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
16/783,497	02/06/2020	Joseph A. Murray	438/32/2 UTIL

CONFIRMATION NO. 4990

PUBLICATION NOTICE

OC000000119011491

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

Title:METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS

Publication No.US-2020-0246774-A1
Publication Date:08/06/2020

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.

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

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/783,497	02/06/2020	Joseph A. Murray	438/32/2 UTIL

CONFIRMATION NO. 4990

NEW OR REVISED PPD NOTICE

OC000000116644405

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

NOTICE OF NEW OR REVISED PROJECTED PUBLICATION DATE

The above-identified application has a new or revised projected publication date. The current projected publication date for this application is 08/06/2020. If this is a new projected publication date (there was no previous projected publication date), the application has been cleared by Licensing & Review or a secrecy order has been rescinded and the application is now in the publication queue.

If this is a revised projected publication date (one that is different from a previously communicated projected publication date), the publication date has been revised due to processing delays in the USPTO or the abandonment and subsequent revival of an application. The application is anticipated to be published on a date that is more than six weeks different from the originally-projected publication date.

More detailed publication information is available through the private side of Patent Application Information Retrieval (PAIR) System. The direct link to access PAIR is currently http://pair.uspto.gov. Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Questions relating to this Notice 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.

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
16/783,497	02/06/2020	3761	1065	438/32/2 UTIL	24	2

CONFIRMATION NO. 4990

UPDATED FILING RECEIPT

OC000000115642454

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

Date Mailed: 03/24/2020

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)

Joseph A. Murray, Raleigh, NC;
Julie A. Morris, Flower Mound, TX;
Tushar Tank, Raleigh, NC;

Applicant(s)

IH IP Holdings Limited, St. Helier, JERSEY

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of PCT/US18/45305 08/06/2018
which claims benefit of 62/542,022 08/07/2017

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.

Projected Publication Date: To Be Determined - pending completion of Security Review

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS

Preliminary Class

219

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

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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

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

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

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

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

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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

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

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

NOT GRANTED

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

SelectUSA

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

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
16/783,497	02/06/2020	Joseph A. Murray	438/32/2 UTIL

CONFIRMATION NO. 4990

INFORMAL NOTICE

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

OC000000115642455

Date Mailed: 03/24/2020

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  Joseph A. Murray
  Julie A. Morris
  Tushar Tank

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**.

/yteferra/

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number
16/783,497

APPLICATION AS FILED - PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	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))	24 minus 20 =	* 4	x 50 =	200	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	985		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
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	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.	:	16/783,497	Confirmation No.:	4990
Applicant	:	IH IP Holdings Limited		
First Named Inventor	:	Joseph A. Murray		
Filing Date	:	Feb 6, 2020		
TC/A.U.	:	3761		
Examiner	:			
Docket No.	:	438/32/2 UTIL		
Customer No.	:	76934		

Title of Invention: METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS

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 March 12, 2020. In this Notice the applicant is given a two-month period for response, expiring on May 12, 2020. This reply is timely submitted.

REMARKS

Applicant herewith submits a substitute specification, both clean and marked-up versions) adding a brief description of FIG. 7C as required by 37 CFR 1.74 and 37 CFR 1.77(b)(9) and correcting a typographical error in paragraph 33. 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: March 20, 2020

/Justin R. Nifong/
Justin R. Nifong
Reg. No. 59,389

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

Customer No. 76934

Methods and Apparatus for Triggering Exothermic Reactions Using AC or DC Electromagnetics

Cross-Reference to Related Applications

[001] This application is a continuation of International Application No. PCT/US18/45305, filed on August 6, 2018, entitled "METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS", which claims priority to U.S. Provisional Patent Application No. 62/542,022 filed on August 7, 2017, entitled "METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS", the entire contents of which are incorporated by reference herein.

Technical field

[002] The present disclosure relates generally to how to trigger an exothermic reaction, and more specifically, to triggering an exothermic reaction using AC or DC electromagnetics.

Background

[003] Exothermic reactions involving metal hydrides, such as palladium hydride or nickel hydride, have been observed and documented on many occasions. However, reproducibility of these exothermic reactions has been a noted problem. Scientists and engineers have tried to determine the exact conditions under which those exothermic reactions can be triggered and sustained. Yet, many issues remain unresolved and many questions are still waiting to be answered.

[004] For example, studies of past reported exothermic reactions show that the amount of deuterium loaded in the palladium hydride or nickel hydride is critical in one type of exothermic reactions in which low energy nuclear reactions involving deuterium atoms take place inside the palladium lattice. However, the threshold atom ratio of loaded deuterium to palladium is still in debate and largely speculative. For another example, the exact nature of these exothermic reactions needs to be verified and confirmed. To that end, precise calibration and heat measurements are required in these heat generation experiments. However, it appears that the above-noted problems that have been plaguing this technological field stem from the reproducibility of these exothermic reactions. Reliable triggering mechanisms are needed ab initio before many questions in this field can be answered.

[005] The present disclosure teaches advantageous methods and apparatus for triggering an exothermic reaction.

Summary

[006] The present disclosure relates to how to trigger an exothermic reaction.

[007] In some embodiments, a method for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction is disclosed. The exothermic reactor comprises a vessel and one or more reaction materials. The reactor maintains a pressure and a temperature and is surrounded by one or more coils. The method comprises supplying a current to the one or more coils. The strength of the current is determined based on a desired characteristic of the magnetic field. The method further comprises switching off the current after a first time period. The magnetic field is designed to trigger the

exothermic reaction. The first time period is also selected so that it is conducive to triggering the exothermic reaction. The pre-determined magnetic field and the selected time period are dependent on the type of the exothermic reactor or reaction. In one embodiment, the desired characteristic of the magnetic field and the first time period depend on one or more of the following factors: the reaction materials, the temperature, the pressure, the substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

[008] In one embodiment, both the magnitude and the polarity of the magnetic field are pre-determined for triggering an exothermic reaction. For example, the current is supplied to the one or more coils and the current induces a magnetic field. The strength of the current is 20A. In some other embodiments, the current typically ranges from 100 mA to 60A. The magnitude of the magnetic field increases until the current is switched off after the first time period. The first time period is calculated based on a desired magnitude of the magnetic field and the current.

[009] In one embodiment, the current is supplied to the one or more coils for the first time period. The first time period is determined based on the desired strength of the magnetic field and the current. The strength of the magnetic field increases until the current is switched off. In one embodiment, the current is switched off after a first time period and is switched on after a second time period. The direction of the current may be reversed when the current is turned on again. The frequency at which the direction of the current is reversed is determined so at to trigger the exothermic reaction. In yet another embodiment, the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

[010] In some embodiments, the two coils are placed in parallel and the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil. In some embodiments, the first coil is placed perpendicular to the second coil and the currents running through the first and second coil are turned on and off alternately, i.e., phase-shifted by 180^{o} relatively to each other. The currents in the first and second coils may be phase locked.

[011] The present disclosure also discloses an apparatus for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction. The exothermic reactor comprises a vessel and one or more reaction materials. The reactor maintains a temperature and a pressure. The apparatus comprises one or more coils and one or more power supplies for supplying a current to the one or more coils. The power supplies are configured to supply the current to the one or more coils and switch off the current after a first time period. In one embodiment, both the magnitude and the polarity of the magnetic field are pre-determined for triggering an exothermic reaction. For example, the current is supplied to the one or more coils and the current induces a magnetic field. The strength of the current is 20A. In some other embodiments, the current typically ranges from 100mA to 60A. The magnitude of the magnetic field increases until the current is switched off after the first time period. The first time period is calculated based on a desired magnitude of the magnetic field and the current.

[012] In one embodiment of the apparatus, the current is supplied to the one or more coils for the first time period that is determined based on the desired strength of the magnetic field and the current. The strength of the magnetic field increases until the current is switched off. In one embodiment, the current is switched off after a first time

period and is switched back on after a second time period. The direction of the current may be reversed when the current is switched back on. The frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction. In yet another embodiment of the apparatus, the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

[013] In some embodiments of the apparatus, the two coils are placed in parallel and the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil. In some embodiments, the first coil is placed perpendicular to the second coil and the currents running through the first and second coil are turned on and off alternately, i.e., phase-shifted by 180° relatively to each other. The currents in the first and second coils may be phase locked.

Brief Description of Figures

[014] FIG. 1 illustrates an exemplary power supply circuit configured to generate electromagnetic fields for triggering an exothermic reaction.

[015] FIGS. 2A and 2B illustrate an exemplary RL circuit and a current profile generated by the RL circuit.

