

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
22 January 2009 (22.01.2009)

PCT

(10) International Publication Number
WO 2009/009864 A1

(51) International Patent Classification:

F01D 25/28 (2006.01) *F02C 7/20* (2006.01)
B65D 85/68 (2006.01) *F16C 39/00* (2006.01)
F02C 7/06 (2006.01) *F16C 41/04* (2006.01)

(21) International Application Number:

PCT/CA2008/001167

(22) International Filing Date: 18 June 2008 (18.06.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

11/777,634 13 July 2007 (13.07.2007) US

(71) Applicant (for all designated States except US): **PRATT & WHITNEY CANADA CORP.** [CA/CA]; 1000 Marie Victorin, (01BE5), Longueuil, Québec J4G 1A1 (CA).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **URAC, Tibor** [CA/CA]; Unit 506, 50 Camden Street, Toronto, Ontario M5V 3N1 (CA). **ISABEL, Yves** [CA/CA]; 10844 Drapeau, Montreal-nord, Québec H1H 3J8 (CA). **BEAUVAIS, Gilles** [CA/CA]; 1211 - 16th Avenue, Pointes-aux-trembles, Québec H1B 3N4 (CA). **GIROUX, Sylvain**

[CA/CA]; #5, 2 Place Dubuc, Ville Mercier, Québec J6R 2M6 (CA).

(74) Agent: **OGILVY RENAULT LLP / S.E.N.C.R.L., S.R.L.**; Suite 1600, 1981 McGill College Avenue, Montreal, Québec H3A 2Y3 (CA).

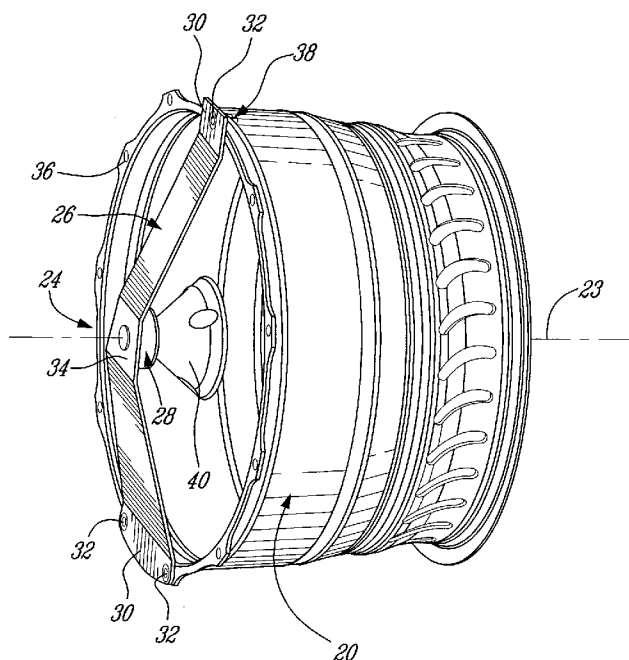
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, 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, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,

[Continued on next page]

(54) Title: PRELOADING BRACE FOR GAS TURBINE ENGINE TRANSPORTATION

Fig. 2



(57) Abstract: An assembly for preventing damage to bearings of a gas turbine engine (10) during transportation is provided. The assembly comprises a turbofan gas turbine engine (10) having an engine casing (20) and at least one turbine shaft (22) supported by a plurality of bearings, and, a brace (24) secured relative to the engine casing and biasing the shaft (22) along an axial direction of the shaft (22).



NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG,
CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

PRELOADING BRACE FOR GAS TURBINE ENGINE TRANSPORTATION

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This application claims priority on United States Patent Application No. 11/777,634 filed July 13, 2007, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

10 The invention relates generally to gas turbine engines and, more particularly, to the prevention of engine bearing damage caused during the transportation of gas turbine engines.

