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| APPLICATION NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/361,825 | 09/08/2020 | 10767273 | 438/98 UTIL | 3063 |

76934 7590 08/19/2020

NK Patent Law - Industrial Heat
4917 Waters Edge Dr.
Suite 275
Raleigh, NC 27606

# 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 0 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):

Dennis Cravens, Cloudcroft, NM;
IH IP Holdings Limited, St. Helier, JERSEY;

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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL |

**CONFIRMATION NO. 3063**

76934
NK Patent Law - Industrial Heat
4917 Waters Edge Dr.
Suite 275
Raleigh, NC 27606

**PUBLICATION NOTICE**

*OC000000119232115*

**Title:**METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

**Publication No.**US-2020-0259166-A1
**Publication Date:**08/13/2020

## 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 Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, 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 https://portal.uspto.gov/pair/PublicPair. 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.

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

Document Description: Issue Fee Payment (PTO-85B)

# Issue Fee Transmittal Form

| Application Number | Filing Date | First Named Inventor | Atty. Docket No. | Confirmation No. |
|---|---|---|---|---|
| 16361825 | 22-Mar-2019 | Dennis Cravens | 438/98 UTIL | 3063 |

**TITLE OF INVENTION :**

METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

| Entity Status | Application Type | Art Unit | Class - Subclass | EXAMINER |
|---|---|---|---|---|
| Small | Utility under 35 USC 111(a) | 1794 | 229400 | NICHOLAS SMITH |

| Issue Fee Due | Publication Due | Total Fee(s) Due | Date Due | Prev. Paid Fee |
|---|---|---|---|---|
| $500 | $0 | $500 | 29-Jul-2020 | $0 |

## 1.Change of Correspondence Address and/or Indication Of Fee Address (37 CFR 1.33 & 1.363)

| Current Correspondence Address: | Current Indicated Fee Address : |
|---|---|
| 76934<br>NK Patent Law - Industrial Heat<br><br>4917 Waters Edge Dr.<br>Suite 275<br>Raleigh NC 27606<br>UNITED STATES<br>19193482194<br>eofficeaction@appcoll.com | |
| ☐ Change of correspondence address requested, system generated AIA/122-EFS form attached | ☐ Fee Address indication requested, system generated SB/47-EFS form attached |

## 2.Entity Status

**Change in Entity Status**

○ Applicant certifying micro entity status; system generated Micro Entity certification form attached. See 37 CFR 1.29.
Note: Absent a valid certification of micro entity status, issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment. If this box is checked, you will be prompted to choose a micro entity status on the gross income basis (37 CFR 1.29(a)) or the institution of higher education basis (37 CFR 1.29(d)), and make the applicable certification online.

◉ 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.

Doc Code: IFEE PTOL/85B-EFS

Document Description: Issue Fee Payment (PTO-85B)

**3.The Following Fee(s) Are Submitted:**

☒ Issue Fee

☐ I authorize USPTO to apply my previously paid issue fee to the current fees due

☐ Publication Fee

☐ The Director is hereby authorized to apply my previously paid issue fee to the current fee due and to charge deficient fees to Deposit Account Number _____

☐ Advance Order - # of copies _____

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**4.Firm and/or Attorney Names To Be Printed**

**NOTE: If no name is listed, no name will be printed**
For printing on the patent front page, list to be displayed as entered

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2.
3.

**5.Assignee Name(s) and Residence Data To Be Printed**

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.

| Name | City | State | Country | Category |
|---|---|---|---|---|
| IH IP Holdings Limited | St. Helier | | jersey | corporation |

**6.Signature**

I certify, in accordance with 37 CFR 1.4(d)(4) that I am an attorney or agent registered to practice before the Patent and Trademark Office who has filed and has been granted power of attorney in this application. I also certify that this Fee(s) Transmittal form is being transmitted to the USPTO via EFS-WEB on the date indicated below.

| | | | |
|---|---|---|---|
| **Signature** | /Brian D. MacDonald/ | **Date** | 07-28-2020 |
| **Name** | Brian D. MacDonald | **Registration Number** | 54288 |

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16361825 |
| **Filing Date:** | 22-Mar-2019 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Filer:** | Brian D. MacDonald/Sandra Hess |
| **Attorney Docket Number:** | 438/98 UTIL |

Filed as Small Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| UTILITY APPL ISSUE FEE | 2501 | 1 | 500 | 500 |
| PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL | 1504 | 1 | 0 | 0 |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **500** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 40126496 |
| **Application Number:** | 16361825 |
| **International Application Number:** | |
| **Confirmation Number:** | 3063 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Customer Number:** | 76934 |
| **Filer:** | Brian D. MacDonald/Sandra Hess |
| **Filer Authorized By:** | Brian D. MacDonald |
| **Attorney Docket Number:** | 438/98 UTIL |
| **Receipt Date:** | 28-JUL-2020 |
| **Filing Date:** | 22-MAR-2019 |
| **Time Stamp:** | 15:26:19 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $500 |
| RAM confirmation Number | E20207RF26167790 |
| Deposit Account | 506191 |
| Authorized User | Sandra Hess |

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

37 CFR 1.20 (Post Issuance fees)

## 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) | Web85b.pdf | 45998<br>2942c362e9a27bbb623ba28b94a7cd302cd262c5 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 31735<br>8dd976154263baa6cd009c0b3e65f281666c7b5b | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 77733 | | |

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**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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**United States Patent and Trademark Office**
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www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL | 3063 |

76934 7590 06/16/2020

NK Patent Law - Industrial Heat
4917 Waters Edge Dr.
Suite 275
Raleigh, NC 27606

| EXAMINER |
|---|
| SMITH, NICHOLAS A |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1794 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 06/16/2020 | ELECTRONIC |

**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.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

eofficeaction@appcoll.com
jrnifong@nkpatentlaw.com
usptomail@nkpatentlaw.com

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| APPLICATION NO./ CONTROL NO. | FILING DATE | FIRST NAMED INVENTOR/ PATENT IN REEXAMINATION | ATTORNEY DOCKET NO. |
|---|---|---|---|
| 16/361,825 | 03/22/2019 | Cravens, Dennis | 438/98 UTIL |

NK Patent Law - Industrial Heat
4917 Waters Edge Dr. Suite 275
Raleigh, NC 27606

| EXAMINER | |
|---|---|
| NICHOLAS A SMITH | |
| ART UNIT | PAPER |
| 1794 | 20200610 |

DATE MAILED: _____

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

**Commissioner for Patents**

The IDS submitted 4 June 2020 has been considered.

/NICHOLAS A SMITH/
Primary Examiner, Art Unit 1794

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 16361825 |
| Filing Date | 2019-03-22 |
| First Named Inventor | Dennis J. Cravens |
| Art Unit | 1794 |
| Examiner Name | Nicholas A. Smith |
| Attorney Docket Number | 438/98 UTIL |

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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 |
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|---|---|---|---|



ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /N.A.S/

# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 16361825 |
| Filing Date | 2019-03-22 |
| First Named Inventor | Dennis J. Cravens |
| Art Unit | 1794 |
| Examiner Name | Nicholas A. Smith |
| Attorney Docket Number | 438/98 UTIL |

| | | | |
|---|---|---|---|
| | 1 | PCT/ International search Report and Written Opinion in International Application No. PCT/US2020/017908 dated 28 May 2020 | |

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**EXAMINER SIGNATURE**

| | | | |
|---|---|---|---|
| Examiner Signature | /NICHOLAS A SMITH/ | Date Considered | 06/10/2020 |

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[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.



ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /N.A.S/

# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

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|---|---|
| Application Number | 16361825 |
| Filing Date | 2019-03-22 |
| First Named Inventor | Dennis J. Cravens |
| Art Unit | 1794 |
| Examiner Name | Nicholas A. Smith |
| Attorney Docket Number | 438/98 UTIL |

## CERTIFICATION STATEMENT

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

X 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.

X 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 | /Justin R. Nifong/ | Date (YYYY-MM-DD) | 2020-06-04 |
| Name/Print | Justin R. Nifong | Registration Number | 59389 |

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.**



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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:

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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.

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PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 16361825 |
| Filing Date | 2019-03-22 |
| First Named Inventor | Dennis J. Cravens |
| Art Unit | 1794 |
| Examiner Name | Nicholas A. Smith |
| Attorney Docket Number | 438/98 UTIL |

**U.S.PATENTS** Remove

| 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 |
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| | 1 | | | | | |

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| | 1 | | | | | |

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| Examiner Initial* | Cite No | Foreign Document Number[3] | Country Code[2] i | Kind Code[4] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear | T[5] |
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|---|---|---|---|

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 16361825 |
| | Filing Date | 2019-03-22 |
| | First Named Inventor | Dennis J. Cravens |
| | Art Unit | 1794 |
| | Examiner Name | Nicholas A. Smith |
| | Attorney Docket Number | 438/98 UTIL |

| | | | |
|---|---|---|---|
| | 1 | PCT/ International search Report and Written Opinion in International Application No. PCT/US2020/017908 dated 28 May 2020 | |

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**EXAMINER SIGNATURE**

| Examiner Signature | | Date Considered | |
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[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.

# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 16361825 |
| Filing Date | 2019-03-22 |
| First Named Inventor | Dennis J. Cravens |
| Art Unit | 1794 |
| Examiner Name | Nicholas A. Smith |
| Attorney Docket Number | 438/98 UTIL |

## 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 | /Justin R. Nifong/ | Date (YYYY-MM-DD) | 2020-06-04 |
| Name/Print | Justin R. Nifong | Registration Number | 59389 |

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.**

# 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.

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference<br>438-98PCT | **FOR FURTHER ACTION** | see Form PCT/ISA/220<br>as well as, where applicable, item 5 below. |
|---|---|---|
| International application No.<br>PCT/US 2020/017908 | International filing date *(day/month/year)*<br>12 February 2020 (12.02.2020) | (Earliest) Priority Date *(day/month/year)*<br>13 February 2019 (13.02.2019) |
| Applicant<br>INDUSTRIAL HEAT, LLC | | |

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

☒ 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 (Rules 12.3(a) and 23.1(b)).

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title,**

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings,**

a. the figure of the drawings to be published with the abstract is Figure No. 1

☒ as suggested by the applicant.

☐ as selected by this Authority, because the applicant failed to suggest a figure.

☐ as selected by this Authority, because this figure better characterizes the invention.

b. ☐ none of the figures is to be published with the abstract.

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US 2020/017908

A. CLASSIFICATION OF SUBJECT MATTER

***C25B 1/04*** *(2006.01)*
***C25B 15/02*** *(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)

C25B 1/00 - 1/12, 9/00 - 9/20, 11/00 - 11/18, 15/00 - 15/08, C02F 1/46 - 1/48

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)

PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 7452449 B2 (LECTRO PRESS, INC) 18.11.2008, col. 2, lines 5-22, 55-66, col. 3, lines 1-25, 49-56, col. 4, lines 4-5, col. 5, lines 14-37, col. 6, lines 36-66, col. 7-11, example, table 1, claims, fig.1-6 | 1-6, 8, 12-17, 19, 23 |
| A | | 7, 9-11, 18, 20-22 |
| Y | US 5840172 A (WHATMAN INC) 24.11.1998, claims, col. 1-3, fig. 1-2 | 1-6, 8, 12-17, 19, 23 |

☐ 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 document 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 |
|---|---|
| 19 May 2020 (19.05.2020) | 28 May 2020 (28.05.2020) |


Name and mailing address of the ISA/RU:
Federal Institute of Industrial Property,
Berezhkovskaya nab., 30-1, Moscow, G-59,
GSP-3, Russia, 125993
Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37

Authorized officer

T. Korobova

Telephone No. 8(495) 531-64-81

# PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

# PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

To:
SHIN, Joseph
NK Patent Law
4917 Waters Edge Drive
Suite 275
Raleigh, North Carolina 27606
United States of America

| | |
|---|---|
| Date of mailing *(day/month/year)*<br>28 May 2020 (28.05.2020) | |
| Applicant's or agent's file reference<br>438-98PCT | **FOR FURTHER ACTION**<br>See paragraph 2 below |

| International application No. | International filing date *(day/month/year)* | Priority date *(day/month/year)* |
|---|---|---|
| PCT/US 2020/017908 | 12 February 2020 (12.02.2020) | 13 February 2019 (13.02.2019) |

International Patent Classification (IPC) or both national classification and IPC
***C25B 1/04*** *(2006.01)*
***C25B 15/02*** *(2006.01)*

Applicant
INDUSTRIAL HEAT, LLC

1. This opinion contains indications relating to the following items:

- [X] Box No. I Basis of the opinion
- [ ] 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
- [X] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and 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

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

| Name and mailing address of the ISA/RU: | Date of completion of this opinion | Authorized officer |
|---|---|---|
| Federal Institute of Industrial Property,<br>Berezhkovskaya nab., 30-1, Moscow, G-59,<br>GSP-3, Russia, 125993<br>Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37 | 19 May 2020 (19.05.2020) | T. Korobova<br><br>Telephone No. 8(495) 531-64-81 |

**WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US 2020/017908

**Box No. I Basis of this opinion**

1. With regard to the **language**, this opinion has been established on the basis of:
   - [X] 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 (Rules 12.3(a) and 23.1(b)).

2. [ ] This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:
   - a. [ ] forming part of the international application as filed:
     - [ ] in the form of an Annex C/ST.25 text file.
     - [ ] on paper or in the form of an image file.
   - b. [ ] furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
   - c. [ ] furnished subsequent to the international filing date for the purposes of international search only:
     - [ ] in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
     - [ ] on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. [ ] In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

**WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US 2020/017908

**Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Claims | 1-23 | YES |
| | Claims | | NO |
| Inventive step (IS) | Claims | 7, 9-11, 18, 20-22 | YES |
| | Claims | 1-6, 8, 12-17, 19, 23 | NO |
| Industrial applicability (IA) | Claims | 1-23 | YES |
| | Claims | | NO |

2. Citations and explanations:

D1: US 7452449 B2;
D2: US 5840172 A.

D1, the closest prior art to the invention according to independent claim 1, discloses a method of producing hydrogen by water electrolysis (an electrolytic method of loading hydrogen into a cathode) comprising placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent, mixing a DC component and an AC component to produce an electrolytic current, applying the electrolytic current to the cathode, wherein the DC component includes cycling between a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period time. Wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time, and the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent (column 2 lines 5–22, 55–66, column 3 lines 1–25, 49–56, column 4, lines 4–5, column 5 lines 14–37, column 6 lines 36–66, columns 7–11, example, table 1, claims, fig. 1–6). The AC component has a frequency over 200 kHz (column 10, lines 62–65).

The method according to claim 1 differs from D1 in that the AC component has a frequency between about 1 Hz and about 100 kHz allowing to load hydrogen into an electrode.

Therefore, claims 1–12 are novel.

However, D2 discloses that the AC component can have a frequency from 50 Hz to 60 kHz, increasing to a high frequency in the range from 20 to 100 kHz (claim 9), allowing to load hydrogen into an electrode in the same way as in the claimed invention.

Therefore, claim 1 does not involve an inventive step.

The features of dependent claim 2, characterising performing an initial loading comprising: mixing an initial DC component and an initial AC component to produce an initial electrolytic current; applying the initial electrolytic current to the cathode, wherein the initial DC component includes cycling between: a third voltage applied to the cathode for a third period of time; a fourth voltage applied to the cathode for a fourth period time; wherein the fourth voltage is higher than the third voltage; wherein the third period of time and the fourth period of time are

**Supplemental Box**

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of V:

approximately the same; and wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage, are known from D1 (see column 2 lines 5–22, 55–66, column 3 lines 1–25, 49–56, column 5 lines 14–37, column 6 lines 36–66, columns 7–11, example, table 1, claims, fig. 1–6).

The features of dependent claim 2, characterising that the initial AC component has a frequency between 50 Hz and 100 kHz, are known from D2 (see columns 1–3, claims, fig. 1–2).

The features of dependent claims 3–6, characterising that the method comprises sealing the electrochemical vessel, flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical vessel, applying a magnetic field to the electrochemical reaction vessel, and that the frequency of the AC component is dynamically adjusted, are known from D1 (see column 2 lines 5–22, 55–66, column 3 lines 1–25, 49–56, column 5 lines 14–37, column 6 lines 36–66, column 7–11, example, table 1, claims, fig. 1–6).

The features of dependent claim 8, characterising that the cathode is comprised of palladium or a palladium alloy, are known from D1 (see column 4, lines 4–5).

The features of dependent claim 12, characterising that the solvent is a solution containing LiOD, are known from D1 (see column 11, lines 51–52).

Therefore, claims 2–6, 8, 12 do not involve an inventive step because they are obvious to a person skilled in the art from a combination of D1 and D2.

However, the prior art does not disclose the features of dependent claim 7, namely, that the DC component and AC component of the electrolytic current is mixed with a DC bias, and the features of dependent claims 9 and 10, namely, that the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$, and the features of dependent claim 11, characterising that the solvent is a solution containing LiOH, which allow to increase electrode loading, allowing the AC component to assist transport through the double layer during fluxing to and from the metal surface. Such embodiment is not obvious for a person skilled in the art.

Therefore, claims 7, 9–11 involve an inventive step.

D1, the closest prior art to the invention according to independent claim 13, discloses a system an electrochemical reaction vessel filled with a solvent; a cathode and an anode disposed within the electrochemical reaction vessel; an electrolytic current source connected to the cathode, wherein the electrolytic current comprises: a DC component, wherein the DC component cycles between: a first voltage applied to the cathode for a first period of time; a second voltage applied to the cathode for a second period time; wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time; wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent (column 2 lines 5–22, 55–66, column 3 lines 1–25, 49–56, column 4, lines 4–5, column 5 lines 14–37, column 6 lines 36–66, columns 7–11, example, table 1, claims, fig. 1–6).

The system according to claim 13 differs from D1 in that the AC component has a frequency from 1 Hz to 100 kHz allowing to load hydrogen into an electrode.

Therefore, claims 13–23 are novel.

However, D2 discloses that the AC component can have a frequency from 50 Hz to 60 kHz, increasing to a high frequency in the range from 20 to 100 kHz (see claim 9), allowing to load hydrogen into an electrode in the same way as in the claimed invention.

**Supplemental Box**

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of V:

Therefore, claim 13 does not involve an inventive step.

The features of dependent claims 14–17, characterising that the electrochemical reaction vessel is sealed, the electrochemical reaction vessel is flushed with a reductive gas prior to sealing, a magnetic field is applied to the electrochemical reaction vessel, and that the frequency of the AC component is dynamically adjusted, are known from D1 (see column 2 lines 5–22, 55–66, column 3 lines 1–25, 49–56, column 5 lines 14–37, column 6 lines 36–66, column 7–11, example, table 1, claims, fig. 1–6).

The features of dependent claim 19, characterising that the cathode is comprised of palladium or a palladium alloy, are known from D1 (see column 4, lines 4–5).

The features of dependent claim 23, characterising that the solvent is a solution containing LiOD, are known from D1 (see column 11, lines 51–52).

Therefore, claims 14–17, 19, 23 do involve an inventive step.

However, the prior art does not disclose the features of dependent claim 18, namely, that the DC component and AC component of the electrolytic current is mixed with a DC bias, and the features of dependent claims 20 and 21, namely, that the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$, and the features of dependent claim 22, characterising that the solvent is a solution containing LiOH, which allow to increase electrode loading, allowing the AC component to assist transport through the double layer during fluxing to and from the metal surface. Such embodiment is not obvious for a person skilled in the art.

Therefore, claims 18, 20–22 meet the criterion of inventive step.

The group of inventions according to claims 1–23 is industrially applicable.

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16361825 |
| **Filing Date:** | 22-Mar-2019 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Filer:** | Justin Robert Nifong/Donna Donovan |
| **Attorney Docket Number:** | 438/98 UTIL |

Filed as Small Entity

**Filing Fees for Utility under 35 USC 111(a)**

| 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:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| SUBMISSION- INFORMATION DISCLOSURE STMT | 2806 | 1 | 120 | 120 |
| | | **Total in USD ($)** | | **120** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 39627139 |
| **Application Number:** | 16361825 |
| **International Application Number:** | |
| **Confirmation Number:** | 3063 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Customer Number:** | 76934 |
| **Filer:** | Justin Robert Nifong/Donna Donovan |
| **Filer Authorized By:** | Justin Robert Nifong |
| **Attorney Docket Number:** | 438/98 UTIL |
| **Receipt Date:** | 04-JUN-2020 |
| **Filing Date:** | 22-MAR-2019 |
| **Time Stamp:** | 14:19:50 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $120 |
| RAM confirmation Number | E202064E21256980 |
| Deposit Account | 506191 |
| Authorized User | Donna Donovan |

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

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 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 | Information Disclosure Statement (IDS) Form (SB08) | 438-98UTIL-20200604-IDS.pdf | 1034294<br>5a2bf25a1388c3a632c937f3ad371b808325cece | no | 4 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems. | | | | | |
| 2 | Non Patent Literature | 438-98PCT-20200528-ISA210-ISR.pdf | 162688<br>9c8e1dcba509302a97b5a1350d019cb43aa2a174 | no | 7 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Fee Worksheet (SB06) | fee-info.pdf | 30478<br>6bc5852e31b32ef3f1304367fcf88c587fed5563 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 1227460 | | |

**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
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 |
|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL |

**CONFIRMATION NO. 3063**

**POA ACCEPTANCE LETTER**

76934
NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

*OC000000116654144*

Date Mailed: 05/01/2020

## NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 04/29/2020.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/hteffera/

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 |
|---|---|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | 1794 | 935 | 438/98 UTIL | 23 | 2 |

**CONFIRMATION NO. 3063**

**CORRECTED FILING RECEIPT**

76934
NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

Date Mailed: 05/01/2020

Receipt is acknowledged of this non-provisional utility 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 FIRST INVENTOR, 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 corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction 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 provided that the request is grantable.

**Inventor(s)**

Dennis Cravens, Cloudcroft, NM;

**Applicant(s)**

IH IP Holdings Limited, St. Helier, JERSEY;

**Power of Attorney:** The patent practitioners associated with Customer Number 76934

**Domestic Priority data as claimed by applicant**

This appln claims benefit of 62/804,989 02/13/2019

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 04/05/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/361,825**

**Projected Publication Date:** 08/13/2020

**Non-Publication Request:** No

**Early Publication Request:** No
**** SMALL ENTITY ****
**Title**

METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

**Preliminary Class**

204

**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).

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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# NOTICE OF ALLOWANCE AND FEE(S) DUE

76934 7590 04/29/2020

NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

| EXAMINER |
|---|
| SMITH, NICHOLAS A |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1794 | |

DATE MAILED: 04/29/2020

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL | 3063 |

TITLE OF INVENTION: METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | SMALL | $500 | $0.00 | $0.00 | $500 | 07/29/2020 |

**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: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.**

## PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (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)

76934 7590 04/29/2020

NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

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 transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

| |
|---|
| (Typed or printed name) |
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL | 3063 |

TITLE OF INVENTION: METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | SMALL | $500 | $0.00 | $0.00 | $500 | 07/29/2020 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| SMITH, NICHOLAS A | 1794 | 204-229400 |

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 03-09 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 must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). 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. Fees submitted: ❑ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

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.
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.
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. _____

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. |
|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL | 3063 |

76934 7590 04/29/2020

NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

| EXAMINER | |
|---|---|
| SMITH, NICHOLAS A | |
| ART UNIT | PAPER NUMBER |
| 1794 | |

DATE MAILED: 04/29/2020

**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 30 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. 16/361,825 | Applicant(s) Cravens, Dennis | |
|---|---|---|---|
| | Examiner NICHOLAS A SMITH | Art Unit 1794 | AIA (FITF) Status Yes |

***-- 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 interview on 23 April 2020.
   ☐ 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 1-23 . 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. 4/23/20.
5. ☑ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/NICHOLAS A SMITH/
Primary Examiner, Art Unit 1794

## DETAILED ACTION

### *Notice of Pre-AIA or AIA Status*

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

### *Continued Examination Under 37 CFR 1.114*

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 2 April 2020 has been entered.

## EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in an interview with Brian MacDonald on 23 April 2020.

The application has been amended as follows:

Claim 1 now reads:

1. (Currently Amended) An electrolytic method of loading hydrogen into a cathode comprising:
placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent;
mixing a DC component and an AC component to produce an electrolytic current such that the electrolytic current comprises a DC biased waveform wherein an AC waveform is superimposed onto a DC waveform;
applying the electrolytic current to the cathode, wherein a first voltage and a second voltage applied to the cathode relative to the anode that load hydrogen onto the cathode are negative,
wherein the DC component includes cycling between:
the [[a]] first voltage applied to the cathode for a first period of time;
the [[a]] second voltage applied to the cathode for a second period time;
wherein ~~the second voltage is higher than~~ the first voltage is more negative than the second voltage, and

wherein the second period of time is shorter than the first period of time; and

wherein the AC component has a frequency between about 1Hz and about 100kHz; and

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

Claim 2 now reads:

2. (Currently Amended) The method of claim 1, further comprising:

performing an initial loading comprising:

mixing an initial DC component and an initial AC component to produce an initial electrolytic current such that the initial electrolytic current comprises a DC biased waveform wherein an AC waveform is superimposed onto a DC waveform;

applying the initial electrolytic current to the cathode, wherein a third voltage and a fourth voltage applied to the cathode relative to the anode that load hydrogen onto the cathode are negative,

wherein the initial DC component includes cycling between:

the [[a]] third voltage applied to the cathode for a third period of time;

the [[a]] fourth voltage applied to the cathode for a fourth period time;

wherein the fourth voltage is higher than the third voltage;

wherein the third period of time and the fourth period of time are approximately the same; and

wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage; and

wherein the initial AC component has a frequency between about 1Hz and about 100kHz.

Claim 13 now reads:

13. (Currently Amended) A system for electrolytic loading of hydrogen into a cathode comprising:

an electrochemical reaction vessel filled with a solvent;

a cathode and an anode disposed within the electrochemical reaction vessel;

an electrolytic current source connected to the cathode, wherein the electrolytic current source is programmed to apply an electrolytic current to the cathode, wherein a first voltage and a second voltage applied to the cathode relative to the anode that load hydrogen onto the cathode are negative, and wherein the electrolytic current comprises:

a DC component, wherein the DC component cycles between:

the [[a]] first voltage applied to the cathode for a first period of time;

the [[a]] second voltage applied to the cathode for a second period time;

wherein ~~the second voltage is higher than~~ the first voltage is more negative than the second voltage, and

wherein the second period of time is shorter than the first period of time; and

a AC component with a frequency between about 1Hz and about 100kHz;

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent and

wherein the DC component and the AC component are mixed such that the electrolytic current comprises a DC biased waveform wherein an AC waveform is superimposed onto a DC waveform.

***Reasons for Allowance***

The following is an examiner's statement of reasons for allowance: in regards to claim(s) 1, prior art does not explicitly disclose, teach or suggest an electrolytic method of loading hydrogen into a cathode, wherein voltages applied to the cathode relative to the anode that load hydrogen onto the cathode are negative, applying an electrolytic current comprising a mixed waveform of an AC component and a DC component, wherein the DC component has a first voltage applied for a longer period of time than a second higher voltage, and wherein the first voltage is more negative than the second voltage. Weinberg (US 7452449 B2) discloses electrolytic loading of hydrogen on a cathode (col. 2, lines 8-22) with a mixed AC/DC waveform (Fig. 2). However, Weinberg discloses the shorter pulse of DC (**4**) is a higher potential (col. 8, lines 4-8) and would result in enhanced hydrogen packing (col. 8, lines 17-26). Thus, when Weinberg discloses that the shorter pulse (**4**) is of "higher potential," it is clearly disclosing that it is meant to be a "higher absolute value potential" as that would result in enhanced hydrogen packing, and thus teaches the opposite of the instant invention. Steinberg (US 20130044847 A1) also discloses mixed DC and AC being applied for electrolytic loading of a cathode (para 27), but does not explicitly disclose the above specific DC waveform being applied. The system of claim 13 has an electrolytic current source programmed to apply the same electrolytic current as instant claim 1 and defines over the prior art for the same reasons.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to NICHOLAS A SMITH whose telephone number is (571)272-8760. The examiner can normally be reached on M-F 9am-5:30pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, James Lin can be reached on 571-272-8902. 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 https://ppair-my.uspto.gov/pair/PrivatePair. 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.

