydney, New South Wales 2000 Australia
IV-1-3	Telephone No.	(612) 9777 1111
IV-1-4	Facsimile No.	(612) 9241 4666
IV-1-5	e-mail	email@ShelstonIP.com
IV-1-5(a)	E-mail authorization The receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority are authorized to use this e-mail address, if the Office or Authority so wishes, to send notifications issued in respect of this international application:	as advance copies followed by paper notifications
V	**DESIGNATIONS**	
V-1	**The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.**	
VI-1	**Priority claim of earlier national application**	
VI-1-1	Filing date	28 June 2012 (28.06.2012)
VI-1-2	Number	2012902770
VI-1-3	Country	AU
VI-2	**Priority document request**	▲|
	The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1

▲RO

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VI-3	**Incorporation by reference :** where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.		
VII-1	**International Searching Authority Chosen**	European Patent Office (EPO) (ISA/EP)	
VIII	**Declarations**	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	-	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	-	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	-	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-	
IX	**Check list**	Number of sheets	Electronic file(s) attached
IX-1	Request (including declaration sheets)	5	✓
IX-2	Description	28	✓
IX-3	Claims	8	✓
IX-4	Abstract	1	✓
IX-5	Drawings	13	✓
IX-7	TOTAL	55	
	Accompanying Items	Paper document(s) attached	Electronic file(s) attached
IX-8	Fee calculation sheet	-	✓
IX-18	PCT-SAFE physical media	-	-
IX-20	**Figure of the drawings which should accompany the abstract**	6	
IX-21	**Language of filing of the international application**	English	

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X-1	**Signature of applicant, agent or common representative**	(PKCS7 Digital Signature)
X-1-1	Name	SHELSTON IP
X-1-2	Name of signatory	Andrew Lowe
X-1-3	Capacity (if such capacity is not obvious from reading the request)	Patent Attorney

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported international application**	28 June 2013 (28.06.2013)
10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/EP
10-6	**Transmittal of search copy delayed until search fee is paid**	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	**Date of receipt of the record copy by the International Bureau**	

ADVANCE E-MAIL

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92*bis*.1 and Administrative Instructions, Section 422)

To:

SHELSTON IP
Shelston IP
Level 21, 60 Margaret Street
Sydney, New South Wales 2000
AUSTRALIE

Date of mailing *(day/month/year)*
10 June 2014 (10.06.2014)

Applicant's or agent's file reference
74861WOP00

IMPORTANT NOTIFICATION

International application No.
PCT/IB2013/055305

International filing date *(day/month/year)*
28 June 2013 (28.06.2013)

1. The following indications appeared on record concerning:

☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address
OUTOTEC OYJ
Puolikkotie 10
FI-02230 Espoo
Finland

State of Nationality: FI
State of Residence: FI
Telephone No.: (358) 205 29211
Facsimile No.: (358) 205 292988
E-mail address:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person ☒ the name ☐ the address ☐ the nationality ☐ the residence

Name and Address
OUTOTEC (FINLAND) OY
Puolikkotie 10
FI-02230 Espoo
Finland

State of Nationality: FI
State of Residence: FI
Telephone No.: (358) 205 29211
Facsimile No.: (358) 205 292988
E-mail address:
☐ Notifications by e-mail authorized

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

☐ the receiving Office
☐ the International Searching Authority
☐ the Authority(ies) specified for supplementary search
☒ the International Preliminary Examining Authority
☐ the designated Offices concerned
☒ the elected Offices concerned
☐ other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 916 06 10

Authorized officer
Santiago Hortensia
e-mail ro.ib@wipo.int
Telephone No. +4122 338 9588

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(71) Applicant: **OUTOTEC OYJ** [FI/FI]; Puolikkotie 10, FI-02230 Espoo (FI).

(72) Inventors; and

(71) Applicants *(for US only)*: **BRAITHWAITE, Daniel** [AU/AU]; 5/17 Hertha Road, Innaloo, Western Australia 6018 (AU). **BELKE, Jeffrey, Victor** [AU/AU]; 11 Cowrie Cresent, Mt Pleasant, Western Australia 6153 (AU). **GREEN, Nicholas John** [AU/AU]; 98a Toorak Road, Rivervale, Western Australia 6103 (AU). **TATE, Chris** [AU/AU]; 187 Delgado Parade, Iluka, Western Australia 6028 (AU). **HARRISON, Oscar** [AU/AU]; 35 Campsbourne Street, Balcatta, Western Australia 6021 (AU). **VAAGE, Knut** [NO/NO]; Middlethunsgate 23, N-0368 Oslo (NO).

(74) Agent: **SHELSTON IP**; Shelston IP, Level 21, 60 Margaret Street, Sydney, New South Wales 2000 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title**: IMPROVEMENTS IN FLUID BEARINGS

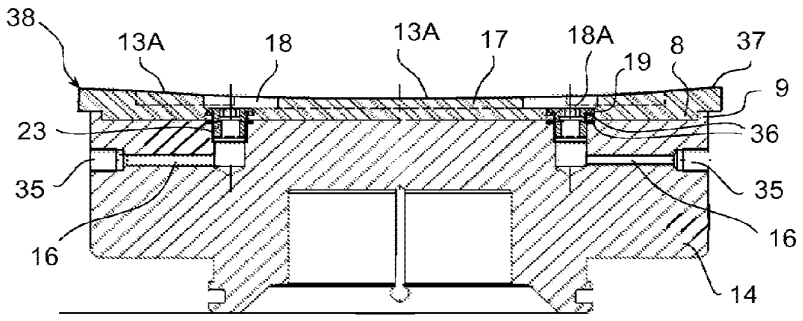


Fig. 6

(57) **Abstract**: The present invention provides improvements to a fluid bearing (11, 12) for a journal (4), one being a polymer bearing pad (17) comprising an outer surface (13), at least one recess (18) for receiving lubricating fluid from a base (14) of said fluid bearing and distributing said lubricating fluid to said outer surface and a mounting means (8, 8A) for securely mounting said polymer bearing pad to said base. Other improvements include a fluid bearing (11, 12) comprising the polymer bearing pad (17), methods of making the polymer bearing pad and fluid bearing, a fluid bearing comprising a polymer bearing pad (17) having a chamfer (37) and a multidirectional fluid bearing (70).

WO 2014/002060 A1

Exhibit 1002
FLS v. Metso

"Improvements in fluid bearings"

Field of the Invention

[0001] The present invention relates to a fluid bearing and in a particular a hydrostatic polymeric bearing for use in a mill. The invention has been developed primarily for use as a hydrostatic polymeric bearing in grinding mills and will be described hereinafter by reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use, but also extends to other types of fluid bearings such as hydrodynamic bearings and hybrid bearings (i.e. bearings that use a combination of hydrodynamic and continuous hydrostatic flow for lubrication).

Background of the Invention

[0002] The following discussion of the prior art is intended to present the invention in an appropriate technical context and allow its advantages to be properly appreciated. Unless clearly indicated to the contrary, however, reference to any prior art in this specification should not be construed as an express or implied admission that such art is widely known or forms part of common general knowledge in the field.

[0003] A grinding mill has a mill chamber and two journal shafts, the journals being mounted upon supports for rotation. Typical bearings have two main components; a steel base for mounting to the support and a bearing pad or surface for contact with the mill journal. These mill bearings are installed between the mill journals and the supports so that the mill journals rotate on the bearing pads during operation of the grinding mill.

[0004] The applicant developed a hydrostatic pad bearing system for grinding mills that is currently in use. In this hydrostatic pad bearing system, an external oil supply system pumps high-pressure oil to recesses machined into the bearing so that the oil forms a thin film on the bearing pad surface. The resultant hydraulic pressure is sufficient to completely lift the mill journal off the hydrostatic pads and separate the sliding surfaces. Thus, mill actually “floats” on a film of oil between journal and bearing. As such the bearing will operate under both static and dynamic conditions. Since the surfaces are completely separated and the bearing is self aligning there is no metal-to-metal contact between the bearing surface and the mill journal due to the oil film, thus

resulting in only low friction. Consequently, maintaining the oil film between the surfaces means that there is virtually no wear in the bearing.

[0005] Despite the advantages conferred by this hydrostatic bearing system, a loss of oil pressure (and thus a reduction in the oil film thickness) can cause failure of the bearings, leading to damage to the bearing pad and/or the mill journal. For example, it can take a few seconds for a grinding mill to stop turning in the event of a power failure, and when this happens there is a high risk of damage to the mill bearing pads or journal surfaces due to a loss of oil reducing the oil film thickness, thereby bringing the journal and bearings into direct metal to metal contact. The consequential downtime for replacement of any damaged bearings and/or journals severely impairs operation of the mill, reducing its efficiency.

[0006] To prevent this type of damage, grinding mill lubrication systems usually have pressure accumulator systems that are typically used to store and deliver high pressure oil to the bearing in the event of a power failure and the oil supply system fails. These pressure accumulators are expensive, require frequent maintenance to ensure that they are at the appropriate pressure level and can interfere with control systems in the mill. Thus, there are increased operational and maintenance costs of the mill.

[0007] Typically, to manufacture hydrostatic bearings, the recesses are machined into the steel base and then the oil supply ports for delivering high pressure oil to the recesses are then drilled into the base. Bronze is spray welded or cast onto the relevant parts of the steel base to form the bearing pad or lining. Spray welding enables the bronze metal to form a seal with the base. White metal may be used instead of bronze, but is cast onto the base. Due to this manufacturing process, the repair and/or refurbishment of these bearings involves initially cleaning the damaged bearing surface, machining any parts of the steel base and either spray welding the bronze or re-casting the bronze/white metal. This repair process cannot be performed on-site but requires the bearing to be returned to the manufacturer. Consequently, mills must keep a sufficient stock of spare bearings to account for the absence of damaged bearings being repaired. This adds to the maintenance costs of the mill.

[0008] It is an object of the present invention to overcome or substantially ameliorate one or more of the disadvantages of prior art, or at least to provide a useful alternative.

[0009] It is an object of the invention in at least one preferred form to provide improved fluid bearings for mills that are more tolerant to the loss of oil film, distortions in the journal, require less strict manufacturing tolerances, can be easily repaired, minimise waste and reduce or eliminate the need for pressure accumulators, and a method for making such fluid bearings.

Summary of the Invention

[0010] According to a first aspect of the invention, there is provided a polymer bearing pad for a fluid bearing, comprising an outer surface, at least one recess for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface and a mounting means for securely mounting said polymer bearing pad to said base.

[0011] Unless the context clearly requires otherwise, throughout the description and the claims, the words “comprise”, “comprising”, and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of “including, but not limited to”.

[0012] As used herein, unless otherwise specified the use of the ordinal adjectives "first", "second", "third", etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0013] Preferably, said mounting means comprises a mounting portion extending from said polymer bearing pad. More preferably, said mounting portion comprises a protrusion from a mounting surface opposite to said outer surface for engaging a flange of said base. In one preferred form, said mounting surface comprises an inner surface of said polymer bearing pad. In another preferred form, said inner surface is the underside of said polymer bearing pad.

[0014] Alternatively or additionally, said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer bearing pad to

said base. More preferably, said at least one recess has a locking tab for retaining a head portion of said fastener within said at least one recess.

[0015] Preferably, said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

[0016] Preferably, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said base.

[0017] Preferably, said outer surface is partially curved. Alternatively, said outer surface is substantially planar.

[0018] Preferably, said polymer bearing pad comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said polymer bearing pad comprises two chamfers at opposing outer edges. In one preferred form, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In a particularly preferred form, said chamfer is inclined approximately 8° from said tangent.

[0019] Preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer bearing pad.

[0020] Preferably, said polymer bearing pad comprises at least one complementary connecting portion for connecting said polymer bearing pad to an adjacent polymer bearing pad. In a particularly preferred form, said polymer pad has at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of said adjacent polymer bearing pad.

[0021] Preferably, said polymer bearing pad is made from any suitable polymer, including, but not limited to, polyetheretherketone (PEEK), PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the polymer pad is made of PEEK.

[0022] According to a second aspect of the invention, there is provided a fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port, and

the polymer bearing pad of the first aspect of the present invention mountable to said base.

[0023] Preferably, said polymer bearing pad has the preferred features of the abovementioned first aspect of the invention. In this second aspect, said at least one recess comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage.

[0024] Preferably, said base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base. More preferably, said at least one flange is located at an outer edge of said base. In one preferred form, said base comprises two of said flanges located at opposing outer edges of said base.

[0025] Preferably, said fluid bearing comprises at least one fastener for mounting said polymer bearing pad to said base. More preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said bore conveys lubricating fluid from said at least one passage to said interconnecting passage.

[0026] Preferably, said fluid bearing is a hydrostatic bearing. More preferably, said outer surface is partially curved such that said fluid bearing acts as a radial hydrostatic bearing. In one preferred form, said fluid bearing is a self-aligning radial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted radial hydrostatic bearing. In a further preferred form, said fluid bearing is a hydrostatic slipper bearing.