BACKGROUND OF THE ART

15 During transportation, aircraft engines such as gas turbine engines must be handled carefully in order to avoid shock loading to engine bearings. Shock loading can occur during an impact, a drop or abrupt back and forth movements. When the engine rotor is not rotating and the engine bearings are supporting the weight of the rotor, only a few rolling elements are in contact with the raceways. In some cases, only two or three rolling elements may be in contact with the raceway of a particular bearing. Therefore, due to the relatively small contact area between the rolling elements and the raceway, a shock load while transporting the engine may result in a very high contact pressure between the rolling elements and the raceway which can be beyond the material's elasticity limit.

20 Consequently, this phenomenon can produce true brinelling defects in the bearing raceway. True brinelling defects are characterised by indentations or material deformations on the raceway which are of the shape of the contact area between the rolling elements and the raceway, and, are spaced according to the rolling element spacing. True brinelling defects in a bearing raceway can lead to vibrations and noisy engines particularly at slower rotational speeds or at run down and can lead to premature failure of the bearing. Conventional ball bearings are typically more prone to true

brinelling damage, however this type of damage can also occur in roller bearings or the like.

Accordingly, there is a need to provide a solution through which engine bearing damage caused by shock loading during the transport of gas turbine engines may be prevented or reduced.

SUMMARY

It is therefore an object of this invention to provide an assembly which addresses the above mentioned concerns.

In one aspect, there is provided an assembly comprising: a turbofan gas turbine engine, the engine having an engine casing and at least one turbine shaft supported by a plurality of bearings, the bearings having a static portion mounted to the casing; a brace secured relative to the engine casing and disposed in contact with a rotating member of the engine mounted to the shaft, the brace biasing the shaft along an axial direction of the shaft.

There is also provided, in accordance with another aspect, an assembly comprising: a turbofan gas turbine engine having a fan mounted to a fan shaft, the fan shaft being supported on bearings and the bearings being secured to an engine casing; and means for axially biasing the fan shaft relative to the engine casing.

There is further provided, in accordance with another aspect, a method for transporting a turbofan gas turbine engine, wherein the engine comprises a turbine shaft having a rotating member mounted thereto, the shaft being supported by a plurality of bearings, the engine having a casing to which a static portion of the bearings are mounted, the method comprising the steps of: a) exerting a force on the shaft in relation to the static portion of the bearings, the force being exerted along a central axis of the shaft; b) transporting the engine; and c) removing the force on the shaft prior to the operation of the engine.

Further details of these and other aspects of the present invention will be apparent from the detailed description and figures included below.

DESCRIPTION OF THE DRAWINGS

Reference is now made to the accompanying figures depicting aspects of the present invention, in which:

Fig. 1 is a schematic axial cross-section view of a gas turbine engine;

5 Fig. 2 is an isometric view of a brace according to one embodiment of the present invention, secured to a fan case of the gas turbine engine of Fig. 1;

Fig. 3 is a front elevation view of a bracing member of the brace of Fig. 2;

Fig. 4 is a side elevation view of the bracing member of Fig. 2; and

10 Fig. 5 is an isometric view of a brace according to another embodiment of the present invention, secured to a fan case of a different configuration.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates a turbofan gas turbine engine 10 of a type preferably provided for use in subsonic flight, generally comprising in serial flow communication a fan 12 through which ambient air is drawn, a multistage compressor 14 for pressurizing the air, a
15 combustor 16 in which the compressed air is mixed with fuel and ignited for generating an annular stream of hot combustion gases, and a turbine section 18 for extracting energy from the combustion gases.

The fan 12 is a rotating member of the gas turbine engine 10 and is disposed within a static fan case 20 which defines a fan inlet. The fan 12 is secured to a main shaft
20 22 which is supported within the engine 10 by a plurality of engine bearings which are not shown. The fan 12 and the shaft 22 have a common central axis of rotation 23. The types of bearings that are used to support the shaft 22 typically comprise rolling elements and a raceway disposed on a static portion of the bearing that is mounted to a static casing of the engine. These types of bearings may experience true brinelling damage when subjected to
25 significant shock loading during, for example, transportation of the engine 10.