/NICHOLAS A SMITH/
Primary Examiner, Art Unit 1794

| *Applicant-Initiated Interview Summary* | **Application No.** 16/361,825 | **Applicant(s)** Cravens, Dennis | |
|---|---|---|---|
| | **Examiner** NICHOLAS A SMITH | **Art Unit** 1794 | **AIA (FITF) Status** Yes |

All participants (applicant, applicants representative, PTO personnel):

(1) Nicholas A. Smith. (3) _____.

(2) Brian MacDonald. (4) _____.

Date of Interview: 23 April 2020.

Type: ☑ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☑ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☑102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 1-2 and 13.

Identification of prior art discussed: Weinberg and Steinberg.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Examiner proposes amendments to define over the prior art; Applicant agrees. See attached Examiner's Amendment in the Notice of Allowance..

**Applicant recordation instructions:** The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview.

**Examiner recordation instructions**: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

| /NICHOLAS A SMITH/<br>Primary Examiner, Art Unit 1794 | |
|---|---|

# Summary of Record of Interview Requirements

**Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record**
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

**Title 37 Code of Federal Regulations (CFR) 1.133 Interviews**
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

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The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiners responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicants correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,-
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
(The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicants record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

**Examiner to Check for Accuracy**

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiners version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, Interview Record OK on the paper recording the substance of the interview along with the date and the examiners initials.

| Notice of References Cited | Application/Control No. 16/361,825 | Applicant(s)/Patent Under Reexamination Cravens, Dennis | |
|---|---|---|---|
| | Examiner NICHOLAS A SMITH | Art Unit 1794 | 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-20130044847-A1 | 02-2013 | Steinberg; Dan | G21B3/002 | 376/151 |
| | B | | | | | |
| | C | | | | | |
| | D | | | | | |
| | E | | | | | |
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**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | CPC Classification |
|---|---|---|---|---|---|---|
| | N | | | | | |
| | O | | | | | |
| | P | | | | | |
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| | 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.

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/361,825 | Cravens, Dennis |
| | **Examiner** | **Art Unit** |
| | NICHOLAS A SMITH | 1794 |

| **CPC - Searched*** | | |
|---|---|---|
| **Symbol** | **Date** | **Examiner** |
| C25B1/04 | 04/22/2020 | NS |
| C25B9/04 | 04/22/2020 | NS |
| C25B15/02 | 04/22/2020 | NS |
| G21B3/00 | 04/22/2020 | NS |
| G21B3/002 | 04/22/2020 | NS |

| **CPC Combination Sets - Searched*** | | |
|---|---|---|
| **Symbol** | **Date** | **Examiner** |
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| **US Classification - Searched*** | | | |
|---|---|---|---|
| **Class** | **Subclass** | **Date** | **Examiner** |
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* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| /NICHOLAS A SMITH/<br>Primary Examiner, Art Unit 1794 | |
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| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/361,825 | Cravens, Dennis |
| | **Examiner** | **Art Unit** |
| | NICHOLAS A SMITH | 1794 |

| **Search Notes** | | |
|---|---|---|
| **Search Notes** | **Date** | **Examiner** |
| consulted Primary Examiner Harry Wilkins | 08/08/2019 | NS |
| inventor search | 08/09/2019 | NS |
| EAST search (see EAST search history) | 08/09/2019 | NS |
| IP.com ("electrolytic loading of a cathode with hydrogen and altemating current"; additional modifiers: A) low energy nuclear reaction; B) cold fusion) | 04/22/2020 | NS |
| C25B1/04.cpc,ipc,ipcr. (see EAST search history: L8) | 04/22/2020 | NS |
| C25B9/04.cpc,ipc,ipcr. (see EAST search history: L10) | 04/22/2020 | NS |
| C25B15/02.cpc,ipc,ipcr. (see EAST search history: L11) | 04/22/2020 | NS |
| G21B3/00.cpc,ipc,ipcr. (see EAST search history: L17) | 04/22/2020 | NS |
| G21B3/002 (see EAST search history: L17) | 04/22/2020 | NS |

| **Interference Search** | | | |
|---|---|---|---|
| **US Class/CPC Symbol** | **US Subclass/CPC Group** | **Date** | **Examiner** |
| C25B1/04,9/04,15/02 | PgPub text search (see EAST search history: L12) | 04/22/2020 | NS |
| G21B3/00,3/002 | PgPub text search (see EAST search history: L18) | 04/22/2020 | NS |

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| /NICHOLAS A SMITH/<br>Primary Examiner, Art Unit 1794 | |

| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/361,825 | Cravens, Dennis |
| | **Examiner** | **Art Unit** |
| | NICHOLAS A SMITH | 1794 |

| CPC | | | | | | |
|---|---|---|---|---|---|---|
| **Symbol** | | | | | **Type** | **Version** |
| C25B | / | 15 | / | 02 | F | 2013-01-01 |
| H01M | / | 4 | / | 242 | I | 2013-01-01 |
| H01M | / | 4 | / | 26 | I | 2013-01-01 |
| C25B | / | 1 | / | 04 | I | 2013-01-01 |
| C25B | / | 9 | / | 04 | I | 2013-01-01 |
| G21B | / | 3 | / | 00 | A | 2013-01-01 |
| G21B | / | 3 | / | 002 | A | 2013-01-01 |

| CPC Combination Sets | | | | | | | |
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| NONE | | **Total Claims Allowed:** | |
|---|---|---|---|
| (Assistant Examiner) | (Date) | 23 | |
| /NICHOLAS A SMITH/<br>Primary Examiner, Art Unit 1794 | 22 April 2020 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 2 |

U.S. Patent and Trademark Office — Part of Paper No.: 20200422

| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/361,825 | Cravens, Dennis |
| | **Examiner** | **Art Unit** |
| | NICHOLAS A SMITH | 1794 |

| INTERNATIONAL CLASSIFICATION | | | | |
|---|---|---|---|---|
| **CLAIMED** | | | | |
| C25B15/02 | / | 15 | / | 02 |
| C25B1/04 | / | 1 | / | 04 |
| C25B9/04 | / | 9 | / | 04 |

| NON-CLAIMED | | | | |
|---|---|---|---|---|
| H01M4/24 | / | 4 | / | 24 |
| H01M4/26 | / | 4 | / | 26 |
| G21B3/00 | / | 3 | / | 00 |

| US ORIGINAL CLASSIFICATION | |
|---|---|
| **CLASS** | **SUBCLASS** |
| 204 | 229.4 |

| CROSS REFERENCES(S) | | | | | | |
|---|---|---|---|---|---|---|
| **CLASS** | **SUBCLASS (ONE SUBCLASS PER BLOCK)** | | | | | |
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| NONE | | **Total Claims Allowed:** | |
|---|---|---|---|
| (Assistant Examiner) | (Date) | 23 | |
| /NICHOLAS A SMITH/<br>Primary Examiner, Art Unit 1794 | 22 April 2020 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 2 |

| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/361,825 | Cravens, Dennis |
| | **Examiner** | **Art Unit** |
| | NICHOLAS A SMITH | 1794 |

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

**CLAIMS**

| Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original |
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| NONE | | **Total Claims Allowed:** | |
| (Assistant Examiner) | (Date) | 23 | |
| /NICHOLAS A SMITH/<br>Primary Examiner, Art Unit 1794 | 22 April 2020 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 2 |

**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L5 | 9960 | (C25B1/04.cpc.) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 13:38 |
| L6 | 25208 | (C25B1/04.cpc,ipc,ipcr.) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 13:38 |
| L7 | 20 | (C25B1/04.cpc,ipc,ipcr.) and (cathod$2) with (hydrogen dueterium tritium) with (loading) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 13:38 |
| L8 | 9 | (C25B1/04.cpc,ipc,ipcr.) and (cathod$2) with (hydrogen dueterium tritium) with (loading) and ((alternat$3 waveform square$1wave sine sawtooth) near2 (current component potential voltage)) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 13:40 |
| L9 | 7076 | C25B9/04.cpc,ipc,ipcr. | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 13:42 |
| L10 | 5 | C25B9/04.cpc,ipc,ipcr. and (cathod$2) with (hydrogen dueterium tritium) with (loading) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 13:42 |
| L11 | 7 | C25B15/02.cpc,ipc,ipcr. and (cathod$2) with (hydrogen dueterium tritium) with (loading) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 13:44 |

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|---|---|---|---|---|---|---|
| L16 | 3107 | (G21B3/00.cpc,ipc,ipcr. G21B3/002.cpc.) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 14:08 |
| L17 | 14 | (G21B3/00.cpc,ipc,ipcr. G21B3/002.cpc.) and (cathod$2) with (hydrogen dueterium tritium) with (loading) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2020/04/22 14:09 |
| S1 | 2 | ("20180237924").PN. | US-PGPUB; USPAT; USOCR; DERWENT | OR | ON | 2019/07/29 11:16 |
| S2 | 4 | electrochemical near2 hydrogen near2 loading same palladium | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:18 |
| S3 | 0 | electrochemical near2 dueterium near2 loading same palladium | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:31 |
| S4 | 3 | electrochemical near2 deuterium near2 loading same palladium | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:31 |
| S5 | 2 | electrochemical near2 (deuterium hydrogen) near2 loading same palladium same (produc$4) near2 (heat) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:39 |
| S6 | 2 | electrochemical with (deuterium hydrogen) near2 loading same palladium same (produc$4) near2 (heat) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:40 |

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|---|---|---|---|---|---|---|
| S7 | 2 | electrochemical with (deuterium hydrogen) with loading same palladium same (produc$4) near2 (heat) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:40 |
| S8 | 10 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:40 |
| S9 | 4 | deuterated adj palladium adj alloy$1 | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:46 |
| S10 | 2 | "6991719".pn. | US-PGPUB; USPAT; USOCR; DERWENT | OR | ON | 2019/08/08 10:31 |
| S11 | 2 | "7452449".pn. | US-PGPUB; USPAT; USOCR; DERWENT | OR | ON | 2019/08/08 10:36 |
| S12 | 1 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and (flush$3) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 12:50 |
| S13 | 1 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and (magnetic adj field$1) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 12:58 |
| S14 | 7 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and (dynamic$4 adjust$3 chang$3) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 13:09 |
| S15 | 2 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and | US-PGPUB; USPAT; USOCR; FPRS; EPO; | OR | ON | 2019/08/08 13:09 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | (dynamic$4 adjust$3 chang$3) with (frequenc$3) | JPO; DERWENT; IBM_TDB | | | |
| S16 | 17 | electrochemical with (deuterium hydrogen) same palladium and (dynamic$4 adjust$3 chang$3) near3 (frequenc$3) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 14:43 |
| S17 | 16 | electrochemical with (deuterium hydrogen) same palladium and (hydrogen near2 diffusion near rate$1) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 14:57 |
| S18 | 88 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:09 |
| S19 | 0 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) with (cm3$) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:10 |
| S20 | 0 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) with (cm3$10) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:10 |
| S21 | 1 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) with (cm) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:12 |
| S22 | 88 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:21 |
| S23 | 1 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and LioH | US-PGPUB; USPAT; USOCR; FPRS; EPO; | OR | ON | 2019/08/08 15:59 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | JPO; DERWENT; IBM_TDB | | | |

**EAST Search History (Interference)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L12 | 16 | (C25B15/02.cpc. C25B1/04.cpc. C25B9/04.cpc.) and (cathod$2) with (hydrogen dueterium tritium) with (loading) | US-PGPUB; USPAT | OR | ON | 2020/04/22 13:47 |
| L18 | 11 | (G21B3/00.cpc,ipc,ipcr. G21B3/002.cpc.) and (cathod$2) with (hydrogen dueterium tritium) with (loading) | US-PGPUB; USPAT | OR | ON | 2020/04/22 14:12 |

**4/22/2020 2:13:20 PM**
**C:\Users\nsmith1\Documents\EAST\Workspaces\16361825.wsp**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | | |
|---|---|---|---|---|
| Application No. | : | 16/361,825 | Confirmation No.: | 3063 |
| Applicant | : | Industrial Heat, LLC | | |
| First Named Inventor | : | Dennis J. Cravens | | |
| Filing Date | : | Mar 22, 2019 | | |
| TC/A.U. | : | 1794 | | |
| Examiner | : | Nicholas A SMITH | | |
| Docket No. | : | 438/98 UTIL | | |
| Customer No. | : | 76934 | | |

---

Title of Invention: METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

**Via EFS-Web**
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

## REQUEST FOR CORRECTED FILING RECEIPT

Applicant hereby submits this Request for Corrected Filing Receipt. It is requested to correct the Applicant. Please issue a corrected filing receipt in view of this request.

A Power of Attorney, Statement under 37 CFR 3.73c and a replacement ADS in compliance with 37 CFR 1.76 are provided herewith to reflect this request.

## DEPOSIT ACCOUNT

It is not believed that any additional fees are due at this time; however, the Commissioner is hereby authorized to charge any otherwise unpaid fees associated with the filing of this correspondence to Deposit Account No. **50-6191**.

Respectfully submitted,

Date: April 29, 2020

/Brian D. MacDonald/
Brian D. MacDonald
Reg. No. 54288

NK Patent Law
4917 Waters Edge Drive, Suite 275
Raleigh, NC 27606
Telephone: (919) 348-2194
Facsimile: (919) 882-8195

Customer No. 76934

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


| REPLACEMENT Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

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 |
|---|---|---|---|---|
| | Dennis | | Cravens | |

**Residence Information (Select One)** ◉ US Residency ○ Non US Residency ○ Active US Military Service

| City | Cloudcroft | State/Province | NM | Country of Residence | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| Address 1 | P.O. Box 1317 | | |
|---|---|---|---|
| Address 2 | | | |
| City | Cloudcroft | State/Province | NM |
| Postal Code | 88317 | Country | US |

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 | 76934 | | |
|---|---|---|---|
| Email Address | docket@nkpatentlaw.com | Add Email | Remove Email |

## Application Information:

| Title of the Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | | |
|---|---|---|---|
| Attorney Docket Number | 438/98 UTIL | Small Entity Status Claimed | ☒ |
| Application Type | Nonprovisional | | |
| Subject Matter | Utility | | |
| Total Number of Drawing Sheets (if any) | 6 | Suggested Figure for Publication (if any) | |

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

## 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 |
|---|---|---|
| | | |

## 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 | 76934 | | |

## Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim 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" field blank.

| Prior Application Status | Pending | | Remove |
|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |
| | Claims benefit of provisional | 62/804989 | 2019-02-13 |

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

## 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. 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(i)(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) |
|---|---|---|---|
| | | | |

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

## 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.

PTO/AIA/14 (11-15)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

# Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

**NOTE**: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

**1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)**

**A. Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is 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 State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

**B. Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

**2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)**

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

**NOTE:** Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

PTO/AIA/14 (11-15)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

## 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.

**Applicant 1**

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 | ~~Industrial Heat, LLC~~ IH IP Holdings Limited | | |
| **Mailing Address Information For Applicant:** | | | |
| **Address 1** | ~~310 West Street, Suite 100~~ 44 Esplanade | | |
| Address 2 | | | |
| **City** | ~~Raleigh~~ St. Helier | **State/Province** | ~~NC~~ |
| **Country** ~~US~~ JE | | Postal Code | ~~27603~~ JE4 9WG |
| Phone Number | | Fax Number | |
| Email Address | | | |

Additional Applicant Data may be generated within this form by selecting the Add button.

## Assignee Information including Non-Applicant Assignee 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.

PTO/AIA/14 (11-15)
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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

**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.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

| Prefix | **Given Name** | Middle Name | **Family Name** | Suffix |
|---|---|---|---|---|
| | | | | |

**Mailing Address Information For Assignee including Non-Applicant Assignee:**

| | | | |
|---|---|---|---|
| **Address 1** | | | |
| Address 2 | | | |
| **City** | | **State/Province** | |
| **Country** | | Postal Code | |
| Phone Number | | Fax Number | |
| Email Address | | | |

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

## Signature:

**NOTE:** This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

| **Signature** | /Justin R. Nifong/ | | | Date (YYYY-MM-DD) | 2020-04-29 ~~2019-03-22~~ |
|---|---|---|---|---|---|
| First Name | Justin | Last Name | Nifong | Registration Number | 59389 |

Additional Signature may be generated within this form by selecting the Add button.

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

# 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 records.

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 CooperationTreaty.

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.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


# STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: IH IP Holdings Limited

Application No./Patent No.: 16/361,825 Filed/Issue Date: March 22, 2019

Titled: METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

IH IP Holdings Limited, a Limited Liability Corporation

(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.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 050035, Frame 0547, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

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## STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

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6. From: _____ To: _____

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Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[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.

| | |
|---|---|
| /Brian D. MacDonald/ | April 29, 2020 |
| Signature | Date |
| Brian D. MacDonald | 54288 |
| Printed or Typed Name | Title or Registration 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.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
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

# POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

| Application Number | Filing Date |
|---|---|
| 16/361,825 | March 22, 2019 |

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 76934

**OR**

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

**Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:**

☑ The address associated with the above-mentioned Customer Number

**OR**

☐ The address associated with Customer Number:

**OR**

| | | | | | |
|---|---|---|---|---|---|
| Firm or Individual Name | | | | | |
| Address | | | | | |
| City | | State | | Zip | |
| Country | | | | | |
| Telephone | | Email | | | |

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

**SIGNATURE of Applicant for Patent**

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

| | | | |
|---|---|---|---|
| Signature | | Date (Optional) | |
| Name | John T. Vaughn | | |
| Title | Director, IH IP Holdings Limited | | |

**NOTE:** Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 39303062 |
| **Application Number:** | 16361825 |
| **International Application Number:** | |
| **Confirmation Number:** | 3063 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Customer Number:** | 76934 |
| **Filer:** | Brian D. MacDonald/Donna Donovan |
| **Filer Authorized By:** | Brian D. MacDonald |
| **Attorney Docket Number:** | 438/98 UTIL |
| **Receipt Date:** | 29-APR-2020 |
| **Filing Date:** | 22-MAR-2019 |
| **Time Stamp:** | 15:54:59 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Request for Corrected Filing Receipt | 438-98UTIL-20200429-Request-for-Corrected-Filing-Receipt.pdf | 19879<br>231ff34dd23516a9a3845f271c4389da7496b62a | no | 2 |

**Warnings:**

| | | | | | |
|---|---|---|---|---|---|
| **Information:** | | | | | |
| 2 | Application Data Sheet | 438-98UTIL-20200429-Replacement-ADS.pdf | 179598<br>754e1b25b75bdb45c68a4c971f1b4cd9ff51cc95 | no | 8 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| This is not an USPTO supplied ADS fillable form | | | | | |
| 3 | Assignee showing of ownership per 37 CFR 3.73 | 438-98UTIL-20200429-373-Statement.pdf | 118071<br>b87406e33b453abb84ec604c4c9a90b82157f4c1 | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Power of Attorney | 438-98UTIL-20200429-Executed-POA.pdf | 117514<br>3159a12dd008e4ba8e3c6c63dc1e6abdeb79fa63 | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 435062 | | |

**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.**

**<u>New Applications Under 35 U.S.C. 111</u>**

**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.**

**<u>National Stage of an International Application under 35 U.S.C. 371</u>**

**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.**

**<u>New International Application Filed with the USPTO as a Receiving Office</u>**

**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.**

Doc code: RCEX
Doc description: Request for Continued Examination (RCE)

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


# REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
## (Submitted Only via EFS-Web)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Application Number | 16/361,825 | Filing Date | 2019-03-22 | Docket Number (if applicable) | 438/98 UTIL | Art Unit | 1794 |
| First Named Inventor | Dennis Cravens | | | Examiner Name | Nicholas A. SMITH | | |

**This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.**
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

### SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☐ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

### MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

### FEES

**The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**

☒ The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 506191

### SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

X Patent Practitioner Signature

Applicant Signature

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


| Signature of Registered U.S. Patent Practitioner | | | |
|---|---|---|---|
| Signature | /Joseph Shin/ | Date (YYYY-MM-DD) | 2020-04-02 |
| Name | Joseph Shin | Registration Number | 67873 |

This collection of information is required by 37 CFR 1.114. 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 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.

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

# 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.

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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 records.

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.

**COMMUNICATION TO THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | | | |
|---|---|---|---|---|---|
| **Application No.** | **:** | **16/361,825** | **Confirmation No.** | **:** | **3063** |
| **Inventor** | **:** | **Dennis Cravens** | **Art Unit** | **:** | **1794** |
| **Filing Date(*)** | **:** | **March 22, 2019** | **Examiner:** | **Nicholas A. Smith** | |
| **Title** | **:** | **METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN** | | | |
| **Docket No.** | **:** | **438/98 UTIL** | | | |
| **Customer No.** | **:** | **115007** | | | |

**Mail Stop RCE**
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

**REQUEST FOR CONTINUED EXAMINATION AND RESPONSE TO FINAL OFFICE ACTION DATED JANUARY 13, 2020**

Commissioner:

This reply responds to the Final Office Action dated January 13, 2020 and is being filed with a request for continued examination (RCE).

**Amendments to the Claims** begin on page 2 of this reply.

**Remarks** begin on page 6 of this reply.

(*) Excluding any claim to earlier priority

**Amendments to the Claims:**

The claims are amended as follows and will replace all previous versions and listings of claims:

**Claims:**

1. (Currently Amended) An electrolytic method of loading hydrogen into a cathode comprising:
placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent;
mixing a DC component and an AC component to produce an electrolytic current such that the electrolytic current comprises a DC biased waveform wherein an AC waveform is superimposed onto a DC waveform;
applying the electrolytic current to the cathode,
wherein the DC component includes cycling between:
a first voltage applied to the cathode for a first period of time;
a second voltage applied to the cathode for a second period time;
wherein the second voltage is higher than the first voltage, and
wherein the second period of time is shorter than the first period of time; and
wherein the AC component has a frequency between about 1Hz and about 100kHz; and
wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

2. (Currently Amended) The method of claim 1, further comprising:
performing an initial loading comprising:
mixing an initial DC component and an initial AC component to produce an initial electrolytic current such that the initial electrolytic current comprises a DC biased waveform wherein an AC waveform is superimposed onto a DC waveform;
applying the initial electrolytic current to the cathode,
wherein the initial DC component includes cycling between:

a third voltage applied to the cathode for a third period of time;

a fourth voltage applied to the cathode for a fourth period time;

wherein the fourth voltage is higher than the third voltage;

wherein the third period of time and the fourth period of time are approximately the same; and

wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage; and

wherein the initial AC component has a frequency between about 1Hz and about 100kHz.

3. (Previously Presented) The method of claim 1, further comprising sealing the electrochemical reaction vessel.

4. (Previously Presented) The method of claim 3, further comprising flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical vessel.

5. (Previously Presented) The method of claim 1, further comprising applying a magnetic field to the electrochemical reaction vessel.

6. (Previously Presented) The method of claim 1, wherein the frequency of the AC component is dynamically adjusted.

7. (Previously Presented) The method of claim 1, wherein the DC component and AC component of the electrolytic current is mixed with a DC bias.

8. (Previously Presented) The method of claim 1, wherein the cathode is comprised of at least one

of palladium or a palladium alloy.

9. (Previously Presented) The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

10. (Previously Presented) The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

11. (Previously Presented) The method of claim 1, wherein the solvent is a solution containing LiOH.

12. (Previously Presented) The method of claim 1, wherein the solvent is a solution containing LiOD.

13. (Currently Amended) A system for electrolytic loading of hydrogen into a cathode comprising:

an electrochemical reaction vessel filled with a solvent;

a cathode and an anode disposed within the electrochemical reaction vessel;

an electrolytic current source connected to the cathode, wherein the electrolytic current comprises:

a DC component, wherein the DC component cycles between:

a first voltage applied to the cathode for a first period of time;

a second voltage applied to the cathode for a second period time;

wherein the second voltage is higher than the first voltage, and

wherein the second period of time is shorter than the first period of time; and

a AC component with a frequency between about 1Hz and about 100kHz;

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent and

wherein the DC component and the AC component are mixed such that the electrolytic current comprises a DC biased waveform wherein an AC waveform is superimposed onto a DC waveform.

14. (Previously Presented) The system of claim 13, wherein the electrochemical reaction vessel is sealed.

15. (Previously Presented) The system of claim 14, wherein the electrochemical reaction vessel is flushed with a reductive gas prior to sealing.

16. (Previously Presented) The system of claim 13, further comprising a magnetic field applied to the electro chemical reaction vessel.

17. (Previously Presented) The system of claim 13, wherein the frequency of the AC component is dynamically adjusted.

18. (Previously Presented) The system of claim 13, further comprising a mixer, wherein the mixer mixes the DC component and AC component of the electrolytic current with a DC bias.

19. (Previously Presented) The system of claim 13, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

20. (Previously Presented) The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

21. (Previously Presented) The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

22. (Previously Presented) The system of claim 13, wherein the solvent is a solution containing LiOH.

23. (Previously Presented) The system of claim 13, wherein the solvent is a solution containing LiOD.

## REMARKS

This is in response to the Final office action mailed January 13, 2020. Claims 1-23 stand rejected. Claims 1, 2, and 13 have been amended. Support for the amendments can be found, *inter alia*, paragraphs [0006], [0009], and [0023]-[0030] of the specification. No new matter has been added. Reconsideration and withdrawal of the rejections are respectfully requested in view of the remarks below.

### Rejections under 35 U.S.C. § 102

Claims 1, 3, 7-8, 12-13, 18-19 and 23 stand rejected under 35 U.S.C. § 102 as being unpatentable over Weinberg (U.S. 7,452,449). The rejection is traversed. Respectfully, Applicant submits that Weinberg fails to teach each and every limitation of amended independent claims 1 and 13.

Claim 1, as amended, recites in pertinent part, "*mixing a DC component and an AC component to produce an electrolytic current such that the electrolytic current comprises a DC biased waveform wherein an AC waveform is superimposed onto a DC waveform.*" Independent claim 13 recites similar or identical limitations.

Respectfully, Applicant submits that Weinberg does not teach mixing DC and AC waveforms in the manner recited in the instant limitation. Weinberg teaches applying a repeating sequence of voltages across the cathode, each sequence consisting of a first cell voltage regime and a second cell voltage regime. *See, e.g.*, Weinberg at 4:18-23. Weinberg teaches that the first cell voltage comprises a DC current, Weinberg at 6:53-59, while the second cell voltage may comprise an AC current. Weinberg at 8:4-16. In other words, Weinberg only teaches applying AC and DC currents *in repeating sequence*, rather than applying a mixed DC biased AC-DC waveform as the amended claim recites. Thus, Weinberg does not teach the recited limitation.

Weinberg does not teach each and every limitation of independent claims 1 and 13. Accordingly, Weinberg does not anticipate claims 1 and 13. Claims 3, 7-8, 12, 18-19 and 23 depend from claims 1 and 13 and are allowable for at least the same reasons.

**Rejections under 35 U.S.C. § 103**

Claim 2 stands rejected as being unpatentable over Weinberg.

Claims 4 and 15 stand rejected as being unpatentable over Weinberg in view of Alcaraz (US 2018/0087165).

Claims 5, 11, 16, and 22 stand rejected as being unpatentable over Weinberg in view of Hubber (US 2017/0323692).

Claims 6 and 17 stand rejected as being unpatentable over Weinberg in view of Jouanneau (US 2006/0088138).

Claims 9-10 and 20-21 stand rejected as being unpatentable over Weinberg in view of Bellanger (US 4,487,670).

Applicant respectfully submits that Weinberg fails to teach each and every limitation of the independent claims for the reasons discussed above. The secondary references of record do not address the shortcomings of Weinberg. Claims 2, 4-6, 9-11, 15-17, and 20-22 depend from independent claim 1 and 13 and are therefore allowable for at least the same reasons.

## CONCLUSION

In view of the foregoing, Applicant respectfully submits that the application is in condition for allowance. Applicant respectfully requests the Examiner to contact the undersigned attorney/agent if there are any outstanding issues.

## DEPOSIT ACCOUNT

The Commissioner is hereby authorized to charge any otherwise unpaid fees associated with the filing of this correspondence to Deposit Account No. **50-6191**.