[016] FIGS. 3A -5 illustrate exemplary current profiles generated by RL circuits.

[017] FIGS. 6A -6D illustrate different configurations of one or more electromagnetic circuits placed around a reactor.

[018] FIGS. 7A –[[7B]]<u>7C</u> illustrate examples of AC currents supplied to the electromagnetic circuits.

Detailed Description

[019] In referring to FIG. 1, a block diagram illustrating an exemplary electric circuit 100 that comprises a controller 102, an H-Bridge circuit 104, a coil 106, an optional resistor Rsense 108 and a power supply 110. The circuit 100 is configured to generate magnetic fields of desired magnitudes and/or polarities by controlling the current that runs through the coil 106. In some embodiments, the coil 106 is a piece of metal wire with inductance L and resistance R. The H-Bridge Circuit 104 is configured to apply a reversible and variable voltage across the coil to generate variable currents of reversible directions. The controller 102 controls the H-Bridge Circuit 104. The controller 102 can be configured or programmed to enable the H-Bridge Circuit 104 to apply suitable voltages over the coil 106. The voltage over the coil 106 induces a current across the coil 106. The current generates a magnetic field in the space surrounding the coil.

[020] It is known in previous studies that a magnetic field of a suitable strength and polarity can trigger certain types of exothermic reactions. However, those studies are preliminary and do not provide sufficient details on the circuit used to generate the magnetic field and on the exact configuration of the magnetic field that can trigger the exothermic reactions. The present disclosure teaches methods and apparatus that can be utilized to generate a suitable magnetic field, of which the magnitude and polarity inside the reactor is designed to trigger an exothermic reaction. Depending on the type of the exothermic reactions or reactors, the characteristics of the triggering magnetic field may differ and the current supplied to the coil 106 will vary accordingly. For example, the following factors may be taken into consideration in designing a magnetic field as triggering mechanism: the reaction materials used in the reaction, whether they are

ferromagnetic, for instance, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

[021] FIG. 2A illustrates a simplified circuit representation of the coil 106 and FIG. 2B depicts an exemplary current induced in the coil 106 by the circuit 100. In FIG. 2A, the coil 106 is represented by an ideal inductor 202 of inductance L and an ideal resistor 204 of resistance R. The voltage applied across the coil 106 is represented by the power source 206 of voltage V. The current in the coil 106 as a function of time is depicted in FIG. 2B. $\tau = \frac{L}{R}$ is a time scale that measures the rate at which the current in the coil 106 increases. When the voltage V is applied to the coil 106, the current ramps up and quickly reaches the maximum value $\frac{V}{R}$ within a time period of 3τ - 5τ. Parameter τ sets the limit on how fast the current induced in the coil 106 can change in response to the applied voltage V.

[022] FIG. 3A illustrates the current, i, induced in the coil 106 as a function of time in response to the voltage V applied across the coil 106 as shown in FIG. 3b. The voltage V is switched on and off periodically. It is switched on for a time period of t_1 and then switched off for a time period of t_2, …, and switched on for a time period of t_{2i-1} and switched off for a time period of t_{2i+1}. The current induced in the coil 106 in response to the applied voltage V is shown in FIG. 3A. The current ramps up and drops down in response to the switching on and off of the voltage. Because the voltage is switched off before 5τ, the voltage is switched off before the current could reach the maximum value $\frac{V}{R}$. During t_2, the current drops down to zero more precipitously.

[023] FIG. 4 illustrates another variable current as a function of time. In FIG. 4, the direction of the current is reversed each time the current is turned on. For example, the voltage across the coil 106 is applied during time period t_1 and is turned off during time period t_2. The voltage is turned on again during time period t_3 but the polarity is reversed. As a result, the current in the coil 106 is positive during time period t_1 and negative during time period t_3. The current becomes positive again during time period t_5 and so on and so forth. The direction of the current dictates the direction of the magnetic field generated by the current under the right hand rule. When the direction of the current in the coil 106 is reversed, the direction of the magnetic field is reversed. By programming the controller 102, the time periods, t_1, t_2, t_3…, can be adjusted to produce a desired magnetic field according to specification.

[024] In FIG. 3A and FIG. 4, during time period t_1, t_3, t_5…, the current in the coil 106 does not reach the maximum value, $\frac{V}{R}$, before it is switched off. FIG. 5 illustrates a variable current supplied to the coil 106 that reaches the maximum value $\frac{V}{R}$ within approximately 5τ and maintains the maximum value for an extended time before it is switched off. After it is switched off, the current drops down to zero within a time period of 5τ. The current is turned off during time period t_2 and is turned back on during time period t_3. During time period t_3, the current stays at the maximum value, $\frac{V}{R}$, for a majority portion of the duration. When the current reaches the maximum value, the magnitude of the magnetic field induced by the current reaches its maximum and the maximum magnetic field is maintained for the majority portion of the duration. In some embodiments, the magnetic field is used as a triggering mechanism of an exothermic reaction. The magnitude, the polarity and/or the variability of the magnetic field are

characteristics or parameters that should be carefully determined in accordance to the re requirements of the exothermic reaction or reactor. Based on the requirements, the controller 102 can be programmed to control the H-Bridge Circuit 104 to supply the current to the coil 106 according to specification.

[025] To produce a magnetic field of a desired magnitude or polarity, the current in the coil 106 can be adjusted as well as the placement of the coil or coils 106. FIGS. 6A – 6D illustrate different placements of one or more coils 106. In FIG. 6A, a coil 106 is wrapped around a reactor 600 longitudinally. The magnetic field $\overrightarrow{B_1}$ produced by the current in the coil 106 runs parallel to the $\vec{x}$ axis. FIG. 6B illustrates a coil 106 configured to generate a desired magnetic field $\overrightarrow{B_2}$ along the $\vec{y}$ axis. The coil 106 is placed on top of the reactor 600.

[026] To enhance the strength of a magnetic field produced by a coil, multiple coils arranged in parallel can be used as shown in FIG. 6C and FIG. 6D. In FIG. 6C, a large coil 112 is wrapped around a reactor 600 longitudinally. Two small coils 114 and 116 are placed in parallel with the large coil 112, one on top of the reactor 600 and one beneath the reactor 600. The magnetic fields generated by the three parallel coils, $\overrightarrow{B_3}$, $\overrightarrow{B_4}$, $\overrightarrow{B_5}$, run parallel to the $\vec{y}$ axis and enhance each other. The total magnetic field is the vector summation of the three magnetic fields.

[027] FIG. 6D shows another configuration of multiple coils so arranged to generate a magnetic field of a desired magnitude and polarity. Around the reactor 600, the coils 118 and 120 are placed horizontally on top of and horizontally beneath the reactor 600 respectively, while the coils 122 and 124 are placed vertically to the right and vertically to the left of the reactor 600 respectively. The coils 118 and 120 produce magnetic fields

$\overrightarrow{B_6}$ and $\overrightarrow{B_7}$ that run parallel to the $\vec{y}$ axis. These two magnetic fields, $\overrightarrow{B_6}$ and $\overrightarrow{B_7}$, enhance each other. The sum of these two fields is $\overrightarrow{B_y} = \overrightarrow{B_6} + \overrightarrow{B_7}$. Along the $\vec{x}$ axis, the two vertically placed coils, 122 and 124, generate a magnetic field respectively. The sum of these two fields is $\overrightarrow{B_x} = \overrightarrow{B_8} + \overrightarrow{B_9}$. The two magnetic fields, $\overrightarrow{B_x}$ and $\overrightarrow{B_y}$, combine to yield a resultant magnetic field $\vec{B} = \overrightarrow{B_x} + \overrightarrow{B_y}$. This resultant magnetic field is designed to trigger an exothermic reaction in the reactor 600 in accordance to the requirements of the exothermic reaction or the reactor 600.

[028] In yet another embodiment, a Helmholtz coil may be employed to generate a uniform magnetic field inside the reactor. The placement of the coil determines the orientation and polarity of the field. The Helmholtz coil is configured to generate a magnetic field of a desired magnitude to trigger an exothermic reaction.

[029] In the above description of FIGS. 6A -6D, the current supplied to the coils 106 is assumed to be the same, for the convenience of illustration. In some embodiments, the current supplied to the coils 106 may be different, depending on the desired strength, polarity and/or orientation of the magnetic field. For instance, in FIG. 6D, when the current supplied to the coil 118 and 120 is twice as large as the current supplied to the coil 122 and 124, the magnetic field $\overrightarrow{B_y}$ is twice as large as the magnetic field $\overrightarrow{B_x}$, yielding a resultant magnetic field $\vec{B}$ of a different orientation and magnitude.