Fig. 2 shows a brace 24 that is removably secured to the fan case 20. The brace 24 comprises a bracing member 26 and a load transfer member 28 disposed on the bracing member 26. A front view and a side view of the bracing member 26 are shown in Figs. 3

and 4 respectively. The bracing member 26 has two mounting portions 30 wherein each mounting portion 30 has one or more holes 32 that are used to secure the bracing member 26 to the fan case 20. The two mounting portions 30 are located at opposite ends of the bracing member 26. The bracing member 26 also comprises a holding portion 34 on which the load transfer member 28 is disposed. The holding portion 34 is located approximately mid-span between the two mounting portions 30. Fig. 5 shows another brace 24 wherein the mounting portions 30 are adapted to be secured to a fan case 20 having a different configuration.

The brace 24 is removably secured to the fan case 20 prior to the transport of the gas turbine engine 10 in order to prevent or reduce damage to the engine bearings, especially true brinelling defects, caused by shock loading. The bracing member 26 is secured to the fan case 20 by fastening the mounting portions 30 to a flange 36 of the fan case 20 using bolts 38. During packaging of the gas turbine engine 10 prior to transportation, the brace 24 is installed and the gas turbine engine 10 may be packaged or prepared in accordance with conventional procedures. The brace 24 is intended to be reusable and must be removed prior to the operation of the gas turbine engine 10.

When the brace 24 is removably secured to the fan case 20, the holding portion 34 of the bracing member 26 urges the load transfer member 28 against a nose cone 40 of the fan 12. The nose cone 40 is shown in Figs. 2 and 5 for clarity. Accordingly, an axial preloading force is applied to the fan 12 in a direction parallel to the central axis of rotation 23 and transferred to the bearings via the shaft 22. This axial force causes all the rolling elements of one or more bearings supporting the shaft 22 to become seated against their respective raceway. Since all the rolling elements of the bearing are kept in contact with the raceway, a larger contact area is provided for transmitting the forces induced by shock loading during transportation of the gas turbine engine 10. Hence, the true brinelling damage that can occur during engine transportation, when only a few rolling elements are in contact with the raceway, is prevented or significantly reduced. Consequently, the installation of the brace 24 also limits the unwanted movement of the fan relative to the fan case 20.

Referring to Figs. 1 and 2, the load transfer member 28 transfers the axial load from the bracing member 26 to the nose cone 40 of the fan 12 by pushing against the nose cone 40 and thereby biasing the shaft along a downstream direction relative to the turbine engine 10. The direction in which the axial force should be applied to the fan 12 along the central axis 23 will depend on the type of bearings that are used to support the shaft 22. In any case, the magnitude of the axial preloading force should be sufficient to cause all the rolling elements of at least one bearing to become seated against the raceway. Typically, the preload force required ranges from 30 lbs to 100 lbs for an engine of the type shown in Fig. 1.

The load transfer member 28 may be ring-shaped to receive the nose cone 40 of the fan 12 and may comprise a resilient and/or compressible material which allows the load transfer member 28 to be held in a compressed state against the nose cone 40 of the fan 12. For example, in the case where the load transfer member 28 comprises a resilient material, the spacing between the bracing member 26 and the nose cone 40 may be such that when the bracing member 26 is installed, the load transfer member 28 is in a compressed state and therefore urges the nose cone 40 of the fan 12 away from the bracing member 26. Suitable materials that may be used for the load transfer member 28 are for example StyrofoamTM, rubber or the like. The load transfer member 28 may be affixed to the bracing member 26 or may be separate and simply compressed between the bracing member 26 and the nose cone 40. It will be apparent to one skilled in the art that other configurations of load transfer members could also be used. For example a spring-loaded pad urging the fan 12 away from the bracing member 26 would achieve similar results.

Alternatively or in combination with a resilient and/or compressible load transfer member 28, the bracing member 26 itself may be designed to be flexible and resilient. For example, in such case the bracing member 26 would be secured to the fan case 20 in a deflected or biased state and would thereby urge the load transfer member 28 against the nose cone 40 of the fan 12 in order to exert a suitable axial preload force.