Respectfully submitted,

Date: April 2, 2020

/Joseph Shin/
Joseph Shin
Attorney for Applicant
Reg. No. 67,873

NK Patent Law
4917 Waters Edge Drive, Suite 275
Raleigh, NC 27606
Telephone: (919) 348-2194
Facsimile: (919) 882-8195

Customer No. 115007

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16361825 |
| **Filing Date:** | 22-Mar-2019 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Filer:** | Joseph Shin/Donna Donovan |
| **Attorney Docket Number:** | 438/98 UTIL |

Filed as Small Entity

**Filing Fees for Utility under 35 USC 111(a)**

| 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:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| RCE- 1ST REQUEST | 2801 | 1 | 650 | 650 |
| | | **Total in USD ($)** | | **650** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 39046693 |
| **Application Number:** | 16361825 |
| **International Application Number:** | |
| **Confirmation Number:** | 3063 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Customer Number:** | 76934 |
| **Filer:** | Joseph Shin/Donna Donovan |
| **Filer Authorized By:** | Joseph Shin |
| **Attorney Docket Number:** | 438/98 UTIL |
| **Receipt Date:** | 02-APR-2020 |
| **Filing Date:** | 22-MAR-2019 |
| **Time Stamp:** | 15:20:43 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $650 |
| RAM confirmation Number | E202042F21075743 |
| Deposit Account | 506191 |
| Authorized User | Donna Donovan |

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

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 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 | Request for Continued Examination (RCE) | 438-98UTIL_20200402-RCE.pdf | 1364300<br>8e5504f87bd8af386321f1c07ca50b101b36cbc0 | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | | 438-98UTIL-20200402-Resp-to-FOA-of-20200113.pdf | 49368<br>74f953991e8c16598a375066d7698a2d56f5f834 | yes | 9 |

**Multipart Description/PDF files in .zip description**

| Document Description | Start | End |
|---|---|---|
| Response After Final Action | 1 | 1 |
| Claims | 2 | 5 |
| Applicant Arguments/Remarks Made in an Amendment | 6 | 9 |

| | | | | | |
|---|---|---|---|---|---|
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Fee Worksheet (SB06) | fee-info.pdf | 30252<br>f89479a30df5a398f6852d88adc9b82cd05cf985 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 1443920 | | |

**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.**

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


| PATENT APPLICATION FEE DETERMINATION RECORD<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/361,825 | Filing Date<br>03/22/2019 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☐ LARGE ☑ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $50 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $230 = | |
| ☐ 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

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | 04/02/2020 | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * 23 | Minus | ** 23 | = 0 | | x $50 = | 0 |
| | Independent<br>(37 CFR 1.16(h)) | * 2 | Minus | *** 3 | = 0 | | x $230 = | 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 |

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent<br>(37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ 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. | SLIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /PARTHENIA D MERRILL/ |
| *** 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. | |

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. |
|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL | 3063 |

76934 7590 01/13/2020

NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

| EXAMINER | |
|---|---|
| SMITH, NICHOLAS A | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1794 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 01/13/2020 | ELECTRONIC |

**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.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

eofficeaction@appcoll.com
jrnifong@nkpatentlaw.com
usptomail@nkpatentlaw.com

| Office Action Summary | Application No. 16/361,825 | Applicant(s) Cravens, Dennis | |
|---|---|---|---|
| | Examiner NICHOLAS A SMITH | Art Unit 1794 | AIA (FITF) Status Yes |

*-- 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 12 December 2019.

☐ 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) 1-23 is/are pending in the application.

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

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-23 is/are rejected.

8) ☐ Claim(s) _____ 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 _____ 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 _____.

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

4) ☐ Other: _____.

## DETAILED ACTION

### *Notice of Pre-AIA or AIA Status*

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

### *Claim Rejections - 35 USC § 102*

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale or otherwise available to the public before the effective filing date of the claimed invention.

Claim(s) 1, 3, 7-8, 12-14, 18-19 and 23 is/are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Weinberg (US 7452449 B2).

In regards to claim(s) 1, Weinberg discloses a method of loading hydrogen onto a cathode (col. 3, line 66 to col. 4, line 17) comprising applying to the cathode pulsed DC mixed with an AC waveform (Fig. 2). Weinberg discloses the DC component is pulsed (the pulse reading on the second, shorter period of time and the second, higher voltage; Fig. 2; Table 1). Weinberg discloses the AC waveform has a frequency matching that of the DC pulse frequency (Fig. 2). Weinberg discloses the DC duty cycle is 1 μsec + 1050 μsec, corresponding to 951 Hz. Weinberg discloses the solvent ($D_2O$/LiOD; example) dissociates under these voltages (col. 4, lines 16-30).

In regards to claim(s) 3, Weinberg discloses sealing the reactor (cell cover **40**; Fig. 5).

In regards to claim(s) 7, Weinberg discloses that there is a non-zero value for the first voltage (Fig. 2) and thus there is a DC bias.

In regards to claim(s) 8, Weinberg discloses a palladium cathode (col. 11, lines 44-47).

In regards to claim(s) 12, Weinberg discloses LiOD (Example).

In regards to claim(s) 13, Weinberg discloses a system with an electrochemical reaction vessel filled with a solvent (Fig. 5), an anode (**30**) and a cathode (**26**). Weinberg discloses an electrolytic current source (**32**; Fig. 5). Weinberg discloses loading hydrogen onto a cathode (col. 3, line 66 to col. 4, line 17) comprising applying to the cathode pulsed DC mixed with an AC waveform (Fig. 2). Weinberg discloses

the DC component is pulsed (the pulse reading on the second, shorter period of time and the second, higher voltage; Fig. 2; Table 1). Weinberg discloses the AC waveform has a frequency matching that of the DC pulse frequency (Fig. 2). Weinberg discloses the DC duty cycle is 1 μsec + 1050 μsec, corresponding to 951 Hz. Weinberg discloses the solvent ($D_2O$/LiOD; example) dissociates under these voltages (col. 4, lines 16-30).

In regards to claim(s) 14, Weinberg discloses sealing the reactor (cell cover **40**; Fig. 5).

In regards to claim(s) 18, Weinberg discloses that there is a non-zero value for the first voltage (Fig. 2) and thus there is a DC bias.

In regards to claim(s) 19, Weinberg discloses a palladium cathode (col. 11, lines 44-47).

In regards to claim(s) 23, Weinberg discloses LiOD (Example).

***Claim Rejections - 35 USC § 103***

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

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

Claim 2 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg.

In regards to claim(s) 2, Weinberg does not explicitly disclose wherein an initial loading period has an initial DC component with third and fourth voltages of a lower voltage than the first and second voltages being applied along with an initial AC component, with third and fourth period of times being approximately the same.

Weinberg discloses an initial loading period (steps (a)-(c) in Fig. 1) that occurs before the first cell voltage regime and second cell voltage regime (steps (d)-(e) in Fig. 1, also corresponding to Fig. 2; see col. 7, line 25 to col. 8, line 31). Weinberg discloses the voltage applied can be any of a list of potentials, including both square wave and biphasic, and combinations thereof (col. 6, lines 36-48). Weinberg's square wave potential meets the limitation of an initial DC component with third and fourth voltages with third and fourth period of times being approximately the same, while Fig. 2 discloses the initial period has lower voltages than the first and second voltages. It would have been obvious to one of ordinary skill in

the art at the time the invention was filed to modify the method of Weinberg to choose the superimposed square wave and biphasic for the initial loading period because there are a limited number of options and Weinberg explicitly discloses combining. See MPEP 2141 III (E).

Claims 4 and 15 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg in view of Alcaraz (US 20180087165 A1).

In regards to claim(s) 4 and 15, Weinberg does not explicitly disclose filling with a reductive gas prior to sealing the vessel.

Alcaraz pertains to electrolysis systems that produce hydrogen (para 2) and is therefore in the same field of endeavor as Weinberg. Alcaraz discloses flushing the system with a carrier gas, such as argon or hydrogen (para 82). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Alcaraz's flushing, reductive gas as it removes oxygen and other gaseous impurities from the reaction chamber (Alcaraz, para 82).

Claims 5, 11, 16 and 22 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg in view of Hubler (US 20170323692 A1).

In regards to claim(s) 5 and 16, Weinberg does not explicitly disclose applying a magnetic field.

Hubler pertains to electrolytic reactions with a crystalline cathode in an electrolytic apparatus (abstract) and is therefore in the same field of endeavor as Weinberg. Hubler discloses applying a magnetic field (para 96). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Hubler's magnetic field because such improves efficiency (Hubler, para 72).

In regards to claim(s) 11 and 22, Weinberg does not explicitly disclose LiOH.

Hubler discloses using $D_2O$/LiOH (para 24). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Hubler's electrolyte/solvent because such is taught in the art; such a modification would provide predictable results since both Hubler and Weinberg pertain to loading Pd cathodes and Weinberg discloses using metal hydroxides (col. 5, lines 14-28). See MPEP 2141 III (A).

Claims 6 and 17 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg in view of Jouanneau (US 20060088138 A1).

In regards to claim(s) 6 and 17, Weinberg does not explicitly disclose dynamically adjusting the frequency of the AC component.

Jouanneau pertains to hydrogen loading of a cathode electrolytically (Fig. 1; para 15) and is therefore in the same field of endeavor as Weinberg. Jouanneau discloses dynamically adjusting the frequency of the AC component (para 87). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Jouanneau's dynamically adjusting the frequency because such allows matching of one of the mechanical resonance frequencies of the cathode (Jouanneau, para 87).

Claims 9-10 and 20-21 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg in view of Bellanger (US 4487670 A).

In regards to claim(s) 9-10 and 20-21, Weinberg does not explicitly disclose a hydrogen diffusion rate greater than either 0.1 $cm^3/cm^2/s$ or 1.4 $cm^3/cm^2/s$.

Bellanger pertains to electrolysis in order to provide diffusion of tritium in palladium (abstract) and is therefore in the same field of endeavor as Weinberg. Bellanger discloses a hydrogen diffusion rate of 3.9 $cm^3/cm^2/s$ (col. 11, lines 5-12). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Bellanger's conditions/cathode because such allows an 83% diffusion efficiency (Bellanger, col. 11, lines 5-12).

***Response to Arguments***

Applicant's arguments filed 12 December 2019 have been fully considered but they are not persuasive. Applicant alleges that Weinberg only discloses a repeating sequence, not mixed. However, see the rejection ground of instant claim 1 above. The basic meaning of the word "mixed" when applied to electric signals/components is the addition of waveforms. As shown in Fig. 2 of Weinberg, the DC waveform and the AC waveform are mixed (col. 8, lines 4-16). If Applicant intends a more limited meaning of mixed DC and AC components, Applicant is advised to reflect this meaning by amending the instant claim language.

***Conclusion***

**THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to NICHOLAS A SMITH whose telephone number is (571)272-8760. The examiner can normally be reached on M-F 9am-5:30pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, James Lin can be reached on 571-272-8902. 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.

/NICHOLAS A SMITH/
Primary Examiner, Art Unit 1794

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/361,825 | Cravens, Dennis |
| | Examiner | Art Unit |
| | NICHOLAS A SMITH | 1794 |

| CPC - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
| | | |

| CPC Combination Sets - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
| | | |

| US Classification - Searched* | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| | | | |

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| consulted Primary Examiner Harry Wilkins | 08/08/2019 | NS |
| inventor search | 08/09/2019 | NS |
| EAST search (see EAST search history) | 08/09/2019 | NS |

| Interference Search | | | |
|---|---|---|---|
| US Class/CPC Symbol | US Subclass/CPC Group | Date | Examiner |
| | | | |

| /NICHOLAS A SMITH/<br>Primary Examiner, Art Unit 1794 | |
|---|---|

**COMMUNICATION TO THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | | | |
|---|---|---|---|---|---|
| **Application No.** | **:** | **16/361,825** | **Confirmation No.** | **:** | **3063** |
| **Inventor** | **:** | **Dennis Cravens** | **Art Unit** | **:** | **1794** |
| **Filing Date(*)** | **:** | **March 22, 2019** | **Examiner:** | **Nicholas A. Smith** | |
| **Title** | **:** | **METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN** | | | |
| **Docket No.** | **:** | **438/98 UTIL** | | | |
| **Customer No.** | **:** | **115007** | | | |

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

**Reply to Non-Final Action under 37 C.F.R. § 1.111**

Commissioner:

This reply responds to the non-final Office Action dated August 14, 2019 and is being filed with a one (1) month extension of time.

**Listing of Claims** begin on page 2 of this reply.

**Remarks** begin on page 6 of this reply.

(*) Excluding any claim to earlier priority

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16361825 |
| **Filing Date:** | 22-Mar-2019 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Filer:** | Joseph Shin/Donna Donovan |
| **Attorney Docket Number:** | 438/98 UTIL |

Filed as Small Entity

**Filing Fees for Utility under 35 USC 111(a)**

| 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:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| Extension - 1 month with $0 paid | 2251 | 1 | 100 | 100 |
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **100** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 38007838 |
| **Application Number:** | 16361825 |
| **International Application Number:** | |
| **Confirmation Number:** | 3063 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Customer Number:** | 76934 |
| **Filer:** | Joseph Shin/Donna Donovan |
| **Filer Authorized By:** | Joseph Shin |
| **Attorney Docket Number:** | 438/98 UTIL |
| **Receipt Date:** | 12-DEC-2019 |
| **Filing Date:** | 22-MAR-2019 |
| **Time Stamp:** | 11:05:54 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $100 |
| RAM confirmation Number | E2019BBB06271256 |
| Deposit Account | 506191 |
| Authorized User | Donna Donovan |

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

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 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 | | 438-98UTIL-20191212-Resp-to-NFOA-of-20190814.pdf | 47322<br>2fdd408156b1f69ae4324afb0bae601259abebe8 | yes | 9 |

| | Multipart Description/PDF files in .zip description | | |
|---|---|---|---|
| | **Document Description** | **Start** | **End** |
| | Applicant Arguments/Remarks Made in an Amendment | 6 | 9 |
| | Claims | 2 | 5 |
| | Amendment/Req. Reconsideration-After Non-Final Reject | 1 | 1 |

**Warnings:**

**Information:**

| | | | | | |
|---|---|---|---|---|---|
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 30425<br>5bac0655f8d1cda877979ce44a53815daaaa3050 | no | 2 |

**Warnings:**

**Information:**

| **Total Files Size (in bytes):** | 77747 |
|---|---|

**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.**

**Listing of Claims:**

The following listing of claims will replace all previous versions and listings of claims:

**Claims:**

1. (Previously Presented) An electrolytic method of loading hydrogen into a cathode comprising:
placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent;
mixing a DC component and an AC component to produce an electrolytic current;
applying the electrolytic current to the cathode,
wherein the DC component includes cycling between:
a first voltage applied to the cathode for a first period of time;
a second voltage applied to the cathode for a second period time;
wherein the second voltage is higher than the first voltage, and
wherein the second period of time is shorter than the first period of time; and
wherein the AC component has a frequency between about 1Hz and about 100kHz; and
wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

2. (Previously Presented) The method of claim 1, further comprising:
performing an initial loading comprising:
mixing an initial DC component and an initial AC component to produce an initial electrolytic current;
applying the initial electrolytic current to the cathode,
wherein the initial DC component includes cycling between:
a third voltage applied to the cathode for a third period of time;
a fourth voltage applied to the cathode for a fourth period time;

wherein the fourth voltage is higher than the third voltage;

wherein the third period of time and the fourth period of time are approximately the same; and

wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage; and

wherein the initial AC component has a frequency between about 1Hz and about 100kHz.

3. (Previously Presented) The method of claim 1, further comprising sealing the electrochemical reaction vessel.

4. (Previously Presented) The method of claim 3, further comprising flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical vessel.

5. (Previously Presented) The method of claim 1, further comprising applying a magnetic field to the electrochemical reaction vessel.

6. (Previously Presented) The method of claim 1, wherein the frequency of the AC component is dynamically adjusted.

7. (Previously Presented) The method of claim 1, wherein the DC component and AC component of the electrolytic current is mixed with a DC bias.

8. (Previously Presented) The method of claim 1, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

9. (Previously Presented) The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

10. (Previously Presented) The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

11. (Previously Presented) The method of claim 1, wherein the solvent is a solution containing LiOH.

12. (Previously Presented) The method of claim 1, wherein the solvent is a solution containing LiOD.

13. (Previously Presented) A system for electrolytic loading of hydrogen into a cathode comprising:

an electrochemical reaction vessel filled with a solvent;

a cathode and an anode disposed within the electrochemical reaction vessel;

an electrolytic current source connected to the cathode, wherein the electrolytic current comprises:

a DC component, wherein the DC component cycles between:

a first voltage applied to the cathode for a first period of time;

a second voltage applied to the cathode for a second period time;

wherein the second voltage is higher than the first voltage, and

wherein the second period of time is shorter than the first period of time; and

a AC component with a frequency between about 1Hz and about 100kHz;

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

14. (Previously Presented) The system of claim 13, wherein the electrochemical reaction vessel is sealed.

15. (Previously Presented) The system of claim 14, wherein the electrochemical reaction vessel is flushed with a reductive gas prior to sealing.

16. (Previously Presented) The system of claim 13, further comprising a magnetic field applied to the electro chemical reaction vessel.

17. (Previously Presented) The system of claim 13, wherein the frequency of the AC component is dynamically adjusted.

18. (Previously Presented) The system of claim 13, further comprising a mixer, wherein the mixer mixes the DC component and AC component of the electrolytic current with a DC bias.

19. (Previously Presented) The system of claim 13, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

20. (Previously Presented) The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

21. (Previously Presented) The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

22. (Previously Presented) The system of claim 13, wherein the solvent is a solution containing

LiOH.

23. (Previously Presented) The system of claim 13, wherein the solvent is a solution containing LiOD.

## REMARKS

This paper is responsive to the non-final Office action dated August 14, 2019, and is being submitted with a one (1) month extension of time. No new matter is added.

### Rejections under 35 U.S.C. § 102

Claims 1, 3, 7-8, 12-13, 18-19 and 23 stand rejected under 35 U.S.C. § 102 as being unpatentable over Weinberg (U.S. 7,452,449). The rejection is traversed. Respectfully, Applicant submits that Weinberg fails to teach each and every limitation of independent claims 1 and 13.

Claim 1 recites, in pertinent part, "*mixing a DC component and an AC component to produce an electrolytic current;*" and "*wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.*" Respectfully, Applicant submits that Weinberg teaches neither of these limitations. Independent claim 13 recites similar or identical limitations.

Weinberg teaches applying a repeating sequence of voltages across the cathode, each sequence consisting of a first cell voltage regime and a second cell voltage regime. *See, e.g.*, Weinberg at 4:18-23. Weinberg teaches that the first cell voltage comprises a DC current, Weinberg at 6:53-59, while the second cell voltage may comprise an AC current. Weinberg at 8:4-16. Importantly, Weinberg teaches that the first cell voltage regime and second cell voltage regime are applied *in repeating sequence*, not mixed. Thus, Weinberg does not teach an electrolytic current produced by mixing a DC component and an AC component. Rather, it teaches an electrolytic current produced by applying a DC component and an AC component in sequence.

Furthermore, because the DC component and AC components in Weinberg are not mixed, Weinberg does not teach that "peak sum voltage supplied by the DC component and AC component is higher than the dissociation voltage of the solvent." In fact, in FIG. 2, cited by the

Examiner, the peak voltage shown in element 4 is produced solely by the DC component, not by the sum of mixed DC and AC components.

Weinberg does not teach each and every limitation of independent claims 1 and 13. Accordingly, Weinberg does not anticipate claims 1 and 13. Claims 3, 7-8, 12, 18-19 and 23 depend from claims 1 and 13 and are allowable for at least the same reasons.

**Rejections under 35 U.S.C. § 103**

Claim 2 stands rejected as being unpatentable over Weinberg.

Claims 4 and 15 stand rejected as being unpatentable over Weingberg in view of Alcaraz (US 2018/0087165).

Claims 5, 11, 16, and 22 stand rejected as being unpatentable over Weinberg in view of Hubber (US 2017/0323692).

Claims 6 and 17 stand rejected as being unpatentable over Weinberg in view of Jouanneau (US 2006/0088138).

Claims 9-10 and 20-21 stand rejected as being unpatentable over Weinberg in view of Bellanger (US 4,487,670).

Applicant respectfully submits that Weinberg fails to teach each and every limitation of the independent claims for the reasons discussed above. The secondary references of record do not address the shortcomings of Weinberg. Claims 2, 4-6, 9-11, 15-17, and 20-22 depend from independent claim 1 and 13 and are therefore allowable for at least the same reasons.

## CONCLUSION

In view of the foregoing, Applicant respectfully submits that the application is in condition for allowance. Applicant respectfully requests the Examiner to contact the undersigned attorney/agent if there are any outstanding issues.

## DEPOSIT ACCOUNT

The Commissioner is hereby authorized to charge any otherwise unpaid fees associated with the filing of this correspondence to Deposit Account No. **50-6191**.

Respectfully submitted,

Date: December 12, 2019

/Joseph Shin/
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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


| PATENT APPLICATION FEE DETERMINATION RECORD<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/361,825 | Filing Date<br>03/22/2019 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☐ LARGE ☑ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $50 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $230 = | |
| ☐ 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

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | 12/12/2019 | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * 23 | Minus | ** 23 | = 0 | | x $50 = | 0 |
| | Independent<br>(37 CFR 1.16(h)) | * 2 | Minus | *** 3 | = 0 | | x $230 = | 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 |

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent<br>(37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ 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. | LIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /GOIGA N DUCKETT/ |
| *** 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. | |

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.**

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL | 3063 |

76934 7590 08/14/2019

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| EXAMINER | |
|---|---|
| SMITH, NICHOLAS A | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1794 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 08/14/2019 | ELECTRONIC |

**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.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

eofficeaction@appcoll.com
jrnifong@nkpatentlaw.com
usptomail@nkpatentlaw.com

| Office Action Summary | Application No. 16/361,825 | Applicant(s) Cravens, Dennis | |
|---|---|---|---|
| | Examiner NICHOLAS A SMITH | Art Unit 1794 | AIA (FITF) Status Yes |

*-- 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 22 March 2019.

☐ 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) 1-23 is/are pending in the application.

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

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-23 is/are rejected.

8) ☐ Claim(s) _____ 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 _____ 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 _____.

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

4) ☐ Other: _____.

## DETAILED ACTION

### *Notice of Pre-AIA or AIA Status*

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

### *Claim Rejections - 35 USC § 102*

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale or otherwise available to the public before the effective filing date of the claimed invention.

Claim(s) 1, 3, 7-8, 12-14, 18-19 and 23 is/are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Weinberg (US 7452449 B2).

In regards to claim(s) 1, Weinberg discloses a method of loading hydrogen onto a cathode (col. 3, line 66 to col. 4, line 17) comprising applying to the cathode pulsed DC mixed with an AC waveform (Fig. 2). Weinberg discloses the DC component is pulsed (the pulse reading on the second, shorter period of time and the second, higher voltage; Fig. 2; Table 1). Weinberg discloses the AC waveform has a frequency matching that of the DC pulse frequency (Fig. 2). Weinberg discloses the DC duty cycle is 1 μsec + 1050 μsec, corresponding to 951 Hz. Weinberg discloses the solvent ($D_2O$/LiOD; example) dissociates under these voltages (col. 4, lines 16-30).

In regards to claim(s) 3, Weinberg discloses sealing the reactor (cell cover **40**; Fig. 5).

In regards to claim(s) 7, Weinberg discloses that there is a non-zero value for the first voltage (Fig. 2) and thus there is a DC bias.

In regards to claim(s) 8, Weinberg discloses a palladium cathode (col. 11, lines 44-47).

In regards to claim(s) 12, Weinberg discloses LiOD (Example).

In regards to claim(s) 13, Weinberg discloses a system with an electrochemical reaction vessel filled with a solvent (Fig. 5), an anode (**30**) and a cathode (**26**). Weinberg discloses an electrolytic current source (**32**; Fig. 5). Weinberg discloses loading hydrogen onto a cathode (col. 3, line 66 to col. 4, line 17) comprising applying to the cathode pulsed DC mixed with an AC waveform (Fig. 2). Weinberg discloses

the DC component is pulsed (the pulse reading on the second, shorter period of time and the second, higher voltage; Fig. 2; Table 1). Weinberg discloses the AC waveform has a frequency matching that of the DC pulse frequency (Fig. 2). Weinberg discloses the DC duty cycle is 1 μsec + 1050 μsec, corresponding to 951 Hz. Weinberg discloses the solvent ($D_2O$/LiOD; example) dissociates under these voltages (col. 4, lines 16-30).

In regards to claim(s) 14, Weinberg discloses sealing the reactor (cell cover **40**; Fig. 5).

In regards to claim(s) 18, Weinberg discloses that there is a non-zero value for the first voltage (Fig. 2) and thus there is a DC bias.

In regards to claim(s) 19, Weinberg discloses a palladium cathode (col. 11, lines 44-47).

In regards to claim(s) 23, Weinberg discloses LiOD (Example).

***Claim Rejections - 35 USC § 103***

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

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

Claim 2 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg.

In regards to claim(s) 2, Weinberg does not explicitly disclose wherein an initial loading period has an initial DC component with third and fourth voltages of a lower voltage than the first and second voltages being applied along with an initial AC component, with third and fourth period of times being approximately the same.

Weinberg discloses an initial loading period (steps (a)-(c) in Fig. 1) that occurs before the first cell voltage regime and second cell voltage regime (steps (d)-(e) in Fig. 1, also corresponding to Fig. 2; see col. 7, line 25 to col. 8, line 31). Weinberg discloses the voltage applied can be any of a list of potentials, including both square wave and biphasic, and combinations thereof (col. 6, lines 36-48). Weinberg's square wave potential meets the limitation of an initial DC component with third and fourth voltages with third and fourth period of times being approximately the same, while Fig. 2 discloses the initial period has lower voltages than the first and second voltages. It would have been obvious to one of ordinary skill in

the art at the time the invention was filed to modify the method of Weinberg to choose the superimposed square wave and biphasic for the initial loading period because there are a limited number of options and Weinberg explicitly discloses combining. See MPEP 2141 III (E).

Claims 4 and 15 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg in view of Alcaraz (US 20180087165 A1).

In regards to claim(s) 4 and 15, Weinberg does not explicitly disclose filling with a reductive gas prior to sealing the vessel.

Alcaraz pertains to electrolysis systems that produce hydrogen (para 2) and is therefore in the same field of endeavor as Weinberg. Alcaraz discloses flushing the system with a carrier gas, such as argon or hydrogen (para 82). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Alcaraz's flushing, reductive gas as it removes oxygen and other gaseous impurities from the reaction chamber (Alcaraz, para 82).

Claims 5, 11, 16 and 22 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg in view of Hubler (US 20170323692 A1).

In regards to claim(s) 5 and 16, Weinberg does not explicitly disclose applying a magnetic field.

Hubler pertains to electrolytic reactions with a crystalline cathode in an electrolytic apparatus (abstract) and is therefore in the same field of endeavor as Weinberg. Hubler discloses applying a magnetic field (para 96). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Hubler's magnetic field because such improves efficiency (Hubler, para 72).

In regards to claim(s) 11 and 22, Weinberg does not explicitly disclose LiOH.

Hubler discloses using $D_2O$/LiOH (para 24). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Hubler's electrolyte/solvent because such is taught in the art; such a modification would provide predictable results since both Hubler and Weinberg pertain to loading Pd cathodes and Weinberg discloses using metal hydroxides (col. 5, lines 14-28). See MPEP 2141 III (A).

Claims 6 and 17 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg in view of Jouanneau (US 20060088138 A1).

In regards to claim(s) 6 and 17, Weinberg does not explicitly disclose dynamically adjusting the frequency of the AC component.

Jouanneau pertains to hydrogen loading of a cathode electrolytically (Fig. 1; para 15) and is therefore in the same field of endeavor as Weinberg. Jouanneau discloses dynamically adjusting the frequency of the AC component (para 87). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Jouanneau's dynamically adjusting the frequency because such allows matching of one of the mechanical resonance frequencies of the cathode (Jouanneau, para 87).

Claims 9-10 and 20-21 is/are rejected under 35 U.S.C. 103 as being unpatentable over Weinberg in view of Bellanger (US 4487670 A).

In regards to claim(s) 9-10 and 20-21, Weinberg does not explicitly disclose a hydrogen diffusion rate greater than either 0.1 $cm^3/cm^2/s$ or 1.4 $cm^3/cm^2/s$.

Bellanger pertains to electrolysis in order to provide diffusion of tritium in palladium (abstract) and is therefore in the same field of endeavor as Weinberg. Bellanger discloses a hydrogen diffusion rate of 3.9 $cm^3/cm^2/s$ (col. 11, lines 5-12). It would have been obvious to one of ordinary skill in the art at the time the invention was filed to modify the method or system of Weinberg with Bellanger's conditions/cathode because such allows an 83% diffusion efficiency (Bellanger, col. 11, lines 5-12).