[0027] Alternatively, said outer surface is substantially planar such that said fluid bearing acts as an axial bearing. In one preferred form, said fluid bearing is a self-aligning axial hydrostatic bearing. In another preferred form, said fluid bearing is a fixedly mounted axial hydrostatic bearing.

[0028] Preferably, said at least one fastener is partially received in said at least one passage. Preferably, said at least one fastener comprises a head portion for engagement with said at least one recess. More preferably, said at least one recess has a locking tab for retaining said head portion within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

[0029] Alternatively, said fluid bearing comprises a plug for engagement with said head portion and said at least one recess to retain said at least one fastener. In one preferred form, said at least one fastener is countersunk into said at least one recess.

[0030] Preferably, said at least one fastener is substantially retained within said at least one recess by a locking element. More preferably, said locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

[0031] Preferably, the fluid bearing comprises a plurality of said polymer pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

[0032] Preferably, said polymer pads are connected together. More preferably, each of said polymer pads has at least one complementary connecting portion for connecting said polymer pad to an adjacent polymer pad. In one preferred form, each of said polymer pads has at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0033] Preferably, said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

a first of said polymer bearing pads is mountable to said first surface and a second of said polymer bearing pads is mountable to said second surface,

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

[0034] Preferably, said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer bearing pad acts as a self-aligning radial hydrostatic bearing.

[0035] Preferably, said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing. In one preferred form, said second polymer bearing pad acts as a fixedly mounted axial hydrostatic bearing.

[0036] Preferably, said first surface is orthogonal to said second surface. In one preferred form, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0037] According to a third aspect of the invention, there is provided a method of making a polymer bearing pad for a fluid bearing, comprising forming a polymer pad having an outer surface, forming at least one recess in said polymer pad for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface, and forming a mounting means on said polymer pad for securely mounting said polymer pad to said base.

[0038] Preferably, said mounting means forming step comprises forming a mounting portion to extend from said polymer pad. More preferably, said mounting portion forming step comprises machining said polymer pad to form said mounting portion. Alternatively, said mounting portion forming step comprises placing said polymer pad in a mould to form said mounting portion. Alternatively or additionally, said mounting means forming step comprises forming an opening in said at least one recess for receiving at least one fastener. More preferably, said opening is drilled, punched, cut or machined into said at least one recess.

[0039] Preferably, said at least one recess forming step comprises machining said at least one recess in said polymer pad. More preferably, said at least one recess forming

step comprises machining at least one interconnecting passage to interconnect said at least one recess to said base.

[0040] Preferably, said method further comprises chamfering an outer edge of said polymer pad. In one preferred form, said chamfering step comprises chamfering two opposing outer edges of said polymer pad.

[0041] According to a fourth aspect of the invention, there is provided a method of making a fluid bearing for a journal, comprising the steps of:

providing a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port;

forming a polymer pad having an outer surface and at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to said outer surface, and

mounting said polymer bearing pad to said base.

[0042] Preferably, said method comprises each of the preferred steps in the abovementioned third aspect of the invention. In this aspect, said forming step further comprises machining at least one interconnecting passage to interconnect said at least one recess to said passage.

[0043] Preferably, said mounting step comprising mechanically fastening said polymer bearing pad to said base. More preferably, the method further comprises the steps of using a fastener to mechanically fasten said polymer bearing pad to said base and forming a bore in said at least one fastener for conveying lubricating fluid from said at least one passage to said at least one recess. In one preferred form, said mounting step comprises bolting said polymer pads to said base.

[0044] Preferably, where there are a plurality of said polymer pads, said method further comprises the step of connecting said polymer bearing pads such that said outer surfaces of said polymer bearing pads form a substantially uniform bearing surface for said journal. More preferably, said forming step further comprises the step of forming at least one connecting portion in each said polymer bearing pad for connecting said polymer pad to an adjacent polymer bearing pad. In one preferred form, said forming step comprises forming at least one lateral connecting portion in each said polymer

bearing pad for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0045] Preferably, said method further comprises selecting one or more polymer bearing pads for mounting at the outer edges of said base and chamfering an outer edge of each selected polymer bearing pad.

[0046] Where said fluid bearing is a radial hydrostatic bearing, each of said polymer pads have curved outer surfaces such that said outer surfaces define a substantially curved uniform bearing surface.

[0047] According to a fifth aspect of the invention, there is provided a fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a polymer bearing pad having at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to an outer surface of said bearing pad,

said polymer bearing pad being mountable to said base and further comprising a chamfer at an outer edge for retaining said lubricating fluid thereon and transferring said lubricating fluid to said journal.

[0048] Preferably, said chamfer is inclined approximately 0.01° to 89° from a tangent of an edge of said outer surface. In one preferred form, said chamfer is inclined approximately 8° from a tangent of an edge of said outer surface.

[0049] Preferably, said chamfer has an outer edge that is displaced from said journal when said journal engages said polymer bearing pad.

[0050] Preferably, the polymer bearing pad is composed of a polymer material that includes, but is not limited to, PEEK, PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. In one preferred form, the bearing pad is composed of polyetheretherketone (PEEK).

[0051] Preferably, said fluid bearing is a hydrostatic bearing.

[0052] According to a sixth aspect of the invention, there is provided a multidirectional fluid bearing for a journal, comprising:

a base having a first surface, a second surface, at least one lubricating fluid supply port and a plurality of passages in fluid communication with said at least one lubricating fluid supply port, said first surface and said second surface,

a first polymer pad mountable to said first surface, said polymer pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer pad mountable to said second surface, said polymer pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

[0053] Preferably, said first polymer bearing pad substantially covers said first outer surface and said polymer bearing pad substantially covers said second outer surface to respectively create fluid seals between said first and second polymer bearing pads and said base.

[0054] Preferably, at least one of said first and second polymer bearing pads comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal. More preferably, said chamfer has an outer edge that is displaced from a journal when said journal engages said at least one polymer bearing pad.

[0055] Preferably, at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base. More preferably, said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess. In one preferred form, said head portion is tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

[0056] Preferably, said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess, said at least one fastener being partially received in said at least one passage.

[0057] Preferably, at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base. Preferably, said at least one polymer bearing pad comprises a locking element for retaining said at least one fastener within said at least one recess.

[0058] Preferably, least one of said first and second polymer bearing pads comprises a plurality of said polymer bearing pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal. More preferably, each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

[0059] Preferably, said first outer surface is partially curved such that said first polymer pad acts as a radial hydrostatic bearing. In one preferred form, said first polymer pad acts as a self-aligning radial hydrostatic bearing.

[0060] Preferably, said second outer surface is substantially planar such that said second polymer pad acts as an axial bearing. In one preferred form, said second polymer pad acts as a fixedly mounted axial hydrostatic bearing.

[0061] Preferably, said first surface is orthogonal to said second surface. In one preferred form, said first surface is an upper or top surface of said base and said second surface is a side surface of said base.

[0062] Preferably, said first polymer bearing pad and said second polymer bearing pad have the preferred features of the abovementioned aspects of the invention.

[0063] Preferably, said lubricating fluid includes oil or water.

Brief Description of the Drawings

[0064] Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0065] Figure 1 is a cross-sectional side view of a grinding mill for receiving a hydrostatic bearing according to a first embodiment of the invention;

[0066] Figure 2 is a perspective view of a bearing assembly in the mill of Figure 1;

[0067] Figure 3 is a front view of the bearing assembly of Figure 2;

[0068] Figure 4 is a schematic plan view of a radial hydrostatic bearing for the bearing assembly of Figure 3;

[0069] Figure 5 is a cross-sectional view of the radial hydrostatic bearing along section A-A of Figure 4;

[0070] Figure 5A is a expanded partial cross-sectional view of the chamfer of the radial hydrostatic bearing of Figure 4;

[0071] Figure 6 is a cross-sectional view of the radial hydrostatic bearing taken along section B-B of Figure 4;

[0072] Figure 7 is a schematic plan view of the base of the radial hydrostatic bearing of Figure 4;

[0073] Figure 8 is a schematic cross-sectional view of the base of Figure 7;

[0074] Figure 9 is a schematic cross-sectional view of an axial hydrostatic bearing for the bearing assembly of Figure 3;

[0075] Figure 10 is a schematic plan view of the axial hydrostatic bearing of Figure 9;

[0076] Figures 11 and 11A are schematic partial views of a fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0077] Figure 12 and 12A are schematic partial views of an alternative fastener for use with the hydrostatic bearings of Figures 4 to 10;

[0078] Figure 13 is a schematic partial view of the chamfer of Figure 5A;

[0079] Figure 14 is a schematic cross-sectional view of a prior art hydrostatic bearing;

[0080] Figure 15 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with another embodiment of the invention;

[0081] Figures 16 and 16A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0082] Figures 17 and 17A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0083] Figures 18 and 18A are a schematic plan and cross-sectional views, respectively, of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0084] Figure 19 is a schematic cross-sectional view of a hydrostatic bearing manufactured in accordance with a further embodiment of the invention;

[0085] Figure 20 is a schematic partial cross-sectional view of an axial hydrostatic bearing according to a further embodiment of the invention;

[0086] Figure 21 is a schematic partial expanded view of the axial hydrostatic bearing of Figure 20;

[0087] Figure 22 is a schematic side view of the axial hydrostatic bearing of Figure 20;

[0088] Figure 23 is a schematic plan view of a hydrostatic bearing in accordance with a further embodiment of the invention;

[0089] Figure 24 is a schematic end view of the hydrostatic bearing of Figure 23;

[0090] Figure 25 is a schematic side view of the hydrostatic bearing of Figure 23, and

[0091] Figure 26 is a schematic perspective view of a hydrostatic bearing in accordance with a further embodiment of the invention.

Preferred Embodiments of the Invention

[0092] Referring to Figure 1, a typical grinding mill 1 comprises a milling chamber or body 2 rotatably mounted on supports 3 via journal shafts 4 and bearing assemblies 5. The mill body 2 has an inlet 6 for introducing a charge for grinding and a discharge outlet 7 for removing the processed charge from the mill 1.

[0093] As best shown in Figures 2 and 3, each bearing assembly 5 has a frame 10 and a plurality of fluid bearings in the form of radial hydrostatic bearings 11 and axial hydrostatic bearings 12, which are designed to transport a lubricating fluid in the form of a high pressure oil to an outer surface 13A, 13B of each bearing 11, 12.

[0094] Referring to Figures 4 to 8, where corresponding features have been given the same reference numerals, each radial hydrostatic bearing 11 comprise a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. The hydrostatic bearings 11, 12 are self-aligning in that the hydrostatic bearings self-adjust to any changes in the angular position of the journals 4 during operation of the mill 1. This is typically achieved by having the base 14 mounted on a spherical seat (not shown) to permit self-adjustment to any angular movement of the journals 4. The base 14 is composed of cast iron, but can be made of any other suitable metal or material.

[0095] A polymer pad 17 is mountable to the base 14 of each radial hydrostatic bearing 11 via a mounting portion 8 extending from the polymer pad. In this embodiment, the mounting portion 8 is a protrusion extending from a mounting surface opposite the outer surface 13A to engage flanges 9 located at respective outer edges or sides of the base 14. Generally, the mounting surface will be an inner surface or the underside of the polymer pad 17, but in other embodiments can be located elsewhere. Likewise, the flanges 9 need not be located at opposing outer edges of the base 14, but

can be arranged in any manner that would act to hold captive the bearing pad 17, such as the flanges 9 being located closer to the centre of the base 14 rather than at the outer edges or the flanges 9 being opposed herringbone flanges positioned on the base 14 between which the mounting portions 8 are constrained.

[0096] The polymer bearing pad 17 has at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13A to act as a lubricating fluid between the radial hydrostatic bearing 11 and the journal shafts 4. In the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19. Also, the radial hydrostatic bearings 11 have a plurality of oil supply ports 15, oil galleries 16, recesses 18 and interconnecting passages 19.

[0097] The outer surface 13A of the polymer pad 17 of the radial hydrostatic bearings 11, 12 is curved to receive the curved bearing surface 20 of the journal 4, as best shown in Figures 1, 9, 11 and 11A. Thus, the outer surface 13A of the polymer pad 17 forms a bearing surface, and hence the polymer pad is a bearing pad for the bearings 11 when assembled with the base 14.

[0098] Referring to Figures 9 and 10, where corresponding features have been given the same reference numerals, each of the axial hydrostatic bearings 12 also comprises a base 14 having at least one lubricating fluid supply port in the form of an oil supply port 15 and at least one passage in the form of an oil gallery 16 in fluid communication with the oil supply port 15. A polymer pad 17 is mountable to the base 14 of each axial hydrostatic bearing 12, the polymer pad 17 having at least one recess 18 for receiving oil from the oil gallery 16 and distributing it to the outer surface 13B to act as a lubricating fluid between the axial hydrostatic bearings 12 and the journal shafts 4. Again, in the preferred embodiment, the recess 18 is fluidly connected to the oil gallery 16 via an interconnecting passage 19 in the polymer pad 17. In addition, the axial hydrostatic bearings 12 have a plurality of oil galleries 16 in the base 14, and recesses 18 and interconnecting passages 19 in the polymer pad 17.