The above description is meant to be exemplary only, and one skilled in the art will recognize that changes may be made to the embodiments described without

department from the scope of the invention disclosed. For example, it is apparent that providing a brace that is adapted to be secured to a static component or casing of the gas turbine engine 10 other than the fan case 20 is also feasible. Alternatively, the brace could also be secure to or form part of a shipping container in which the gas turbine engine is packaged during transportation in order to exert an axial force on the shaft 22 relative to the static portion of the bearings. Further, the axial preload force could be transmitted to a different location on the fan 12 or to another rotating member mounted on the shaft 22 in order to cause the rolling elements of at least one bearing supporting the shaft 22 to become seated on the raceway. It is also apparent that the brace 24 described above can be fabricated using conventional manufacturing procedures using suitable materials that would be apparent to a person skilled in the relevant art. Furthermore, it is apparent that the use of such brace is not limited to turbofan gas turbine engines but could also be useful for the transport of other types of turbines or rotary machinery where similar brinelling damage to support bearings may be of concern. Still other modifications which fall within the scope of the present invention will be apparent to those skilled in the art, in light of a review of this disclosure, and such modifications are intended to fall within the appended claims.

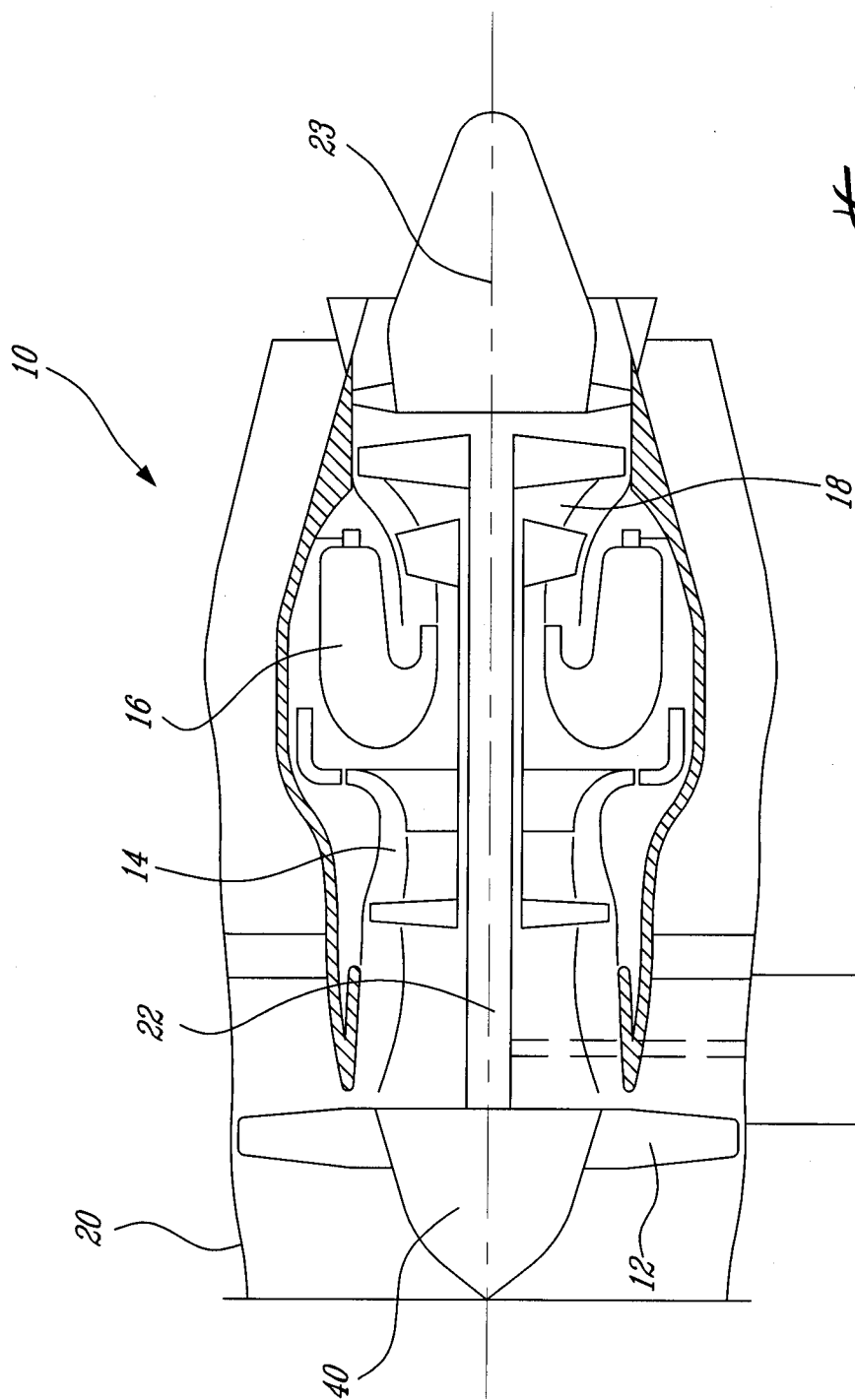
WHAT IS CLAIMED IS:

1. An assembly comprising:
 - a turbofan gas turbine engine, the engine having an engine casing and at least one turbine shaft supported by a plurality of bearings, the bearings having a static portion mounted to the casing; and
 - a brace secured relative to the engine casing and disposed in contact with a rotating member of the engine mounted to the shaft, the brace biasing the shaft along an axial direction of the shaft.
2. The assembly as defined in claim 1, wherein the brace is mounted directly to the engine casing.
3. The assembly as defined in claim 1, wherein the brace includes a resilient member in contact with the rotating member of the engine.
4. The assembly as defined in claim 1, wherein the rotating member is a fan, and the brace contacts a nose cone of the fan.
5. The assembly as defined in claim 2, wherein the brace is secured to the engine casing at two locations, and contacts the rotating member mid-span of the two locations.
6. The assembly as defined in claim 1, wherein the brace is resilient.
7. An assembly comprising:
 - a turbofan gas turbine engine having a fan mounted to a fan shaft, the fan shaft being supported on bearings and the bearings being secured to an engine casing; and
 - means for axially biasing the fan shaft relative to the engine casing.
8. The assembly as defined in claim 7, wherein the means comprises a resilient member disposed between the fan and a brace fixed relative to the engine casing.

9. The assembly as defined in claim 8, wherein the resilient member is held in a compressed state against the fan.
10. The assembly as defined in claim 7, wherein the means engages a nose cone of the fan.
11. The assembly as defined in claim 10, wherein the means is disposed diametrically across a fan inlet of the engine.
12. A method for transporting a turbofan gas turbine engine, wherein the engine comprises a turbine shaft having a rotating member mounted thereto, the shaft being supported by a plurality of bearings, the engine having a casing to which a static portion of the bearings are mounted, the method comprising the steps of:
 - a) exerting a force on the shaft in relation to the static portion of the bearings, the force being exerted along a central axis of the shaft;
 - b) transporting the engine; and
 - c) removing the force on the shaft prior to the operation of the engine.
13. The method as defined in claim 12 wherein the force is exerted by mounting a brace biased against the rotating member.
14. The method as defined in claim 12, wherein the force exerted is sufficient to cause all rolling elements of at least one bearing to become seated to a raceway disposed on the static portion of the at least one bearing.
15. The method as defined in claim 12, wherein the force is exerted in a downstream direction relative to the engine.
16. The method as defined in claim 12, wherein a magnitude of the force is from 30 lbs to 100 lbs inclusively.

17. The method as defined in claim 12, further comprising:
 - i) packaging the engine to be ready for transportation, prior to the transporting step
 - b).
18. The method as defined in claim 12, wherein the force of step a) is exerted to the shaft via a fan that is mounted to the shaft.
19. The method as defined in claim 12, wherein the exerting step a) includes securing a brace to the casing of the engine and biasing the brace against a fan that is mounted to the shaft.
20. The method as defined in claim 19, wherein the brace comprises a resilient member that is biased in a compressed state against a nose cone of the fan.