***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to NICHOLAS A SMITH whose telephone number is (571)272-8760. The examiner can normally be reached on M-F 9am-5:30pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, James Lin can be reached on 571-272-8902. 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.

/NICHOLAS A SMITH/
Primary Examiner, Art Unit 1794

| Notice of References Cited | Application/Control No. 16/361,825 | Applicant(s)/Patent Under Reexamination Cravens, Dennis | |
|---|---|---|---|
| | Examiner NICHOLAS A SMITH | Art Unit 1794 | 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-7452449-B2 | 11-2008 | Weinberg; Norman L. | C25B1/02 | 204/229.4 |
| * | B | US-20180087165-A1 | 03-2018 | Alcaraz; Ernest Charles | C25B15/02 | 1/1 |
| * | C | US-20170323692-A1 | 11-2017 | Hubler; Graham K. | G21B3/00 | 1/1 |
| * | D | US-20060088138-A1 | 04-2006 | Jouanneau; Andre | G21B3/00 | 376/131 |
| * | E | US-4487670-A | 12-1984 | Bellanger; Gilbert | G21F9/06 | 205/627 |
| | F | | | | | |
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**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | CPC Classification |
|---|---|---|---|---|---|---|
| | N | | | | | |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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| | 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.

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/361,825 | Cravens, Dennis |
| | Examiner | Art Unit |
| | NICHOLAS A SMITH | 1794 |

| CPC - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
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| CPC Combination Sets - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
| | | |

| US Classification - Searched* | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| | | | |

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| consulted Primary Examiner Harry Wilkins | 08/08/2019 | NS |
| inventor search | 08/09/2019 | NS |
| EAST search (see EAST search history) | 08/09/2019 | NS |

| Interference Search | | | |
|---|---|---|---|
| US Class/CPC Symbol | US Subclass/CPC Group | Date | Examiner |
| | | | |

| /NICHOLAS A SMITH/<br>Primary Examiner, Art Unit 1794 | |
|---|---|

# Bibliographic Data

Application No: 16/361,825

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☐ No ☐ Met After Allowance

Verified and Acknowledged: /NICHOLAS A SMITH/ (Examiner's Signature) | (Initials)

Title: METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

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| FILING or 371(c) DATE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|
| 03/22/2019 | 204 | 1794 | 438/98 UTIL |
| RULE | | | |

**APPLICANTS**

Industrial Heat, LLC, Raleigh, NC, UNITED STATES

**INVENTORS**

Dennis Cravens Cloudcroft, NM, UNITED STATES

**CONTINUING DATA**

This application has PRO of 62804989 02/13/2019

**FOREIGN APPLICATIONS**

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

04/05/2019

** SMALL ENTITY **

**STATE OR COUNTRY**

UNITED STATES

**ADDRESS**

NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606
UNITED STATES

**FILING FEE RECEIVED**

$935

**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| S1 | 2 | ("20180237924").PN. | US-PGPUB; USPAT; USOCR; DERWENT | OR | ON | 2019/07/29 11:16 |
| S2 | 4 | electrochemical near2 hydrogen near2 loading same palladium | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:18 |
| S3 | 0 | electrochemical near2 dueterium near2 loading same palladium | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:31 |
| S4 | 3 | electrochemical near2 deuterium near2 loading same palladium | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:31 |
| S5 | 2 | electrochemical near2 (deuterium hydrogen) near2 loading same palladium same (produc$4) near2 (heat) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:39 |
| S6 | 2 | electrochemical with (deuterium hydrogen) near2 loading same palladium same (produc$4) near2 (heat) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:40 |
| S7 | 2 | electrochemical with (deuterium hydrogen) with loading same palladium same (produc$4) near2 (heat) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:40 |
| S8 | 10 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:40 |
| S9 | 4 | deuterated adj palladium adj alloy$1 | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/07/30 09:46 |
| S10 | 2 | "6991719".pn. | US-PGPUB; USPAT; USOCR; DERWENT | OR | ON | 2019/08/08 10:31 |
| S11 | 2 | "7452449".pn. | US-PGPUB; USPAT; USOCR; DERWENT | OR | ON | 2019/08/08 10:36 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S12 | 1 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and (flush$3) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 12:50 |
| S13 | 1 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and (magnetic adj field$1) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 12:58 |
| S14 | 7 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and (dynamic$4 adjust$3 chang$3) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 13:09 |
| S15 | 2 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and (dynamic$4 adjust$3 chang$3) with (frequenc$3) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 13:09 |
| S16 | 17 | electrochemical with (deuterium hydrogen) same palladium and (dynamic$4 adjust$3 chang$3) near3 (frequenc$3) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 14:43 |
| S17 | 16 | electrochemical with (deuterium hydrogen) same palladium and (hydrogen near2 diffusion near rate$1) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 14:57 |
| S18 | 88 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:09 |
| S19 | 0 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) with (cm3$) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:10 |
| S20 | 0 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) with (cm3$10) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:10 |
| S21 | 1 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) with (cm) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:12 |
| S22 | 88 | (hydrogen) same palladium same (hydrogen near2 diffusion near rate$1) | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:21 |
| S23 | 1 | electrochemical with (deuterium hydrogen) same palladium same (produc$4) near2 (heat) and LioH | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2019/08/08 15:59 |

**8/ 9/ 2019 10:36:23 AM**
**C:\ Users\ nsmith1\ Documents\ EAST\ Workspaces\ 16361825.wsp**

# PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/361,825

## 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 | 75 | | N/A | |
| SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | 330 | | N/A | |
| EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | 380 | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | 23 minus 20 = | * 3 | x 50 = | 150 | OR | | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | 2 minus 3 = | * | x 230 = | 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 | 935 | | TOTAL | |

## 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 | RATE($) | ADDITIONAL FEE($) | | RATE($) | ADDITIONAL FEE($) |
|---|---|---|---|---|---|---|---|---|---|---|
| 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.

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www.uspto.gov

| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | 2844 | 935 | 438/98 UTIL | 23 | 2 |

**CONFIRMATION NO. 3063**

**UPDATED FILING RECEIPT**

76934
NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

Date Mailed: 07/15/2019

Receipt is acknowledged of this non-provisional utility 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 FIRST INVENTOR, 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 corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction 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 provided that the request is grantable.

**Inventor(s)**

Dennis Cravens, Cloudcroft, NM;

**Applicant(s)**

Industrial Heat, LLC, Raleigh, NC;

**Power of Attorney:** None

**Domestic Priority data as claimed by applicant**

This appln claims benefit of 62/804,989 02/13/2019

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 04/05/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/361,825**

**Projected Publication Date:** 08/13/2020

**Non-Publication Request:** No

**Early Publication Request:** No
**** SMALL ENTITY ****
**Title**

METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

**Preliminary Class**

315

**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).

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## Title 35, United States Code, Section 184

## Title 37, Code of Federal Regulations, 5.11 & 5.15

**GRANTED**

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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.

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**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).

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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL | 3063 |

76934 7590 06/17/2019

NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

| EXAMINER | |
|---|---|
| ART UNIT | PAPER NUMBER |
| 2844 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 06/17/2019 | ELECTRONIC |

**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.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

eofficeaction@appcoll.com
jrnifong@nkpatentlaw.com
usptomail@nkpatentlaw.com

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Alexandria, VA 22313-1450
www.uspto.gov

| | | |
|---|---|---|
| In re Application of | : | |
| Cravens, Dennis | : | |
| Application No. 16/361,825 | : | DECISION ON PETITION |
| Filed: March 22, 2019 | : | TO MAKE SPECIAL UNDER |
| Attorney Docket No.: 438/98 UTIL | : | 37 CFR 1.102(c)(1) |

This is a decision on the petition under 37 CFR 1.102(c)(1), filed March 22, 2019, to make the above-identified application special based on applicant's age as set forth in M.P.E.P. § 708.02, Section IV.

The petition is **GRANTED**.

A grantable petition to make an application special under 37 CFR 1.102(c)(1) and MPEP § 708.02, Section IV: Applicant's Age must be accompanied by evidence showing that at least one of the applicants is 65 years of age, or more, such as a birth certificate or a statement by applicant. No fee is required.

The instant petition includes a statement from a registered practitioner that he has evidence that the inventor Dennis Cravens is 65 years of age or older. Accordingly, the above-identified application has been accorded "special" status.

The application is being forwarded to the Technology Center Art Unit 2844 for action on the merits to commensurate with this decision.

Telephone inquiries concerning this decision should be directed to Joy Dobbs at 571-272-3001.
All other inquiries concerning either the examination or status of the application should be directed to the Technology Center.

/Joy Dobbs/
Petition Paralegal Specialist

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | | |
|---|---|---|---|---|
| Application No. | : | 16/361,825 | Confirmation No.: | 3063 |
| Applicant | : | Industrial Heat, LLC | | |
| First Named Inventor | : | Dennis J. Cravens | | |
| Filing Date | : | Mar 22, 2019 | | |
| TC/A.U. | : | 2844 | | |
| Examiner | : | - | | |
| Docket No. | : | 438/98 UTIL | | |
| Customer No. | : | 76934 | | |

---

Title of Invention: METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

**Via EFS-Web**
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

## RESPONSE TO NOTICE TO FILE CORRECTED APPLICATION PAPERS

Commissioner:

This is in response to the Notice to File Corrected Application Papers mailed April 8, 2019. In this Notice the applicant is given a two-month period for response, expiring on June 8, 2019. This reply is timely submitted.

## REMARKS

Applicant herewith submits a substitute specification (in both clean and marked-up versions) which now contains a brief description of the drawings and the abstract. No new matter has been added.

## CONCLUSION

If any issues remain outstanding, or if a phone call could resolve any pending issues, the Commissioner is encouraged to call the attorney identified below in order to expeditiously resolve these matters.

## DEPOSIT ACCOUNT

The Applicant does not believe that any fees are due at this time, however, the Commissioner is hereby authorized to charge any otherwise unpaid fees or credit any overpayment of fees associated with the filing of this correspondence to Deposit Account No. **50-6191**.

Respectfully submitted,

Date: April 10, 2019

/Joseph Shin/
Joseph Shin
Reg. No. 67873

NK Patent Law
4917 Waters Edge Drive, Suite 275
Raleigh, NC 27606
Telephone: (919) 348-2194
Facsimile: (919) 882-8195

Customer No. 76934

# METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[001]** This application claims the benefit of priority of U.S. provisional patent application no. 62/804,989, titled "METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN," filed on February 13, 2019, which is incorporated herein in its entirety by this reference.

## TECHNICAL FIELD

**[002]** The present disclosure relates to methods of producing heat through electrochemical means. Specifically, the present disclosure relates to the production of heat through electrolytic loading of hydrogen into a cathode.

## BACKGROUND

**[003]** Some electrochemical applications involve the loading of hydrogen or similar species into one or more electrodes. There are three primary competing technologies for the loading of hydrogen into an electrode: "Low High" DC voltage application by Takahashi, the "q wave" method of Brillouin, and the "superwave" forms of Dardik.

**[004]** Most current methods of electrolytic loading of hydrogen into metals involve slow, steady loading with constant current DC or with a constant voltage. Some systems use pulsed high-low series of DC pulses to aid the process. Shaped AC waves are known in the art, however these still require long, slow loading and do not achieve internal compression of the hydrogen within the metal electrodes. Some experimental and engineering designs require

regions of very high hydrogen concentrations to be reached before the desired effects can be achieved or studied. For example, United States Patent Application No. 20070280398 describes a fractal based superwaves technique for hydrogen loading involving the addition of many AC waveforms without DC bias.

**[005]** The problem with known methods of electrochemical hydrogen loading is that the production of the capacitive double layer around the electrode often limits the loading rates and levels reached in the electrode. Therefore, a protocol that can achieve high regions of hydrogen loading within or upon the surface of electrodes in a shorter time and can continue to produce or maintain high loading levels for extended times is needed.

## SUMMARY OF THE INVENTION

**[006]** The present invention uses the synergistic addition of both Low-High DC stepped switching with a shaped AC superimposed to the DC in the hydrogen loading process. This allows the DC to increase loading during the lower (i.e., less negative) voltage, high current step by taking advantage of the in and out flushing of the hydrogen at the surface utilizing the capacitance nature of the well-known electrochemical double layer formed by the electrolyte near the surface. Additionally, during the higher voltage and lower current DC step, the AC can cause added egress of the hydrogen from the metal and keep diffusion channels open. (For cathode loading the cathode is at a negative potential.) By altering the duty cycle of the DC stepping between the high and low stages, the loading rate during the high voltage step can add more hydrogen than is lost during the low voltage stage. The in and out migration of the hydrogen tends to open up more transport routes and other features that allow much higher levels of loading and faster loading than either DC or AC alone or one following the other in

succession independently. The advantage of this synergistic effect is greatly desired in some application.

**[007]** One of ordinary skill in the art will appreciate that references to hydrogen throughout the specification may refer to all stable isotopes of hydrogen including protium, deuterium, and/or tritium. Likewise, the term water includes its various isotopic forms.

**[008]** In one embodiment, an electrolytic method of loading hydrogen into a cathode may include placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent, mixing a DC component and an AC component to produce an electrolytic current, and applying the electrolytic current to the cathode. The DC component may include cycling between: a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period of time, wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time. The AC component may have a frequency between about 1 Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

**[009]** In yet another embodiment, the method may further include performing an initial loading. The initial loading may include mixing an initial DC component and an initial AC component to produce an initial electrolytic current and applying the initial electrolytic current to the cathode. The initial DC component may include cycling between: a third voltage applied to the cathode for a third period of time, a fourth voltage applied to the cathode for a fourth period of time, wherein the fourth voltage is higher than the third voltage, wherein the third period of time and the fourth period of time are approximately the same, and wherein the third voltage is

lower than the first voltage and the fourth voltage is lower than the second voltage. The initial AC component may have a frequency between about 1Hz and about 100kHz.

**[0010]** In another embodiment, a system for electrolytic loading of hydrogen into a cathode may include an electrochemical reaction vessel filled with a solvent, a cathode and an anode disposed within the electrochemical reaction vessel, and an electrolytic current source connected to the cathode. The electrolytic current may include a DC component, wherein the DC component may cycle between a first voltage applied to the cathode for a first period of time, and a second voltage applied to the cathode for a second period of time, wherein the second voltage may be higher than the first voltage, and wherein the second period of time may be shorter than the first period of time. The electrolytic current may further include an AC component with a frequency between about 1Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

**[0011]** In yet another embodiment, the method may further comprise sealing the electrochemical reaction vessel.

**[0012]** In yet another embodiment, the method may further include flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical reaction vessel.

**[0013]** In yet another embodiment, the method may further include applying a magnetic field to the electrochemical reaction vessel.

**[0014]** In yet another embodiment, the frequency of the AC component may be dynamically adjusted.

**[0015]** In yet another embodiment, the DC component and the AC component of the electrolytic current may be mixed with a DC bias.

**[0016]** In yet another embodiment, the cathode may be comprised of at least one of palladium or a palladium alloy.

**[0017]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

**[0018]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

**[0019]** In yet another embodiment, the solvent may be solutions containing LiOH.

**[0020]** In yet another embodiment, the solvent may be solutions containing LiOD.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0021]** These and other objects, features, and characteristics will become more apparent to those skilled in the art from a study of the following Detailed Description in conjunction with the appended claims and drawings, all of which form a part of this specification. While the accompanying drawings include illustrations of various embodiments, the drawings are not intended to limit the claimed subject matter.

**[0022]** FIG. 1 is a flow diagram of an electrolytic method of loading hydrogen into a cathode according to an embodiment of the present invention.

**[0023]** FIG. 2 is a voltage vs. time graph of AC, DC, and AC/DC mixed signals.

**[0024]** FIG. 3 is a system diagram of a AC/DC mixing according to an embodiment of the present invention.

**[0025]** FIG. 4 is a voltage vs. time graph of the stepped-DC portion of a signal according to an embodiment of the present invention.

**[0026]** FIG. 5 is a voltage vs. time graph of the AC portion of a signal according to an embodiment of the present invention.

**[0027]** FIG. 6 is a system diagram of a system for electrolytic loading of hydrogen into a cathode according to an embodiment of the present invention.

## DETAILED DESCRIPTION

**[0028]** In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the embodiments of the invention. One skilled in the art will recognize that the embodiments of the invention may be practiced without these specific details or with an equivalent arrangement. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the embodiments of the invention.

**[0029]** The presently disclosed subject matter is presented with sufficient details to provide an understanding of one or more particular embodiments of broader inventive subject matters. The descriptions expound upon and exemplify particular features of those particular embodiments without limiting the inventive subject matters to the explicitly described embodiments and features. Considerations in view of these descriptions will likely give rise to additional and similar embodiments and features without departing from the scope of the

presently disclosed subject matter.

**[0030]** Referring now to FIG.1, in one embodiment of the present invention, an electrolytic method of loading hydrogen into a cathode may comprise placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent 10, mixing a DC component and an AC component to produce an electrolytic current 30, and applying an electrolytic current to the cathode 40. The DC component may include cycling between: a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period of time, wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time. The AC component may have a frequency between about 1 Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

**[0031]** DC currents and voltages used here may be switched in time but have a specific polarity above 0 volts as measured by traditional electrochemical methods, i.e. related to uncharged unbounded hydrogen. For clarity, the term DC includes switched DC where the desired voltage remains stable over an extended time. The term AC currents and voltages are used to describe currents which pass through the 0 voltage levels or through the value set by the DC voltages. That is we are using the term relative to the anode of the electrochemical system and AC is meant to be current that alternates between positive and negative charge on the cathode.

**[0032]** It should be clear to those skilled in the art of electrochemistry, that the desired DC biased AC wave forms are applied to electrodes within an electrochemical cell. Specifically, at least the primary current of the DC applied to the cell is polarized so that the electrode (cathode) to receive the hydrogen is negatively charged compared to one of the other electrodes

so that hydrogen species are moved toward the cathode.

**[0033]** When the frequency of the AC waveform is discussed it is meant to refer to the Fourier component of that waveform which has the greatest amplitude. It should be realized that the waveform can take a variety of forms. Waveforms having a component with rise-times shorter than 250 ns are preferred.

**[0034]** To avoid confusion, it should be noticed in electrochemical system one electrode is taken as a reference. For this electrolysis system, the anode is taken as the reference and set to ground. The cathode is negatively charge with respect to the anode and to ground.

**[0035]** It is preferred that the DC component's duty cycle be such to have a greater on time for the high voltage or high currents than for the lower ones after the initial loading protocol. This is for the purpose of giving a net ingress of the hydrogen into the electrode. In one embodiment, the cycle timing was 5 minutes with 90% on time for the lower voltage and 10% on time for the higher voltage. (Note: the cathode being loaded is at a negative potential.) In that embodiment, the high voltage was set at 10 VDC and the low voltage at 1 VDC.

**[0036]** In the preferred embodiment, the time between the DC Lo-High cycles (period) should be less than 20 minutes for electrodes with maximum thicknesses of 1mm. Longer times do not seem to be beneficial for such commonly used materials.

**[0037]** The AC waveform component to the electrolytic current can be of many different functional forms such as sine, square, pulsed, or triangular as commonly available from function generators. Sine waves are used in the description herein but others waveforms can be envisioned by those skilled in the art of electrical engineering. The AC component is added to

the stepped cycle DC component for the purpose of causing dynamic movement of the hydrogen into, though, and out of the electrochemical double layer and the surface of the electrode. The sum of the DC and AC components is applied between the electrode to be loaded with hydrogen and another electrode in a manor customary to electrolysis and known within the art of electrochemistry. In the preferred embodiment the addition of the AC and DC components should allow the voltage at the cathode to rise above zero voltage to release hydrogen from the electrode but not, however, to strip the hydrogen completely. Thus the greatest rise of the voltage should be slightly above zero volts but not significantly above zero nor remain at such levels for extended times. It is desired that the cathode be at a negative potential compared to the anode electrode (taken as ground) for longer total times than the positive times. In one embodiment the DC volts where chosen at -10V (90% of the time) and -1.5V (10% of the time) volts and the AC sine amplitude was chosen as 2.5 volts with a frequency of 100 Hz. This results in short-term peak voltages at the cathode to rise to 1 volt. However, the majority of the time the cathode experiences voltages above the dissociation voltage of the water solvent of about 1.5 volts and thus loads hydrogen into the electrode.

**[0038]** Referring now to FIG. 2, deloading can occur when the AC component adds to the DC in such a way to raise it above zero potential. The anode potential is taken as ground or 0 potential. The primary loading occurs during the time the DC component is at a more negative potential. There is a greater current flow when the cathode is at its more negative potentials. In the embodiment illustrated in FIG. 2, the two DC supplies are two DC-DC Adjustable Power Supply Output Step-down Module 6.5V-60V to 1.25-30V 10A UPC 741870439544. Their purpose is to supply a DC bias to the cathode for loading of hydrogen into the electrode. To that end, it is important that voltages in excess of the dissociation of the solvent (i.e. water) be

developed between the two electrodes. For water-basedsolvents, this is around 1.2 to 1.5 V dependent on pressures, electrolyte concentration, isotopic makeup, and temperatures. The two currents are wired to a double pole double throw relay (in one embodiment this was an Enclosed Power Relay,8 Pin,24VDC, DPDT SCHNEIDER ELECTRIC 92S11D22D-24D). The relay was cycled by a repeating unit 12V DC Multifunction Self-lock Relay PLC Cycle Timer Module Delay Time Switch UPC 714046658482.Its function is to activate the relay to cycle between the two DC power supplies. One of ordinary skill in the art would appreciate that any suitable DC supply, controller, and relay may be used in the present invention.

**[0039]** Referring now to FIG. 3, a general conception of the AC/-DC mixing according to an embodiment of the present invention is shown. It is shown as component units with discrete purposes. The parts' purpose is to supply a cycled DC voltage in a repetitive low- high cycle. It should be obvious by those skilled in the art of electrical engineering that many circuit designs can be employed for the same purpose. For example, a single programmable DC supply could replace the unit or a computer controlled DC supply. Alternatively, a dedicated AC generator which can provide DC Fourier components could be used. However, the separate components of the figure illustrates one embodiment the desired DC part of the input power can be obtained.

**[0040]** As mentioned elsewhere, one supply should be set so that there is net hydrogen-mediated current into the electrode and it should also have a voltage setting so the hydrogen can be dissociated in the solvent. The output of the stepped DC part of the system 303 is then directed to an AC/DC mixing unit 304 for the purpose of adding the two components for supply to the electrodes within the electrochemical system.

**[0041]** Referring now to FIG. 4, a voltage vs. time output from the stepped DC portion of

the system is shown. The duty cycle provides for the greater potential difference, and hence greater electrochemical current, for longer times than the lesser potential difference between electrodes. Thus, greater time is spent at the larger negative values for the purpose of providing hydrogen to the cathode.

**[0042]** The AC may be supplied by any suitable AC supply 305, for example, a HIGH PRECISION Audio Signal Generator 1Hz-1MHz with Sine Triangle Square outputs, UPC 0713893274877 or the like. It should be noted that other frequencies may be used, however, frequencies between 1Hz and 100kHz have been observed to be adequate for most applications. The primary factor in setting frequencies is the electrochemical double layer capacitance at the cathode. It is preferred that the expected frequencies range of the specific cell be determined by a method common within the art of electrochemical impedance spectroscopy. That is the primary AC frequency applied should allow for the greatest current flow into the cathode. The output of the AC or functional form device is fed via a current sensor into the AC/DC mixer 304.

**[0043]** In yet another embodiment, the frequency of the AC component 305 may be dynamically adjusted. A current sensor may indicate the absorption of the AC by the electrochemical cell. This, in turn, may signal the transport of the ionic species into, through, and out of the electrochemical double layer and eventually the movement of the hydrogen at the surface or near the surface of the cathode. The AC current sensor may relay the information to a frequency controller whose role is to keep the AC frequency center near the area of maximum AC absorption. Thus it assures a large movement of the hydrogen at the surface and near the surface of the cathode. It is conjectured that this keeps the surface clean and diffusion pathways open. It also shuttles ions through the double layer from the solvent. However, since the cathode experiences outflow of some hydrogen for only short limited times there is net loading of the

cathode. It is envisioned that the entire AC part of the system could comprise a single electronic unit.

**[0044]** Referring now to FIG. 5, a typical AC output using a simple sine form is shown. Other functional forms are contemplated in the present invention.

**[0045]** In yet another embodiment, the DC component and the AC component of the electrolytic current may be mixed with a DC bias. For enhanced loading of the electrode, the AC or other functional form and the stepped DC current need to be mixed while retaining the DC bias of the output. The goal is to enhance loading by allowing the AC to assist transport through the double layer while fluxing into and out of the metal surface. The DC bias gives a net influx of ions and other species into the cathode. Thus the combination has greater utility than either method alone and greater utility than one following later in time by the other. This synergistic combination is important for the performance of the method and device described herein.

**[0046]** A large number of DC bias AC mixing circuits are known within the art. A typical embodiment is a simple bias Tee circuit designed to pass the AC through a capacitor and the DC through an inductor while blocking the reflection back into the supplies.

**[0047]** Such circuits are well known and component sizes should be selected based on the expected frequency ranges. In one embodiment, the bias tee mixer was constructed using a series of 10mH inductors and a parallel circuit of Metallized Polyester Film 22mF Capacitors.

**[0048]** Referring again to FIG. 1, in yet another embodiment, the method may further comprise performing an initial loading 20. The initial loading may comprise applying an initial electrolytic current to the cathode, the initial electrolytic current may include an initial DC component, wherein the initial DC component may include cycling between: a third voltage applied to the cathode for a third period of time, a fourth voltage applied to the cathode for a

fourth period of time, wherein the fourth voltage is higher than the third voltage, wherein the third period of time and the fourth period of time are approximately the same, and wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage. The initial electrolytic current may further include an AC component with a frequency between about 1Hz and about 100kHz.

**[0049]** It is preferred that the initial loading of the electrode is conducted at lower temperatures such as below room temperature and that the initial loading is first to be done with low currents and voltages and with the high low DC component duty cycle be near 50%. After 1 hour, the currents can be raised and the duty cycle reduced. This is thought to provide a more gradual loading and avoid some volume expansion distortions due to unequal loading. Once the electrode has been initial loaded and conditioned above 0.6 H/Pd atomic ratios, it can be later be loaded more quickly. Additionally, the duty cycle may be set to 0% after the initial loading protocols and a simple flat DC voltage biased AC can be used with care taken so that the average potential is favorable to retaining loading.

**[0050]** In yet another embodiment, the method may further comprise sealing the electrochemical reaction vessel.

**[0051]** In yet another embodiment, the method may further include flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical reaction vessel.

**[0052]** In most electrochemical systems, gases are released during operation. Such cells are termed "open" when the system is open for gas exchange to and from the environment and termed "closed" when sealed against such exchanges or have methods to control such exchanges.

**[0053]** In systems designed for hydrogen loading into electrodes, the gas is retained by

the electrode and a companion gas such as oxygen from electrolysis is released into the system. This often results in the accumulation of so-called "orphaned oxygen" since there is not enough free hydrogen or reductive species to react with the free oxygen. This is usually detrimental to most thermal energy studies and devices. To that end, it is preferred to first run the system be conducted open or vented to the atmosphere so the orphaned oxygen can leave during the initial loading stages and then be closed later to limit contamination and conserve the electrolyte. In one embodiment this is accomplished by first loading a Pd based cathode run with amp-secs in excess of the time calculated amount that would be required from an estimate based on Faraday's laws of electrolysis of hydrogen needed to fully load the amount of Pd used in said system. In many embodiments, runs were run open longer than ten times the estimated time calculated by Faraday's law. After such time, the cell was sealed or pressure monitored for controlled release or for overpressures leading to higher operating pressures and temperatures. In one embodiment, Pd on $Al_2O_3$ recombination catalyst was used with a cell that was first run open for 4 days and then closed.

**[0054]** The initial running systems open before closing also allows for volatiles to be removed from the solution. This is especially important when trying to load with deuterium from heavy water solutions. Since deuterium oxide (i.e. heavy water) is hygroscopic, solutions often are supplied or become contaminated with the lighter isotope of hydrogen. Light hydrogen is more quickly evolved than the deuterium isotope of hydrogen in electrolytic systems due to its lower voltage required for dissociation. Running open at low voltages and currents preferentially remove the lighter isotope.