[030] In the above description of FIGS. 6A – 6D, the magnetic fields generated by the coils 106 are static when the current supplied to various coils are DC. With AC currents, the generated magnetic fields are variable. The frequencies with which the magnetic fields shift directions and/or vary in magnitude are determined by the frequency of the AC currents. For example, an AC current of 50 Hz supplied to the coil 106 in FIG. 6A

will produce a sinusoidal magnetic field $\vec{B}$. The direction of the magnetic field $\vec{B}$ oscillates along the $\vec{x}$ axis at a frequency of 50 Hz.

[031] In some embodiments, the AC currents supplied to the different coils are phase-shifted relatively to each other. For example, in FIG. 6C, the AC current supplied to the coil 114 and 116, I_1, is 180° shifted from the AC current supplied to the coil 112, I_2, as shown in FIG. 7A. In one embodiment, the two AC currents are phase-locked to create a steadily oscillating magnetic field of the same frequency as the AC currents.

[032] In some embodiments, the currents supplied to the different coils may be phase-shifted relatively to each other and may be of different amplitudes. For example, as illustrated in FIG. 7B, the current supplied to the coil 114 and 116, I_1, and the current supplied to the coil 112, I_2, are phase-shifted 180° relatively to each other. Besides the difference in phase, the two currents, I_1 and I_2, also differ in amplitude. As a result, the resultant magnetic field differs from that shown in FIG. 7A, because the magnetic field generated by a current carrying coil is proportional to the amplitude of the current according to Ampere's law.

[033] In FIGS. 7A and 7B, two-phase currents are used to generate a desired magnetic field as a triggering mechanism of an exothermic reaction in the reactor 600. Multi-phase currents, e.g., currents supplied by a three-phase circuit, can be used to generate a rotating magnetic field. FIG. [[7c]]7C shows a balanced three phase currents, I_1, I_2, and I_3. All three currents are of the same amplitude but each is 120° shifted from the next one. The magnetic field generated by the currents can be expressed as $\vec{B}(\sin \alpha t + \sin(\alpha t + 120) + \sin(\alpha t + 240))$ and is a rotating magnetic field.

[034] In some embodiments, a static magnetic field generated by a DC current supplied to the coil 106 shown in FIG. 6A can be used to trigger certain types of exothermic reactions in the reactor 600. The magnitude and/or the polarity of the magnetic field can be controlled by the current and the placement of the coil 106, in accordance to the requirements of the exothermic reaction.

[035] In some embodiments, an oscillating magnetic field generated by the AC current supplied to the coils 118, 120, 122, and 124 can be used to trigger a certain type of exothermic reactions. In some embodiments, a rotating magnetic field generated by a balanced three-phase current system supplied to the coils 112, 114, and 116 can be used as triggering mechanism.

[036] The present invention may be carried out in other specific ways than those herein set forth without departing from the scope and essential characteristics of the invention. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

Claims

What is claimed is:

1. A method for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction, the exothermic reactor comprising a vessel and one or more reaction materials, the reactor maintaining a pressure and a temperature and being surrounded by one or more coils, the method comprising:

    supplying a current to the one or more coils, wherein the strength of the current is determined based on a desired characteristic of the magnetic field; and

    switching off the current after a first time period;

    wherein the desired characteristic of the magnetic field and the first time period are determined to trigger the exothermic reaction and wherein the desired characteristic of the magnetic field and the first time period are dependent on the type of the exothermic reactor.

2. The method of claim 1, wherein the desired characteristic of the magnetic field is a desired strength of the magnetic field or a desired polarity of the magnetic field.

3. The method of claim 2, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field increases until the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

4. The method of claim 2, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field reaches the maximum when the current reaches the maximum before the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

5. The method of claim 1, further comprising supplying the current to the one or more coils after a second time period.

6. The method of claim 5, wherein the direction of the current is reversed.

7. The method of claim 5, wherein the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

8. The method of claim 6, wherein the frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction.

9. The method of claim 1, wherein a first coil of the one or more coils is parallel to a second coil of the one or more coils, and wherein the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil.

10. The method of claim 1, wherein a first coil of the one or more coils is perpendicular to a second coil of the one or more coils, and wherein a current running through the first coil and a current running through the second coil are turned on and off alternately.

11. The method of claim 10, wherein the current in the first coil and the current in the second coil are phase locked.

12. The method of claim 1, wherein the desired characteristic of the magnetic field and the first time period further depend on one or more of the following factors: the one or more reaction materials, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

13. An apparatus for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction, the exothermic reactor comprising a vessel, one or more

reaction materials, the exothermic reactor maintaining a temperature and a pressure, said apparatus comprising:

one or more coils positioned in the surround of the exothermic reactor;

one or more power supplies for supplying one or more currents to the one or more coils;

wherein the one or more power supplies are configured to:

supply the currents to the one or more coils, wherein the strength of each of the currents is determined based on a desired characteristic of the magnetic field; and

switch off the currents after a first time period;

wherein the desired characteristic of the magnetic field and the first time period are determined to trigger the exothermic reaction and wherein the desired characteristic of the magnetic field and the first time period are dependent on the type of the exothermic reactor.

14. The apparatus of claim 13, wherein the desired characteristic of the magnetic field is a desired strength of the magnetic field or a desired polarity of the magnetic field.

15. The apparatus of claim 14, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field increases until the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

16. The apparatus of claim 14, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field reaches the maximum when the current reaches the maximum before the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

17. The apparatus of claim 13, further comprising supplying the current to the one or more coils after a second time period.

18. The apparatus of claim 17, wherein the direction of the current is reversed.

19. The apparatus of claim 17, wherein the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

20. The apparatus of claim 18, wherein the frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction.

21. The apparatus of claim 13, wherein a first coil of the one or more coils is parallel to a second coil of the one or more coils, and wherein the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil.

22. The apparatus of claim 13, wherein a first coil of the one or more coils is perpendicular to a second coil of the one or more coils, and wherein a current running through the first coil and a current running through the second coil are turned on and off alternately.

23. The apparatus of claim 22, wherein the current running through the first coil and the current running through the second coil are phase locked.

24. The apparatus of claim 14, wherein the desired characteristic of the magnetic field and the first time period further depends on one or more of the following factors: the one or more reaction materials, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

Abstract

Methods and apparatus are disclosed for generating an electromagnetic field inside a reactor to trigger an exothermic reaction. The design and implementation of the electromagnetics are based on the requirements of a particular exothermic reaction or reactor. For example, the triggering mechanism of a particular exothermic reaction or reactor may require a magnetic field with a specific magnitude, polarity, and/or orientation.

Electronic Acknowledgement Receipt

EFS ID:	38923399
Application Number:	16783497
International Application Number:	
Confirmation Number:	4990
Title of Invention:	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS
First Named Inventor/Applicant Name:	Joseph A. Murray
Customer Number:	76934
Filer:	Justin Robert Nifong/Donna Donovan
Filer Authorized By:	Justin Robert Nifong
Attorney Docket Number:	438/32/2 UTIL
Receipt Date:	20-MAR-2020
Filing Date:	06-FEB-2020
Time Stamp:	12:11:36
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	Applicant Response to Pre-Exam Formalities Notice	438-32-2UTIL-20200320-Resp-to-NTFCAP-dated-20200312.pdf	20764 b892f2a08a1666b8a5b5b75227051a77ce29de4b	no	2

Warnings:

Information:					
2	Specification	438-32-2UTIL-20200320-Marked-Up-Specification.pdf	95370 db67744c9ff8d3d45ddc94ea47f26111ab10ce11	no	17
Warnings:					
Information:					
3	Specification	438-32-2UTIL-20200320-Clean-Specification.pdf	94950 e32e228de3c66165b705e549104dfa499103fb11	no	17
Warnings:					
Information:					
		Total Files Size (in bytes):	211084		

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.

Methods and Apparatus for Triggering Exothermic Reactions Using AC or DC Electromagnetics

Cross-Reference to Related Applications

[001] This application is a continuation of International Application No. PCT/US18/45305, filed on August 6, 2018, entitled "METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS", which claims priority to U.S. Provisional Patent Application No. 62/542,022 filed on August 7, 2017, entitled "METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS", the entire contents of which are incorporated by reference herein.

Technical field

[002] The present disclosure relates generally to how to trigger an exothermic reaction, and more specifically, to triggering an exothermic reaction using AC or DC electromagnetics.