1 / 4



2 / 4

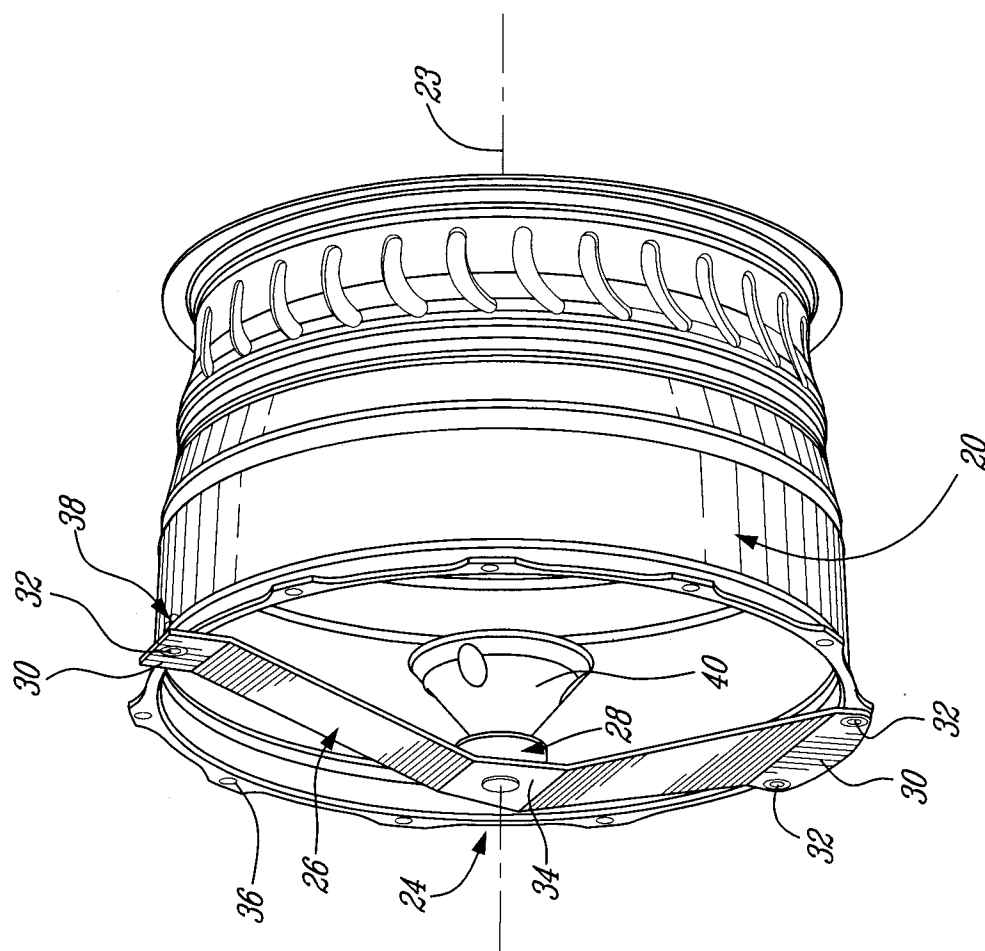