**[0055]** One alternative is to flush the gas out of the cell with a reductive species such as hydrogen and then sealed so that any orphaned oxygen will have enough hydrogen to react and

be sequestered in the form of water.

**[0056]** In yet another embodiment, the method may further include applying a magnetic field to the electrochemical reaction vessel. In many thermally active electrochemical systems, the magnetic fields are applied for either study of the processes or for adjusting internal spin based reactions. This is especially useful when paramagnetic or ferromagnetic materials are used for one or more electrodes. Hence, in one embodiment, a disc magnet (N42 2x1/2 Inch Rare Earth Neodymium Disc Magnet from Magnets4Less) was placed beneath the reactive chamber and a second ring magnet (3 ODx 2 IDx 1/2 Inch Rare Earth Neodymium Ring Magnet Grade N42 from Magnets4Less). This supplied a field of 300 gauss in the region occupied by the central electrode.

**[0057]** In yet another embodiment, the cathode may be comprised of at least one of palladium or a palladium alloy.

**[0058]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

**[0059]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

**[0060]** It is recommended that care is performed in selecting metal electrodes for loading of hydrogen. The material should have a hydrogen diffusion rate greater than 0.1 $cm^3/cm^2/s$ and with rates greater than 1.4 $cm^3/cm^2/s$.

**[0061]** The function of the reaction vessel is to provide a relatively inert and structurally stable container for the electrochemical reaction. Such vessels are known to those skilled in the art of chemistry. In one embodiment a Glass Proglass 250mL Flask fitted with 24/40, 14/20 Two

Necks lid and sealed with an Easy Open PTFE Clamp. The central 24/40 neck of the lid is suited to mount a Graham condenser for returning steam from the system back into the vessel. The 14/20 side neck is suited for passing the electrical connections to the electrodes and sensors. One of ordinary skill in the art would understand any other suitable reaction vessel known in the art may be used in the present invention.

**[0062]** In one embodiment, the electrochemical reaction vessel was partially filled with 100 ml of an LiOD 0.1M heavy water based solution. A Pt coated Ti mesh electrode was used as the anode and the cathode was selected as discussed below. The chemical reflux condenser assembly was insulated with vermiculite and cooling water at 30C was passed down through the condenser (common counter-flow systems in chemistry). This allowed the system to run at boiling temperatures for extended times. This was slightly above 92 C due to the altitude of the inventor's laboratory.

**[0063]** In yet another embodiment, the solvent may be LiOH.

**[0064]** In yet another embodiment, the solvent may be LiOD.

**[0065]** Referring now to FIG. 6, in another embodiment, a system for electrolytic loading of hydrogen 600 into a cathode 604 may comprise an electrochemical reaction vessel 606 filled with a solvent, a cathode 604 and an anode 605 disposed within the electrochemical reaction vessel 606, and an electrolytic current source 603 connected to the cathode 604. The electrolytic current may comprise a DC component 602, wherein the DC component 602 may cycle between a first voltage applied to the cathode 604 for a first period of time, and a second voltage applied to the cathode 604 for a second period of time, wherein the second voltage may be higher than the first voltage, and wherein the second period of time may be shorter than the first period of time. The electrolytic current may further comprise an AC component 601 with a frequency

between about 1Hz and about 100kHz. The peak sum of the voltages supplied by the DC component 602 and AC component 601 may be higher than the dissociation voltage of the solvent.

**[0066]** One of ordinary skill in the art will appreciate the system may be used in a manner consistent with the electrolytic methods of loading hydrogen into a cathode as described above and in the example herein.

**[0067]** **EXAMPLE I**

**[0068]** The increase loading rate and maximum loading ratios of Hydrogen species into metals is useful in a wide range of utilities. For example, in studies of hydrogen storage materials, hydrogen embrittlement studies, measurements of circuit's resistance and inductance, and even in areas where isotopic hydrogen is studied for thermal release or for tritium storage. To verify the utility of the method, a series of experiments were conducted to compare loading rates by the electrochemical method described herein and with traditional loading for simple DC electrolysis.

**[0069]** Resistance versus time measurements of a palladium wire were made to judge loading rates. Such resistance changes need to be well studied for the case of hydrogen being loading electrochemically into Palladium. The relative resistance, $R/R_0$ (i.e. loaded resistance divided by preloaded resistance), increases by a factor of approximately 1.8 as the H to Pd atomic ratio reaches 0.65 at room temperatures and standard atmospheric pressures. Thus the rate of change of resistance upon loading can be used to evaluate the loading rate and levels. Also when both samples are from the same original wire length, operated under the same environmental conditions, and same amp-seconds of electrolysis, a comparison can be made.

**[0070]** In one embodiment, two 1 foot 95% Pd 5% Ru 28 gauge (AGW) wires were cut from a single piece and were loaded by the two methods described herein for comparison. This was done simply by lowering a loop of each wire into a 0.1M LiOH solution which also contained a platinized Ti mesh electrode commonly used for Pd and Rh electroplating. The resistance of each wire was monitored with respect to time. The resistance was measured by an EXTECH 380560 PRECISION MILLIOHM METER via conventional four wire Kelvin clips placed on the wire ends just above the surface of the solution. The clips were adjusted so the two wires had the same initial resistance of 0.971 ohms. The two wires were run at the same RMS average power levels as measured with a Valhalla Scientific 2100 Digital Power Analyzer. One was run at constant DC current and one at a high DC voltage of 5 volts and a low of 1.75 volts and an AC sine wave at 100Hz with an amplitude of 3.5 volts peak to peak. The switching between the DC values was set at 5 minutes with a 20% duty cycle.

**[0071]** The resistance maximum was reached at 14.5 hours and indicates a loading of about 0.75 D/Pd ratio. The turn down in the resistance past that time shows continued loading as the phase of the Pd begins to change.

**[0072]** The average rate over the 18 hour run of the competing loading ratios shows that the method described herein is 1.47 higher than DC current alone for the first 18 hours. It is also worth noting that the ultimate loading ratio achieved by this method is higher than the DC alone. For example, after 10 hours, the DC alone loading only achieved a $R/R_0$ level of 1.3 while the method of this invention achieved a level of over 1.5.

**[0073]** The above description and drawings are illustrative and are not to be construed as limiting the invention to the precise forms disclosed. Persons skilled in the relevant art can

appreciate that many modifications and variations are possible in light of the above disclosure. Numerous specific details are described to provide a thorough understanding of the disclosure. However, in certain instances, well-known or conventional details are not described in order to avoid obscuring the description.

**[0074]** Reference in this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. Moreover, various features are described which may be exhibited by some embodiments and not by others. Similarly, various requirements are described which may be requirements for some embodiments but not other embodiments.

**[0075]** 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." As used herein, the terms "connected," "coupled," or any variant thereof, means any connection or coupling, either direct or indirect, between two or more elements; the coupling of connection between the elements can be physical, logical, or any combination thereof. Additionally, the words "herein," "above," "below," and words of similar import, when used in this application, shall refer to this application as a whole and not to any particular portions of this application. Where the context permits, words in the above Detailed Description using the singular or plural number may also include the plural or singular number respectively. The word "or," in reference to a list of two or more items, covers all of the following

interpretations of the word: any of the items in the list, all of the items in the list, and any combination of the items in the list.

**[0076]** The teachings of the disclosure provided herein can be applied to other systems, not necessarily the system described above. The elements and acts of the various embodiments described above can be combined to provide further embodiments.

**[0077]** These and other changes can be made to the disclosure in light of the above Detailed Description. While the above description describes certain embodiments of the disclosure, and describes the best mode contemplated, no matter how detailed the above appears in text, the teachings can be practiced in many ways. Details of the system may vary considerably in its implementation details, while still being encompassed by the subject matter disclosed herein. As noted above, particular terminology used when describing certain features or aspects of the disclosure should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or aspects of the disclosure with which that terminology is associated. In general, the terms used in the following claims should not be construed to limit the disclosure to the specific embodiments disclosed in the specification, unless the above Detailed Description section explicitly defines such terms. Accordingly, the actual scope of the disclosure encompasses not only the disclosed embodiments, but also all equivalent ways of practicing or implementing the disclosure under the claims.

**[0078]** The terms used in this specification generally have their ordinary meanings in the art, within the context of the disclosure, and in the specific context where each term is used. Certain terms that are used to describe the disclosure are discussed above, or elsewhere in the specification, to provide additional guidance to the practitioner regarding the description of the

disclosure. For convenience, certain terms may be highlighted, for example using capitalization, italics and/or quotation marks. The use of highlighting has no influence on the scope and meaning of a term; the scope and meaning of a term is the same, in the same context, whether or not it is highlighted. It will be appreciated that same element can be described in more than one way.

**[0079]** Consequently, alternative language and synonyms may be used for any one or more of the terms discussed herein, nor is any special significance to be placed upon whether or not a term is elaborated or discussed herein. Synonyms for certain terms are provided. A recital of one or more synonyms does not exclude the use of other synonyms. The use of examples anywhere in this specification including examples of any terms discussed herein is illustrative only, and is not intended to further limit the scope and meaning of the disclosure or of any exemplified term. Likewise, the disclosure is not limited to various embodiments given in this specification.

**[0080]** Without intent to further limit the scope of the disclosure, examples of instruments, apparatus, methods and their related results according to the embodiments of the present disclosure are given below. Note that titles or subtitles may be used in the examples for convenience of a reader, which in no way should limit the scope of the disclosure. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions will control.

**[0081]** Some portions of this description describe the embodiments of the invention in terms of algorithms and symbolic representations of operations on information. These algorithmic descriptions and representations are commonly used by those skilled in the data

processing arts to convey the substance of their work effectively to others skilled in the art. These operations, while described functionally, computationally, or logically, are understood to be implemented by computer programs or equivalent electrical circuits, microcode, or the like. Furthermore, it has also proven convenient at times, to refer to these arrangements of operations as modules, without loss of generality. The described operations and their associated modules may be embodied in software, firmware, hardware, or any combinations thereof.

**[0082]** Finally, the language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the inventive subject matter. It is therefore intended that the scope of the invention be limited not by this detailed description, but rather by any claims that issue on an application based hereon. Accordingly, the disclosure of the embodiments of the invention is intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the following claims.

**[0083]** Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which the presently disclosed subject matter pertains. Although any methods, devices, and materials similar or equivalent to those described herein can be used in the practice or testing of the presently disclosed subject matter, representative methods, devices, and materials are now described.

**[0084]** Following long-standing patent law convention, the terms "a", "an", and "the" refer to "one or more" when used in the subject specification, including the claims. Thus, for example reference to "an additive" can include a plurality of such additives, and so forth.

**[0085]** Unless otherwise indicated, all numbers expressing quantities of components, conditions, and so forth used in the specification and claims are to be understood as being

modified in all instances by the term "about". Accordingly, unless indicated to the contrary, the numerical parameters set forth in the instant specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by the presently disclosed subject matter.

**[0086]** As used herein, the term "about", when referring to a value or to an amount of mass, weight, time, volume, concentration, and/or percentage can encompass variations of, in some embodiments +/-20%, in some embodiments, +/-10%, in some embodiments +/- 5%, in some embodiments +/-1%, in some embodiments +/-0.5%, and in some embodiments, +/-0.1%, from the specified amount, as such variations are appropriate in the disclosed products and methods.

## CLAIMS

1. An electrolytic method of loading hydrogen into a cathode comprising:

placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent;

mixing a DC component and an AC component to produce an electrolytic current;

applying the electrolytic current to the cathode,

wherein the DC component includes cycling between:

a first voltage applied to the cathode for a first period of time;

a second voltage applied to the cathode for a second period time;

wherein the second voltage is higher than the first voltage, and

wherein the second period of time is shorter than the first period of time; and

wherein the AC component has a frequency between about 1Hz and about 100kHz; and

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

2. The method of claim 1, further comprising:

performing an initial loading comprising:

mixing an initial DC component and an initial AC component to produce an initial electrolytic current;

applying the initial electrolytic current to the cathode,

wherein the initial DC component includes cycling between:

a third voltage applied to the cathode for a third period of time;

a fourth voltage applied to the cathode for a fourth period time;

wherein the fourth voltage is higher than the third voltage;

wherein the third period of time and the fourth period of time are approximately the same; and

wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage; and

wherein the initial AC component has a frequency between about 1Hz and about 100kHz.

3. The method of claim 1, further comprising sealing the electrochemical reaction vessel.

4. The method of claim 3, further comprising flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical vessel.

5. The method of claim 1, further comprising applying a magnetic field to the electrochemical reaction vessel.

6. The method of claim 1, wherein the frequency of the AC component is dynamically adjusted.

7. The method of claim 1, wherein the DC component and AC component of the electrolytic current is mixed with a DC bias.

8. The method of claim 1, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

9. The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

10. The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

11. The method of claim 1, wherein the solvent is a solution containing LiOH.

12. The method of claim 1, wherein the solvent is a solution containing LiOD.

13. A system for electrolytic loading of hydrogen into a cathode comprising:

an electrochemical reaction vessel filled with a solvent;

a cathode and an anode disposed within the electrochemical reaction vessel;

an electrolytic current source connected to the cathode, wherein the electrolytic current comprises:

a DC component, wherein the DC component cycles between:

a first voltage applied to the cathode for a first period of time;

a second voltage applied to the cathode for a second period time;

wherein the second voltage is higher than the first voltage, and

wherein the second period of time is shorter than the first period of time; and

a AC component with a frequency between about 1Hz and about 100kHz;

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

14. The system of claim 13, wherein the electrochemical reaction vessel is sealed.

15. The system of claim 14, wherein the electrochemical reaction vessel is flushed with a reductive gas prior to sealing.

16. The system of claim 13, further comprising a magnetic field applied to the electro chemical reaction vessel.

17. The system of claim 13, wherein the frequency of the AC component is dynamically adjusted.

18. The system of claim 13, further comprising a mixer, wherein the mixer mixes the DC component and AC component of the electrolytic current with a DC bias.

19. The system of claim 13, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

20. The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

21. The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

22. The system of claim 13, wherein the solvent is a solution containing LiOH.

23. The system of claim 13, wherein the solvent is a solution containing LiOD.

## ABTSRACT

An electrolytic method of loading hydrogen into a cathode includes placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent, mixing a DC component and an AC component to produce an electrolytic current, and applying an electrolytic current to the cathode. The DC component includes cycling between: a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period of time, wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time. The AC component has a frequency between about 1 Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

# Electronic Acknowledgement Receipt

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| **First Named Inventor/Applicant Name:** | Dennis Cravens |
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| 1 | Applicant Response to Pre-Exam Formalities Notice | 438-98UTIL-20190410-Rsp-to-NTFCAP.pdf | 20363<br>372e087271686627774e3aa61c62e64d59a00482 | no | 2 |

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**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.**

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# METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[001]** This application claims the benefit of priority of U.S. provisional patent application no. 62/804,989, titled "METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN," filed on February 13, 2019, which is incorporated herein in its entirety by this reference.

## TECHNICAL FIELD

**[002]** The present disclosure relates to methods of producing heat through electrochemical means. Specifically, the present disclosure relates to the production of heat through electrolytic loading of hydrogen into a cathode.

## BACKGROUND

**[003]** Some electrochemical applications involve the loading of hydrogen or similar species into one or more electrodes. There are three primary competing technologies for the loading of hydrogen into an electrode: "Low High" DC voltage application by Takahashi, the "q wave" method of Brillouin, and the "superwave" forms of Dardik.

**[004]** Most current methods of electrolytic loading of hydrogen into metals involve slow, steady loading with constant current DC or with a constant voltage. Some systems use pulsed high-low series of DC pulses to aid the process. Shaped AC waves are known in the art, however these still require long, slow loading and do not achieve internal compression of the hydrogen within the metal electrodes. Some experimental and engineering designs require

regions of very high hydrogen concentrations to be reached before the desired effects can be achieved or studied. For example, United States Patent Application No. 20070280398 describes a fractal based superwaves technique for hydrogen loading involving the addition of many AC waveforms without DC bias.

**[005]** The problem with known methods of electrochemical hydrogen loading is that the production of the capacitive double layer around the electrode often limits the loading rates and levels reached in the electrode. Therefore, a protocol that can achieve high regions of hydrogen loading within or upon the surface of electrodes in a shorter time and can continue to produce or maintain high loading levels for extended times is needed.

## SUMMARY OF THE INVENTION

**[006]** The present invention uses the synergistic addition of both Low-High DC stepped switching with a shaped AC superimposed to the DC in the hydrogen loading process. This allows the DC to increase loading during the lower (i.e., less negative) voltage, high current step by taking advantage of the in and out flushing of the hydrogen at the surface utilizing the capacitance nature of the well-known electrochemical double layer formed by the electrolyte near the surface. Additionally, during the higher voltage and lower current DC step, the AC can cause added egress of the hydrogen from the metal and keep diffusion channels open. (For cathode loading the cathode is at a negative potential.) By altering the duty cycle of the DC stepping between the high and low stages, the loading rate during the high voltage step can add more hydrogen than is lost during the low voltage stage. The in and out migration of the hydrogen tends to open up more transport routes and other features that allow much higher levels of loading and faster loading than either DC or AC alone or one following the other in

succession independently. The advantage of this synergistic effect is greatly desired in some application.

**[007]** One of ordinary skill in the art will appreciate that references to hydrogen throughout the specification may refer to all stable isotopes of hydrogen including protium, deuterium, and/or tritium. Likewise, the term water includes its various isotopic forms.

**[008]** In one embodiment, an electrolytic method of loading hydrogen into a cathode may include placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent, mixing a DC component and an AC component to produce an electrolytic current, and applying the electrolytic current to the cathode. The DC component may include cycling between: a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period of time, wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time. The AC component may have a frequency between about 1 Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

**[009]** In yet another embodiment, the method may further include performing an initial loading. The initial loading may include mixing an initial DC component and an initial AC component to produce an initial electrolytic current and applying the initial electrolytic current to the cathode. The initial DC component may include cycling between: a third voltage applied to the cathode for a third period of time, a fourth voltage applied to the cathode for a fourth period of time, wherein the fourth voltage is higher than the third voltage, wherein the third period of time and the fourth period of time are approximately the same, and wherein the third voltage is

lower than the first voltage and the fourth voltage is lower than the second voltage. The initial AC component may have a frequency between about 1Hz and about 100kHz.

**[0010]** In another embodiment, a system for electrolytic loading of hydrogen into a cathode may include an electrochemical reaction vessel filled with a solvent, a cathode and an anode disposed within the electrochemical reaction vessel, and an electrolytic current source connected to the cathode. The electrolytic current may include a DC component, wherein the DC component may cycle between a first voltage applied to the cathode for a first period of time, and a second voltage applied to the cathode for a second period of time, wherein the second voltage may be higher than the first voltage, and wherein the second period of time may be shorter than the first period of time. The electrolytic current may further include an AC component with a frequency between about 1Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

**[0011]** In yet another embodiment, the method may further comprise sealing the electrochemical reaction vessel.

**[0012]** In yet another embodiment, the method may further include flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical reaction vessel.

**[0013]** In yet another embodiment, the method may further include applying a magnetic field to the electrochemical reaction vessel.

**[0014]** In yet another embodiment, the frequency of the AC component may be dynamically adjusted.

**[0015]** In yet another embodiment, the DC component and the AC component of the electrolytic current may be mixed with a DC bias.

**[0016]** In yet another embodiment, the cathode may be comprised of at least one of palladium or a palladium alloy.

**[0017]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

**[0018]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

**[0019]** In yet another embodiment, the solvent may be solutions containing LiOH.

**[0020]** In yet another embodiment, the solvent may be solutions containing LiOD.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0021] These and other objects, features, and characteristics will become more apparent to those skilled in the art from a study of the following Detailed Description in conjunction with the appended claims and drawings, all of which form a part of this specification. While the accompanying drawings include illustrations of various embodiments, the drawings are not intended to limit the claimed subject matter.

[0022] FIG. 1 is a flow diagram of an electrolytic method of loading hydrogen into a cathode according to an embodiment of the present invention.

[0023] FIG. 2 is a voltage vs. time graph of AC, DC, and AC/DC mixed signals.

[0024] FIG. 3 is a system diagram of a AC/DC mixing according to an embodiment of the present invention.

[0025] FIG. 4 is a voltage vs. time graph of the stepped-DC portion of a signal according to an embodiment of the present invention.

[0026] FIG. 5 is a voltage vs. time graph of the AC portion of a signal according to an embodiment of the present invention.

[0027] FIG. 6 is a system diagram of a system for electrolytic loading of hydrogen into a cathode according to an embodiment of the present invention.

## DETAILED DESCRIPTION

[0028] In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the embodiments of the invention. One skilled in the art will recognize that the embodiments of the invention may be practiced without these specific details or with an equivalent arrangement. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the embodiments of the invention.

[0029] The presently disclosed subject matter is presented with sufficient details to provide an understanding of one or more particular embodiments of broader inventive subject matters. The descriptions expound upon and exemplify particular features of those particular embodiments without limiting the inventive subject matters to the explicitly described embodiments and features. Considerations in view of these descriptions will likely give rise to additional and similar embodiments and features without departing from the scope of the

presently disclosed subject matter.

[0023][0030] Referring now to FIG.1, in one embodiment of the present invention, an electrolytic method of loading hydrogen into a cathode may comprise placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent 10, mixing a DC component and an AC component to produce an electrolytic current 30, and applying an electrolytic current to the cathode 40. The DC component may include cycling between: a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period of time, wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time. The AC component may have a frequency between about 1 Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

[0024][0031] DC currents and voltages used here may be switched in time but have a specific polarity above 0 volts as measured by traditional electrochemical methods, i.e. related to uncharged unbounded hydrogen. For clarity, the term DC includes switched DC where the desired voltage remains stable over an extended time. The term AC currents and voltages are used to describe currents which pass through the 0 voltage levels or through the value set by the DC voltages. That is we are using the term relative to the anode of the electrochemical system and AC is meant to be current that alternates between positive and negative charge on the cathode.

[0025][0032] It should be clear to those skilled in the art of electrochemistry, that the desired DC biased AC wave forms are applied to electrodes within an electrochemical cell. Specifically, at least the primary current of the DC applied to the cell is polarized so that the electrode (cathode) to receive the hydrogen is negatively charged compared to one of the other electrodes

so that hydrogen species are moved toward the cathode.

[0026][0033] When the frequency of the AC waveform is discussed it is meant to refer to the Fourier component of that waveform which has the greatest amplitude. It should be realized that the waveform can take a variety of forms. Waveforms having a component with rise-times shorter than 250 ns are preferred.

[0027][0034] To avoid confusion, it should be noticed in electrochemical system one electrode is taken as a reference. For this electrolysis system, the anode is taken as the reference and set to ground. The cathode is negatively charge with respect to the anode and to ground.

[0028][0035] It is preferred that the DC component's duty cycle be such to have a greater on time for the high voltage or high currents than for the lower ones after the initial loading protocol. This is for the purpose of giving a net ingress of the hydrogen into the electrode. In one embodiment, the cycle timing was 5 minutes with 90% on time for the lower voltage and 10% on time for the higher voltage. (Note: the cathode being loaded is at a negative potential.) In that embodiment, the high voltage was set at 10 VDC and the low voltage at 1 VDC.

[0029][0036] In the preferred embodiment, the time between the DC Lo-High cycles (period) should be less than 20 minutes for electrodes with maximum thicknesses of 1mm. Longer times do not seem to be beneficial for such commonly used materials.

[0030][0037] The AC waveform component to the electrolytic current can be of many different functional forms such as sine, square, pulsed, or triangular as commonly available from function generators. Sine waves are used in the description herein but others waveforms can be envisioned by those skilled in the art of electrical engineering. The AC component is added to

the stepped cycle DC component for the purpose of causing dynamic movement of the hydrogen into, though, and out of the electrochemical double layer and the surface of the electrode. The sum of the DC and AC components is applied between the electrode to be loaded with hydrogen and another electrode in a manor customary to electrolysis and known within the art of electrochemistry. In the preferred embodiment the addition of the AC and DC components should allow the voltage at the cathode to rise above zero voltage to release hydrogen from the electrode but not, however, to strip the hydrogen completely. Thus the greatest rise of the voltage should be slightly above zero volts but not significantly above zero nor remain at such levels for extended times. It is desired that the cathode be at a negative potential compared to the anode electrode (taken as ground) for longer total times than the positive times. In one embodiment the DC volts where chosen at -10V (90% of the time) and -1.5V (10% of the time) volts and the AC sine amplitude was chosen as 2.5 volts with a frequency of 100 Hz. This results in short-term peak voltages at the cathode to rise to 1 volt. However, the majority of the time the cathode experiences voltages above the dissociation voltage of the water solvent of about 1.5 volts and thus loads hydrogen into the electrode.

[0031][0038] Referring now to FIG. 2, deloading can occur when the AC component adds to the DC in such a way to raise it above zero potential. The anode potential is taken as ground or 0 potential. The primary loading occurs during the time the DC component is at a more negative potential. There is a greater current flow when the cathode is at its more negative potentials. In the embodiment illustrated in FIG. 2, the two DC supplies are two DC-DC Adjustable Power Supply Output Step-down Module 6.5V-60V to 1.25-30V 10A UPC 741870439544. Their purpose is to supply a DC bias to the cathode for loading of hydrogen into the electrode. To that end, it is important that voltages in excess of the dissociation of the solvent (i.e. water) be

developed between the two electrodes. For water-basedsolvents, this is around 1.2 to 1.5 V dependent on pressures, electrolyte concentration, isotopic makeup, and temperatures. The two currents are wired to a double pole double throw relay (in one embodiment this was an Enclosed Power Relay,8 Pin,24VDC, DPDT SCHNEIDER ELECTRIC 92S11D22D-24D). The relay was cycled by a repeating unit 12V DC Multifunction Self-lock Relay PLC Cycle Timer Module Delay Time Switch UPC 714046658482.Its function is to activate the relay to cycle between the two DC power supplies. One of ordinary skill in the art would appreciate that any suitable DC supply, controller, and relay may be used in the present invention.

[0032][0039] Referring now to FIG. 3, a general conception of the AC/-DC mixing according to an embodiment of the present invention is shown. It is shown as component units with discrete purposes. The parts' purpose is to supply a cycled DC voltage in a repetitive low- high cycle. It should be obvious by those skilled in the art of electrical engineering that many circuit designs can be employed for the same purpose. For example, a single programmable DC supply could replace the unit or a computer controlled DC supply. Alternatively, a dedicated AC generator which can provide DC Fourier components could be used. However, the separate components of the figure illustrates one embodiment the desired DC part of the input power can be obtained.

[0033][0040] As mentioned elsewhere, one supply should be set so that there is net hydrogen-mediated current into the electrode and it should also have a voltage setting so the hydrogen can be dissociated in the solvent. The output of the stepped DC part of the system 303 is then directed to an AC/DC mixing unit 304 for the purpose of adding the two components for supply to the electrodes within the electrochemical system.

[0034][0041] Referring now to FIG. 4, a voltage vs. time output from the stepped DC portion of

the system is shown. The duty cycle provides for the greater potential difference, and hence greater electrochemical current, for longer times than the lesser potential difference between electrodes. Thus, greater time is spent at the larger negative values for the purpose of providing hydrogen to the cathode.

[0035][0042] The AC may be supplied by any suitable AC supply 305, for example, a HIGH PRECISION Audio Signal Generator 1Hz-1MHz with Sine Triangle Square outputs, UPC 0713893274877 or the like. It should be noted that other frequencies may be used, however, frequencies between 1Hz and 100kHz have been observed to be adequate for most applications. The primary factor in setting frequencies is the electrochemical double layer capacitance at the cathode. It is preferred that the expected frequencies range of the specific cell be determined by a method common within the art of electrochemical impedance spectroscopy. That is the primary AC frequency applied should allow for the greatest current flow into the cathode. The output of the AC or functional form device is fed via a current sensor into the AC/DC mixer 304.

[0036][0043] In yet another embodiment, the frequency of the AC component 305 may be dynamically adjusted. A current sensor may indicate the absorption of the AC by the electrochemical cell. This, in turn, may signal the transport of the ionic species into, through, and out of the electrochemical double layer and eventually the movement of the hydrogen at the surface or near the surface of the cathode. The AC current sensor may relay the information to a frequency controller whose role is to keep the AC frequency center near the area of maximum AC absorption. Thus it assures a large movement of the hydrogen at the surface and near the surface of the cathode. It is conjectured that this keeps the surface clean and diffusion pathways open. It also shuttles ions through the double layer from the solvent. However, since the cathode experiences outflow of some hydrogen for only short limited times there is net loading of the

cathode. It is envisioned that the entire AC part of the system could comprise a single electronic unit.