[0099] Also, the outer surface 13B of the axial hydrostatic bearing 12 is substantially planar as it receives the substantially planar end surface 21 of the journal 4, as best shown in Figure 1. Similarly to outer surface 13A, the outer surface 13B of the polymer

pad 17 also forms a bearing surface, and hence the polymer pad is a bearing pad for the bearings 12 when assembled with the base 14.

[00100] In both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 substantially covers the entire outer surface 22 of the base 14 to form a substantially fluid impermeable seal between the base and the polymer pad. Also, the polymer pad 17 is mounted to the base 14 using at least one fastener in the form of bolts 23, as best shown in Figures 5 and 9. The fastening system for both the radial hydrostatic bearing 11 and the axial hydrostatic bearing 12 is described in more detail below.

[00101] The fastening system for mounting the polymer pad 17 to the bases 14 of the radial and axial hydrostatic bearings 11, 12 is illustrated in more detail in Figures 11 and 11A, where corresponding features have been given the same reference numerals. The fastening system comprises one of more bolts 23 that are inserted into corresponding openings 18A that are in fluid communication with the oil galleries 16. Each bolt 23 has a bore in the form of through bore 24 for conveying oil from the oil galleries 16 to the recesses 18 via a discharge port 25, as best shown in Figure 11. Thus, there is no need to provide separate oil passages between the oil galleries 16 in the base 14 and the recesses 18 in the polymer pad 17, unlike conventional bronze/white metal hydrostatic bearings. This reduces the complexity and cost in the manufacture of the hydrostatic polymer bearings. It will be appreciated that not all the bolts necessarily will have a bore as sometimes more fasteners are required to mount the polymer bearing pad 17 than the number of oil passages to connect the oil galleries 16 to the recesses 18.

[00102] The bolt 23 is inserted into the oil gallery 16 via the opening 18A and has a head portion 26 for engagement with a seat 27 of the recess 18, as best shown in Figure 11A. The bolt 23 engages the recess 18 to ensure that, in the event of the bolt becoming loose, it is held captive within the recess 18. This prevents any loose bolts 23 coming into contact with and damaging the journal 4. A locking tab 28 is also provided for retaining the head portion 26 within the recess 18. In addition, the head portion 26 has a tapered portion 29 to facilitate retention of the bolt 23 within the recess 18 by the locking tab 28.

[00103] Also, the mounting portion 8 of the polymer pad 17 engages the flanges 9 of the base 14 to help lock the polymer pad in place. This ensures that frictional loads

generated during the rotation of the journal 4 do not forcibly remove or "wipe" the polymer pad 17 from the base 14, even where the bolts 23 become loose, such that the mounting portion 8 and flanges 9 in effect replace the restraint of the bolts 23 against frictional related lateral loads. This makes for a very simple but reliable arrangement, with a level of redundancy to ensure correct operation even if the bolts 23 become loose.

[00104] Moreover, hydrostatic pressure acts between the journal 4 and the polymer bearing pad 17, while there is atmospheric pressure between the polymer bearing pad and the base 14. This pressure difference during operation of the fluid bearing 11, 12, together with the engagement of the mounting portion 8 and the flange or shoulder 9, acts to hold the polymer bearing pad 17 in place. In practice, the fastening system primarily assists in the initial installation of the polymer bearing pad 17 since there is no pressure between polymer bearing pad and the journal 4. This means that in the event bolts 23 are loose the polymer bearing pad 17 would be free to move or "float" until the hydrostatic pressure at the journal 4 is greater than the atmospheric pressure between polymer bearing pad and the base 14.

[00105] An alternative fastening arrangement is illustrated in Figure 12, where corresponding features have been given the same reference numerals. The fastener takes the form of a countersunk screw 30 having a tapered head portion 31 for engagement with a seat 27 recessed in the polymer pad 17. Due to the screw 30 being countersunk into the base 14 and the polymer pad 17, the head portion 31 is tapered in the reverse direction to the taper of the head portion 26 of the bolt 23. To prevent any screw 30 becoming loose and coming into contact with the journal 4, a plug 32 is used to engage the head portion 31 and a locking tab 28 is used to retain the plug 32, and thus the screw 30, within the seat 27. Oil is delivered to the outer surface 13 through a separate recess in the form of a hole 33 that is connected to a bore 34 located over the same position as the oil gallery 16 in the base 14 below, as best shown in Figure 12A.

[00106] In either fastening arrangement, separate O-rings 36 are fitted to the base 14 to provide a fluid seal preventing oil leaking in between the polymer pad 17 and the base, as best shown in Figures 9, 11, 11A and 12A. The thread into which the bolts 23 also assists in forming a fluid seal between the polymer bearing pad 17 and the base 14.

The threads 35 act as plugs to close off holes that are required for machining the oil galleries 16 that direct lubricating fluid into the corner pockets from the central pocket.

[00107] In operation, the radial and axial hydrostatic bearings 11, 12 are installed in the bearing assembly 5 in the positions generally shown in Figure 3 in a manner readily understood by a person skilled in the art. The mill body 2 is then mounted on the bearing assembly 5 via the journals 4. An oil supply system is fluidly connected to the oil supply ports 15 in the base 14 of each radial and axial hydrostatic bearing 11, 12. Typically, the oil is positively pumped to the oil supply ports 15. However, in some variants, the oil need not be supplied by positive displacement pump. In either case, high pressure oil is conveyed from the oil supply ports 15 through the passages 16, bores 23 and interconnecting passages 19 to the recesses 18 and discharge ports 25 and up to the outer surfaces 13A, 13B, as best shown by arrow 39 in Figure 11. The oil collects on the outer surfaces 13A, 13B to create an oil film and lubricate the bearing surfaces 20, 21 of the journals 4.

[00108] Where there is a loss of oil due to a failure in the oil supply system, the polymer pad 17 absorbs most, if not all, of the detrimental effects so any damage is limited to the polymer pad 17 rather than the bearing surfaces 20, 21 of the journal 4 or the base 14. Thus, the base 14 (and its oil galleries 16 and oil supply ports 15) are protected from damage and any damage is suffered by the polymer pad 17. Thus, by having the polymer pad 17 provided with recesses 18 for distributing oil to the outer surface 13, rather than the base 14, the polymer pad can be easily replaced in the event of damage without having to repair the entire bearing. In addition, this advantage is further facilitated by using mechanical fasteners described above to mount the polymer pad 17. Thus, a damaged polymer pad 17 can be removed simply by removing the fasteners 23, 30, enabling easy replacement of the polymer pads 17. Thus, maintenance and operational costs of the mill 1 are reduced, increasing the efficiency of the mill.

[00109] It has also been discovered that providing a polymer pad for the hydrostatic bearings 11, 12 confer numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads, as follows:

(1) It has been discovered that the polymer pad 17 behaves similar to white metal/bronze pads, but is able to self-mould to the journal 4. That is, the polymer pad 17 is able to modify its outer surface 13A, 13B to accommodate circumferential surface imperfections on the bearing surfaces 20, 21 of the journal 4. This reduces or eliminates the need for tight machining tolerances required for bronze bearings, and can subsequently reduce the associated machining costs. Hence, there is a reduced manufacturing cost for the hydrostatic bearings by using a polymer pad.

(2) The polymer bearing pads 17 enable reduced lubrication rates to be used over traditional bronze bearing pads due to the running in characteristics of polymer material, thus conserving lubricating fluid. However, where necessary or desirable, the polymer pads 17 operate equally well at the same lubrication rates used for conventional bronze/white metal bearing pads.

(3) The hydrostatic polymer bearing pads 17 have a lower modulus of elasticity, and thus are able to create a "hovercraft" type cushion around the perimeter of the polymer pad. This acts to accommodate journal imperfections whilst maintaining pressure, much like the cushioning effect produced when a hovercraft moves over bumpy ground.

(4) The hydrostatic polymer bearing pads 17 are much more tolerant than traditional materials to a loss of oil to the bearing 11,12, to contact between journal 4 and outer surface 13A, 13B, and to deformations in the journal bearing surfaces 20, 21. Thus, a loss of oil film due to oil viscosity being too low (from such causes as a high temperature or oil degradation) can be more tolerably managed by the polymer pad 17.

(5) The polymer is elastic, unlike bronze, and is significantly softer than bronze. Thus, the elastic nature of the polymer pads 17 dampen excessive forces that are applied to the hydrostatic bearings 11, 12. For example, where there is a loss of oil through a shock load placed on the hydrostatic bearing 11, 12 there is little or no risk of damage to the metal journal 4 because the polymer pad 17 dampens the shock to some extent and any damage sustained is suffered by the polymer pad rather than the journal. By way of contrast, with white metal/bronze bearings there

is a significant risk of damage to metal journals, resulting in on-site machining and costly stoppages. This advantage of the elasticity of the polymer bearing pads also extends to white metal bearing pads, which are brittle and so are more easily damaged when subjected to typical shock loads.

(6) Any contaminants in the oil that would normally damage the bearing surfaces of the journal 4 or a standard bearing pad tend to be embedded into the polymer pad 17 without adversely affecting operation of the hydrostatic bearing 11, 12.

(7) The self-moulding property of the polymer pads 17 means that the outer surfaces 13A, 13B of the polymer pads tend to conform to the profile of the bearing surface 21 of the journal 4 that it is running against. As a consequence, the polymer pads 17 (and hence bearing 11) do not necessarily require a self-alignment mechanism (such as a spherical seat) within certain limits, unlike conventional bearings. It is also contemplated that the self-moulding property also permits the design and installation of hydrostatic bearings that ordinarily would be outside of the capacity of conventional bearings, since the polymer pad 17 can provide some degree of self-alignment in addition to a conventional self-alignment mechanism.

[00110] These advantages of the polymer pad 17 means that the hydrostatic bearings can be operated at lower oil film thicknesses. This has a flow on effect, permitting the use of smaller and cheaper lubrication systems, reducing power consumption and conserving the use of oil. Also, in the event of operational problems damage to the journals 4 and polymer bearing pads 17 is significantly reduced, increasing product life and reducing the frequency of maintenance and repair. Furthermore, any damage is limited to the polymer bearing pads 17 and does not adversely affect operation of the journal 4. Finally, the complex and expensive accumulator systems can be removed, saving installation costs and eliminating their associated maintenance costs.

[00111] Referring now to Figures 5A, 9 and 13, another aspect of the invention is described, where corresponding features have been given the same reference numerals. In this aspect of the invention, a chamfer is provided at an outer edge of a bearing pad for retaining lubricating fluid on the chamfer, thus enabling recycling of lubricating fluid in the bearing. In applying this aspect of the invention to both the radial and axial hydrostatic bearings 11, 12, the polymer pad 17 has a chamfer 37 at both

outer edges 38 for retaining oil on the chamfer, as best shown in Figures 5A, 9 and 13. The chamfer 37 creates a lead-in and lead-out for the oil, especially when residual oil on the outer surfaces 13A, 13B must be relied upon for lubrication in the event of an unexpected loss of normal oil supply to the bearings 11, 12. The chamfer 37 inhibits or prevents oil being wiped off the journal 4, as would occur with a bearing having a sharp straight edge. Thus, the chamfer 37 helps to ensure that there is a residual amount of oil between the polymer pad 17 and the metal journal 4.

[00112] In a conventional bearing, the straight edge would wipe off oil from the journal and thus increase the loss of oil from the bearing. By way of contrast, in this aspect of the invention, the chamfer 37 provides a capture point for the oil that may be lost during operation. As the journal 4 rotates on the hydrostatic bearing 11, 12 the "lead-in" chamfer 37 enables the bearing surface 20 of the journal 4 to capture oil from the chamfer 37 and thus is lubricated before coming into contact with the outer surface 13A, 13B of the hydrostatic bearing. The inventors believe that the oil held by the "lead-in" chamfer 37 is recaptured by the journal 4 due to a hydrodynamic effect produced by its rotation. When the bearing surface 20 of the journal 4 leaves the outer surface 13A, 13B of the hydrostatic bearing, the "lead-out" chamfer 37 on the other side of the hydrostatic bearing 11, 12 feeds any discharging oil from the outer surface 13A, 13B onto the journal to provide a consistent oil thickness over the journal, thus maintaining its lubrication. The provision of chamfers 37 at each outer edge 38 enables the mill journal 4 to be operated in either rotational direction. As a consequence, the use of the chamfers 37 minimises the loss of oil and effectively removes the need to provide oil pressure accumulators with their associated high maintenance and installation costs. Therefore, the chamfers 37 provide the radial and axial hydrostatic bearings 11, 12 provide a cost effective solution and safety measure for the hydrostatic bearings.

[0100] The chamfer 37 is inclined approximately at an angle α to the outer surface 13A, 13B. In the case of the radial hydrostatic bearing 11, the angle α is defined relative to a tangent 39 from the curved outer surface 13A, as best shown in Figure 13. In the case of the axial hydrostatic bearing 12, the angle α is defined relative to the horizontal plane of the planar outer surface 13B. In either case, the angle α is in the range of 0.01° to 89°, and is preferably 8°.

