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(71) Applicant: **ORMAT TECHNOLOGIES INC.** [US/US];
6225 Neil Road, Suite 300, Reno, Nevada NV 89511-1136
(US).

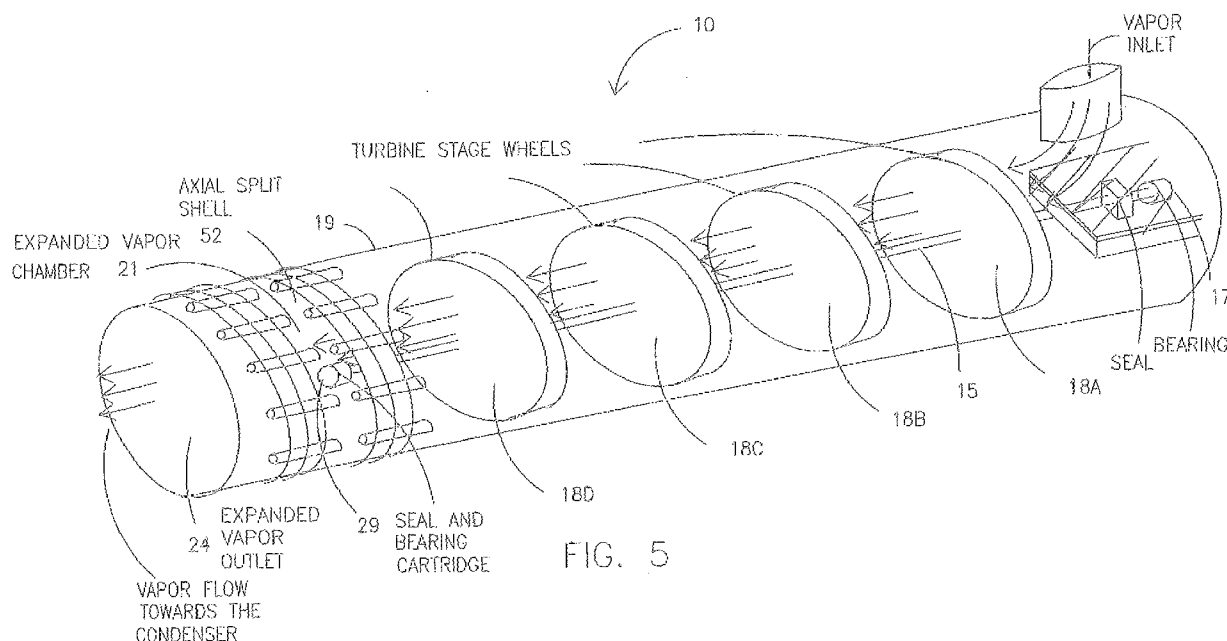
(72) Inventors: **BATSCHA, Dany**; 23 Saadia Gaon Road, Kiri-
at Ono (IL). **RAM, Oren**; 33 Gluskin Street, Rehovot

(IL). **FITERMAN, Anton**; No. 51, 90411 Yishuv Shani
(IL). **RESHEF, Ran**; 6 Hamztrit Street, Bat Hefer (IL).
SHARONI, Herzl; 34 Menucha Venachela Street, Rehovot
(IL). **KAPLAN, Uri**; Moshav Galia, Doar Na Emek Soreq
(IL).

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(54) Title: TURBINE SHAFT BEARING AND TURBINE APPARATUS



(57) Abstract: The present invention provides a turbine shaft bearing apparatus comprising inlet side and outlet side bearings for providing support to a turbine shaft to which are connected a plurality of turbine wheels such that the turbine shaft, the two spaced bearings, and the plurality of turbine wheels are coaxial. The outlet side bearing is protected from overheating by the motive fluid by a solid bearing housing which includes a conduit through which a lubricating medium for lubricating said outlet side bearing is supplied. The present invention is also directed to a turbine module comprising a plurality of axially spaced turbine wheels, a structured bleeding exit opening formed in an outer turbine casing; and a passage defined between two of the turbine wheels and in fluid communication with the bleeding exit opening, wherein expanded motive fluid vapor is extracted through said structured bleeding exit opening for heating the motive fluid condensate.

GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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))*

(88) Date of publication of the international search report:

26 April 2018 (26.04.2018)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 17/55528

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F01D 25/16 (2017.01)

CPC - F01D 25/162

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)

See Search History Document

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

See Search History Document

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

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- A	US 2,484,952 A (LEDWITH) 18 October 1949 (18.10.1949) entire document	1-3, 5-9 ----- 10-20
X -- A	US 2,936,999 A (COAR et al) 17 May 1960 (17.05.1960) entire document	1, 3-6 ----- 10-20
X -- Y -- A	US 2009/0100845 A1 (AMIR et al) 23 April 2009 (23.04.2009) entire document	21, 25-27 ----- 22-24 ----- 10-20
Y -- A	US 2013/0047614 A1 (GAIA et al) 28 February 2013 (28.02.2013) entire document	22, 23 ----- 10-20
Y -- A	US 4,548,043 A (KALINA) 22 October 1985 (22.10.1985) entire document	24 ----- 10-20

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"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

14 February 2018

Date of mailing of the international search report

26 FEB 2018

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 17/55528

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 EXTRA 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 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.

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

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-9, directed to a turbine shaft bearing apparatus including bearings, a solid bearing housing and a conduit through which a lubricating medium.

Group II: Claims 10-20 directed to a single turbine module including a structured bleeding exit opening and a passage defined between two of said turbine wheels.

Group III: Claims 21-27 directed to a power enhanced Organic Rankine Cycle (ORC) based power plant including an organic vapor turbine, a direct recuperator, and a vaporizer.

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

SPECIAL TECHNICAL FEATURES

The invention of Group I includes the special technical feature of a turbine shaft bearing apparatus, comprising two axially spaced, inlet side and outlet side bearings, wherein said outlet side bearing is protected by a solid bearing housing which is supported and provided with a conduit through which a lubricating medium for lubricating said outlet side bearing; not required by the claims of Groups II and III.

The invention of Group II includes the special technical feature of a single turbine module, a structured bleeding exit opening formed in an outer turbine casing of said turbine module; and a passage defined between two of said turbine wheels and in fluid communication with said bleeding exit opening, wherein expanded motive fluid vapor is extracted through said bleeding exit opening and is supplied to a heat exchange component, for heating the motive fluid condensate; not required by the claims of Groups I and III.

The invention of Group III includes the special technical feature of a power enhanced Organic Rankine Cycle (ORC) based power plant, comprising an organic vapor turbine adapted for interstage bleeding of organic motive fluid; a direct recuperator to which interstage-bled motive fluid is extracted and wherein said interstage-bled motive fluid is brought into direct contact with liquid condensate of the motive fluid; and a vaporizer for vaporizing said directly recuperated motive fluid so that vaporized motive fluid is supplied to said turbine; not required by the claims of Groups I and II.

COMMON TECHNICAL FEATURES

Groups I-III share the common technical features of a turbine. However, this shared technical feature does not represent a contribution over prior art as being anticipated by US 2,484,952 A to Ledwith (hereinafter referred to as Ledwith), which discloses a turbine (Col. 1, Line 29; Fig. 1).

Groups I-II share the common technical feature of four axially spaced turbine wheels connected to a common turbine shaft and coaxial therewith.

However, this shared technical feature does not represent a contribution over prior art as being anticipated by Ledwith, which discloses four axially spaced turbine wheels (wheels of rotor 12 supporting blades 18 as shown in Fig. 1; Col. 1, Lines 41-45) connected to a common turbine shaft (12) and coaxial therewith (Col. 2, Lines 5-8).

As the common technical features were known in the art at the time of the invention, these cannot be considered special technical feature that would otherwise unify the groups.

Therefore, Groups I-III lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.

Claims 10, 11 and 25-27 are objected to under PCT Rule 66.2(a)(v) as lacking clarity under PCT Article 6 because Claims 10 and 11 are indefinite for the following reason(s):

Regarding Claim 10, the recitation "the motive fluid condensate" has no proper antecedent basis, since "a motive fluid condensate" has not been previously recited as part of the invention.

Regarding Claim 11, the recitation "the radial passage" has no proper antecedent basis, since "a radial passage" has not been previously recited as part of the invention.

Regarding Claims 25-26, Claims 25-26 refer to power plant according to claim 15. For the purposes of this Written Opinion, it is assumed that Claims 25-27 are referring to the power plant according to claim 21.

Regarding Claim 27, Claim 27 refers to power plant according to claim 18. For the purposes of this Written Opinion, it is assumed that Claim 27 is referring to the power plant according to claim 26.