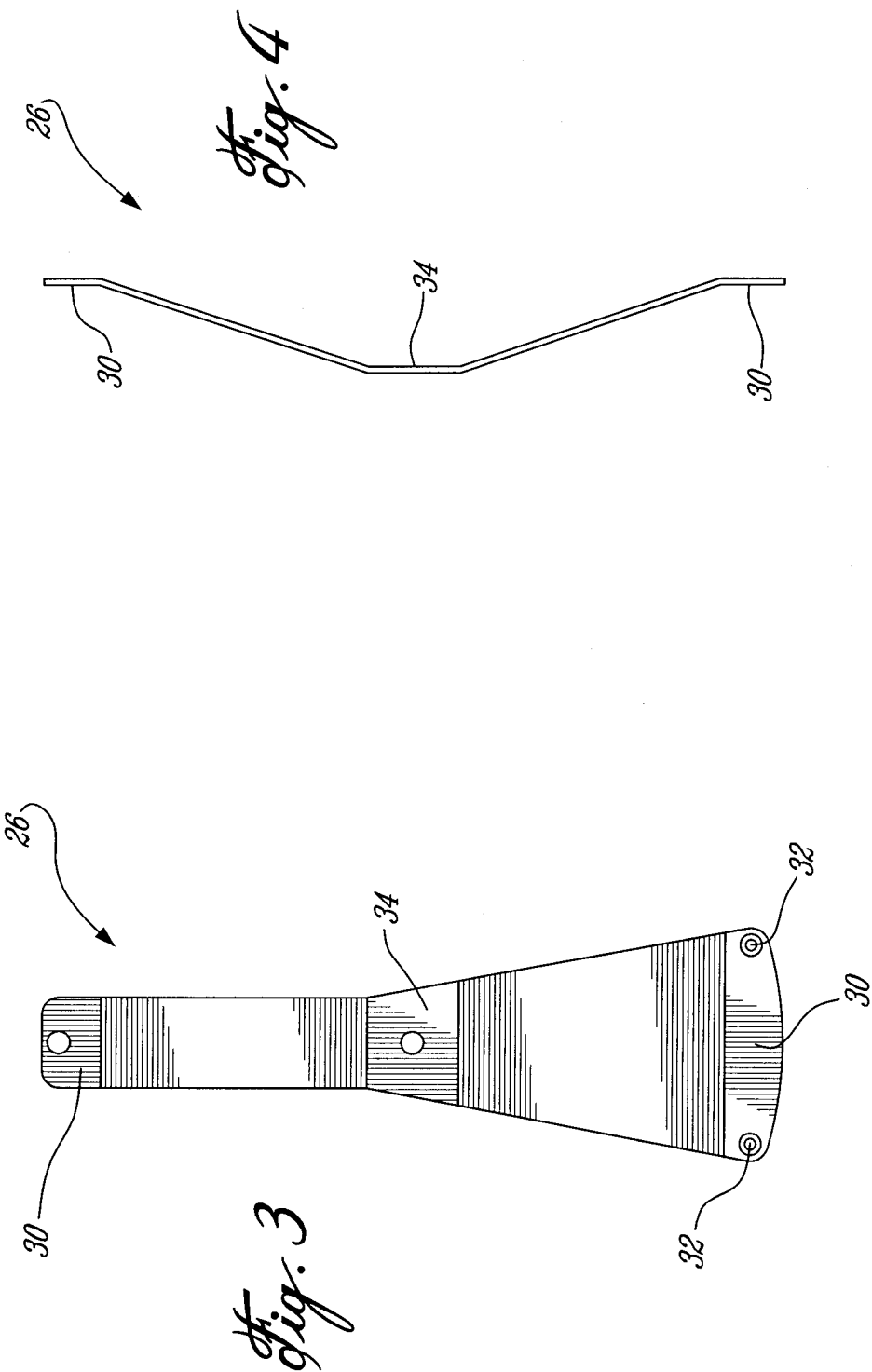