[0101] In addition, the chamfer 37 has an outer edge 40 that is displaced from the journal 4 when the journal engages the polymer pad 17. In both the radial and axial hydrostatic bearings 11, 12 the outer edge 40 of the chamfer 27 is displaced approximately 0.5mm to 1.5 mm from the journal 4. The displacement β is preferably displaced by approximately 0.85 mm from the journal 4.

[0102] It will be appreciated by a person skilled in the art that the chamfer 37 could also be applied to existing bronze/white metal hydrostatic bearings and is not limited to hydrostatic bearings having a polymer pad.

[0103] Referring now to Figures 14 to 19, various methods of making the polymer pads 17 and the hydrostatic bearings 11, 12 of Figures 4 to 10 are illustrated, where corresponding features have been given the same reference numerals. As best shown in Figure 14, manufacturing the curved surface for a radial hydrostatic bearing involves removing the hatched area 41 from the material. This waste material can be a significant, especially on larger bearings, and contributes to unnecessary additional manufacturing costs. Furthermore, the manufacturing process is not environmentally sustainable.

[0104] With the hydrostatic bearings of Figures 4 to 10, polymer material can be purchased "off the shelf" in sheet form and subsequently formed to produce the polymer pads 17. One method involves heating the polymer material to a holding temperature which does not melt the material, but the polymer retains some structural integrity while having some malleability or pliability to be able to be formed. There are various procedures that can be used to heat and form the polymer readily understood by the person skilled in the art.

[0105] In one example, the polymer can be placed in a shaped former or mould and lightly clamped. The former or mould is then heated to an intermediate temperature, removed from oven, fully clamped and returned to the oven. After heating to a holding temperature, the former is held for a set period of time, removed from oven and allowed to cool.

[0106] In another example, the polymer is placed in a shaped former and clamped using springs or a dead weight. The former is heated to the holding temperature and

kept at this temperature for a set period of time. After being allowed to cool, the polymer is removed from the former.

[0107] In a further example, the polymer sheet is heated to the holding temperature for set period of time to ensure uniform heating of material. The polymer is then removed from the heat, immediately placed in cold former and pressed to profile. In the case of a radial hydrostatic bearing 11, the former also creates the curved outer surface 13A. After being allowed to cool, the polymer pad 17 is removed from the former.

[0108] After assuming the required shape for the hydrostatic bearing 11, 12, the recesses 18 and interconnecting passages 19 are machined into the outer surface 13A, 13B of the polymer pad 17. Also, the chamfer 37 is machined at the same time. The mounting portion 8 is machined, either before or after machining of the recesses 18, interconnecting passages 19 and the chamfer 37. Alternatively, the mounting portion 8 is formed during the initial moulding of the polymer sheet. The openings 18A can also be formed either during the initial moulding or by drilling, punching, cutting or machining the polymer pad 17. The machined polymer pad 17 is then mechanically mounted to the base 14 using the fastener systems described above to complete assembly of the hydrostatic bearing 11, 12.

[0109] Referring now to Figures 15 to 16, another method of making the hydrostatic bearings is illustrated, where corresponding features have been given the same reference numerals. This method involves making a plurality of polymer pads in the form of slats 50 each having outer surfaces 51 that form a substantially uniform bearing surface 52 for the journal 4, as best shown in Figure 15. The slats 50 are produced using the same heating and forming method described above, and then fastened to the base 14 using either of the fastener systems as described in relation to Figures 4 to 10. As best shown in Figure 15, the resultant amount of removed material indicated by hatched area 53 is considerably less than the amount of material removed in a conventional bearing indicated by hatched area 41.

[0110] Also, the polymer pad 17 can be divided into any number of smaller polymer pads or slats 50 of any shape and/or size, as required. For example, there could be six polymeric slats 50 that are rectangular and uniform in shape but have differently shaped

recesses, as best shown in Figures 16, 16A, 17 and 17A. Similarly, the polymeric slats 50 could be larger in size, as best shown in Figures 18 and 18A.

[0111] In a further variation to this method, the polymeric slats 55 each have complementary connecting portions 56 to connect with an adjacent polymer pad 55, as best shown in Figure 19. The complementary connecting portions in this variation take the form of teeth 56 that are splayed together so that the slats 55 form a complete polymer pad 17. The polymer pads 55 are then mounted to the base 14 using either of the fastener systems as described in relation to Figures 4 to 10. Once in position, glue may be applied at adjacent surfaces of the polymer slats and their teeth 56 to enhance sealing. Then, the polymer slats 55 are clamped and heated to cure the adhesive joint. The joint formed by the connecting teeth 56 is such that the weight of mill journal 4 on the polymeric slats 55 works to ensure the joint is always in compression. It has been found by testing such bearings that they are strong enough as a bearing surface for the journal 4. It will be appreciated that other profiles for the connecting portions 56 can be used, such as tabs and detents of any polygonal shape.

[0112] The inventors believe that segmenting the surface area of the polymer pad 17 into individual polymer pads or slats 50reduces the amount of wastage involved with machining standard bearings, as indicated in area 41 of Figure 14, and provides a suitable supplementary option to heating and forming the entire polymer pad 17 as described above.

[0113] While the hydrostatic bearings 11, 12 have been described in the context of self-aligning hydrostatic bearings, it will be appreciated that the various aspects of the invention are also equally applicable to fixedly mounted hydrostatic bearings. Referring now to Figures 20 to 22, one example of a fixedly mounted hydrostatic bearing 60 is illustrated, where corresponding features have been given the same reference numerals. In this embodiment, the fixedly mounted hydrostatic bearing is an axial hydrostatic bearing 60 comprises a polymer pad 17 mounted on a base 14, which is fixedly mounted to mounting plate 61 via fasteners 62. Due to the polymeric nature of the polymer bearing pad 17, the outer surface 13B of the polymer pad will conform to the profile of the bearing surface 21 of the journal 4 that it is running against. This means that the axial hydrostatic bearing can provide some degree of self-alignment, if necessary, which is not possible in a conventional axial hydrostatic bearing. Aside from

the manner of its mounting, the axial hydrostatic bearing 60 operates in substantially same manner as the self-aligning axial hydrostatic bearing 12 described above. Furthermore, while this embodiment concerns as axial hydrostatic bearing, it is also applicable to a fixedly mounted radial hydrostatic bearing.

[0114] Referring now to Figures 23 to 25, a fluid bearing 70 according to another aspect of the invention is illustrated, where corresponding features have been given the same reference numerals. The fluid bearing 70 is a hydrostatic bearing that is a combination of the radial and axial hydrostatic bearings 11, 12, 60 described above. The base 71 has been adapted to receive both a polymer pad 17A having a radial or curved outer surface 13A mounted on its outer surface 72 and two polymer pads 17B having a substantially planar outer surface 13B mounted on opposing side surfaces 73 that are orthogonal to the outer surface 72. Thus, the combination hydrostatic bearing 70 acts as a self-aligning radial hydrostatic bearing 11 in one direction and as two fixedly mounted axial hydrostatic bearings 60 in two other directions, as best shown in Figure 25. Again, due to the polymer's characteristics the outer surfaces 13B of the polymer pads 17B with conform to the profile of the bearing surface 21 of the journal 4 that it is running against. Thus, there is no need for a separate base for the axial hydrostatic bearings. The inventors contemplate that this combination hydrostatic bearing 70 avoids the need to install three separate hydrostatic bearings and thus allows for ease of installation in the mill 1. Due to the easy replacement of the polymer pads 17A, 17B, there is no need to remove the base 71 in the event one or more of the polymer pads 17A, 17B are damaged during operation of the mill 1. Thus, the combination hydrostatic bearing 70 creates cost savings in installation and repair.

[0115] The inventors also contemplate that the combination bearing 70 can be modified so as to minimise or eliminate the "axial float". Axial float is the difference between the distance between axial bearing pads and the distance between axial journal faces. Axial float is generally required so that the axial hydrostatic bearings are not tightly fitted with the mill journal 4. Typically, this axial float is set to around 0.5 to 1mm, meaning that the mill journal is able to freely float in the axial direction by this 0.5 to 1mm. A potential advantage of this combination bearing 70 is that the amount of axial float can be reduced or eliminated, since one of the axial bearings on the combination bearing 70 can be configured to move axially on a piston which is supplied by pressurised oil. This effectively ensures that axial float is minimised or removed.

[0116] In other embodiments, the hydrostatic bearing takes the form of a slipper bearing 80, as best shown in Figure 26. Due to the larger size of the bearing pad for a slipper bearing and its 120° curvature, it could be difficult to mould a single polymer pad 17. Thus, segmenting the bearing pad surface into multiple polymer pads or slats 81 having curved outer surfaces and laterally connected together enables the invention to be used for a slipper bearing. The lateral connections can be formed as described in relation to Figure 19. Thus, the advantages of the polymer pad 17 can be extended to a slipper bearing.

[0117] In the preferred embodiments of the invention, the polymer pad 17 is made of polyetheretherketone (PEEK). However, it will be appreciated that other polymer materials are also suitable for the hydrostatic bearings 11, 12, such as PEEK composites, polyamide, polyamide composites, polyamide-imide and polyamide-imide composites. Also, while the preferred embodiments of the invention have been described as employing oil as the lubricating fluid, other lubricating fluids can be used such as water.

[0118] It will be appreciated by a person skilled in the art that the hydrostatic bearings of the preferred embodiments of the invention can be readily retrofitted into existing bearing assemblies, and thus do not require the replacement of each bearing in a milling apparatus.

[0119] While the preferred embodiments of the invention have been described using one of two possible fastener arrangements as illustrated in Figures 11, 11A, 12 and 12A, it will be appreciated that other fastener type arrangements may be used to implement the invention. For example, in one preferred form the fasteners are substantially retained within the recesses 18 by a locking element. The locking element comprises, but is not limited to, a liquid thread locker, a Scotch key, a non-loosening thread, a non-loosening washer or similar locking device.

[0120] In another embodiment, the outer (bearing) surface of the polymer bearing pad comprises two co-planar surfaces at 45° to each other. In this embodiment, the polymer bearing pad acts as both a linear and axial bearing pad simultaneously, similar to a lathe bed bearing.

[0121] It will further be appreciated that any of the features in the preferred embodiments of the invention can be combined together and are not necessarily applied in isolation from each other. For example, the chamfer 37 could be readily applied to the outermost polymer slats 81 in the slipper bearing to provide the advantages of reducing oil loss and elimination of oil pressure accumulators.

[0122] Also, while the preferred embodiment of the invention have been described in relation to hydrostatic bearings in general, it will be appreciated that each of the aspects of the invention and the corresponding preferred features are also applicable to other types of fluid bearings, such as hydrodynamic bearings and hybrid bearings that use a combination of hydrodynamic and a continuous hydrostatic flow for lubrication.

[0123] By providing a polymer bearing pad for a hydrostatic bearing, the invention confers numerous advantages over existing hydrostatic bearings with white metal/bronze bearing pads. The polymer bearing pads 17 reduces or eliminates damage to the journal and the base of the hydrostatic bearing, thus increasing product life and reducing the frequency of maintenance and repair. Moreover, the polymer pads 17 are easily replaceable, enabling easy installation and removal for repair. This advantage is facilitated by the use of the mounting portion 8, flange 9 and a mechanical fastening system to mount the polymer pad 17 to the base 14.

[0124] Also, the polymer pads 17 do not require tight machining tolerances, can conform to the profile of the journal, have reduced lubrication rates enabling the use of less oil, resistant to damage caused by the loss of oil or contaminants, and dampen any excessive shock forces, protecting the journal bearing surface. These advantages permits the operation of the hydrostatic bearings of the preferred embodiments of the invention at lower oil film thicknesses, thus reducing oil consumption, permitting the use of smaller and cheaper lubrication systems and more efficient power consumption and conserving the use of oil.

[0125] Also, the use of chamfer in hydrostatic bearings in general obviates the need for expensive accumulator systems that are difficult to operate and maintain. Furthermore, the chamfer conserves the use of oil and thus reduces oil consumption. Furthermore, since the base is of a standard design, the hydrostatic bearings of the

invention can be readily retrofitted to existing mills. In all these respects, the invention represents a practical and commercially significant improvement over the prior art.

[0126] Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

Claims

1. A polymer bearing pad for a fluid bearing, comprising an outer surface, at least one recess for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface and mounting means for securely mounting said polymer bearing pad to said base.

2. The polymer bearing pad of claim 1, wherein said mounting means comprises a mounting portion extending from said polymer bearing pad.

3. The polymer bearing pad of claim 2, wherein said mounting portion comprises a protrusion from a mounting surface opposite to said outer surface for engaging a flange of said base.

4. The polymer bearing pad of any one of the preceding claims, wherein said mounting means comprises at least one opening for receiving at least one fastener for mounting said polymer pad to said base.