Background

[003] Exothermic reactions involving metal hydrides, such as palladium hydride or nickel hydride, have been observed and documented on many occasions. However, reproducibility of these exothermic reactions has been a noted problem. Scientists and engineers have tried to determine the exact conditions under which those exothermic reactions can be triggered and sustained. Yet, many issues remain unresolved and many questions are still waiting to be answered.

[004] For example, studies of past reported exothermic reactions show that the amount of deuterium loaded in the palladium hydride or nickel hydride is critical in one type of exothermic reactions in which low energy nuclear reactions involving deuterium atoms take place inside the palladium lattice. However, the threshold atom ratio of loaded deuterium to palladium is still in debate and largely speculative. For another example, the exact nature of these exothermic reactions needs to be verified and confirmed. To that end, precise calibration and heat measurements are required in these heat generation experiments. However, it appears that the above-noted problems that have been plaguing this technological field stem from the reproducibility of these exothermic reactions. Reliable triggering mechanisms are needed ab initio before many questions in this field can be answered.

[005] The present disclosure teaches advantageous methods and apparatus for triggering an exothermic reaction.

Summary

[006] The present disclosure relates to how to trigger an exothermic reaction.

[007] In some embodiments, a method for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction is disclosed. The exothermic reactor comprises a vessel and one or more reaction materials. The reactor maintains a pressure and a temperature and is surrounded by one or more coils. The method comprises supplying a current to the one or more coils. The strength of the current is determined based on a desired characteristic of the magnetic field. The method further comprises switching off the current after a first time period. The magnetic field is designed to trigger the

exothermic reaction. The first time period is also selected so that it is conducive to triggering the exothermic reaction. The pre-determined magnetic field and the selected time period are dependent on the type of the exothermic reactor or reaction. In one embodiment, the desired characteristic of the magnetic field and the first time period depend on one or more of the following factors: the reaction materials, the temperature, the pressure, the substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

[008] In one embodiment, both the magnitude and the polarity of the magnetic field are pre-determined for triggering an exothermic reaction. For example, the current is supplied to the one or more coils and the current induces a magnetic field. The strength of the current is 20A. In some other embodiments, the current typically ranges from 100 mA to 60A. The magnitude of the magnetic field increases until the current is switched off after the first time period. The first time period is calculated based on a desired magnitude of the magnetic field and the current.

[009] In one embodiment, the current is supplied to the one or more coils for the first time period. The first time period is determined based on the desired strength of the magnetic field and the current. The strength of the magnetic field increases until the current is switched off. In one embodiment, the current is switched off after a first time period and is switched on after a second time period. The direction of the current may be reversed when the current is turned on again. The frequency at which the direction of the current is reversed is determined so at to trigger the exothermic reaction. In yet another embodiment, the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

[010] In some embodiments, the two coils are placed in parallel and the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil. In some embodiments, the first coil is placed perpendicular to the second coil and the currents running through the first and second coil are turned on and off alternately, i.e., phase-shifted by 180° relatively to each other. The currents in the first and second coils may be phase locked.

[011] The present disclosure also discloses an apparatus for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction. The exothermic reactor comprises a vessel and one or more reaction materials. The reactor maintains a temperature and a pressure. The apparatus comprises one or more coils and one or more power supplies for supplying a current to the one or more coils. The power supplies are configured to supply the current to the one or more coils and switch off the current after a first time period. In one embodiment, both the magnitude and the polarity of the magnetic field are pre-determined for triggering an exothermic reaction. For example, the current is supplied to the one or more coils and the current induces a magnetic field. The strength of the current is 20A. In some other embodiments, the current typically ranges from 100mA to 60A. The magnitude of the magnetic field increases until the current is switched off after the first time period. The first time period is calculated based on a desired magnitude of the magnetic field and the current.

[012] In one embodiment of the apparatus, the current is supplied to the one or more coils for the first time period that is determined based on the desired strength of the magnetic field and the current. The strength of the magnetic field increases until the current is switched off. In one embodiment, the current is switched off after a first time

period and is switched back on after a second time period. The direction of the current may be reversed when the current is switched back on. The frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction. In yet another embodiment of the apparatus, the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

[013] In some embodiments of the apparatus, the two coils are placed in parallel and the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil. In some embodiments, the first coil is placed perpendicular to the second coil and the currents running through the first and second coil are turned on and off alternately, i.e., phase-shifted by 180° relatively to each other. The currents in the first and second coils may be phase locked.

Brief Description of Figures

[014] FIG. 1 illustrates an exemplary power supply circuit configured to generate electromagnetic fields for triggering an exothermic reaction.

[015] FIGS. 2A and 2B illustrate an exemplary RL circuit and a current profile generated by the RL circuit.

[016] FIGS. 3A -5 illustrate exemplary current profiles generated by RL circuits.

[017] FIGS. 6A -6D illustrate different configurations of one or more electromagnetic circuits placed around a reactor.

[018] FIGS. 7A -7C illustrate examples of AC currents supplied to the electromagnetic circuits.

Detailed Description

[019] In referring to FIG. 1, a block diagram illustrating an exemplary electric circuit 100 that comprises a controller 102, an H-Bridge circuit 104, a coil 106, an optional resistor Rsense 108 and a power supply 110. The circuit 100 is configured to generate magnetic fields of desired magnitudes and/or polarities by controlling the current that runs through the coil 106. In some embodiments, the coil 106 is a piece of metal wire with inductance L and resistance R. The H-Bridge Circuit 104 is configured to apply a reversible and variable voltage across the coil to generate variable currents of reversible directions. The controller 102 controls the H-Bridge Circuit 104. The controller 102 can be configured or programmed to enable the H-Bridge Circuit 104 to apply suitable voltages over the coil 106. The voltage over the coil 106 induces a current across the coil 106. The current generates a magnetic field in the space surrounding the coil.

[020] It is known in previous studies that a magnetic field of a suitable strength and polarity can trigger certain types of exothermic reactions. However, those studies are preliminary and do not provide sufficient details on the circuit used to generate the magnetic field and on the exact configuration of the magnetic field that can trigger the exothermic reactions. The present disclosure teaches methods and apparatus that can be utilized to generate a suitable magnetic field, of which the magnitude and polarity inside the reactor is designed to trigger an exothermic reaction. Depending on the type of the exothermic reactions or reactors, the characteristics of the triggering magnetic field may differ and the current supplied to the coil 106 will vary accordingly. For example, the following factors may be taken into consideration in designing a magnetic field as triggering mechanism: the reaction materials used in the reaction, whether they are

ferromagnetic, for instance, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

[021] FIG. 2A illustrates a simplified circuit representation of the coil 106 and FIG. 2B depicts an exemplary current induced in the coil 106 by the circuit 100. In FIG. 2A, the coil 106 is represented by an ideal inductor 202 of inductance L and an ideal resistor 204 of resistance R. The voltage applied across the coil 106 is represented by the power source 206 of voltage V. The current in the coil 106 as a function of time is depicted in FIG. 2B. $\tau = \frac{L}{R}$ is a time scale that measures the rate at which the current in the coil 106 increases. When the voltage V is applied to the coil 106, the current ramps up and quickly reaches the maximum value $\frac{V}{R}$ within a time period of 3τ - 5τ. Parameter τ sets the limit on how fast the current induced in the coil 106 can change in response to the applied voltage V.

[022] FIG. 3A illustrates the current, i, induced in the coil 106 as a function of time in response to the voltage V applied across the coil 106 as shown in FIG. 3b. The voltage V is switched on and off periodically. It is switched on for a time period of t_1 and then switched off for a time period of t_2, …, and switched on for a time period of t_{2i-1} and switched off for a time period of t_{2i+1}. The current induced in the coil 106 in response to the applied voltage V is shown in FIG. 3A. The current ramps up and drops down in response to the switching on and off of the voltage. Because the voltage is switched off before 5τ, the voltage is switched off before the current could reach the maximum value $\frac{V}{R}$. During t_2, the current drops down to zero more precipitously.

[023] FIG. 4 illustrates another variable current as a function of time. In FIG. 4, the direction of the current is reversed each time the current is turned on. For example, the voltage across the coil 106 is applied during time period t_1 and is turned off during time period t_2. The voltage is turned on again during time period t_3 but the polarity is reversed. As a result, the current in the coil 106 is positive during time period t_1 and negative during time period t_3. The current becomes positive again during time period t_5 and so on and so forth. The direction of the current dictates the direction of the magnetic field generated by the current under the right hand rule. When the direction of the current in the coil 106 is reversed, the direction of the magnetic field is reversed. By programming the controller 102, the time periods, t_1, t_2, t_3…, can be adjusted to produce a desired magnetic field according to specification.