Fig. 2



4 / 4

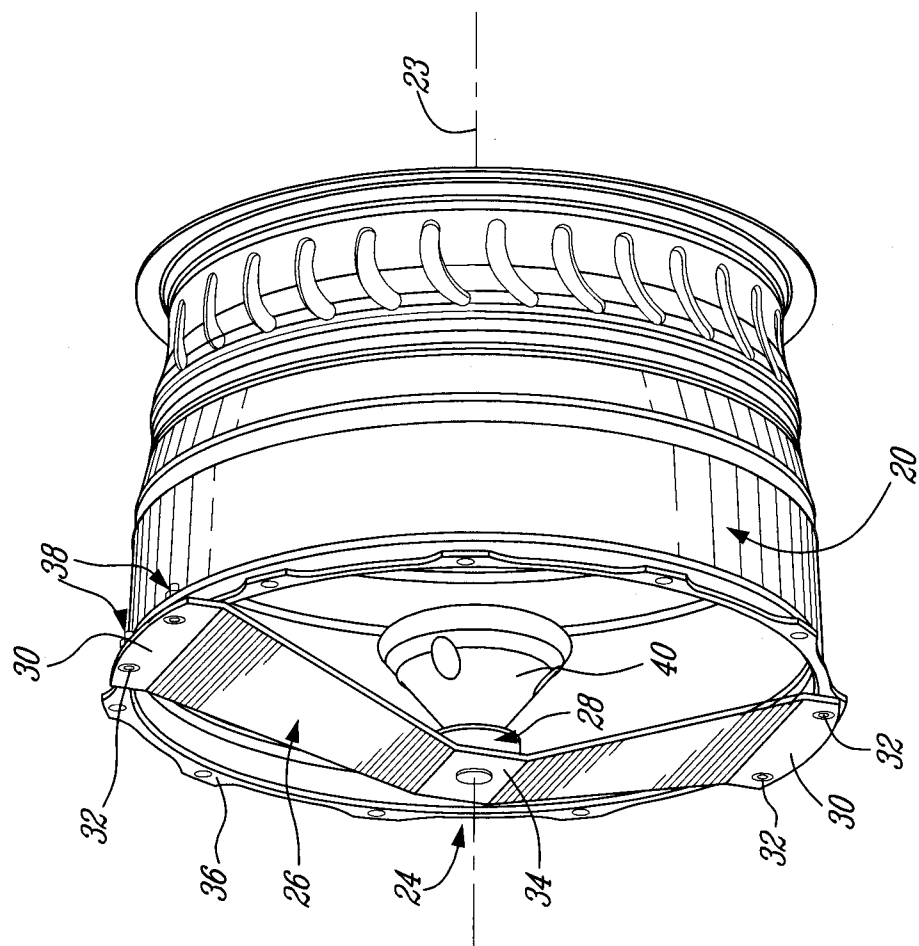


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2008/001167

A. CLASSIFICATION OF SUBJECT MATTER

IPC: **F01D 25/28** (2006.01) , **B65D 85/68** (2006.01) , **F02C 7/06** (2006.01) , **F02C 7/20** (2006.01) ,
F16C 39/00 (2006.01) , **F16C 41/04** (2006.01)

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)

IPC: F01D all, B65D all, F02C all, F16C all. Keyword searches.

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

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

Delphion, Knovel, internet using Google. Keywords: brinell*, distress, dent*, fretting, bearing, race*, contact, rotor, shaft, turbine, transport, shipping, handling, shock, damage*, defect*, engine, axial, brace, retainer, tensioner, tie-down, "Tedric Harris". Inventors and

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4668109 (BASSO) 26 May 1987 (26-05-1987) *Whole document*	1-20
Y	SKF Product information 401: Bearing failures and their causes. Monograph [online]. SKF Group, 1994 [retrieved on 2008-09-17]. Retrieved from the Internet: <URL: http://www.skf.com/portal/skf/home/aptitudexchange?contentId=0.237932.237933.237935.237962.238715>. *Page 13, including Fig. 25*	1-20
A	NTN Corporation Ball and Roller Bearings catalogue. Monograph [online]. NTN Corporation, 2001 [retrieved on 2008-09-17]. Retrieved from the Internet: <URL:http://pdf.directindustry.com/pdf/ntn/ball-and-roller-bearings/7395-25633-96.html >. *Page A-94, section entitled "Fretting"*	1-20
A	US 6298536 (STANLEY AVIATION CORPORATION) 9 October 2001 (09-10-2001) *Whole document*	1-20

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

[x] See patent family annex.

* Special categories of cited documents :	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

17 September 2008 (17-09-2008)

Date of mailing of the international search report

1 October 2008 (01-10-2008)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
Place du Portage I, C114 - 1st Floor, Box PCT
50 Victoria Street
Gatineau, Quebec K1A 0C9
Facsimile No.: 001-819-953-2476

Authorized officer

Roland Jonasch 819- 934-4895

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2008/001167

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US4668109	26-05-1987	NONE	
US6298536	09-10-2001	US6170141 B1 US6292999 B1	09-01-2001 25-09-2001