5. The polymer bearing pad of claim 4, wherein said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess.

6. The polymer bearing pad of any one of the preceding claims, wherein said polymer bearing pad substantially covers an outer surface of said base to create a fluid seal between said polymer bearing pad and said base.

7. The polymer bearing pad of any one of the preceding claims, further comprising a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal.

8. The polymer bearing pad of claim 7, wherein said chamfer has an outer edge that is displaced from a journal when said journal engages said polymer pad.

9. The polymer bearing pad of any one of the preceding claims, wherein said outer surface is partially curved. .

10. The polymer bearing pad of any one of claims 1 to 8, wherein said outer surface is substantially planar.

11. The polymer bearing pad of any one of the preceding claims, further comprising at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

12. A fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port and at least one passage in fluid communication with said at least one lubricating fluid supply port, and

the polymer bearing pad of any one of the preceding claims mountable to said base.

13. The fluid bearing of claim 12, wherein base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base.

14. The fluid bearing of claim 13, wherein said flange is located at an outer edge of said base.

15. The fluid bearing of any one of claims 10 to 14, said at least one recess of said polymer bearing pad comprises at least one interconnecting passage for fluidly connecting said at least one recess to said at least one passage of said base.

16. The fluid bearing of any one of claims 10 to 15, further comprising at least one fastener for mounting said polymer bearing pad to said base, said at least one fastener comprising a bore for conveying lubricating fluid from said at least one passage to said at least one recess.

17. The fluid bearing of claim 16, wherein said at least one recess has a locking tab for retaining said head portion within said at least one recess.

18. The fluid bearing of claim 16, further comprising a plug for engagement with said head portion and said at least one recess.

19. The fluid bearing of claim 16 or 18, further comprising a locking element for retaining said at least one fastener within said at least one recess.

20. The fluid bearing of any one of claims 12 to 19, further comprising a plurality of said polymer bearing pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

21. The fluid bearing of claim 20, wherein each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

22. The fluid bearing of any one of claims 12 to 21, wherein said base further comprises a first surface, a second surface, a plurality of said at least one passages and a plurality of said at least one lubricating fluid supply ports, wherein said at least one passages are in fluid communication with said at least one lubricating fluid supply ports, said first surface and said second surface, and

a first of said polymer bearing pads is mountable to said first surface and a second of said polymer bearing pads is mountable to said second surface.

wherein said first polymer bearing pad comprises a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

said second polymer bearing pad comprises a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

23. The fluid bearing of claim 22, wherein said first surface is orthogonal to said second surface.

24. The fluid bearing of claim 22 or 23, wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

25. The fluid bearing of any one of claims 12 to 21, wherein said fluid bearing is at least one of a radial hydrostatic bearing, a self-aligning radial hydrostatic bearing, a

fixedly mounted radial hydrostatic bearing, a hydrostatic slipper bearing, an axial bearing, a self-aligning axial hydrostatic bearing and a fixedly mounted axial hydrostatic bearing.

26. A method of making a polymer bearing pad for a fluid bearing, comprising forming a polymer pad having an outer surface, forming at least one recess in said polymer pad for receiving lubricating fluid from a base of said fluid bearing and distributing said lubricating fluid to said outer surface, and forming a mounting means on said polymer pad for securely mounting said polymer pad to said base.

27. The method of claim 26, wherein said mounting means forming step comprises machining said polymer pad to form a mounting portion extending from said polymer pad.

28. The method of claim 26, wherein said mounting means forming step comprises drilling, punching, cutting or machining an opening in said at least one recess to receive at least one fastener.

29. The method of claim 26 or 28, further comprising chamfering an outer edge of said polymer pad.

30. The method of any one of claims 26 to 29, wherein said at least one recess forming step comprises machining said at least one recess in said polymer pad and machining at least one interconnecting passage to interconnect said at least one recess to said base.

31. A method of making a fluid bearing for a journal, comprising:

providing a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port and at least one flange;

making a polymer bearing pad in accordance with the method of any one of claims 26 to 30, and

mounting said polymer bearing pad to said base.

32. The method of claim 31, wherein said mounting step comprising mechanically fastening said polymer bearing pad to said base.

33. The method of claim 31 or 32, wherein there are a plurality of said polymer pads, said method further comprising connecting said polymer bearing pads such that said outer surfaces of said polymer bearing pads form a substantially uniform bearing surface for said journal.

34. The method of claim 33, further comprising forming at least one lateral connecting portion in each said polymer bearing pad for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

35. The method of claim 33 or 34, wherein said further comprises selecting one or more polymer bearing pads for mounting at the outer edges of said base and chamfering an outer edge of each selected polymer bearing pad.

36. A fluid bearing for a journal, comprising:

a base having at least one lubricating fluid supply port, at least one passage in fluid communication with said at least one lubricating fluid supply port, and

a polymer bearing pad having at least one recess for receiving lubricating fluid from said at least one passage and distributing said lubricating fluid to an outer surface of said bearing pad,

said polymer bearing pad being mountable to said base and further comprising a chamfer at an outer edge for retaining said lubricating fluid thereon and transferring said lubricating fluid to said journal.

37. The fluid bearing of claim 36, wherein said chamfer is inclined approximately 8° from a tangent of an edge of said outer surface.

38. The fluid bearing of claim 36 or 37, wherein said chamfer has an outer edge that is displaced from said journal when said journal engages said polymer bearing pad.

39. A multidirectional fluid bearing for a journal, comprising:

a base having a first surface, a second surface, one or more lubricating fluid supply ports and a plurality of passages in fluid communication with said lubricating fluid supply ports, said first surface and said second surface,

a first polymer bearing pad mountable to said first surface, said polymer bearing pad having a first outer surface and at least one recess for receiving lubricating fluid from at least one of said plurality of passages and distributing said lubricating fluid to said first outer surface, and

a second polymer bearing pad mountable to said second surface, said second polymer bearing pad having a second outer surface and at least one recess for receiving lubricating fluid at least one of said plurality of passages and distributing said lubricating fluid to said second outer surface.

40. The multidirectional fluid bearing of claim 39, said first polymer bearing pad substantially covers said first outer surface and said polymer bearing pad substantially covers said second outer surface to respectively create fluid seals between said first and second polymer bearing pads and said base.

41. The multidirectional fluid bearing of claim 40, wherein at least one of said first and second polymer bearing pads comprises a chamfer at an outer edge for retaining lubricating fluid at said outer edge and transferring said lubricating fluid to a journal.

42. The multidirectional fluid bearing of claim 41, wherein said chamfer has an outer edge that is displaced from a journal when said journal engages said at least one polymer bearing pad.

43. The multidirectional fluid bearing of any one of claims 39 to 42, wherein at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base, wherein said at least one recess comprises a locking tab for retaining a head portion of said fastener within said at least one recess, said head portion being tapered to facilitate retention of said at least one fastener within said at least one recess by said locking tab.

44. The multidirectional fluid bearing of any one of claims 39 to 43, wherein said at least one fastener comprises a bore for conveying lubricating fluid from said at least one passage to said at least one recess, said at least one fastener being partially received in said at least one passage.

45. The multidirectional fluid bearing of any one of claims 39 to 42, wherein at least one of said first and second polymer bearing pads comprises at least one opening for receiving at least one fastener for mounting said at least one polymer bearing pad to said base, and further comprising a locking element for retaining said at least one fastener within said at least one recess.

46. The multidirectional fluid bearing of any one of claims 39 to 45, wherein at least one of said first and second polymer bearing pads comprises a plurality of said polymer bearing pads, wherein said outer surfaces of said polymer pads form a substantially uniform bearing surface for said journal.

47. The fluid bearing of claim 46, wherein each of said polymer bearing pads comprises at least one lateral connecting portion for mutual engagement with a corresponding lateral connecting portion of an adjacent polymer bearing pad.

48. The multidirectional fluid bearing of claim 39, wherein at least one of said first polymer bearing pad and said second polymer bearing pad comprises said polymer bearing pad of any one of claims 1 to 11.

49. The multidirectional fluid bearing of claim 48, wherein base comprises at least one flange for engagement with said mounting portion to securely mount said polymer bearing pad to said base.

50. The multidirectional fluid bearing of claim 49, wherein said flange is located at an outer edge of said base.

51. The multidirectional fluid bearing of any one of claims 39 to 50, wherein said first surface is orthogonal to said second surface.

52. The multidirectional fluid bearing of any one of claims 39 to 51, wherein said first outer surface is partially curved such that said first polymer bearing pad acts as a radial hydrostatic bearing and said second outer surface is substantially planar such that said second polymer bearing pad acts as an axial bearing.