[0037][0044] Referring now to FIG. 5, a typical AC output using a simple sine form is shown. Other functional forms are contemplated in the present invention.

[0038][0045] In yet another embodiment, the DC component and the AC component of the electrolytic current may be mixed with a DC bias. For enhanced loading of the electrode, the AC or other functional form and the stepped DC current need to be mixed while retaining the DC bias of the output. The goal is to enhance loading by allowing the AC to assist transport through the double layer while fluxing into and out of the metal surface. The DC bias gives a net influx of ions and other species into the cathode. Thus the combination has greater utility than either method alone and greater utility than one following later in time by the other. This synergistic combination is important for the performance of the method and device described herein.

[0039][0046] A large number of DC bias AC mixing circuits are known within the art. A typical embodiment is a simple bias Tee circuit designed to pass the AC through a capacitor and the DC through an inductor while blocking the reflection back into the supplies.

[0040][0047] Such circuits are well known and component sizes should be selected based on the expected frequency ranges. In one embodiment, the bias tee mixer was constructed using a series of 10mH inductors and a parallel circuit of Metallized Polyester Film 22mF Capacitors.

[0041][0048] Referring again to FIG. 1, in yet another embodiment, the method may further comprise performing an initial loading 20. The initial loading may comprise applying an initial electrolytic current to the cathode, the initial electrolytic current may include an initial DC component, wherein the initial DC component may include cycling between: a third voltage applied to the cathode for a third period of time, a fourth voltage applied to the cathode for a

fourth period of time, wherein the fourth voltage is higher than the third voltage, wherein the third period of time and the fourth period of time are approximately the same, and wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage. The initial electrolytic current may further include an AC component with a frequency between about 1Hz and about 100kHz.

[0042][0049] It is preferred that the initial loading of the electrode is conducted at lower temperatures such as below room temperature and that the initial loading is first to be done with low currents and voltages and with the high low DC component duty cycle be near 50%. After 1 hour, the currents can be raised and the duty cycle reduced. This is thought to provide a more gradual loading and avoid some volume expansion distortions due to unequal loading. Once the electrode has been initial loaded and conditioned above 0.6 H/Pd atomic ratios, it can be later be loaded more quickly. Additionally, the duty cycle may be set to 0% after the initial loading protocols and a simple flat DC voltage biased AC can be used with care taken so that the average potential is favorable to retaining loading.

[0043][0050] In yet another embodiment, the method may further comprise sealing the electrochemical reaction vessel.

[0044][0051] In yet another embodiment, the method may further include flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical reaction vessel.

[0045][0052] In most electrochemical systems, gases are released during operation. Such cells are termed "open" when the system is open for gas exchange to and from the environment and termed "closed" when sealed against such exchanges or have methods to control such exchanges.

[0046][0053] In systems designed for hydrogen loading into electrodes, the gas is retained by

the electrode and a companion gas such as oxygen from electrolysis is released into the system. This often results in the accumulation of so-called "orphaned oxygen" since there is not enough free hydrogen or reductive species to react with the free oxygen. This is usually detrimental to most thermal energy studies and devices. To that end, it is preferred to first run the system be conducted open or vented to the atmosphere so the orphaned oxygen can leave during the initial loading stages and then be closed later to limit contamination and conserve the electrolyte. In one embodiment this is accomplished by first loading a Pd based cathode run with amp-secs in excess of the time calculated amount that would be required from an estimate based on Faraday's laws of electrolysis of hydrogen needed to fully load the amount of Pd used in said system. In many embodiments, runs were run open longer than ten times the estimated time calculated by Faraday's law. After such time, the cell was sealed or pressure monitored for controlled release or for overpressures leading to higher operating pressures and temperatures. In one embodiment, Pd on $Al_2O_3$ recombination catalyst was used with a cell that was first run open for 4 days and then closed.

[0047][0054] The initial running systems open before closing also allows for volatiles to be removed from the solution. This is especially important when trying to load with deuterium from heavy water solutions. Since deuterium oxide (i.e. heavy water) is hygroscopic, solutions often are supplied or become contaminated with the lighter isotope of hydrogen. Light hydrogen is more quickly evolved than the deuterium isotope of hydrogen in electrolytic systems due to its lower voltage required for dissociation. Running open at low voltages and currents preferentially remove the lighter isotope.

[0048][0055] One alternative is to flush the gas out of the cell with a reductive species such as hydrogen and then sealed so that any orphaned oxygen will have enough hydrogen to react and

be sequestered in the form of water.

[0049][0056] In yet another embodiment, the method may further include applying a magnetic field to the electrochemical reaction vessel. In many thermally active electrochemical systems, the magnetic fields are applied for either study of the processes or for adjusting internal spin based reactions. This is especially useful when paramagnetic or ferromagnetic materials are used for one or more electrodes. Hence, in one embodiment, a disc magnet (N42 2x1/2 Inch Rare Earth Neodymium Disc Magnet from Magnets4Less) was placed beneath the reactive chamber and a second ring magnet (3 ODx 2 IDx 1/2 Inch Rare Earth Neodymium Ring Magnet Grade N42 from Magnets4Less). This supplied a field of 300 gauss in the region occupied by the central electrode.

[0050][0057] In yet another embodiment, the cathode may be comprised of at least one of palladium or a palladium alloy.

[0051][0058] In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

[0052][0059] In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

[0053][0060] It is recommended that care is performed in selecting metal electrodes for loading of hydrogen. The material should have a hydrogen diffusion rate greater than 0.1 $cm^3/cm^2/s$ and with rates greater than 1.4 $cm^3/cm^2/s$.

[0054][0061] The function of the reaction vessel is to provide a relatively inert and structurally stable container for the electrochemical reaction. Such vessels are known to those skilled in the art of chemistry. In one embodiment a Glass Proglass 250mL Flask fitted with 24/40, 14/20 Two

Necks lid and sealed with an Easy Open PTFE Clamp. The central 24/40 neck of the lid is suited to mount a Graham condenser for returning steam from the system back into the vessel. The 14/20 side neck is suited for passing the electrical connections to the electrodes and sensors. One of ordinary skill in the art would understand any other suitable reaction vessel known in the art may be used in the present invention.

[0055][0062] In one embodiment, the electrochemical reaction vessel was partially filled with 100 ml of an LiOD 0.1M heavy water based solution. A Pt coated Ti mesh electrode was used as the anode and the cathode was selected as discussed below. The chemical reflux condenser assembly was insulated with vermiculite and cooling water at 30C was passed down through the condenser (common counter-flow systems in chemistry). This allowed the system to run at boiling temperatures for extended times. This was slightly above 92 C due to the altitude of the inventor's laboratory.

[0056][0063] In yet another embodiment, the solvent may be LiOH.

[0057][0064] In yet another embodiment, the solvent may be LiOD.

[0058][0065] Referring now to FIG. 6, in another embodiment, a system for electrolytic loading of hydrogen 600 into a cathode 604 may comprise an electrochemical reaction vessel 606 filled with a solvent, a cathode 604 and an anode 605 disposed within the electrochemical reaction vessel 606, and an electrolytic current source 603 connected to the cathode 604. The electrolytic current may comprise a DC component 602, wherein the DC component 602 may cycle between a first voltage applied to the cathode 604 for a first period of time, and a second voltage applied to the cathode 604 for a second period of time, wherein the second voltage may be higher than the first voltage, and wherein the second period of time may be shorter than the first period of time. The electrolytic current may further comprise an AC component 601 with a frequency

between about 1Hz and about 100kHz. The peak sum of the voltages supplied by the DC component 602 and AC component 601 may be higher than the dissociation voltage of the solvent.

[0059][0066] One of ordinary skill in the art will appreciate the system may be used in a manner consistent with the electrolytic methods of loading hydrogen into a cathode as described above and in the example herein.

[0060][0067] **EXAMPLE I**

[0061][0068] The increase loading rate and maximum loading ratios of Hydrogen species into metals is useful in a wide range of utilities. For example, in studies of hydrogen storage materials, hydrogen embrittlement studies, measurements of circuit's resistance and inductance, and even in areas where isotopic hydrogen is studied for thermal release or for tritium storage. To verify the utility of the method, a series of experiments were conducted to compare loading rates by the electrochemical method described herein and with traditional loading for simple DC electrolysis.

[0062][0069] Resistance versus time measurements of a palladium wire were made to judge loading rates. Such resistance changes need to be well studied for the case of hydrogen being loading electrochemically into Palladium. ~~For example, FIG.9 shows how the loaded resistance of Palladium is altered as natural hydrogen is loaded into it.~~ The relative resistance, $R/R_0$ (i.e. loaded resistance divided by preloaded resistance), increases by a factor of approximately 1.8 as the H to Pd atomic ratio reaches 0.65 at room temperatures and standard atmospheric pressures. ~~Such increase can also be seen, as in FIG. 10, for the deuterium isotope of hydrogen.~~ Thus the rate of change of resistance upon loading can be used to evaluate the loading rate and levels.

Also when both samples are from the same original wire length, operated under the same environmental conditions, and same amp-seconds of electrolysis, a comparison can be made.

[0063][0070] In one embodiment, two 1 foot 95% Pd 5% Ru 28 gauge (AGW) wires were cut from a single piece and were loaded by the two methods described herein for comparison. This was done simply by lowering a loop of each wire into a 0.1M LiOH solution which also contained a platinized Ti mesh electrode commonly used for Pd and Rh electroplating. The resistance of each wire was monitored with respect to time. The resistance was measured by an EXTECH 380560 PRECISION MILLIOHM METER via conventional four wire Kelvin clips placed on the wire ends just above the surface of the solution. The clips were adjusted so the two wires had the same initial resistance of 0.971 ohms. The two wires were run at the same RMS average power levels as measured with a Valhalla Scientific 2100 Digital Power Analyzer. One was run at constant DC current and one at a high DC voltage of 5 volts and a low of 1.75 volts and an AC sine wave at 100Hz with an amplitude of 3.5 volts peak to peak. The switching between the DC values was set at 5 minutes with a 20% duty cycle.

[0064] Resistance data was taken each half hour while the wires loaded and the relative resistance (instantaneous resistance divided by the initial resistance) plot in FIG. 11.

[0065][0071] The resistance maximum was reached at 14.5 hours and indicates a loading of about 0.75 D/Pd ratio. The turn down in the resistance past that time shows continued loading as the phase of the Pd begins to change.

[0066][0072] The average rate over the 18 hour run of the competing loading ratios shows that the method described herein is 1.47 higher than DC current alone for the first 18 hours. It is also worth noting that the ultimate loading ratio achieved by this method is higher than the DC alone.

For example, after 10 hours, the DC alone loading only achieved a $R/R_0$ level of 1.3 while the method of this invention achieved a level of over 1.5.

~~[0067] The resistance was used to calculate the loading ratios during an eighteen hour run and is given in FIG. 12.~~

[0068][0073] The above description and drawings are illustrative and are not to be construed as limiting the invention to the precise forms disclosed. Persons skilled in the relevant art can appreciate that many modifications and variations are possible in light of the above disclosure. Numerous specific details are described to provide a thorough understanding of the disclosure. However, in certain instances, well-known or conventional details are not described in order to avoid obscuring the description.

[0069][0074] Reference in this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. Moreover, various features are described which may be exhibited by some embodiments and not by others. Similarly, various requirements are described which may be requirements for some embodiments but not other embodiments.

[0070][0075] 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." As used herein, the terms "connected," "coupled," or any variant thereof, means any connection or coupling, either direct or indirect, between two or more elements; the

coupling of connection between the elements can be physical, logical, or any combination thereof. Additionally, the words "herein," "above," "below," and words of similar import, when used in this application, shall refer to this application as a whole and not to any particular portions of this application. Where the context permits, words in the above Detailed Description using the singular or plural number may also include the plural or singular number respectively. The word "or," in reference to a list of two or more items, covers all of the following interpretations of the word: any of the items in the list, all of the items in the list, and any combination of the items in the list.

[0071][0076] The teachings of the disclosure provided herein can be applied to other systems, not necessarily the system described above. The elements and acts of the various embodiments described above can be combined to provide further embodiments.

[0072][0077] These and other changes can be made to the disclosure in light of the above Detailed Description. While the above description describes certain embodiments of the disclosure, and describes the best mode contemplated, no matter how detailed the above appears in text, the teachings can be practiced in many ways. Details of the system may vary considerably in its implementation details, while still being encompassed by the subject matter disclosed herein. As noted above, particular terminology used when describing certain features or aspects of the disclosure should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or aspects of the disclosure with which that terminology is associated. In general, the terms used in the following claims should not be construed to limit the disclosure to the specific embodiments disclosed in the specification, unless the above Detailed Description section explicitly defines such terms. Accordingly, the actual scope of the disclosure encompasses not only the disclosed

embodiments, but also all equivalent ways of practicing or implementing the disclosure under the claims.

[0073][0078] The terms used in this specification generally have their ordinary meanings in the art, within the context of the disclosure, and in the specific context where each term is used. Certain terms that are used to describe the disclosure are discussed above, or elsewhere in the specification, to provide additional guidance to the practitioner regarding the description of the disclosure. For convenience, certain terms may be highlighted, for example using capitalization, italics and/or quotation marks. The use of highlighting has no influence on the scope and meaning of a term; the scope and meaning of a term is the same, in the same context, whether or not it is highlighted. It will be appreciated that same element can be described in more than one way.

[0074][0079] Consequently, alternative language and synonyms may be used for any one or more of the terms discussed herein, nor is any special significance to be placed upon whether or not a term is elaborated or discussed herein. Synonyms for certain terms are provided. A recital of one or more synonyms does not exclude the use of other synonyms. The use of examples anywhere in this specification including examples of any terms discussed herein is illustrative only, and is not intended to further limit the scope and meaning of the disclosure or of any exemplified term. Likewise, the disclosure is not limited to various embodiments given in this specification.

[0075][0080] Without intent to further limit the scope of the disclosure, examples of instruments, apparatus, methods and their related results according to the embodiments of the present disclosure are given below. Note that titles or subtitles may be used in the examples for convenience of a reader, which in no way should limit the scope of the disclosure. Unless

otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions will control.

[0076][0081] Some portions of this description describe the embodiments of the invention in terms of algorithms and symbolic representations of operations on information. These algorithmic descriptions and representations are commonly used by those skilled in the data processing arts to convey the substance of their work effectively to others skilled in the art. These operations, while described functionally, computationally, or logically, are understood to be implemented by computer programs or equivalent electrical circuits, microcode, or the like. Furthermore, it has also proven convenient at times, to refer to these arrangements of operations as modules, without loss of generality. The described operations and their associated modules may be embodied in software, firmware, hardware, or any combinations thereof.

[0077][0082] Finally, the language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the inventive subject matter. It is therefore intended that the scope of the invention be limited not by this detailed description, but rather by any claims that issue on an application based hereon. Accordingly, the disclosure of the embodiments of the invention is intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the following claims.

[0078][0083] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which the presently disclosed subject matter pertains. Although any methods, devices, and materials similar or equivalent to those described herein can be used in the practice or testing of the presently

disclosed subject matter, representative methods, devices, and materials are now described.

[0079][0084] Following long-standing patent law convention, the terms "a", "an", and "the" refer to "one or more" when used in the subject specification, including the claims. Thus, for example reference to "an additive" can include a plurality of such additives, and so forth.

[0080][0085] Unless otherwise indicated, all numbers expressing quantities of components, conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about". Accordingly, unless indicated to the contrary, the numerical parameters set forth in the instant specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by the presently disclosed subject matter.

[0081][0086] As used herein, the term "about", when referring to a value or to an amount of mass, weight, time, volume, concentration, and/or percentage can encompass variations of, in some embodiments +/-20%, in some embodiments, +/-10%, in some embodiments +/- 5%, in some embodiments +/-1%, in some embodiments +/-0.5%, and in some embodiments, +/-0.1%, from the specified amount, as such variations are appropriate in the disclosed products and methods.

## CLAIMS

1. An electrolytic method of loading hydrogen into a cathode comprising:

placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent;

mixing a DC component and an AC component to produce an electrolytic current;

applying the electrolytic current to the cathode,

wherein the DC component includes cycling between:

a first voltage applied to the cathode for a first period of time;

a second voltage applied to the cathode for a second period time;

wherein the second voltage is higher than the first voltage, and

wherein the second period of time is shorter than the first period of time; and

wherein the AC component has a frequency between about 1Hz and about 100kHz; and

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

2. The method of claim 1, further comprising:

performing an initial loading comprising:

mixing an initial DC component and an initial AC component to produce an initial electrolytic current;

applying the initial electrolytic current to the cathode,

wherein the initial DC component includes cycling between:

a third voltage applied to the cathode for a third period of time;

a fourth voltage applied to the cathode for a fourth period time;

wherein the fourth voltage is higher than the third voltage;

wherein the third period of time and the fourth period of time are approximately the same; and

wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage; and

wherein the initial AC component has a frequency between about 1Hz and about 100kHz.

3. The method of claim 1, further comprising sealing the electrochemical reaction vessel.

4. The method of claim 3, further comprising flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical vessel.

5. The method of claim 1, further comprising applying a magnetic field to the electrochemical reaction vessel.

6. The method of claim 1, wherein the frequency of the AC component is dynamically adjusted.

7. The method of claim 1, wherein the DC component and AC component of the electrolytic current is mixed with a DC bias.

8. The method of claim 1, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

9. The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

10. The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

11. The method of claim 1, wherein the solvent is a solution containing LiOH.

12. The method of claim 1, wherein the solvent is a solution containing LiOD.

13. A system for electrolytic loading of hydrogen into a cathode comprising:

an electrochemical reaction vessel filled with a solvent;

a cathode and an anode disposed within the electrochemical reaction vessel;

an electrolytic current source connected to the cathode, wherein the electrolytic current comprises:

a DC component, wherein the DC component cycles between:

a first voltage applied to the cathode for a first period of time;

a second voltage applied to the cathode for a second period time;

wherein the second voltage is higher than the first voltage, and

wherein the second period of time is shorter than the first period of time; and

a AC component with a frequency between about 1Hz and about 100kHz;

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

14. The system of claim 13, wherein the electrochemical reaction vessel is sealed.

15. The system of claim 14, wherein the electrochemical reaction vessel is flushed with a reductive gas prior to sealing.

16. The system of claim 13, further comprising a magnetic field applied to the electro chemical reaction vessel.

17. The system of claim 13, wherein the frequency of the AC component is dynamically adjusted.

18. The system of claim 13, further comprising a mixer, wherein the mixer mixes the DC component and AC component of the electrolytic current with a DC bias.

19. The system of claim 13, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

20. The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

21. The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

22. The system of claim 13, wherein the solvent is a solution containing LiOH.

23. The system of claim 13, wherein the solvent is a solution containing LiOD.

## ABTSRACT

An electrolytic method of loading hydrogen into a cathode includes placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent, mixing a DC component and an AC component to produce an electrolytic current, and applying an electrolytic current to the cathode. The DC component includes cycling between: a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period of time, wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time. The AC component has a frequency between about 1 Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

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| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 16/361,825 | 03/22/2019 | 2844 | 935 | 438/98 UTIL | 23 | 2 |

**CONFIRMATION NO. 3063**

76934
NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

**FILING RECEIPT**

Date Mailed: 04/08/2019

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)**

Dennis Cravens, Cloudcroft, NM;

**Applicant(s)**

Industrial Heat, LLC, Raleigh, NC;

**Power of Attorney:** None

**Domestic Priority data as claimed by applicant**

This appln claims benefit of 62/804,989 02/13/2019

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 04/05/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/361,825**

**Projected Publication Date:** To Be Determined - pending completion of Corrected Papers

**Non-Publication Request:** No

**Early Publication Request:** No
**** SMALL ENTITY ****
**Title**

METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

**Preliminary Class**

315

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

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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.

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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.

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## Title 37, Code of Federal Regulations, 5.11 & 5.15

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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/361,825 | 03/22/2019 | Dennis Cravens | 438/98 UTIL |

**CONFIRMATION NO. 3063**

76934
NK Patent Law - Industrial Heat
4917 Waters Edge Drive
Suite 275
Raleigh, NC 27606

**FORMALITIES LETTER**

*OC000000107183157*

Date Mailed: 04/08/2019

# NOTICE TO FILE CORRECTED APPLICATION PAPERS

***Filing Date Granted***

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given TWO MONTHS from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

The required item(s) identified below must be timely submitted to avoid abandonment:

- A substitute specification in compliance with 37 CFR 1.52, 1.121(b)(3), and 1.125, is required. The substitute specification must be submitted with markings and be accompanied by a clean version (without markings) as set forth in 37 CFR 1.125(c) and a statement that the substitute specification contains no new matter (see 37 CFR 1.125(b)). The specification, claims, and/or abstract page(s) submitted is not acceptable and cannot be scanned or properly stored because:
  - The application contains drawings, but the specification does not contain a brief description of the several views of the drawings as required by 37 CFR 1.74 and 37 CFR 1.77(b)(9).
- An abstract of the technical disclosure preferably not exceeding 150 words in length and commencing on a separate sheet in compliance with 37 CFR 1.72(b) is required. An abstract was not provided for this application.

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

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/dnguyen/

# PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/361,825

## 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 | 75 | | N/A | |
| SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | 330 | | N/A | |
| EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | 380 | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | 23 minus 20 = | * 3 | x 50 = | 150 | OR | | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | 2 minus 3 = | * | x 230 = | 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 | 935 | | TOTAL | |

## 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 | RATE($) | ADDITIONAL FEE($) | | RATE($) | ADDITIONAL FEE($) |
|---|---|---|---|---|---|---|---|---|---|---|
| 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.

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

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 |
|---|---|---|---|---|
| | Dennis | | Cravens | |

**Residence Information (Select One)** ● US Residency  Non US Residency  Active US Military Service

| City | Cloudcroft | State/Province | NM | Country of Residence | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| | | | |
|---|---|---|---|
| **Address 1** | P.O. Box 1317 | | |
| **Address 2** | | | |
| **City** | Cloudcroft | **State/Province** | NM |
| **Postal Code** | 88317 | **Country** | US |

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** | 76934 | | |
| **Email Address** | docket@nkpatentlaw.com | Add Email | Remove Email |

## Application Information:

| | | | |
|---|---|---|---|
| **Title of the Invention** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | | |
| **Attorney Docket Number** | 438/98 UTIL | **Small Entity Status Claimed** | ☒ |
| **Application Type** | Nonprovisional | | |
| **Subject Matter** | Utility | | |
| **Total Number of Drawing Sheets (if any)** | 6 | **Suggested Figure for Publication (if any)** | |

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

## 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 |
|---|---|---|
| | | |

## 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 | 76934 | | |

## Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim 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" field blank.

| Prior Application Status | Pending | | Remove |
|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |
| | Claims benefit of provisional | 62/804989 | 2019-02-13 |

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

## 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. 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(i)(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) |
|---|---|---|---|
| | | | |

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.

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

# Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

**NOTE**: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

**1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)**

**A. Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is 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 State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

**B. Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

**2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)**

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

**NOTE:** Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

## 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.

**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 | Industrial Heat, LLC |
|---|---|

**Mailing Address Information For Applicant:**

| **Address 1** | 310 West Street, Suite 100 | | |
|---|---|---|---|
| Address 2 | | | |
| **City** | Raleigh | **State/Province** | NC |
| **Country** | US | Postal Code | 27603 |
| 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 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 Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

**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.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

| Prefix | **Given Name** | Middle Name | **Family Name** | Suffix |
|---|---|---|---|---|
| | | | | |

**Mailing Address Information For Assignee including Non-Applicant Assignee:**

| | | | |
|---|---|---|---|
| **Address 1** | | | |
| Address 2 | | | |
| **City** | | **State/Province** | |
| **Country** i | | Postal Code | |
| Phone Number | | Fax Number | |
| Email Address | | | |

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

## Signature:

Remove

**NOTE:** This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

| **Signature** | /Justin R. Nifong/ | | | Date (YYYY-MM-DD) | 2019-03-22 |
|---|---|---|---|---|---|
| First Name | Justin | Last Name | Nifong | Registration Number | 59389 |

Additional Signature may be generated within this form by selecting the Add button. Add

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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 438/98 UTIL |
|---|---|---|
| | Application Number | |
| Title of Invention | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN | |

# 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 records.

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 CooperationTreaty.

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.

## CLAIMS

1. An electrolytic method of loading hydrogen into a cathode comprising:

placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent;

mixing a DC component and an AC component to produce an electrolytic current;

applying the electrolytic current to the cathode,

wherein the DC component includes cycling between:

a first voltage applied to the cathode for a first period of time;

a second voltage applied to the cathode for a second period time;

wherein the second voltage is higher than the first voltage, and

wherein the second period of time is shorter than the first period of time; and

wherein the AC component has a frequency between about 1Hz and about 100kHz; and

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

2. The method of claim 1, further comprising:

performing an initial loading comprising:

mixing an initial DC component and an initial AC component to produce an initial electrolytic current;

applying the initial electrolytic current to the cathode,

wherein the initial DC component includes cycling between:

a third voltage applied to the cathode for a third period of time;

a fourth voltage applied to the cathode for a fourth period time;

wherein the fourth voltage is higher than the third voltage;

wherein the third period of time and the fourth period of time are approximately the same; and

wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage; and

wherein the initial AC component has a frequency between about 1Hz and about 100kHz.

3. The method of claim 1, further comprising sealing the electrochemical reaction vessel.

4. The method of claim 3, further comprising flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical vessel.

5. The method of claim 1, further comprising applying a magnetic field to the electrochemical reaction vessel.

6. The method of claim 1, wherein the frequency of the AC component is dynamically adjusted.

7. The method of claim 1, wherein the DC component and AC component of the electrolytic current is mixed with a DC bias.

8. The method of claim 1, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

9. The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

10. The method of claim 1, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

11. The method of claim 1, wherein the solvent is a solution containing LiOH.

12. The method of claim 1, wherein the solvent is a solution containing LiOD.

13. A system for electrolytic loading of hydrogen into a cathode comprising:

an electrochemical reaction vessel filled with a solvent;

a cathode and an anode disposed within the electrochemical reaction vessel;

an electrolytic current source connected to the cathode, wherein the electrolytic current comprises:

a DC component, wherein the DC component cycles between:

a first voltage applied to the cathode for a first period of time;

a second voltage applied to the cathode for a second period time;

wherein the second voltage is higher than the first voltage, and

wherein the second period of time is shorter than the first period of time; and

a AC component with a frequency between about 1Hz and about 100kHz;

wherein the peak sum of the voltages supplied by the DC component and AC component is higher than the dissociation voltage of the solvent.

14. The system of claim 13, wherein the electrochemical reaction vessel is sealed.

15. The system of claim 14, wherein the electrochemical reaction vessel is flushed with a reductive gas prior to sealing.

16. The system of claim 13, further comprising a magnetic field applied to the electro chemical reaction vessel.

17. The system of claim 13, wherein the frequency of the AC component is dynamically adjusted.

18. The system of claim 13, further comprising a mixer, wherein the mixer mixes the DC component and AC component of the electrolytic current with a DC bias.

19. The system of claim 13, wherein the cathode is comprised of at least one of palladium or a palladium alloy.

20. The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

21. The system of claim 13, wherein the cathode has a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

22. The system of claim 13, wherein the solvent is a solution containing LiOH.

23. The system of claim 13, wherein the solvent is a solution containing LiOD.

# METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[001]** This application claims the benefit of priority of U.S. provisional patent application no. 62/804,989, titled "METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN," filed on February 13, 2019, which is incorporated herein in its entirety by this reference.

## TECHNICAL FIELD

**[002]** The present disclosure relates to methods of producing heat through electrochemical means. Specifically, the present disclosure relates to the production of heat through electrolytic loading of hydrogen into a cathode.

## BACKGROUND

**[003]** Some electrochemical applications involve the loading of hydrogen or similar species into one or more electrodes. There are three primary competing technologies for the loading of hydrogen into an electrode: "Low High" DC voltage application by Takahashi, the "q wave" method of Brillouin, and the "superwave" forms of Dardik.