[024] In FIG. 3A and FIG. 4, during time period t_1, t_3, t_5…, the current in the coil 106 does not reach the maximum value, $\frac{V}{R}$, before it is switched off. FIG. 5 illustrates a variable current supplied to the coil 106 that reaches the maximum value $\frac{V}{R}$ within approximately 5τ and maintains the maximum value for an extended time before it is switched off. After it is switched off, the current drops down to zero within a time period of 5τ. The current is turned off during time period t_2 and is turned back on during time period t_3. During time period t_3, the current stays at the maximum value, $\frac{V}{R}$, for a majority portion of the duration. When the current reaches the maximum value, the magnitude of the magnetic field induced by the current reaches its maximum and the maximum magnetic field is maintained for the majority portion of the duration. In some embodiments, the magnetic field is used as a triggering mechanism of an exothermic reaction. The magnitude, the polarity and/or the variability of the magnetic field are

characteristics or parameters that should be carefully determined in accordance to the re requirements of the exothermic reaction or reactor. Based on the requirements, the controller 102 can be programmed to control the H-Bridge Circuit 104 to supply the current to the coil 106 according to specification.

[025] To produce a magnetic field of a desired magnitude or polarity, the current in the coil 106 can be adjusted as well as the placement of the coil or coils 106. FIGS. 6A – 6D illustrate different placements of one or more coils 106. In FIG. 6A, a coil 106 is wrapped around a reactor 600 longitudinally. The magnetic field $\overrightarrow{B_1}$ produced by the current in the coil 106 runs parallel to the $\vec{x}$ axis. FIG. 6B illustrates a coil 106 configured to generate a desired magnetic field $\overrightarrow{B_2}$ along the $\vec{y}$ axis. The coil 106 is placed on top of the reactor 600.

[026] To enhance the strength of a magnetic field produced by a coil, multiple coils arranged in parallel can be used as shown in FIG. 6C and FIG. 6D. In FIG. 6C, a large coil 112 is wrapped around a reactor 600 longitudinally. Two small coils 114 and 116 are placed in parallel with the large coil 112, one on top of the reactor 600 and one beneath the reactor 600. The magnetic fields generated by the three parallel coils, $\overrightarrow{B_3}$, $\overrightarrow{B_4}$, $\overrightarrow{B_5}$, run parallel to the $\vec{y}$ axis and enhance each other. The total magnetic field is the vector summation of the three magnetic fields.

[027] FIG. 6D shows another configuration of multiple coils so arranged to generate a magnetic field of a desired magnitude and polarity. Around the reactor 600, the coils 118 and 120 are placed horizontally on top of and horizontally beneath the reactor 600 respectively, while the coils 122 and 124 are placed vertically to the right and vertically to the left of the reactor 600 respectively. The coils 118 and 120 produce magnetic fields

$\overrightarrow{B_6}$ and $\overrightarrow{B_7}$ that run parallel to the $\vec{y}$ axis. These two magnetic fields, $\overrightarrow{B_6}$ and $\overrightarrow{B_7}$, enhance each other. The sum of these two fields is $\overrightarrow{B_y} = \overrightarrow{B_6} + \overrightarrow{B_7}$. Along the $\vec{x}$ axis, the two vertically placed coils, 122 and 124, generate a magnetic field respectively. The sum of these two fields is $\overrightarrow{B_x} = \overrightarrow{B_8} + \overrightarrow{B_9}$. The two magnetic fields, $\overrightarrow{B_x}$ and $\overrightarrow{B_y}$, combine to yield a resultant magnetic field $\vec{B} = \overrightarrow{B_x} + \overrightarrow{B_y}$. This resultant magnetic field is designed to trigger an exothermic reaction in the reactor 600 in accordance to the requirements of the exothermic reaction or the reactor 600.

[028] In yet another embodiment, a Helmholtz coil may be employed to generate a uniform magnetic field inside the reactor. The placement of the coil determines the orientation and polarity of the field. The Helmholtz coil is configured to generate a magnetic field of a desired magnitude to trigger an exothermic reaction.

[029] In the above description of FIGS. 6A -6D, the current supplied to the coils 106 is assumed to be the same, for the convenience of illustration. In some embodiments, the current supplied to the coils 106 may be different, depending on the desired strength, polarity and/or orientation of the magnetic field. For instance, in FIG. 6D, when the current supplied to the coil 118 and 120 is twice as large as the current supplied to the coil 122 and 124, the magnetic field $\overrightarrow{B_y}$ is twice as large as the magnetic field $\overrightarrow{B_x}$, yielding a resultant magnetic field $\vec{B}$ of a different orientation and magnitude.

[030] In the above description of FIGS. 6A – 6D, the magnetic fields generated by the coils 106 are static when the current supplied to various coils are DC. With AC currents, the generated magnetic fields are variable. The frequencies with which the magnetic fields shift directions and/or vary in magnitude are determined by the frequency of the AC currents. For example, an AC current of 50 Hz supplied to the coil 106 in FIG. 6A

will produce a sinusoidal magnetic field $\vec{B}$. The direction of the magnetic field $\vec{B}$ oscillates along the $\vec{x}$ axis at a frequency of 50 Hz.

[031] In some embodiments, the AC currents supplied to the different coils are phase-shifted relatively to each other. For example, in FIG. 6C, the AC current supplied to the coil 114 and 116, I_1, is 180° shifted from the AC current supplied to the coil 112, I_2, as shown in FIG. 7A. In one embodiment, the two AC currents are phase-locked to create a steadily oscillating magnetic field of the same frequency as the AC currents.

[032] In some embodiments, the currents supplied to the different coils may be phase-shifted relatively to each other and may be of different amplitudes. For example, as illustrated in FIG. 7B, the current supplied to the coil 114 and 116, I_1, and the current supplied to the coil 112, I_2, are phase-shifted 180° relatively to each other. Besides the difference in phase, the two currents, I_1 and I_2, also differ in amplitude. As a result, the resultant magnetic field differs from that shown in FIG. 7A, because the magnetic field generated by a current carrying coil is proportional to the amplitude of the current according to Ampere's law.

[033] In FIGS. 7A and 7B, two-phase currents are used to generate a desired magnetic field as a triggering mechanism of an exothermic reaction in the reactor 600. Multi-phase currents, e.g., currents supplied by a three-phase circuit, can be used to generate a rotating magnetic field. FIG. 7C shows a balanced three phase currents, I_1, I_2, and I_3. All three currents are of the same amplitude but each is 120° shifted from the next one. The magnetic field generated by the currents can be expressed as $\vec{B}(\sin\alpha t + \sin(\alpha t + 120) + \sin(\alpha t + 240))$ and is a rotating magnetic field.

[034] In some embodiments, a static magnetic field generated by a DC current supplied to the coil 106 shown in FIG. 6A can be used to trigger certain types of exothermic reactions in the reactor 600. The magnitude and/or the polarity of the magnetic field can be controlled by the current and the placement of the coil 106, in accordance to the requirements of the exothermic reaction.

[035] In some embodiments, an oscillating magnetic field generated by the AC current supplied to the coils 118, 120, 122, and 124 can be used to trigger a certain type of exothermic reactions. In some embodiments, a rotating magnetic field generated by a balanced three-phase current system supplied to the coils 112, 114, and 116 can be used as triggering mechanism.

[036] The present invention may be carried out in other specific ways than those herein set forth without departing from the scope and essential characteristics of the invention. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

Claims

What is claimed is:

1. A method for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction, the exothermic reactor comprising a vessel and one or more reaction materials, the reactor maintaining a pressure and a temperature and being surrounded by one or more coils, the method comprising:

    supplying a current to the one or more coils, wherein the strength of the current is determined based on a desired characteristic of the magnetic field; and

    switching off the current after a first time period;

    wherein the desired characteristic of the magnetic field and the first time period are determined to trigger the exothermic reaction and wherein the desired characteristic of the magnetic field and the first time period are dependent on the type of the exothermic reactor.

2. The method of claim 1, wherein the desired characteristic of the magnetic field is a desired strength of the magnetic field or a desired polarity of the magnetic field.

3. The method of claim 2, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field increases until the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

4. The method of claim 2, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field reaches the maximum when the current reaches the maximum before the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

5. The method of claim 1, further comprising supplying the current to the one or more coils after a second time period.

6. The method of claim 5, wherein the direction of the current is reversed.

7. The method of claim 5, wherein the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

8. The method of claim 6, wherein the frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction.

9. The method of claim 1, wherein a first coil of the one or more coils is parallel to a second coil of the one or more coils, and wherein the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil.