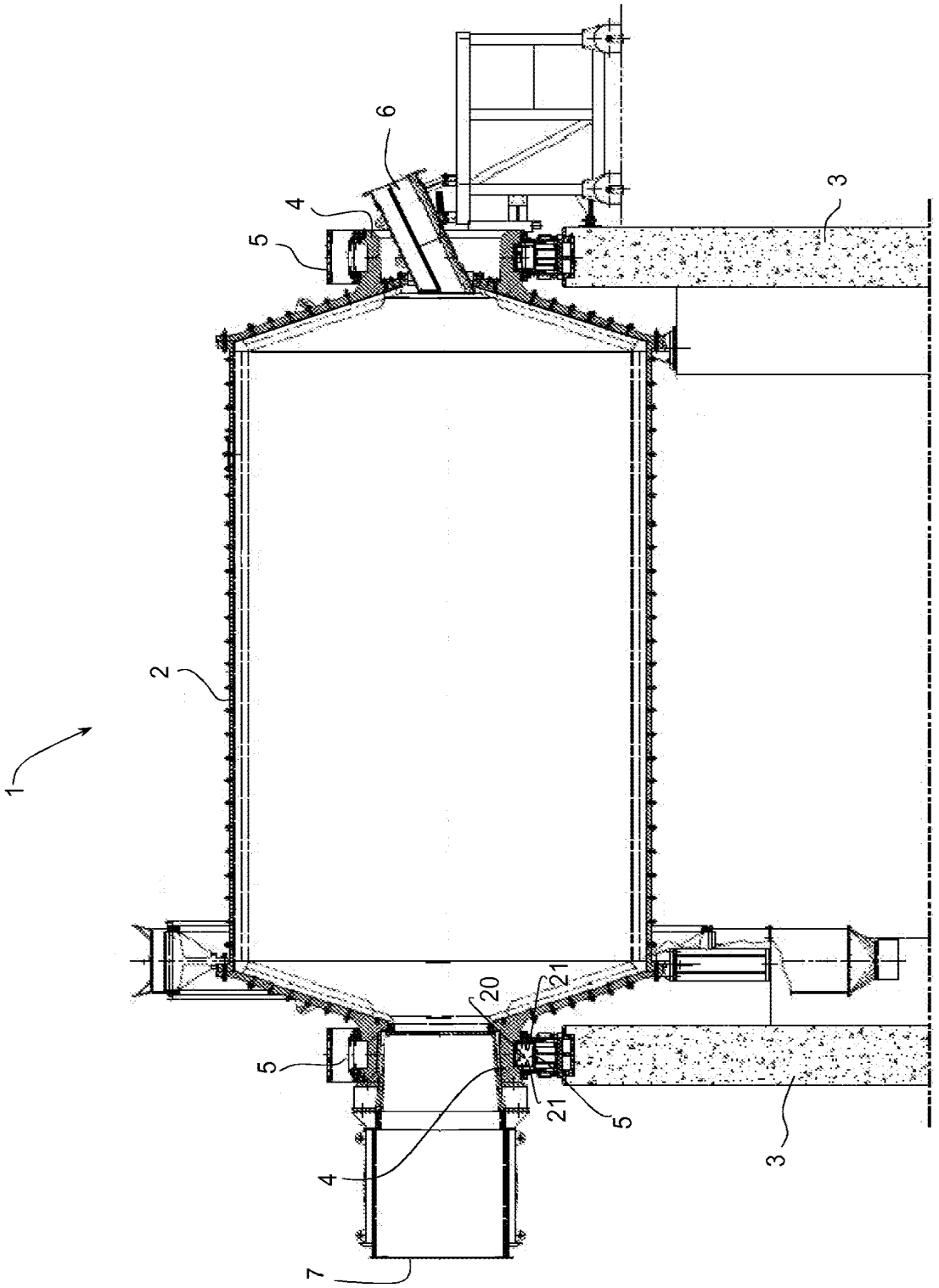


Fig. 1

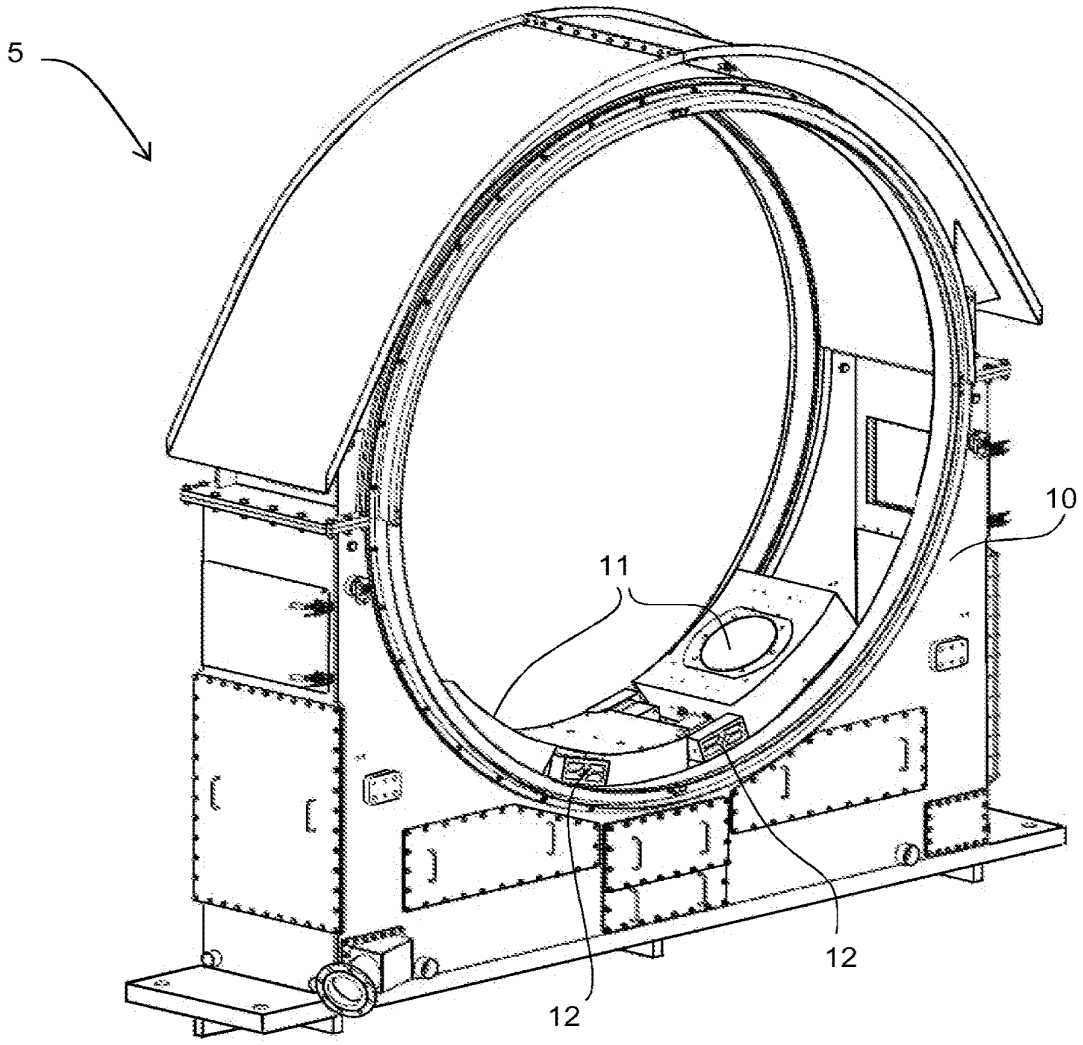


Fig. 2

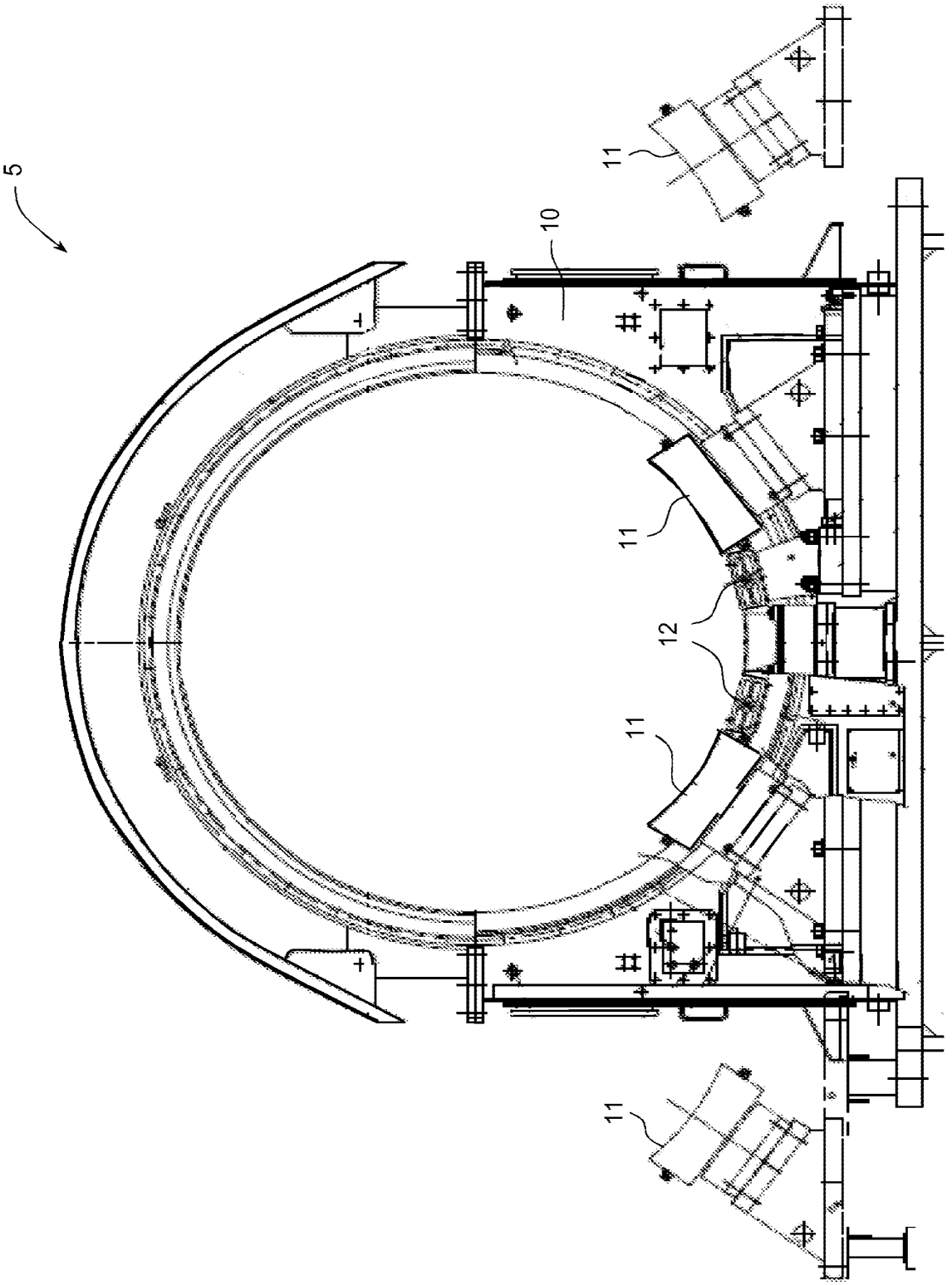


Fig. 3

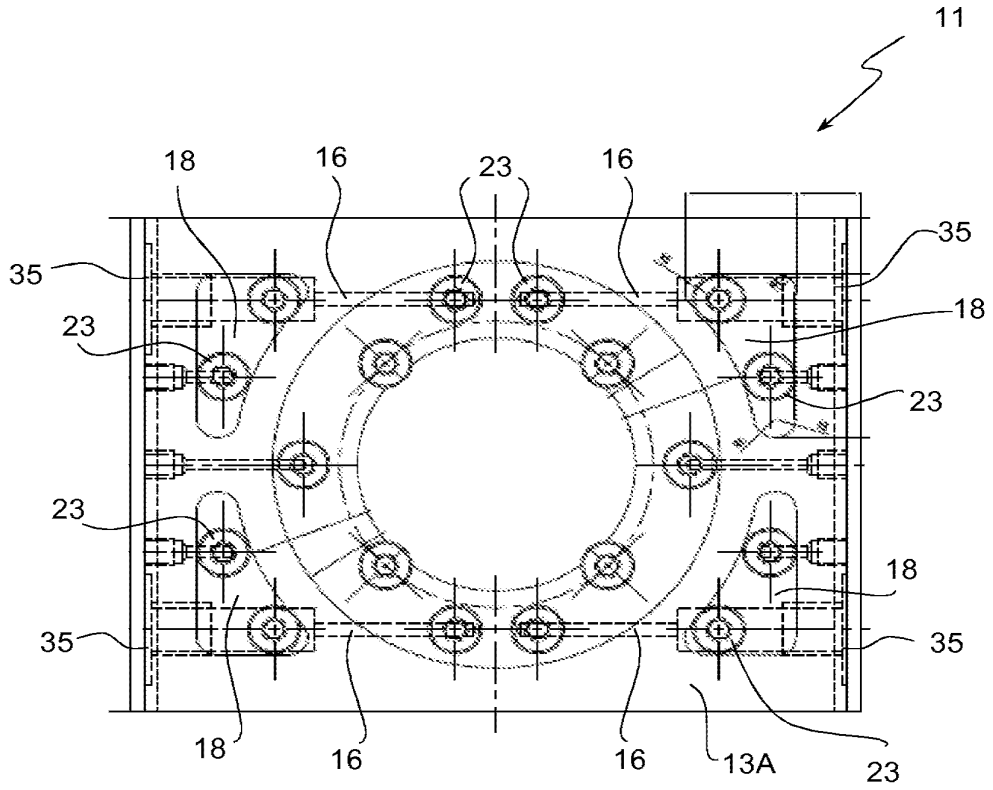


Fig. 4

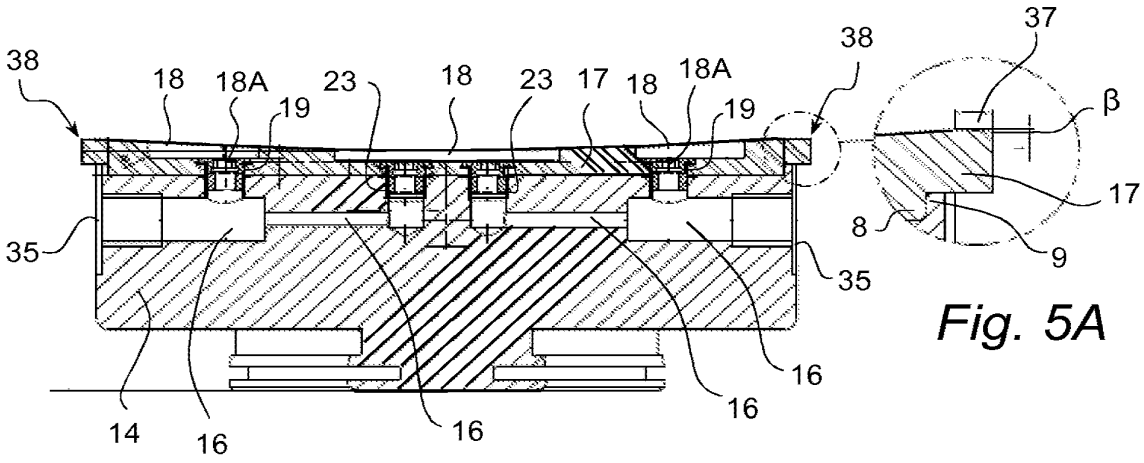


Fig. 5A

Fig. 5

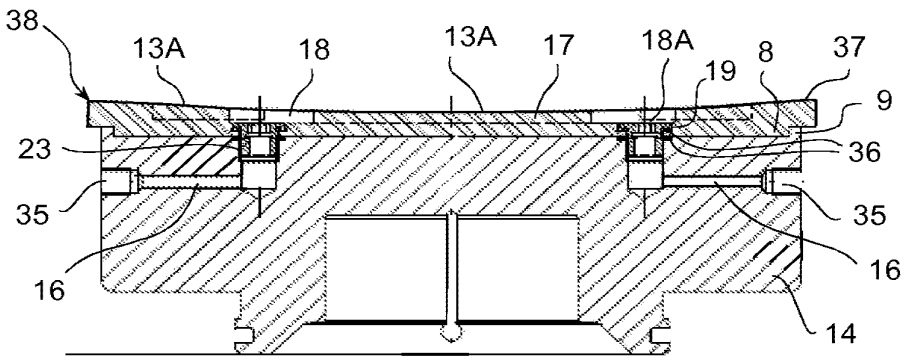


Fig. 6

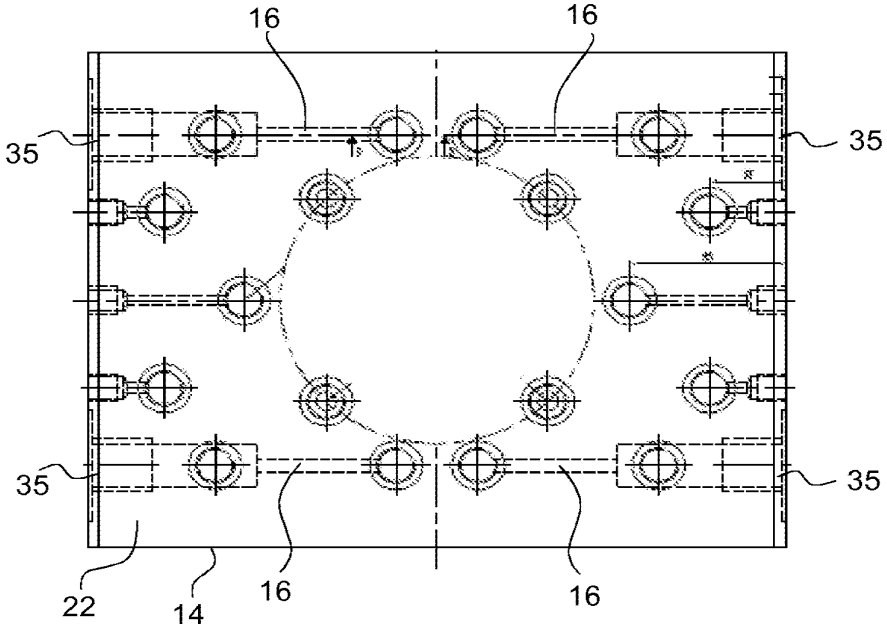