**[004]** Most current methods of electrolytic loading of hydrogen into metals involve slow, steady loading with constant current DC or with a constant voltage. Some systems use pulsed high-low series of DC pulses to aid the process. Shaped AC waves are known in the art, however these still require long, slow loading and do not achieve internal compression of the hydrogen within the metal electrodes. Some experimental and engineering designs require

regions of very high hydrogen concentrations to be reached before the desired effects can be achieved or studied. For example, United States Patent Application No. 20070280398 describes a fractal based superwaves technique for hydrogen loading involving the addition of many AC waveforms without DC bias.

**[005]** The problem with known methods of electrochemical hydrogen loading is that the production of the capacitive double layer around the electrode often limits the loading rates and levels reached in the electrode. Therefore, a protocol that can achieve high regions of hydrogen loading within or upon the surface of electrodes in a shorter time and can continue to produce or maintain high loading levels for extended times is needed.

## SUMMARY OF THE INVENTION

**[006]** The present invention uses the synergistic addition of both Low-High DC stepped switching with a shaped AC superimposed to the DC in the hydrogen loading process. This allows the DC to increase loading during the lower (i.e., less negative) voltage, high current step by taking advantage of the in and out flushing of the hydrogen at the surface utilizing the capacitance nature of the well-known electrochemical double layer formed by the electrolyte near the surface. Additionally, during the higher voltage and lower current DC step, the AC can cause added egress of the hydrogen from the metal and keep diffusion channels open. (For cathode loading the cathode is at a negative potential.) By altering the duty cycle of the DC stepping between the high and low stages, the loading rate during the high voltage step can add more hydrogen than is lost during the low voltage stage. The in and out migration of the hydrogen tends to open up more transport routes and other features that allow much higher levels of loading and faster loading than either DC or AC alone or one following the other in

succession independently. The advantage of this synergistic effect is greatly desired in some application.

**[007]** One of ordinary skill in the art will appreciate that references to hydrogen throughout the specification may refer to all stable isotopes of hydrogen including protium, deuterium, and/or tritium. Likewise, the term water includes its various isotopic forms.

**[008]** In one embodiment, an electrolytic method of loading hydrogen into a cathode may include placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent, mixing a DC component and an AC component to produce an electrolytic current, and applying the electrolytic current to the cathode. The DC component may include cycling between: a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period of time, wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time. The AC component may have a frequency between about 1 Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

**[009]** In yet another embodiment, the method may further include performing an initial loading. The initial loading may include mixing an initial DC component and an initial AC component to produce an initial electrolytic current and applying the initial electrolytic current to the cathode. The initial DC component may include cycling between: a third voltage applied to the cathode for a third period of time, a fourth voltage applied to the cathode for a fourth period of time, wherein the fourth voltage is higher than the third voltage, wherein the third period of time and the fourth period of time are approximately the same, and wherein the third voltage is

lower than the first voltage and the fourth voltage is lower than the second voltage. The initial AC component may have a frequency between about 1Hz and about 100kHz.

**[0010]** In another embodiment, a system for electrolytic loading of hydrogen into a cathode may include an electrochemical reaction vessel filled with a solvent, a cathode and an anode disposed within the electrochemical reaction vessel, and an electrolytic current source connected to the cathode. The electrolytic current may include a DC component, wherein the DC component may cycle between a first voltage applied to the cathode for a first period of time, and a second voltage applied to the cathode for a second period of time, wherein the second voltage may be higher than the first voltage, and wherein the second period of time may be shorter than the first period of time. The electrolytic current may further include an AC component with a frequency between about 1Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

**[0011]** In yet another embodiment, the method may further comprise sealing the electrochemical reaction vessel.

**[0012]** In yet another embodiment, the method may further include flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical reaction vessel.

**[0013]** In yet another embodiment, the method may further include applying a magnetic field to the electrochemical reaction vessel.

**[0014]** In yet another embodiment, the frequency of the AC component may be dynamically adjusted.

**[0015]** In yet another embodiment, the DC component and the AC component of the electrolytic current may be mixed with a DC bias.

**[0016]** In yet another embodiment, the cathode may be comprised of at least one of palladium or a palladium alloy.

**[0017]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

**[0018]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

**[0019]** In yet another embodiment, the solvent may be solutions containing LiOH.

**[0020]** In yet another embodiment, the solvent may be solutions containing LiOD.

## DETAILED DESCRIPTION

**[0021]** In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the embodiments of the invention. One skilled in the art will recognize that the embodiments of the invention may be practiced without these specific details or with an equivalent arrangement. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the embodiments of the invention.

**[0022]** The presently disclosed subject matter is presented with sufficient details to provide an understanding of one or more particular embodiments of broader inventive subject matters. The descriptions expound upon and exemplify particular features of those particular

embodiments without limiting the inventive subject matters to the explicitly described embodiments and features. Considerations in view of these descriptions will likely give rise to additional and similar embodiments and features without departing from the scope of the presently disclosed subject matter.

**[0023]** Referring now to FIG.1, in one embodiment of the present invention, an electrolytic method of loading hydrogen into a cathode may comprise placing the cathode and an anode in an electrochemical reaction vessel filled with a solvent 10, mixing a DC component and an AC component to produce an electrolytic current 30, and applying an electrolytic current to the cathode 40. The DC component may include cycling between: a first voltage applied to the cathode for a first period of time, a second voltage applied to the cathode for a second period of time, wherein the second voltage is higher than the first voltage, and wherein the second period of time is shorter than the first period of time. The AC component may have a frequency between about 1 Hz and about 100kHz. The peak sum of the voltages supplied by the DC component and AC component may be higher than the dissociation voltage of the solvent.

**[0024]** DC currents and voltages used here may be switched in time but have a specific polarity above 0 volts as measured by traditional electrochemical methods, i.e. related to uncharged unbounded hydrogen. For clarity, the term DC includes switched DC where the desired voltage remains stable over an extended time. The term AC currents and voltages are used to describe currents which pass through the 0 voltage levels or through the value set by the DC voltages. That is we are using the term relative to the anode of the electrochemical system and AC is meant to be current that alternates between positive and negative charge on the cathode.

**[0025]** It should be clear to those skilled in the art of electrochemistry, that the desired

DC biased AC wave forms are applied to electrodes within an electrochemical cell. Specifically, at least the primary current of the DC applied to the cell is polarized so that the electrode (cathode) to receive the hydrogen is negatively charged compared to one of the other electrodes so that hydrogen species are moved toward the cathode.

**[0026]** When the frequency of the AC waveform is discussed it is meant to refer to the Fourier component of that waveform which has the greatest amplitude. It should be realized that the waveform can take a variety of forms. Waveforms having a component with rise-times shorter than 250 ns are preferred.

**[0027]** To avoid confusion, it should be noticed in electrochemical system one electrode is taken as a reference. For this electrolysis system, the anode is taken as the reference and set to ground. The cathode is negatively charge with respect to the anode and to ground.

**[0028]** It is preferred that the DC component's duty cycle be such to have a greater on time for the high voltage or high currents than for the lower ones after the initial loading protocol. This is for the purpose of giving a net ingress of the hydrogen into the electrode. In one embodiment, the cycle timing was 5 minutes with 90% on time for the lower voltage and 10% on time for the higher voltage. (Note: the cathode being loaded is at a negative potential.) In that embodiment, the high voltage was set at 10 VDC and the low voltage at 1 VDC.

**[0029]** In the preferred embodiment, the time between the DC Lo-High cycles (period) should be less than 20 minutes for electrodes with maximum thicknesses of 1mm. Longer times do not seem to be beneficial for such commonly used materials.

**[0030]** The AC waveform component to the electrolytic current can be of many different

functional forms such as sine, square, pulsed, or triangular as commonly available from function generators. Sine waves are used in the description herein but others waveforms can be envisioned by those skilled in the art of electrical engineering. The AC component is added to the stepped cycle DC component for the purpose of causing dynamic movement of the hydrogen into, though, and out of the electrochemical double layer and the surface of the electrode. The sum of the DC and AC components is applied between the electrode to be loaded with hydrogen and another electrode in a manor customary to electrolysis and known within the art of electrochemistry. In the preferred embodiment the addition of the AC and DC components should allow the voltage at the cathode to rise above zero voltage to release hydrogen from the electrode but not, however, to strip the hydrogen completely. Thus the greatest rise of the voltage should be slightly above zero volts but not significantly above zero nor remain at such levels for extended times. It is desired that the cathode be at a negative potential compared to the anode electrode (taken as ground) for longer total times than the positive times. In one embodiment the DC volts where chosen at -10V (90% of the time) and -1.5V (10% of the time) volts and the AC sine amplitude was chosen as 2.5 volts with a frequency of 100 Hz. This results in short-term peak voltages at the cathode to rise to 1 volt. However, the majority of the time the cathode experiences voltages above the dissociation voltage of the water solvent of about 1.5 volts and thus loads hydrogen into the electrode.

**[0031]** Referring now to FIG. 2, deloading can occur when the AC component adds to the DC in such a way to raise it above zero potential. The anode potential is taken as ground or 0 potential. The primary loading occurs during the time the DC component is at a more negative potential. There is a greater current flow when the cathode is at its more negative potentials. In the embodiment illustrated in FIG. 2, the two DC supplies are two DC-DC Adjustable Power

Supply Output Step-down Module 6.5V-60V to 1.25-30V 10A UPC 741870439544. Their purpose is to supply a DC bias to the cathode for loading of hydrogen into the electrode. To that end, it is important that voltages in excess of the dissociation of the solvent (i.e. water) be developed between the two electrodes. For water-basedsolvents, this is around 1.2 to 1.5 V dependent on pressures, electrolyte concentration, isotopic makeup, and temperatures. The two currents are wired to a double pole double throw relay (in one embodiment this was an Enclosed Power Relay,8 Pin,24VDC, DPDT SCHNEIDER ELECTRIC 92S11D22D-24D). The relay was cycled by a repeating unit 12V DC Multifunction Self-lock Relay PLC Cycle Timer Module Delay Time Switch UPC 714046658482.Its function is to activate the relay to cycle between the two DC power supplies. One of ordinary skill in the art would appreciate that any suitable DC supply, controller, and relay may be used in the present invention.

**[0032]** Referring now to FIG. 3, a general conception of the AC/-DC mixing according to an embodiment of the present invention is shown. It is shown as component units with discrete purposes. The parts' purpose is to supply a cycled DC voltage in a repetitive low- high cycle. It should be obvious by those skilled in the art of electrical engineering that many circuit designs can be employed for the same purpose. For example, a single programmable DC supply could replace the unit or a computer controlled DC supply. Alternatively, a dedicated AC generator which can provide DC Fourier components could be used. However, the separate components of the figure illustrates one embodiment the desired DC part of the input power can be obtained.

**[0033]** As mentioned elsewhere, one supply should be set so that there is net hydrogen-mediated current into the electrode and it should also have a voltage setting so the hydrogen can be dissociated in the solvent. The output of the stepped DC part of the system 303 is then directed to an AC/DC mixing unit 304 for the purpose of adding the two components for supply

to the electrodes within the electrochemical system.

**[0034]** Referring now to FIG. 4, a voltage vs. time output from the stepped DC portion of the system is shown. The duty cycle provides for the greater potential difference, and hence greater electrochemical current, for longer times than the lesser potential difference between electrodes. Thus, greater time is spent at the larger negative values for the purpose of providing hydrogen to the cathode.

**[0035]** The AC may be supplied by any suitable AC supply 305, for example, a HIGH PRECISION Audio Signal Generator 1Hz-1MHz with Sine Triangle Square outputs, UPC 0713893274877 or the like. It should be noted that other frequencies may be used, however, frequencies between 1Hz and 100kHz have been observed to be adequate for most applications. The primary factor in setting frequencies is the electrochemical double layer capacitance at the cathode. It is preferred that the expected frequencies range of the specific cell be determined by a method common within the art of electrochemical impedance spectroscopy. That is the primary AC frequency applied should allow for the greatest current flow into the cathode. The output of the AC or functional form device is fed via a current sensor into the AC/DC mixer 304.

**[0036]** In yet another embodiment, the frequency of the AC component 305 may be dynamically adjusted. A current sensor may indicate the absorption of the AC by the electrochemical cell. This, in turn, may signal the transport of the ionic species into, through, and out of the electrochemical double layer and eventually the movement of the hydrogen at the surface or near the surface of the cathode. The AC current sensor may relay the information to a frequency controller whose role is to keep the AC frequency center near the area of maximum AC absorption. Thus it assures a large movement of the hydrogen at the surface and near the

surface of the cathode. It is conjectured that this keeps the surface clean and diffusion pathways open. It also shuttles ions through the double layer from the solvent. However, since the cathode experiences outflow of some hydrogen for only short limited times there is net loading of the cathode. It is envisioned that the entire AC part of the system could comprise a single electronic unit.

**[0037]** Referring now to FIG. 5, a typical AC output using a simple sine form is shown. Other functional forms are contemplated in the present invention.

**[0038]** In yet another embodiment, the DC component and the AC component of the electrolytic current may be mixed with a DC bias. For enhanced loading of the electrode, the AC or other functional form and the stepped DC current need to be mixed while retaining the DC bias of the output. The goal is to enhance loading by allowing the AC to assist transport through the double layer while fluxing into and out of the metal surface. The DC bias gives a net influx of ions and other species into the cathode. Thus the combination has greater utility than either method alone and greater utility than one following later in time by the other. This synergistic combination is important for the performance of the method and device described herein.

**[0039]** A large number of DC bias AC mixing circuits are known within the art. A typical embodiment is a simple bias Tee circuit designed to pass the AC through a capacitor and the DC through an inductor while blocking the reflection back into the supplies.

**[0040]** Such circuits are well known and component sizes should be selected based on the expected frequency ranges. In one embodiment, the bias tee mixer was constructed using a series of 10mH inductors and a parallel circuit of Metallized Polyester Film 22mF Capacitors.

**[0041]** Referring again to FIG. 1, in yet another embodiment, the method may further comprise performing an initial loading 20. The initial loading may comprise applying an initial

electrolytic current to the cathode, the initial electrolytic current may include an initial DC component, wherein the initial DC component may include cycling between: a third voltage applied to the cathode for a third period of time, a fourth voltage applied to the cathode for a fourth period of time, wherein the fourth voltage is higher than the third voltage, wherein the third period of time and the fourth period of time are approximately the same, and wherein the third voltage is lower than the first voltage and the fourth voltage is lower than the second voltage. The initial electrolytic current may further include an AC component with a frequency between about 1Hz and about 100kHz.

**[0042]** It is preferred that the initial loading of the electrode is conducted at lower temperatures such as below room temperature and that the initial loading is first to be done with low currents and voltages and with the high low DC component duty cycle be near 50%. After 1 hour, the currents can be raised and the duty cycle reduced. This is thought to provide a more gradual loading and avoid some volume expansion distortions due to unequal loading. Once the electrode has been initial loaded and conditioned above 0.6 H/Pd atomic ratios, it can be later be loaded more quickly. Additionally, the duty cycle may be set to 0% after the initial loading protocols and a simple flat DC voltage biased AC can be used with care taken so that the average potential is favorable to retaining loading.

**[0043]** In yet another embodiment, the method may further comprise sealing the electrochemical reaction vessel.

**[0044]** In yet another embodiment, the method may further include flushing the electrochemical reaction vessel with a reductive gas prior to sealing the electrochemical reaction vessel.

**[0045]** In most electrochemical systems, gases are released during operation. Such cells

are termed "open" when the system is open for gas exchange to and from the environment and termed "closed" when sealed against such exchanges or have methods to control such exchanges.

**[0046]** In systems designed for hydrogen loading into electrodes, the gas is retained by the electrode and a companion gas such as oxygen from electrolysis is released into the system. This often results in the accumulation of so-called "orphaned oxygen" since there is not enough free hydrogen or reductive species to react with the free oxygen. This is usually detrimental to most thermal energy studies and devices. To that end, it is preferred to first run the system be conducted open or vented to the atmosphere so the orphaned oxygen can leave during the initial loading stages and then be closed later to limit contamination and conserve the electrolyte. In one embodiment this is accomplished by first loading a Pd based cathode run with amp-secs in excess of the time calculated amount that would be required from an estimate based on Faraday's laws of electrolysis of hydrogen needed to fully load the amount of Pd used in said system. In many embodiments, runs were run open longer than ten times the estimated time calculated by Faraday's law. After such time, the cell was sealed or pressure monitored for controlled release or for overpressures leading to higher operating pressures and temperatures. In one embodiment, Pd on $Al_2O_3$ recombination catalyst was used with a cell that was first run open for 4 days and then closed.

**[0047]** The initial running systems open before closing also allows for volatiles to be removed from the solution. This is especially important when trying to load with deuterium from heavy water solutions. Since deuterium oxide (i.e. heavy water) is hygroscopic, solutions often are supplied or become contaminated with the lighter isotope of hydrogen. Light hydrogen is more quickly evolved than the deuterium isotope of hydrogen in electrolytic systems due to its lower voltage required for dissociation. Running open at low voltages and currents preferentially

remove the lighter isotope.

**[0048]** One alternative is to flush the gas out of the cell with a reductive species such as hydrogen and then sealed so that any orphaned oxygen will have enough hydrogen to react and be sequestered in the form of water.

**[0049]** In yet another embodiment, the method may further include applying a magnetic field to the electrochemical reaction vessel. In many thermally active electrochemical systems, the magnetic fields are applied for either study of the processes or for adjusting internal spin based reactions. This is especially useful when paramagnetic or ferromagnetic materials are used for one or more electrodes. Hence, in one embodiment, a disc magnet (N42 2x1/2 Inch Rare Earth Neodymium Disc Magnet from Magnets4Less) was placed beneath the reactive chamber and a second ring magnet (3 ODx 2 IDx 1/2 Inch Rare Earth Neodymium Ring Magnet Grade N42 from Magnets4Less). This supplied a field of 300 gauss in the region occupied by the central electrode.

**[0050]** In yet another embodiment, the cathode may be comprised of at least one of palladium or a palladium alloy.

**[0051]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 0.1 $cm^3/cm^2/s$.

**[0052]** In yet another embodiment, the cathode may have a hydrogen diffusion rate greater than about 1.4 $cm^3/cm^2/s$.

**[0053]** It is recommended that care is performed in selecting metal electrodes for loading of hydrogen. The material should have a hydrogen diffusion rate greater than 0.1 $cm^3/cm^2/s$ and with rates greater than 1.4 $cm^3/cm^2/s$.

**[0054]** The function of the reaction vessel is to provide a relatively inert and structurally stable container for the electrochemical reaction. Such vessels are known to those skilled in the art of chemistry. In one embodiment a Glass Proglass 250mL Flask fitted with 24/40, 14/20 Two Necks lid and sealed with an Easy Open PTFE Clamp. The central 24/40 neck of the lid is suited to mount a Graham condenser for returning steam from the system back into the vessel. The 14/20 side neck is suited for passing the electrical connections to the electrodes and sensors. One of ordinary skill in the art would understand any other suitable reaction vessel known in the art may be used in the present invention.

**[0055]** In one embodiment, the electrochemical reaction vessel was partially filled with 100 ml of an LiOD 0.1M heavy water based solution. A Pt coated Ti mesh electrode was used as the anode and the cathode was selected as discussed below. The chemical reflux condenser assembly was insulated with vermiculite and cooling water at 30C was passed down through the condenser (common counter-flow systems in chemistry). This allowed the system to run at boiling temperatures for extended times. This was slightly above 92 C due to the altitude of the inventor's laboratory.

**[0056]** In yet another embodiment, the solvent may be LiOH.

**[0057]** In yet another embodiment, the solvent may be LiOD.

**[0058]** Referring now to FIG. 6, in another embodiment, a system for electrolytic loading of hydrogen 600 into a cathode 604 may comprise an electrochemical reaction vessel 606 filled with a solvent, a cathode 604 and an anode 605 disposed within the electrochemical reaction vessel 606, and an electrolytic current source 603 connected to the cathode 604. The electrolytic current may comprise a DC component 602, wherein the DC component 602 may cycle between a first voltage applied to the cathode 604 for a first period of time, and a second voltage applied

to the cathode 604 for a second period of time, wherein the second voltage may be higher than the first voltage, and wherein the second period of time may be shorter than the first period of time. The electrolytic current may further comprise an AC component 601 with a frequency between about 1Hz and about 100kHz. The peak sum of the voltages supplied by the DC component 602 and AC component 601 may be higher than the dissociation voltage of the solvent.

**[0059]** One of ordinary skill in the art will appreciate the system may be used in a manner consistent with the electrolytic methods of loading hydrogen into a cathode as described above and in the example herein.

**[0060]** **EXAMPLE I**

**[0061]** The increase loading rate and maximum loading ratios of Hydrogen species into metals is useful in a wide range of utilities. For example, in studies of hydrogen storage materials, hydrogen embrittlement studies, measurements of circuit's resistance and inductance, and even in areas where isotopic hydrogen is studied for thermal release or for tritium storage. To verify the utility of the method, a series of experiments were conducted to compare loading rates by the electrochemical method described herein and with traditional loading for simple DC electrolysis.

**[0062]** Resistance versus time measurements of a palladium wire were made to judge loading rates. Such resistance changes need to be well studied for the case of hydrogen being loading electrochemically into Palladium. For example, FIG.9 shows how the loaded resistance of Palladium is altered as natural hydrogen is loaded into it. The relative resistance, $R/R_0$ (i.e. loaded resistance divided by preloaded resistance), increases by a factor of approximately 1.8 as

the H to Pd atomic ratio reaches 0.65 at room temperatures and standard atmospheric pressures. Such increase can also be seen, as in FIG. 10, for the deuterium isotope of hydrogen. Thus the rate of change of resistance upon loading can be used to evaluate the loading rate and levels. Also when both samples are from the same original wire length, operated under the same environmental conditions, and same amp-seconds of electrolysis, a comparison can be made.

**[0063]** In one embodiment, two 1 foot 95% Pd 5% Ru 28 gauge (AGW) wires were cut from a single piece and were loaded by the two methods described herein for comparison. This was done simply by lowering a loop of each wire into a 0.1M LiOH solution which also contained a platinized Ti mesh electrode commonly used for Pd and Rh electroplating. The resistance of each wire was monitored with respect to time. The resistance was measured by an EXTECH 380560 PRECISION MILLIOHM METER via conventional four wire Kelvin clips placed on the wire ends just above the surface of the solution. The clips were adjusted so the two wires had the same initial resistance of 0.971 ohms. The two wires were run at the same RMS average power levels as measured with a Valhalla Scientific 2100 Digital Power Analyzer. One was run at constant DC current and one at a high DC voltage of 5 volts and a low of 1.75 volts and an AC sine wave at 100Hz with an amplitude of 3.5 volts peak to peak. The switching between the DC values was set at 5 minutes with a 20% duty cycle.

**[0064]** Resistance data was taken each half hour while the wires loaded and the relative resistance (instantaneous resistance divided by the initial resistance) plot in FIG. 11.

**[0065]** The resistance maximum was reached at 14.5 hours and indicates a loading of about 0.75 D/Pd ratio. The turn down in the resistance past that time shows continued loading as the phase of the Pd begins to change.

**[0066]** The average rate over the 18 hour run of the competing loading ratios shows that the method described herein is 1.47 higher than DC current alone for the first 18 hours. It is also worth noting that the ultimate loading ratio achieved by this method is higher than the DC alone. For example, after 10 hours, the DC alone loading only achieved a $R/R_0$ level of 1.3 while the method of this invention achieved a level of over 1.5.

**[0067]** The resistance was used to calculate the loading ratios during an eighteen hour run and is given in FIG. 12.

**[0068]** The above description and drawings are illustrative and are not to be construed as limiting the invention to the precise forms disclosed. Persons skilled in the relevant art can appreciate that many modifications and variations are possible in light of the above disclosure. Numerous specific details are described to provide a thorough understanding of the disclosure. However, in certain instances, well-known or conventional details are not described in order to avoid obscuring the description.

**[0069]** Reference in this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. Moreover, various features are described which may be exhibited by some embodiments and not by others. Similarly, various requirements are described which may be requirements for some embodiments but not other embodiments.

**[0070]** 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." As used herein, the terms "connected," "coupled," or any variant thereof, means any connection or coupling, either direct or indirect, between two or more elements; the coupling of connection between the elements can be physical, logical, or any combination thereof. Additionally, the words "herein," "above," "below," and words of similar import, when used in this application, shall refer to this application as a whole and not to any particular portions of this application. Where the context permits, words in the above Detailed Description using the singular or plural number may also include the plural or singular number respectively. The word "or," in reference to a list of two or more items, covers all of the following interpretations of the word: any of the items in the list, all of the items in the list, and any combination of the items in the list.

**[0071]** The teachings of the disclosure provided herein can be applied to other systems, not necessarily the system described above. The elements and acts of the various embodiments described above can be combined to provide further embodiments.

**[0072]** These and other changes can be made to the disclosure in light of the above Detailed Description. While the above description describes certain embodiments of the disclosure, and describes the best mode contemplated, no matter how detailed the above appears in text, the teachings can be practiced in many ways. Details of the system may vary considerably in its implementation details, while still being encompassed by the subject matter disclosed herein. As noted above, particular terminology used when describing certain features or aspects of the disclosure should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or aspects of the disclosure with which that terminology is associated. In general, the terms used in the following claims should

not be construed to limit the disclosure to the specific embodiments disclosed in the specification, unless the above Detailed Description section explicitly defines such terms. Accordingly, the actual scope of the disclosure encompasses not only the disclosed embodiments, but also all equivalent ways of practicing or implementing the disclosure under the claims.

**[0073]** The terms used in this specification generally have their ordinary meanings in the art, within the context of the disclosure, and in the specific context where each term is used. Certain terms that are used to describe the disclosure are discussed above, or elsewhere in the specification, to provide additional guidance to the practitioner regarding the description of the disclosure. For convenience, certain terms may be highlighted, for example using capitalization, italics and/or quotation marks. The use of highlighting has no influence on the scope and meaning of a term; the scope and meaning of a term is the same, in the same context, whether or not it is highlighted. It will be appreciated that same element can be described in more than one way.

**[0074]** Consequently, alternative language and synonyms may be used for any one or more of the terms discussed herein, nor is any special significance to be placed upon whether or not a term is elaborated or discussed herein. Synonyms for certain terms are provided. A recital of one or more synonyms does not exclude the use of other synonyms. The use of examples anywhere in this specification including examples of any terms discussed herein is illustrative only, and is not intended to further limit the scope and meaning of the disclosure or of any exemplified term. Likewise, the disclosure is not limited to various embodiments given in this specification.

**[0075]** Without intent to further limit the scope of the disclosure, examples of

instruments, apparatus, methods and their related results according to the embodiments of the present disclosure are given below. Note that titles or subtitles may be used in the examples for convenience of a reader, which in no way should limit the scope of the disclosure. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions will control.

**[0076]** Some portions of this description describe the embodiments of the invention in terms of algorithms and symbolic representations of operations on information. These algorithmic descriptions and representations are commonly used by those skilled in the data processing arts to convey the substance of their work effectively to others skilled in the art. These operations, while described functionally, computationally, or logically, are understood to be implemented by computer programs or equivalent electrical circuits, microcode, or the like. Furthermore, it has also proven convenient at times, to refer to these arrangements of operations as modules, without loss of generality. The described operations and their associated modules may be embodied in software, firmware, hardware, or any combinations thereof.

**[0077]** Finally, the language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the inventive subject matter. It is therefore intended that the scope of the invention be limited not by this detailed description, but rather by any claims that issue on an application based hereon. Accordingly, the disclosure of the embodiments of the invention is intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the following claims.

**[0078]** Unless defined otherwise, all technical and scientific terms used herein have the

same meaning as commonly understood to one of ordinary skill in the art to which the presently disclosed subject matter pertains. Although any methods, devices, and materials similar or equivalent to those described herein can be used in the practice or testing of the presently disclosed subject matter, representative methods, devices, and materials are now described.

**[0079]** Following long-standing patent law convention, the terms "a", "an", and "the" refer to "one or more" when used in the subject specification, including the claims. Thus, for example reference to "an additive" can include a plurality of such additives, and so forth.

**[0080]** Unless otherwise indicated, all numbers expressing quantities of components, conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about". Accordingly, unless indicated to the contrary, the numerical parameters set forth in the instant specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by the presently disclosed subject matter.