10. The method of claim 1, wherein a first coil of the one or more coils is perpendicular to a second coil of the one or more coils, and wherein a current running through the first coil and a current running through the second coil are turned on and off alternately.

11. The method of claim 10, wherein the current in the first coil and the current in the second coil are phase locked.

12. The method of claim 1, wherein the desired characteristic of the magnetic field and the first time period further depend on one or more of the following factors: the one or more reaction materials, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

13. An apparatus for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction, the exothermic reactor comprising a vessel, one or more

reaction materials, the exothermic reactor maintaining a temperature and a pressure, said apparatus comprising:

one or more coils positioned in the surround of the exothermic reactor;

one or more power supplies for supplying one or more currents to the one or more coils;

wherein the one or more power supplies are configured to:

supply the currents to the one or more coils, wherein the strength of each of the currents is determined based on a desired characteristic of the magnetic field; and

switch off the currents after a first time period;

wherein the desired characteristic of the magnetic field and the first time period are determined to trigger the exothermic reaction and wherein the desired characteristic of the magnetic field and the first time period are dependent on the type of the exothermic reactor.

14. The apparatus of claim 13, wherein the desired characteristic of the magnetic field is a desired strength of the magnetic field or a desired polarity of the magnetic field.

15. The apparatus of claim 14, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field increases until the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

16. The apparatus of claim 14, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field reaches the maximum when the current reaches the maximum before the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

17. The apparatus of claim 13, further comprising supplying the current to the one or more coils after a second time period.

18. The apparatus of claim 17, wherein the direction of the current is reversed.

19. The apparatus of claim 17, wherein the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

20. The apparatus of claim 18, wherein the frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction.

21. The apparatus of claim 13, wherein a first coil of the one or more coils is parallel to a second coil of the one or more coils, and wherein the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil.

22. The apparatus of claim 13, wherein a first coil of the one or more coils is perpendicular to a second coil of the one or more coils, and wherein a current running through the first coil and a current running through the second coil are turned on and off alternately.

23. The apparatus of claim 22, wherein the current running through the first coil and the current running through the second coil are phase locked.

24. The apparatus of claim 14, wherein the desired characteristic of the magnetic field and the first time period further depends on one or more of the following factors: the one or more reaction materials, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

Abstract

Methods and apparatus are disclosed for generating an electromagnetic field inside a reactor to trigger an exothermic reaction. The design and implementation of the electromagnetics are based on the requirements of a particular exothermic reaction or reactor. For example, the triggering mechanism of a particular exothermic reaction or reactor may require a magnetic field with a specific magnitude, polarity, and/or orientation.

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
16/783,497	02/06/2020	3761	1065	438/32/2 UTIL	24	2

CONFIRMATION NO. 4990

FILING RECEIPT

OC000000115312686

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

Date Mailed: 03/11/2020

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)

Joseph A. Murray, Raleigh, NC;
Julie A. Morris, Flower Mound, TX;
Tushar Tank, Raleigh, NC;

Applicant(s)

IH IP Holdings Limited, St. Helier, JERSEY

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of PCT/US18/45305 08/06/2018
which claims benefit of 62/542,022 08/07/2017

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.

Projected Publication Date: To Be Determined - pending completion of Corrected Papers

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS

Preliminary Class

219

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

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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

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

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

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

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

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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

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

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

NOT GRANTED

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

SelectUSA

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

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 16/783,497

APPLICATION AS FILED - PART I

FOR	NUMBER FILED (Column 1)		NUMBER EXTRA (Column 2)	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))	24	minus 20 =	* 4	x 50 =	200	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			
				TOTAL	985		TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
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	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
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.

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
16/783,497	02/06/2020	Joseph A. Murray	438/32/2 UTIL

CONFIRMATION NO. 4990

FORMALITIES LETTER

OC000000115312687

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

Date Mailed: 03/11/2020

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:

- Replacement drawings in compliance with 37 CFR 1.84 and 37 CFR 1.121(d) are required. The drawings submitted are not acceptable because:
  - The application contains a section in the specification containing the brief description of the figures, but is missing the description of Figure(s) **7C** as required by 37 CFR 1.74 and 37 CFR 1.77(b)(9). A brief description of each drawing figure presented is required to satisfy this requirement.
    - To add a brief description of a figure, a proper substitute specification in compliance with 37 CFR 1.121(b)(3) and 1.125, providing a brief description of each drawing figure presented, must be submitted. See also 37 CFR 1.77(b)(9).

  Note: If applicant wishes to delete the undescribed figure, replacement sheets must be submitted to renumber the figure(s) consecutively.

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.

Items Required To Avoid Processing Delays:

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):

  Joseph A. Murray
  Julie A. Morris
  Tushar Tank

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:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

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**.

/fhadera/

____

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

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	16783497
	Filing Date	2020-02-06
	First Named Inventor	Joseph A. Murray
	Art Unit	-
	Examiner Name	-
	Attorney Docket Number	438/32/2 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
	1					

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

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]
	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		16783497
	Filing Date		2020-02-06
	First Named Inventor	Joseph A. Murray	
	Art Unit		-
	Examiner Name	-	
	Attorney Docket Number		438/32/2 UTIL

	1	PCT, International Preliminary Report on Patentability in International Application No. PCT/US2018/045305 dated 11 February 2020	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*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	16783497
	Filing Date	2020-02-06
	First Named Inventor	Joseph A. Murray
	Art Unit	-
	Examiner Name	-
	Attorney Docket Number	438/32/2 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)	2020-02-24
Name/Print	Justin R. Nifong	Registration Number	59389

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 PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference 438/32/2 PCT	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2018/045305	International filing date *(day/month/year)* 06 August 2018 (06.08.2018)	Priority date *(day/month/year)* 07 August 2017 (07.08.2017)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant IH IP HOLDINGS LIMITED		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

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

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 11 February 2020 (11.02.2020)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Xiaofan Tang e-mail: pct.team2@wipo.int

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
NIFONG, Justin R.

NK Patent Law, PLLC 4917 Waters Edge Drive, Suite 275
Raleigh, NC 27606 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing (*day/month/year*) **03 January 2019 (03.01.2019)**

Applicant's or agent's file reference
438/32/2 PCT

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date (*day/month/year*)	Priority date(*day/month/year*)
PCT/US2018/045305	**06 August 2018 (06.08.2018)**	07 August 2017 (07.08.2017)

International Patent Classification (IPC) or both national classification and IPC

B01J 8/02(2006.01)i, B01J 8/42(2006.01)i

Applicant
IH IP HOLDINGS LIMITED et al.

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 43bis.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 66.1bis(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/KR	Date of completion of this opinion	Authorized officer
International Application Division Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	03 January 2019 (03.01.2019)	MIN, In Gyou Telephone No. +82-42-481-3326

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2018/045305

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established 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))

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:

   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 forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

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

1. Statement

Novelty (N)	Claims	1-24	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-24	NO
Industrial applicability (IA)	Claims	1-24	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1 : US 5958273 A (KOCH, THEODORE A. et al.) 28 September 1999
D2 : US 5822669 A (OKABAYASHI, EIJI et al.) 13 October 1998
D3 : US 2017-0094726 A1 (ULTIMAKER B.V.) 30 March 2017

1. Novelty and Inventive Step

1.1. Claims 1-24

1.1.1. Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a method of using an induction heated reactor such as a fluid phase reaction apparatus for producing a chemical product from a reaction that at least initially requires heat-input, the fluid phase reaction apparatus comprising: A) an external reactor casing to contain reactants; B) a tubular induction heating coil positioned within said external casing; C) a first electrically non-conductive annular partition positioned within said induction heating coil; D) said first electrically non-conductive partition defining a reaction zone, said reaction zone being a region of high alternating magnetic field intensity within said induction heating coil and said reaction zone being in communication with said inlet port to receive fluid reactants and in communication with said outlet port to discharge fluids; and E) a source of alternating current electrical power connected to said induction heating coil for creating said region of high intensity alternating magnetic field in the reaction zone by alternating magnetic induction (see claim 3 in D1).

The subject matter of claim 1 differs from D1 in that the strength of a current is determined

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Box No. V

based on a desired characteristic of a magnetic field. However, the difference can be easily derived by repeated experiments practiced by a person skilled in the art, and no unexpected effect has been achieved compared to D1. Accordingly, claim 1 would have been obvious to a person skilled in the art from D1. Therefore, claim 1 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.1.2. Claim 9

Concerning the additional feature of claim 9, D1 discloses that as a current flows through this coil a magnetic field is created, wherein the magnetic field is substantially uniform within the coil and is directed substantially parallel to the axis of the coil (see column 1, lines 39-42 in D1).