Fig. 7

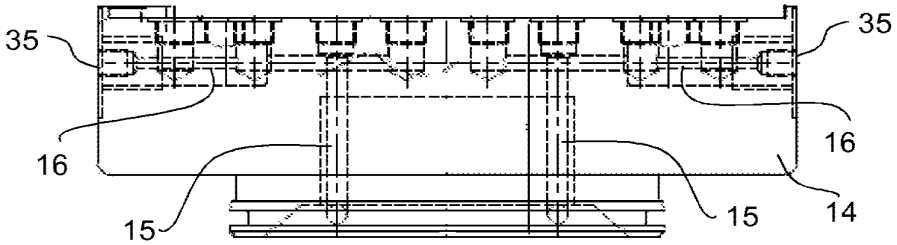


Fig. 8

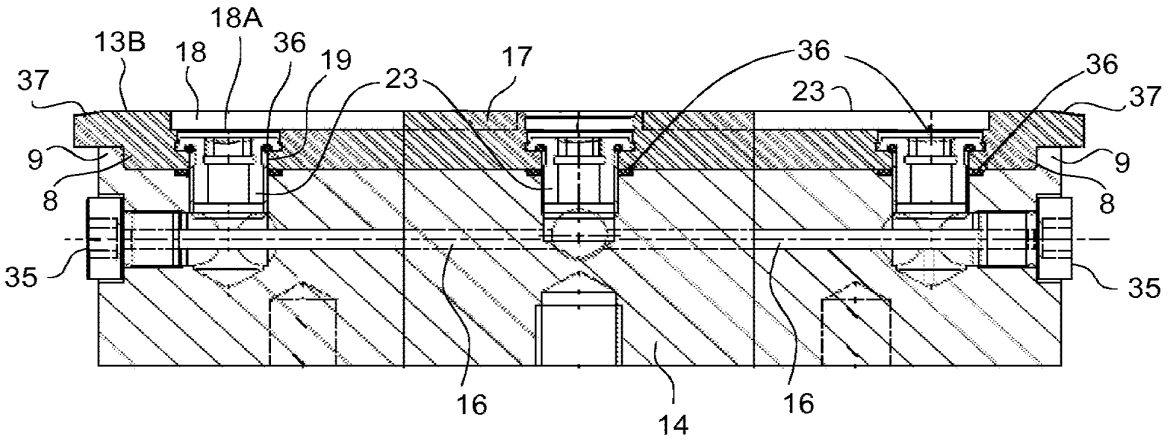

18A
13B
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Fig. 9

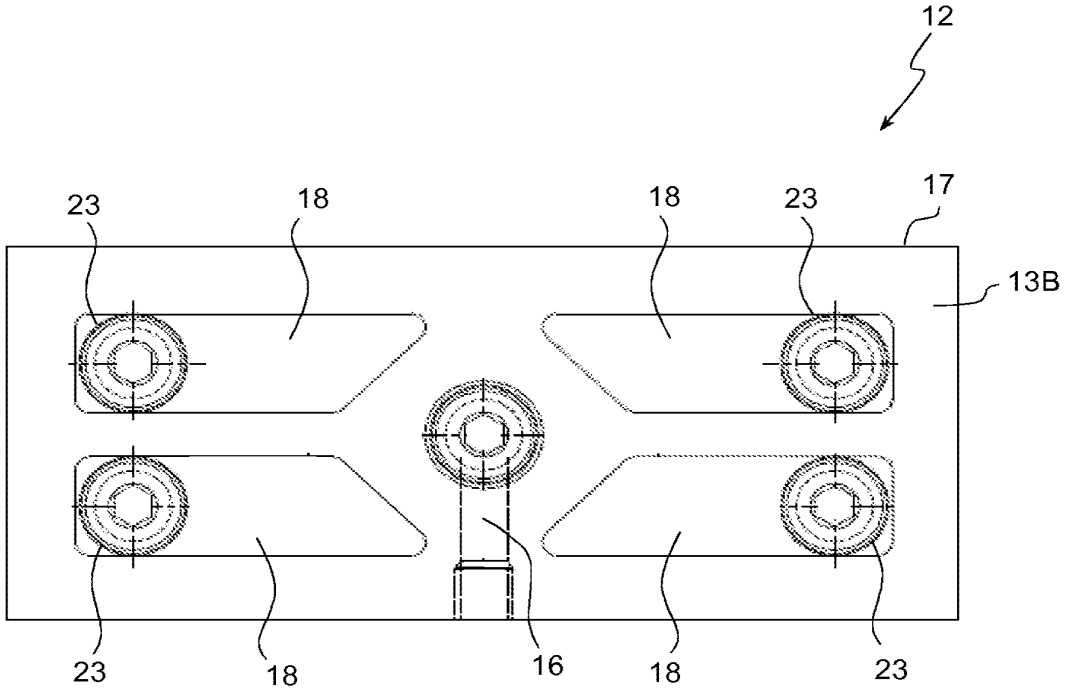

12
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13B
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18
23