**[0081]** As used herein, the term "about", when referring to a value or to an amount of mass, weight, time, volume, concentration, and/or percentage can encompass variations of, in some embodiments +/-20%, in some embodiments, +/-10%, in some embodiments +/- 5%, in some embodiments +/-1%, in some embodiments +/-0.5%, and in some embodiments, +/-0.1%, from the specified amount, as such variations are appropriate in the disclosed products and methods.

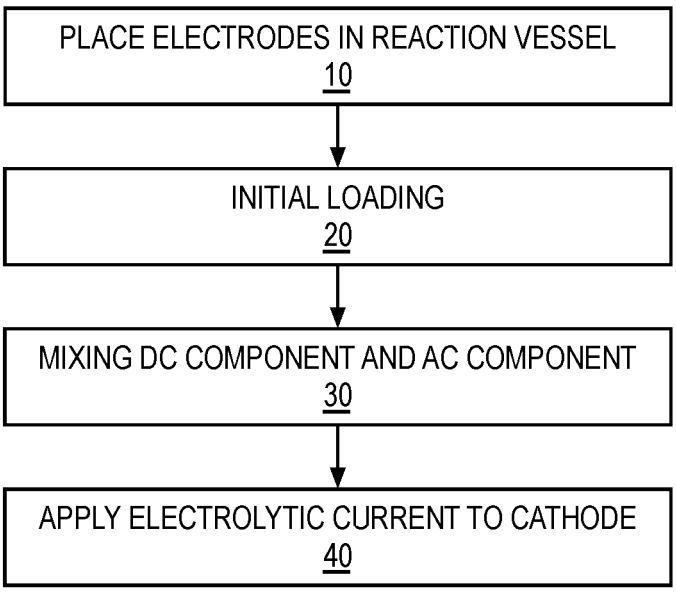
PLACE ELECTRODES IN REACTION VESSEL
10
INITIAL LOADING
20
MIXING DC COMPONENT AND AC COMPONENT
30
APPLY ELECTROLYTIC CURRENT TO CATHODE
40

FIG. 1

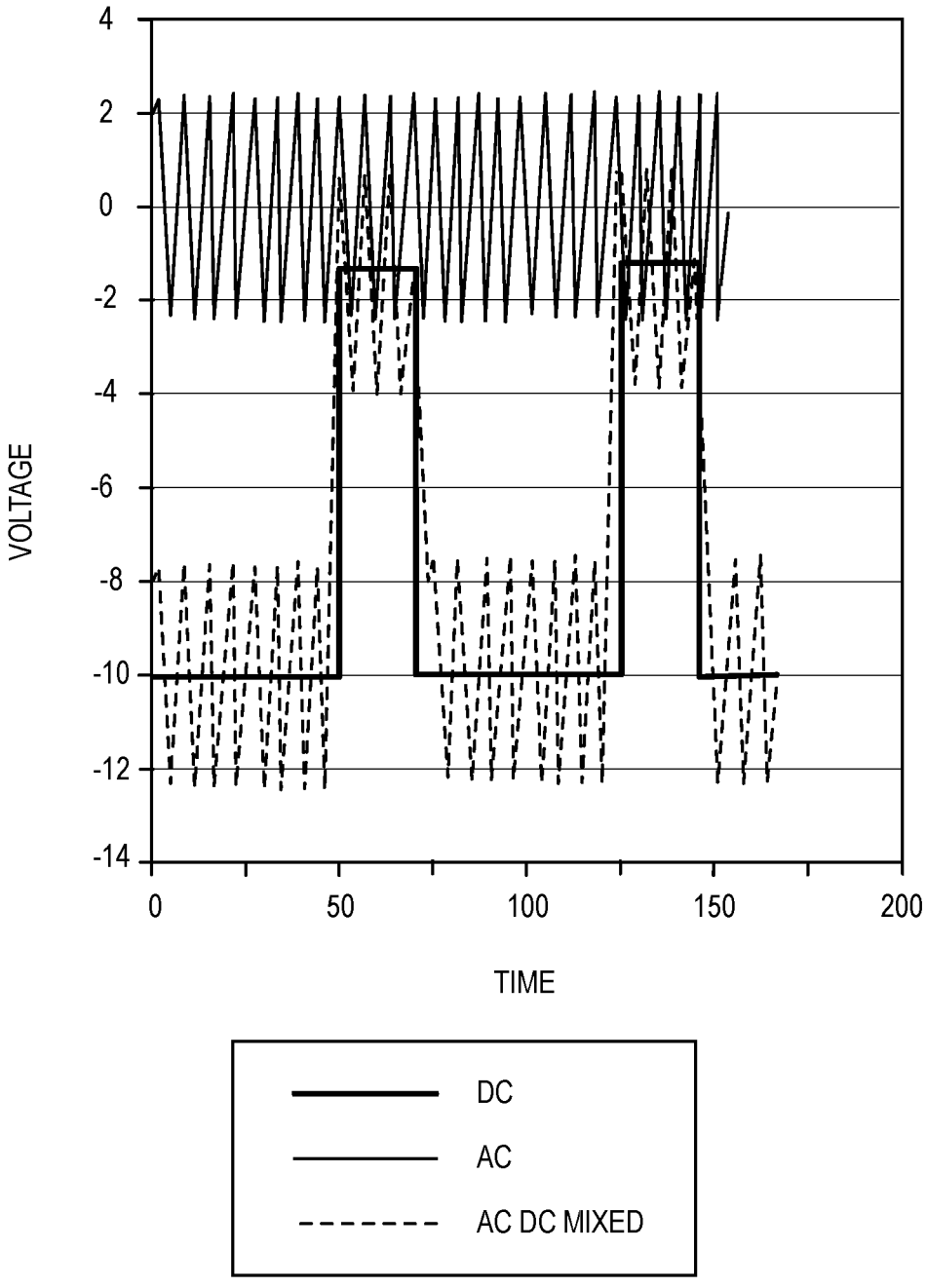


FIG. 2

STEPPED DC SYSTEM PART

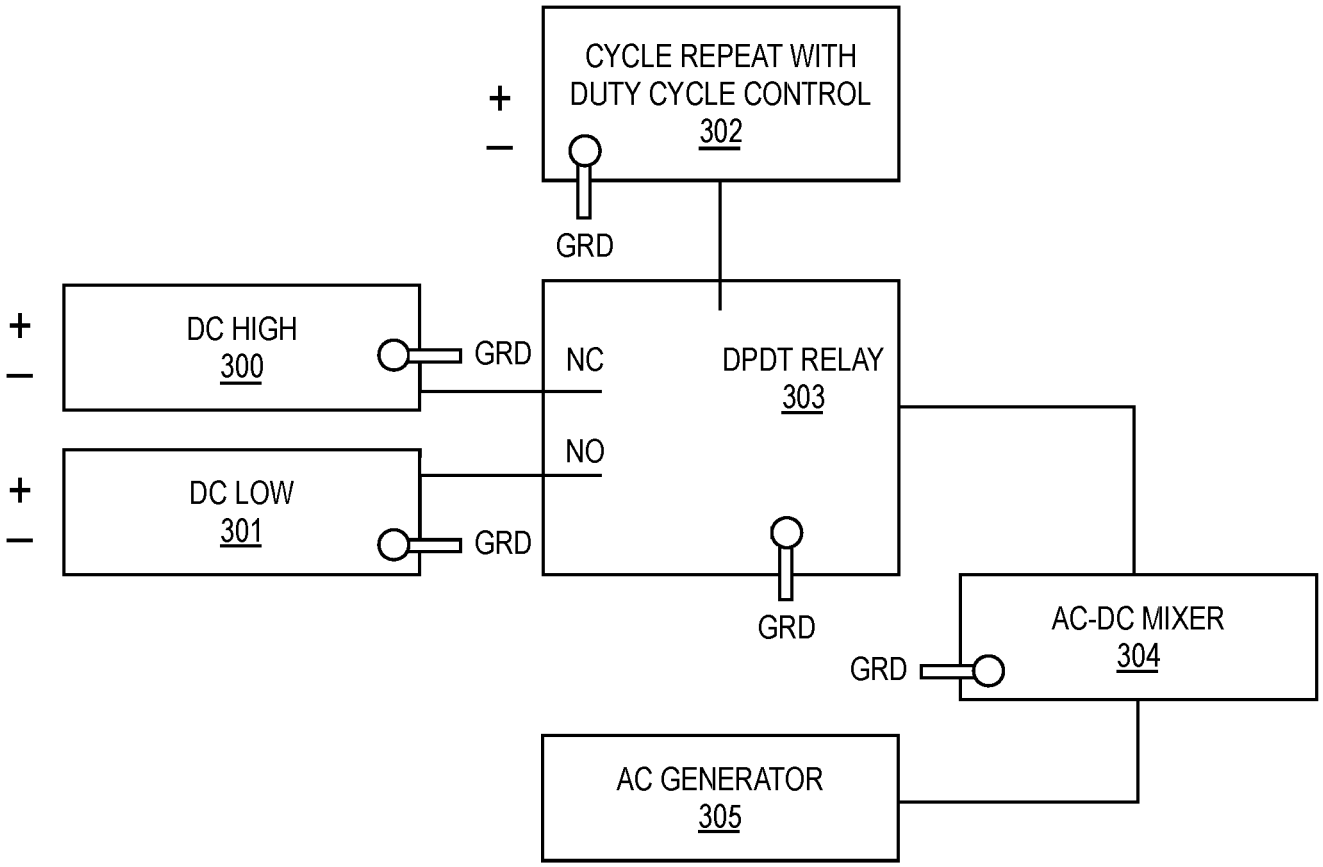


FIG. 3

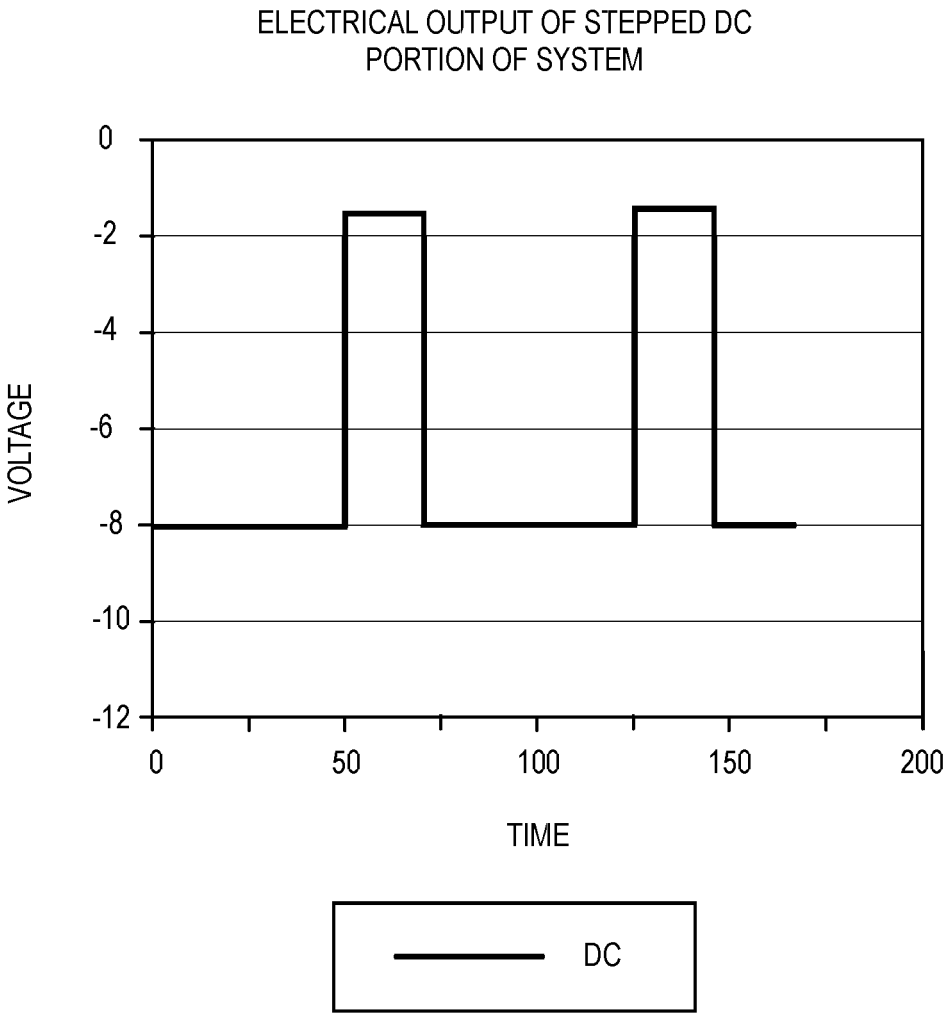
ELECTRICAL OUTPUT OF STEPPED DC
PORTION OF SYSTEM
VOLTAGE
0
-2
-4
-6
-8
-10
-12
0
50
100
150
200
TIME
DC

FIG. 4

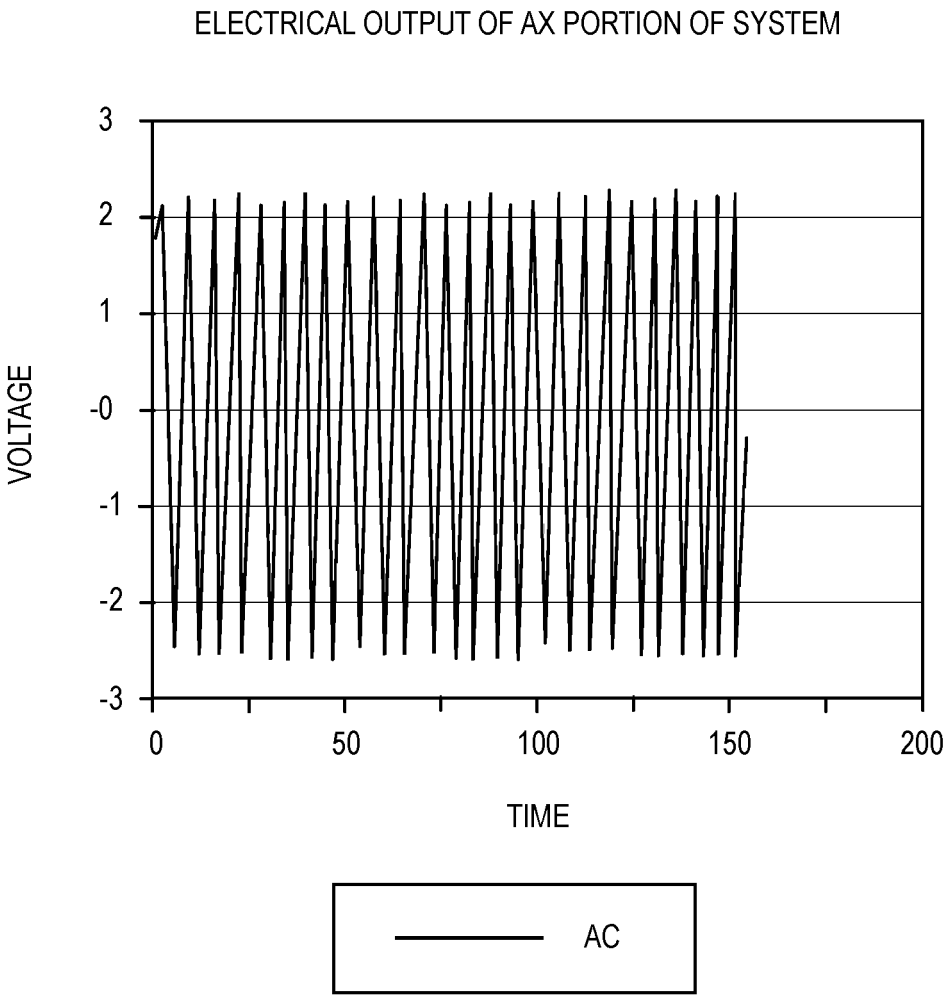
ELECTRICAL OUTPUT OF AX PORTION OF SYSTEM
VOLTAGE
3
2
1
-0
-1
-2
-3
0
50
100
150
200
TIME
AC

FIG. 5

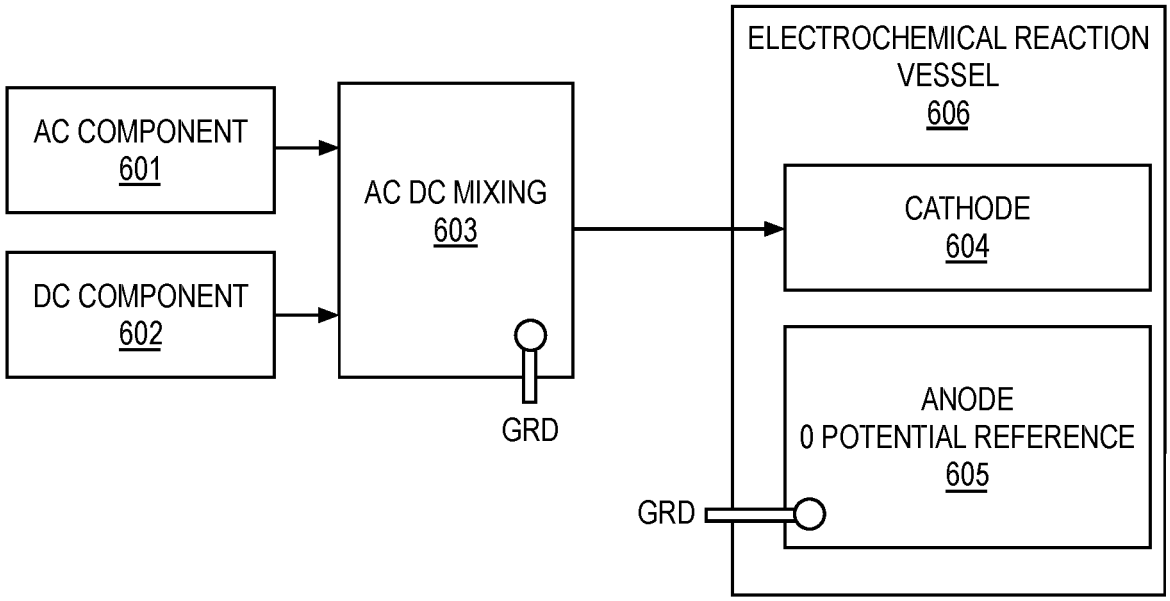
AC COMPONENT
601
DC COMPONENT
602
AC DC MIXING
603
GRD
ELECTROCHEMICAL REACTION VESSEL
606
CATHODE
604
ANODE
0 POTENTIAL REFERENCE
605
GRD

FIG. 6

438/98 PROV

# DECLARATION AND ASSIGNMENT OF RIGHTS

As a below named inventor (hereinafter designated as the undersigned or the Assignor, where appropriate), I hereby declare that:

The application is as identified by the attorney docket number, title, Filing Date, or Application Title as set forth in the following Table I.

The application in Table I was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the applications in Table I.

The undersigned hereby acknowledges that any willful 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.

WHEREAS, the undersigned, **Dennis Cravens**, (hereinafter "Assignor") has/have invented certain new and useful improvements described in the application(s) identified in Table I.

AND, WHEREAS, **Industrial Heat, LLC**, having a place of business at 310 West Street, Suite 100, Raleigh, North Carolina 27603 (hereinafter "Assignee"), has already acquired an interest in the application(s) identified in Table I by and through an employment or other agreement between Assignor and Assignee. I further authorize an agent of the Assignee to insert the filing date, application number, and any other identifying particulars as required for perfecting these assignment papers.

However, in the avoidance of doubt and as confirmation of the already acquired interest by Assignee, NOW, THEREFORE, To Whom It May Concern, be it known that for good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, Assignor has assigned and by these presents does hereby sell, assign, transfer, and convey unto the Assignee, its successors and assigns, his entire right, title, and interest in and to the invention and application, including the right to sue for past infringements and any other prior occurring rights, provided any such rights exist, and in and to any and all domestic and foreign patent applications filed on the invention, and in and to any and all continuations, continuations-in-part, or divisions thereof, and in and to any and all Letters Patent of the United States of America, and all foreign countries or reissues thereof which may be granted therefor or thereon, for the full end of the term for which said Letters Patent may be granted, together with his right to claim the priority of said application in all foreign countries in accordance with the International Convention, the same to be held and enjoyed by said Assignee, its successors and assigns, as fully and

entirely as the same would have been held and enjoyed by Assignor if this assignment and sale had not been made. Assignor further assigns to Assignee the right to claim entitlement and/or priority to any applications that entitlement or priority may be claimed for this or any later filed application, including the assignment of any provisionals or other priority documents to which the inventions claim priority to. The assignment of the right to claim entitlement and/or priority is executed *nunc pro tunc* and is considered effective as of the filing date of the earliest application to which priority and/or entitlement is claimed.

Assignor hereby requests that said Letters Patent be issued in accordance with this assignment.

Assignor further covenants and agrees that, at the time of the execution and delivery of these presents, Assignor possesses full title to the invention and application above-mentioned, and that he has the unencumbered right and authority to make this assignment.

Assignor further covenants and agrees, and likewise binds his heirs, legal representatives and assigns, to promptly communicate to said Assignee or its representatives any facts known to him relating to said invention, to testify in any interference or legal proceedings involving said invention, to execute any additional papers which may be requested to confirm the right of the Assignee, its representatives, successors and assigns to secure patent or similar protection for the said invention in all countries and to vest in the Assignee complete title to the said invention and Letters Patent, without further compensation, but at the expense of said Assignee, its successors, assigns and other legal representatives.

<<<<<<<< TABLE I and Signature Page follows >>>>

**TABLE I**

| Application No. | Attorney Docket No. | Filing Date | Title |
|---|---|---|---|
| 62/804,989 | 438/98 PROV | Feb. 13, 2019 | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |

Executed this 14 day of Feb, 2019.

**DENNIS CRAVENS**

**(Assignor)**

Executed this ____ day of _____, 2019.

_____

**Industrial Heat, LLC**

Name: _____

Title: _____

**(Assignee)**

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | |
| **Filing Date:** | |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Filer:** | Justin Robert Nifong/Donna Donovan |
| **Attorney Docket Number:** | 438/98 PROV |

Filed as Small Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| UTILITY FILING FEE (ELECTRONIC FILING) | 4011 | 1 | 75 | 75 |
| UTILITY SEARCH FEE | 2111 | 1 | 330 | 330 |
| UTILITY EXAMINATION FEE | 2311 | 1 | 380 | 380 |
| **Pages:** | | | | |
| **Claims:** | | | | |
| CLAIMS IN EXCESS OF 20 | 2202 | 3 | 50 | 150 |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | **Total in USD ($)** | | **935** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 35504833 |
| **Application Number:** | 16361825 |
| **International Application Number:** | |
| **Confirmation Number:** | 3063 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Customer Number:** | 76934 |
| **Filer:** | Justin Robert Nifong/Donna Donovan |
| **Filer Authorized By:** | Justin Robert Nifong |
| **Attorney Docket Number:** | 438/98 PROV |
| **Receipt Date:** | 22-MAR-2019 |
| **Filing Date:** | |
| **Time Stamp:** | 14:52:27 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $935 |
| RAM confirmation Number | 032519INTEFSW14530300 |
| Deposit Account | 506191 |
| Authorized User | Donna Donovan |

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

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 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 | Application Data Sheet | 438-98UTIL-20190322-ADS.pdf | 1822880<br>174287d289e410e4f9821b88e8f99c666ddfa88b | no | 8 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | | 438-98UTIL-20190322-Spec-claim-abs.pdf | 122702<br>2f5a18e4a1cb058271573e6275da0886feaf642e | yes | 26 |

**Multipart Description/PDF files in .zip description**

| Document Description | Start | End |
|---|---|---|
| Claims | 23 | 26 |
| Specification | 1 | 22 |

| | | | | | |
|---|---|---|---|---|---|
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Drawings-other than black and white line drawings | 438-98UTIL-20190322-Drawings.pdf | 45222<br>9e3c8de99d0d651e118becc60caada80b5b58290 | no | 6 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Oath or Declaration filed | 438-98PROV_20190222-Executed-Declaration-and-Assignment.pdf | 187229<br>99a72c60eef8edaa5b650d37c5d168e37d472d42 | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 5 | Fee Worksheet (SB06) | fee-info.pdf | 36785<br>458e55ceac6cdfdb1d2bc93f33ec90f7850b7e26 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |

| | |
|---|---|
| **Total Files Size (in bytes):** | 2214818 |

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**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.**

DocCode – SCORE

# SCORE Placeholder Sheet for IFW Content

Application Number: 16361825 Document Date: 03/22/2019

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

Since this was an electronic submission, there is no physical artifact folder, no artifact folder is recorded in PALM, and no paper documents or physical media exist. The TIFF images in the IFW record were created from the original documents that are stored in SCORE.

- Drawing

At the time of document entry (noted above):

- USPTO employees may access SCORE content via eDAN using the Supplemental Content tab, or via the SCORE web page.
- External customers may access SCORE content via PAIR using the Supplemental Content tab.

Form Revision Date: August 26, 2013

Doc code : PET.OP.AGE
Description : Petition to make special based on Age/Health

PTO/SB/130 (07-09)
Approved for use through 01/31/2013. OMB 0651- 0031
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 contains a valid OMB control number

## PETITION TO MAKE SPECIAL BASED ON AGE FOR ADVANCEMENT OF EXAMINATION UNDER 37 CFR 1.102(c)(1)

### Application Information

| | | | | | |
|---|---|---|---|---|---|
| Application Number | 16361825 | Confirmation Number | 3063 | Filing Date | 2019-03-22 |
| Attorney Docket Number (optional) | 438/98 UTIL | Art Unit | | Examiner | |
| First Named Inventor | Dennis Cravens | | | | |
| Title of Invention | METHODS FOR ENHANCED ELECDTROLYTIC LOADING OF HYDROGEN | | | | |

**Attention: Office of Petitions**

An application may be made special for advancement of examination upon filing of a petition showing that the applicant is 65 years of age, or more. No fee is required with such a petition. See 37 CFR 1.102(c)(1) and MPEP 708.02 (IV).

APPLICANT HEREBY PETITIONS TO MAKE SPECIAL FOR ADVANCEMENT OF EXAMINATION IN THIS APPLICATION UNDER 37 CFR 1.102(c)(1) and MPEP 708.02 (IV) ON THE BASIS OF THE APPLICANT'S AGE.

A grantable petition requires one of the following items:
(1) Statement by one named inventor in the application that he/she is 65 years of age, or more; or
(2) Certification by a registered attorney/agent having evidence such as a birth certificate, passport, driver's license, etc. showing one named inventor in the application is 65 years of age, or more.

**Name of Inventor who is 65 years of age, or older**

| Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|
| Dennis | | Cravens | |

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18.
Please see 37 CFR 1.4(d) for the format of the signature.

Select (1) or (2) :

○ (1) I am an inventor in this application and I am 65 years of age, or more.

◉ (2) I am an attorney or agent registered to practice before the Patent and Trademark Office, and I certify that I am in possession of evidence, and will retain such in the application file record, showing that the inventor listed above is 65 years of age, or more.

| | | | |
|---|---|---|---|
| Signature | /Justin R. Nifong/ | Date (YYYY-MM-DD) | 2019-03-22 |
| Name | Justin R. Nifong | Registration Number | 59389 |

PTO/SB/130 (07-09)
Approved for use through 01/31/2013. OMB 0651- 0031
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 contains 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 the Fr eedom of Information Act requires disclosure of these records.

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 indivi duals.

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.

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 35504895 |
| **Application Number:** | 16361825 |
| **International Application Number:** | |
| **Confirmation Number:** | 3063 |
| **Title of Invention:** | METHODS FOR ENHANCED ELECTROLYTIC LOADING OF HYDROGEN |
| **First Named Inventor/Applicant Name:** | Dennis Cravens |
| **Correspondence Address:** | NK Patent Law - Industrial Heat<br>-<br>4917 Waters Edge Drive<br>Suite 275<br>Raleigh NC 27606<br>US 9193482194<br>eofficeaction@appcoll.com |
| **Filer:** | Justin Robert Nifong/Donna Donovan |
| **Filer Authorized By:** | Justin Robert Nifong |
| **Attorney Docket Number:** | 438/98 UTIL |
| **Receipt Date:** | 22-MAR-2019 |
| **Filing Date:** | |
| **Time Stamp:** | 14:55:14 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Petition to make special based on Age/ Health | 438-98UTIL-20190322-Petition-to-Make-Special-Based-on-Age.pdf | 63969<br>b2f7167d2ca7701c98ac096c1233b9573cb057c2 | no | 2 |

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|---|---|
| **Warnings:** | |
| **Information:** | |
| **Total Files Size (in bytes):** | 63969 |

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**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.**