Accordingly, claim 9 would have been obvious to a person skilled in the art from D1. Therefore, claim 9 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.1.3. Claims 2-8, 12

Concerning the additional features of claims 2-8 and 12, D1 discloses the alternating current (see claim 3 in D1). And D2, in the same technical field as D1, relates to a method of using an induction heat fusing device. As D2 discloses that as the size of the core increases, the magnetic field strength increases, even though the number of windings remains the same; basically, the switch-off time is determined by the voltage detection circuit; and by repeating this switching cycle, a high-frequency electrical current flows to the induction heating coil (43) (see column 4, lines 30-32; column 9, lines 60-62 in D2). Claims 3 and 4 differ from D1 and D2 in that the strength of the magnetic field increases or reaches the maximum until the current is switched off. However, the difference is merely one of several straightforward possibilities from which a person skilled in the art would select, in accordance with circumstances, without the exercise of inventive skill. The present invention and the prior art documents D1 and D2 relate to a method for inducing a magnetic field in an exothermic reactor. As those inventions are in the same technical field, a person skilled in the art would have easily combined D2 with D1.

Accordingly, claims 2-8 and 12 would have been obvious to a person skilled in the art from D1 and D2. Therefore, claims 2-8 and 12 are novel under PCT Article 33(2) but lack an

Continued on The Next Page

Supplemental Box

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

inventive step according to the combination of D1 and D2 under PCT Article 33(3).

1.1.4. Claims 10, 11

The additional feature of claim 10 is not explicitly disclosed in D1. However, D3, in the same technical field as D1, relates to a method of heating an inductive nozzle heating assembly. As D3 discloses that a device further comprises one or more sources of high frequency alternating current connected to the one or more coils such as a folded inductive coil member and a perpendicular positioned inductive coil member (see paragraphs [0002], [0016], [0017]; and figures 5, 6 in D3), the feature can be easily derived by a person skilled in the art from D3. The present invention and the prior art documents D1 and D3 relate to a method for inducing a magnetic field in an exothermic reactor. As those inventions are in the same technical field, a person skilled in the art would have easily combined D3 with D1.

The additional feature of claim 11 is not explicitly disclosed in D1 or D3. However, the currents phase locked in the first coil and the second coil are merely one of several straightforward possibilities from which a person skilled in the art would select, in accordance with circumstances, without the exercise of inventive skill.

Accordingly, claims 10 and 11 would have been obvious to a person skilled in the art from D1 and D3. Therefore, claims 10 and 11 are novel under PCT Article 33(2) but lack an inventive step according to the combination of D1 and D3 under PCT Article 33(3).

1.1.5. Claim 13

D1 discloses a fluid phase reaction apparatus for producing a chemical product from a reaction that at least initially requires heat-input comprising: A) an external reactor casing to contain reactants; B) a tubular induction heating coil positioned within said external casing; C) a first electrically non-conductive annular partition positioned within said induction heating coil; D) said first electrically non-conductive partition defining a reaction zone, said reaction zone being a region of high alternating magnetic field intensity within said induction heating coil and said reaction zone being in communication with said inlet port to receive fluid reactants and in communication with said outlet port to discharge fluids; and E) a source of alternating current electrical power connected to said induction heating coil for creating said region of high intensity alternating magnetic field in the reaction zone by alternating magnetic induction (see claim 3 in D1).

Continued on The Next Page

Supplemental Box

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

The subject matter of claim 13 differs from D1 in that the strength of a current is determined based on a desired characteristic of a magnetic field. However, the difference can be easily derived by repeated experiments practiced by a person skilled in the art, and no unexpected effect has been achieved compared to D1. Accordingly, claim 13 would have been obvious to a person skilled in the art from D1. Therefore, claim 13 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.1.6. Claim 21

Concerning the additional feature of claim 21, D1 discloses that as a current flows through this coil a magnetic field is created, wherein the magnetic field is substantially uniform within the coil and is directed substantially parallel to the axis of the coil (see column 1, lines 39-42 in D1).

Accordingly, claim 21 would have been obvious to a person skilled in the art from D1. Therefore, claim 21 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.1.7. Claims 14-20, 24

Concerning the additional features of claims 14-20 and 24, D1 discloses the alternating current (see claim 3 in D1). And D2, in the same technical field as D1, relates to a method of using an induction heat fusing device. As D2 discloses that as the size of the core increases, the magnetic field strength increases, even though the number of windings remains the same; basically, the switch-off time is determined by the voltage detection circuit; and by repeating this switching cycle, a high-frequency electrical current flows to the induction heating coil (43) (see column 4, lines 30-32; column 9, lines 60-62 in D2). Claims 15 and 16 differ from D1 and D2 in that the strength of the magnetic field increases or reaches the maximum until the current is switched off. However, the difference is merely one of several straightforward possibilities from which a person skilled in the art would select, in accordance with circumstances, without the exercise of inventive skill. The present invention and the prior art documents D1 and D2 relate to a method for inducing a magnetic field in an exothermic reactor. As those inventions are in the same technical field, a person skilled in the art would have easily combined D2 with D1.

Continued on The Next Page

Supplemental Box

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

Accordingly, claims 14-20 and 24 would have been obvious to a person skilled in the art from D1 and D2. Therefore, claims 14-20 and 24 are novel under PCT Article 33(2) but lack an inventive step according to the combination of D1 and D2 under PCT Article 33(3).

1.1.8. Claims 22, 23

The additional feature of claim 22 is not explicitly disclosed in D1. However, D3, in the same technical field as D1, relates to a method of heating an inductive nozzle heating assembly. As D3 discloses that a device further comprises one or more sources of high frequency alternating current connected to the one or more coils such as a folded inductive coil member and a perpendicular positioned inductive coil member (see paragraphs [0002], [0016], [0017]; and figures 5, 6 in D3), the feature can be easily derived by a person skilled in the art from D3. The present invention and the prior art documents D1 and D3 relate to a method for inducing a magnetic field in an exothermic reactor. As those inventions are in the same technical field, a person skilled in the art would have easily combined D3 with D1.

The additional feature of claim 23 is not explicitly disclosed in D1 or D3. However, the currents phase locked in the first coil and the second coil are merely one of several straightforward possibilities from which a person skilled in the art would select, in accordance with circumstances, without the exercise of inventive skill. Accordingly, claims 22 and 23 would have been obvious to a person skilled in the art from D1 and D3. Therefore, claims 22 and 23 are novel under PCT Article 33(2) but lack an inventive step according to the combination of D1 and D3 under PCT Article 33(3).

2. Industrial Applicability

Claims 1-24 meet the requirements of industrial applicability under PCT Article 33(4).

Electronic Acknowledgement Receipt

EFS ID:	38671806
Application Number:	16783497
International Application Number:	
Confirmation Number:	4990
Title of Invention:	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS
First Named Inventor/Applicant Name:	Joseph A. Murray
Customer Number:	76934
Filer:	Justin Robert Nifong/Donna Donovan
Filer Authorized By:	Justin Robert Nifong
Attorney Docket Number:	438/32/2 UTIL
Receipt Date:	24-FEB-2020
Filing Date:	
Time Stamp:	15:09:52
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	Information Disclosure Statement (IDS) Form (SB08)	438-32-2UTIL-20200224-IDS.pdf	1034949 beeca2d7e7bbf6450e9aa6e38155501ab29b9287	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	PCTUS2018045305-IPRP-20200211.pdf	375093 abac8b724425414f4a78fcfe2dd1d83e83bf2c8c	no	8
Warnings:					
Information:					
Total Files Size (in bytes):			1410042		

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.

DocCode – SCORE

SCORE Placeholder Sheet for IFW Content

Application Number: 16783497 Document Date: 02/06/2020

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 DAV or via the SCORE web page.
- External customers may access SCORE content via PAIR using the Supplemental Content tab.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	438/32/2 UTIL
	Application Number	
Title of Invention	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS	

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
	Joseph	A.	Murray	

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

City	Raleigh	State/Province	NC	Country of Residence	US

Mailing Address of Inventor:

Address 1	4229 White Chapel Way		
Address 2			
City	Raleigh	**State/Province**	NC
Postal Code	27615	**Country**	US

Inventor 2 [Remove]

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Julie	A.	Morris	

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

City	Flower Mound	State/Province	TX	Country of Residence	US

Mailing Address of Inventor:

Address 1	3404 Tanyard Court		
Address 2			
City	Flower Mound	**State/Province**	TX
Postal Code	75022	**Country**	US

Inventor 3 [Remove]

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Tushar		Tank	

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

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	438/32/2 UTIL
	Application Number	

Title of Invention	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS

City	Raleigh	State/Province	NC	Country of Residence i	US

Mailing Address of Inventor:

Address 1	10208 Lobley Hill Lane		
Address 2			
City	Raleigh	**State/Province**	NC
Postal Code	27613	**Country** i	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 AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS		
Attorney Docket Number	438/32/2 UTIL	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	7	**Suggested Figure for Publication (if any)**	1

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country i

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.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	438/32/2 UTIL
	Application Number	
Title of Invention	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS	

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)
	Continuation of	PCT/US18/45305	2018-08-06
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
PCT/US18/45305	Claims benefit of provisional	62/542022	2017-08-07

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

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. 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).