Fig. 10

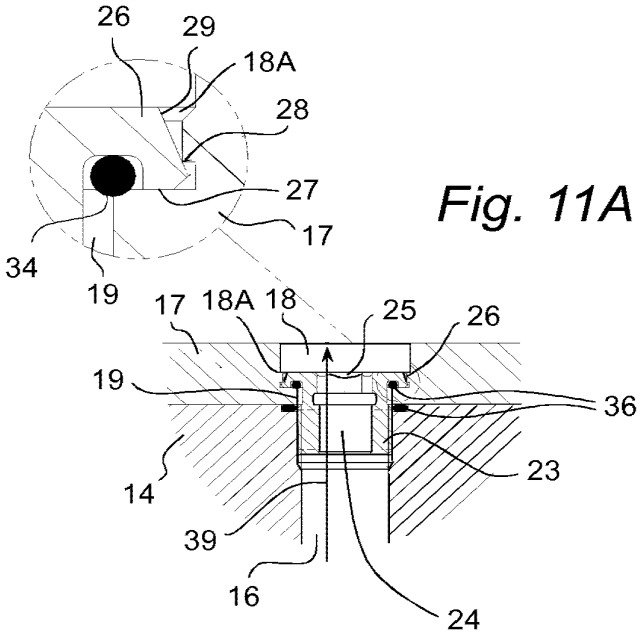


Fig. 11A

Fig. 11

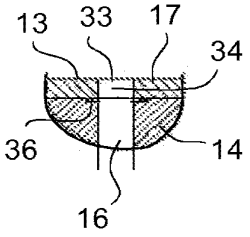


Fig. 12A

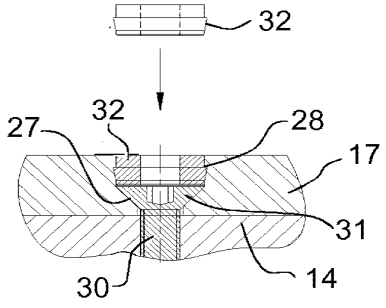


Fig. 12

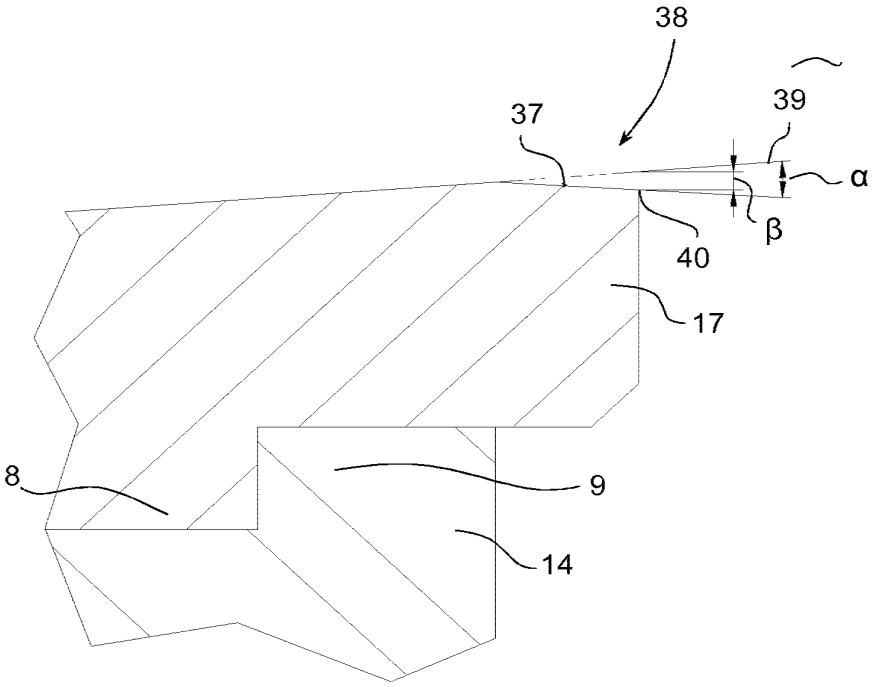


Fig. 13

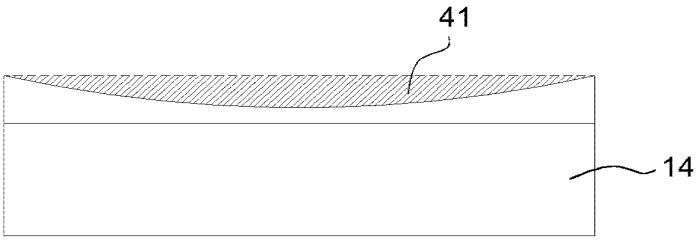


Fig. 14

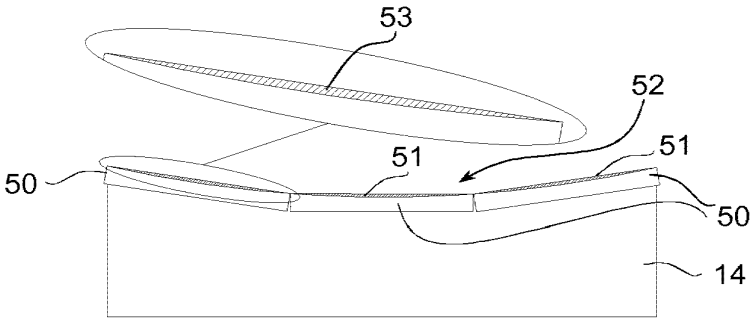


Fig. 15

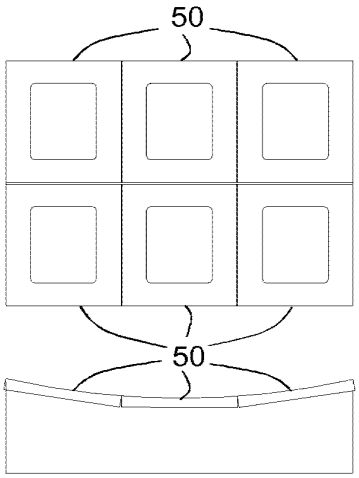


Fig.16

Fig.16A

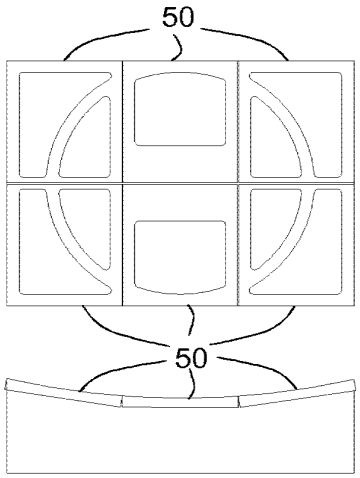


Fig.17

Fig.17A

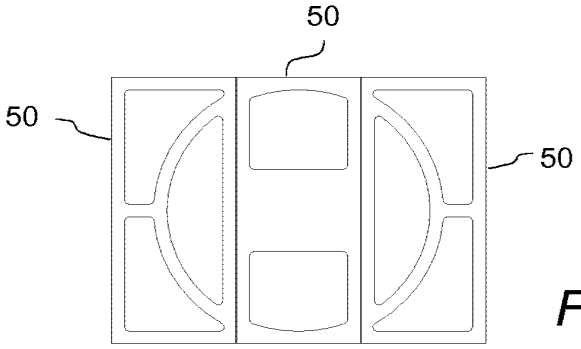


Fig. 18

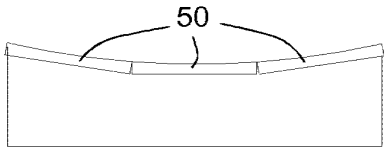


Fig. 18A

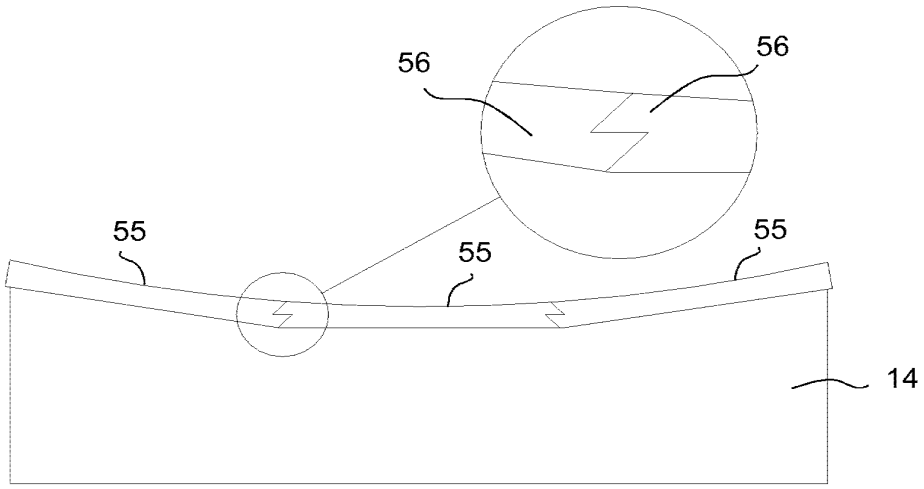


Fig. 19

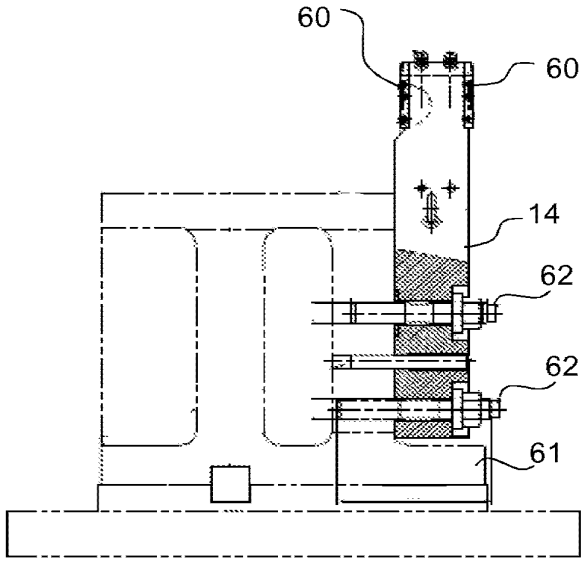


Fig. 22

Fig. 21

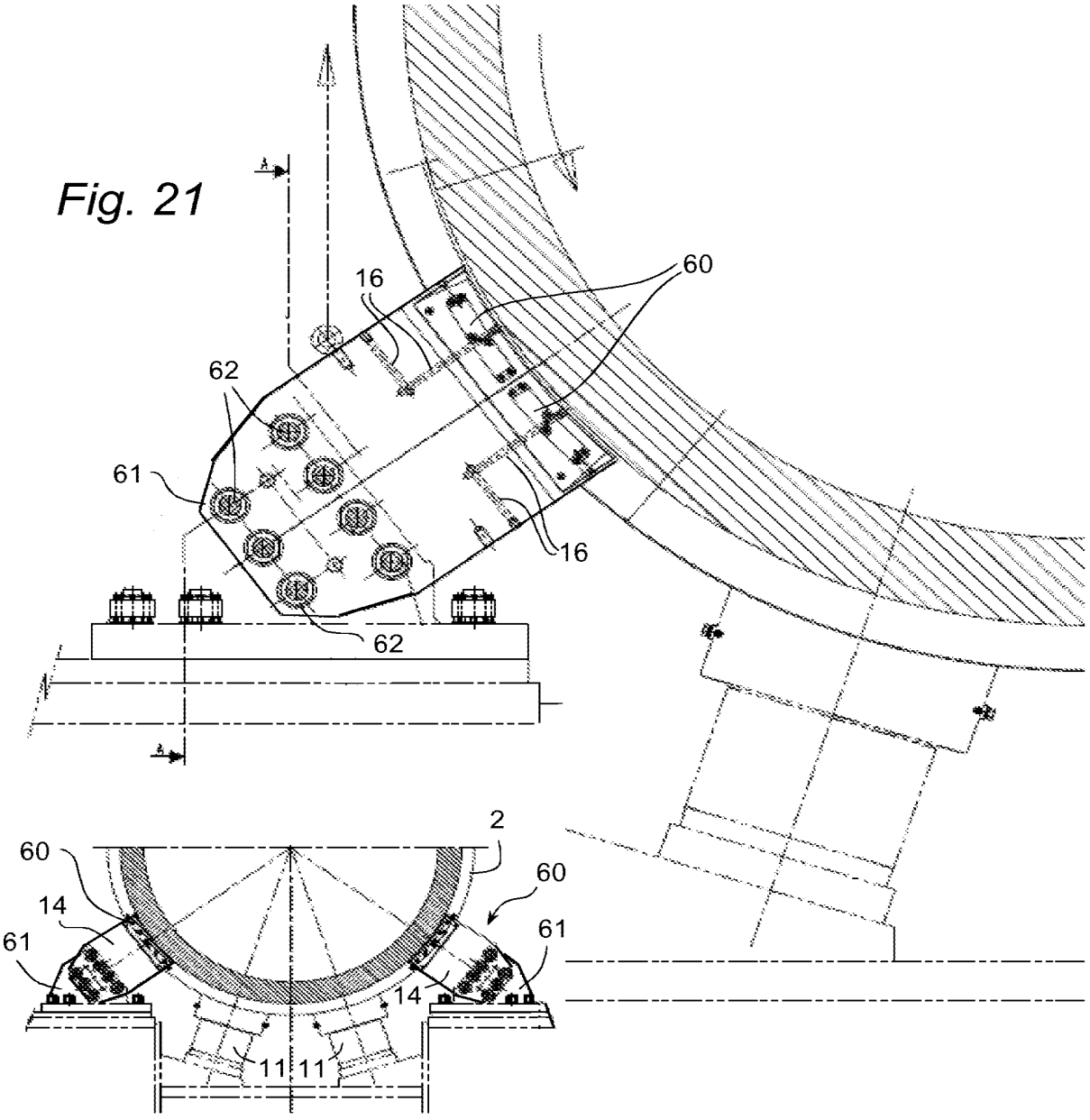


Fig. 20

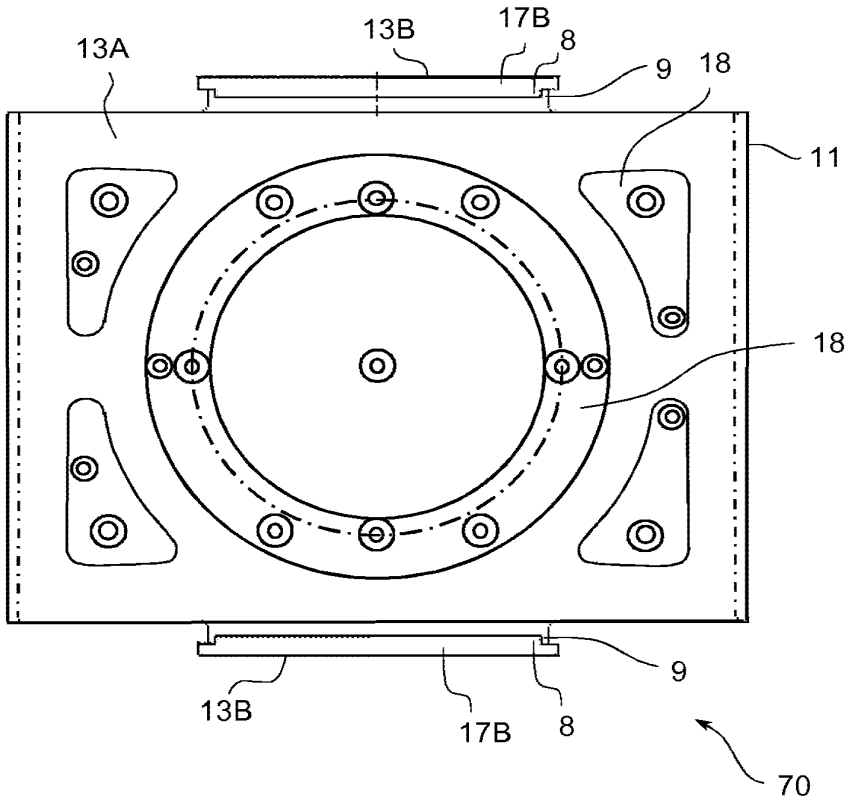


Fig. 23

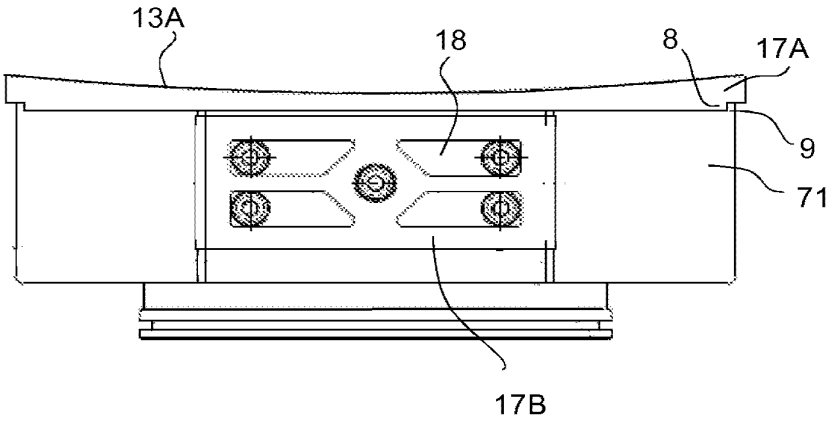


Fig. 24

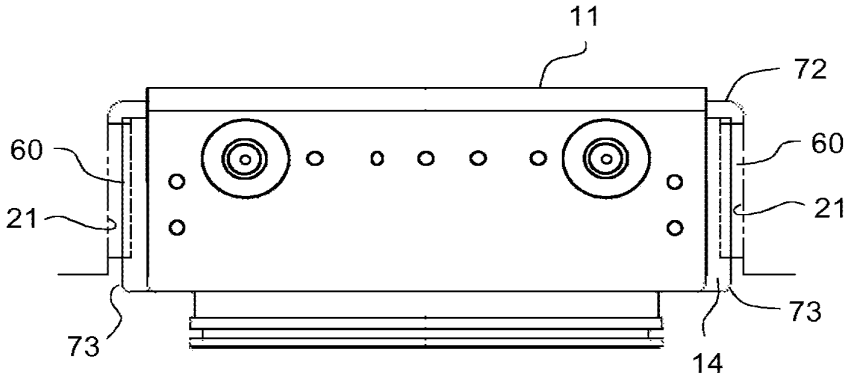


Fig. 25

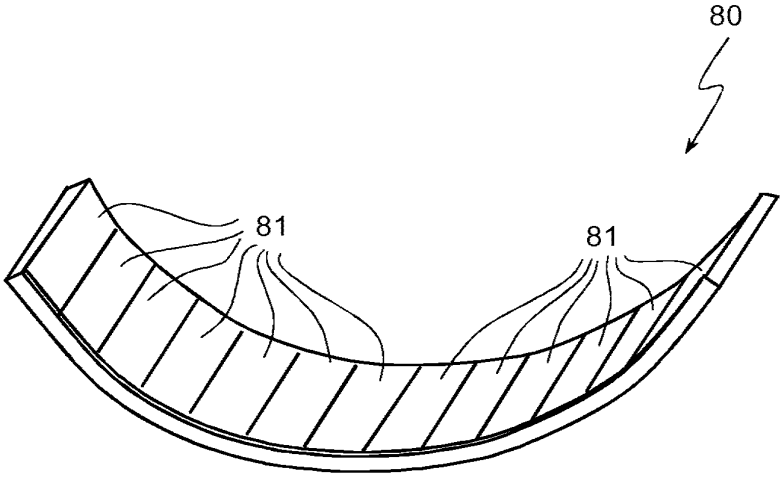


Fig. 26

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/410,241	Filing Date 12/22/2014	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	12/22/2014	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 25	Minus	** 25	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/VANESSA HODGES/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Exhibit 1002
FLS v. Metso