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	438/32/2 UTIL
	Application Number	
Title of Invention	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS	

			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.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	438/32/2 UTIL
	Application Number	
Title of Invention	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS	

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.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	438/32/2 UTIL
	Application Number	
Title of Invention	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS	

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	IH IP Holdings Limited

Mailing Address Information For Applicant:

Address 1	44 Esplanade		
Address 2			
City	St. Helier	**State/Province**	
Country	JE	Postal Code	JE4 9WG
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.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	438/32/2 UTIL
	Application Number	

Title of Invention	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS

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)	2020-02-06
First Name	Justin	Last Name	Nifong	Registration Number	59389

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

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	438/32/2 UTIL
	Application Number	

Title of Invention	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS

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.

Methods and Apparatus for Triggering Exothermic Reactions Using AC or DC Electromagnetics

Cross-Reference to Related Applications

[001] This application is a continuation of International Application No. PCT/US18/45305, filed on August 6, 2018, entitled "METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS", which claims priority to U.S. Provisional Patent Application No. 62/542,022 filed on August 7, 2017, entitled "METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS", the entire contents of which are incorporated by reference herein.

Technical field

[002] The present disclosure relates generally to how to trigger an exothermic reaction, and more specifically, to triggering an exothermic reaction using AC or DC electromagnetics.

Background

[003] Exothermic reactions involving metal hydrides, such as palladium hydride or nickel hydride, have been observed and documented on many occasions. However, reproducibility of these exothermic reactions has been a noted problem. Scientists and engineers have tried to determine the exact conditions under which those exothermic reactions can be triggered and sustained. Yet, many issues remain unresolved and many questions are still waiting to be answered.

[004] For example, studies of past reported exothermic reactions show that the amount of deuterium loaded in the palladium hydride or nickel hydride is critical in one type of exothermic reactions in which low energy nuclear reactions involving deuterium atoms take place inside the palladium lattice. However, the threshold atom ratio of loaded deuterium to palladium is still in debate and largely speculative. For another example, the exact nature of these exothermic reactions needs to be verified and confirmed. To that end, precise calibration and heat measurements are required in these heat generation experiments. However, it appears that the above-noted problems that have been plaguing this technological field stem from the reproducibility of these exothermic reactions. Reliable triggering mechanisms are needed ab initio before many questions in this field can be answered.

[005] The present disclosure teaches advantageous methods and apparatus for triggering an exothermic reaction.

Summary

[006] The present disclosure relates to how to trigger an exothermic reaction.

[007] In some embodiments, a method for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction is disclosed. The exothermic reactor comprises a vessel and one or more reaction materials. The reactor maintains a pressure and a temperature and is surrounded by one or more coils. The method comprises supplying a current to the one or more coils. The strength of the current is determined based on a desired characteristic of the magnetic field. The method further comprises switching off the current after a first time period. The magnetic field is designed to trigger the

exothermic reaction. The first time period is also selected so that it is conducive to triggering the exothermic reaction. The pre-determined magnetic field and the selected time period are dependent on the type of the exothermic reactor or reaction. In one embodiment, the desired characteristic of the magnetic field and the first time period depend on one or more of the following factors: the reaction materials, the temperature, the pressure, the substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

[008] In one embodiment, both the magnitude and the polarity of the magnetic field are pre-determined for triggering an exothermic reaction. For example, the current is supplied to the one or more coils and the current induces a magnetic field. The strength of the current is 20A. In some other embodiments, the current typically ranges from 100 mA to 60A. The magnitude of the magnetic field increases until the current is switched off after the first time period. The first time period is calculated based on a desired magnitude of the magnetic field and the current.

[009] In one embodiment, the current is supplied to the one or more coils for the first time period. The first time period is determined based on the desired strength of the magnetic field and the current. The strength of the magnetic field increases until the current is switched off. In one embodiment, the current is switched off after a first time period and is switched on after a second time period. The direction of the current may be reversed when the current is turned on again. The frequency at which the direction of the current is reversed is determined so at to trigger the exothermic reaction. In yet another embodiment, the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

[010] In some embodiments, the two coils are placed in parallel and the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil. In some embodiments, the first coil is placed perpendicular to the second coil and the currents running through the first and second coil are turned on and off alternately, i.e., phase-shifted by 180^{o} relatively to each other. The currents in the first and second coils may be phase locked.

[011] The present disclosure also discloses an apparatus for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction. The exothermic reactor comprises a vessel and one or more reaction materials. The reactor maintains a temperature and a pressure. The apparatus comprises one or more coils and one or more power supplies for supplying a current to the one or more coils. The power supplies are configured to supply the current to the one or more coils and switch off the current after a first time period. In one embodiment, both the magnitude and the polarity of the magnetic field are pre-determined for triggering an exothermic reaction. For example, the current is supplied to the one or more coils and the current induces a magnetic field. The strength of the current is 20A. In some other embodiments, the current typically ranges from 100mA to 60A. The magnitude of the magnetic field increases until the current is switched off after the first time period. The first time period is calculated based on a desired magnitude of the magnetic field and the current.

[012] In one embodiment of the apparatus, the current is supplied to the one or more coils for the first time period that is determined based on the desired strength of the magnetic field and the current. The strength of the magnetic field increases until the current is switched off. In one embodiment, the current is switched off after a first time

period and is switched back on after a second time period. The direction of the current may be reversed when the current is switched back on. The frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction. In yet another embodiment of the apparatus, the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

[013] In some embodiments of the apparatus, the two coils are placed in parallel and the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil. In some embodiments, the first coil is placed perpendicular to the second coil and the currents running through the first and second coil are turned on and off alternately, i.e., phase-shifted by 180^{o} relatively to each other. The currents in the first and second coils may be phase locked.

Brief Description of Figures

[014] FIG. 1 illustrates an exemplary power supply circuit configured to generate electromagnetic fields for triggering an exothermic reaction.

[015] FIGS. 2A and 2B illustrate an exemplary RL circuit and a current profile generated by the RL circuit.

[016] FIGS. 3A -5 illustrate exemplary current profiles generated by RL circuits.

[017] FIGS. 6A -6D illustrate different configurations of one or more electromagnetic circuits placed around a reactor.

[018] FIGS. 7A -7B illustrate examples of AC currents supplied to the electromagnetic circuits.

Detailed Description

[019] In referring to FIG. 1, a block diagram illustrating an exemplary electric circuit 100 that comprises a controller 102, an H-Bridge circuit 104, a coil 106, an optional resistor Rsense 108 and a power supply 110. The circuit 100 is configured to generate magnetic fields of desired magnitudes and/or polarities by controlling the current that runs through the coil 106. In some embodiments, the coil 106 is a piece of metal wire with inductance L and resistance R. The H-Bridge Circuit 104 is configured to apply a reversible and variable voltage across the coil to generate variable currents of reversible directions. The controller 102 controls the H-Bridge Circuit 104. The controller 102 can be configured or programmed to enable the H-Bridge Circuit 104 to apply suitable voltages over the coil 106. The voltage over the coil 106 induces a current across the coil 106. The current generates a magnetic field in the space surrounding the coil.

[020] It is known in previous studies that a magnetic field of a suitable strength and polarity can trigger certain types of exothermic reactions. However, those studies are preliminary and do not provide sufficient details on the circuit used to generate the magnetic field and on the exact configuration of the magnetic field that can trigger the exothermic reactions. The present disclosure teaches methods and apparatus that can be utilized to generate a suitable magnetic field, of which the magnitude and polarity inside the reactor is designed to trigger an exothermic reaction. Depending on the type of the exothermic reactions or reactors, the characteristics of the triggering magnetic field may differ and the current supplied to the coil 106 will vary accordingly. For example, the following factors may be taken into consideration in designing a magnetic field as triggering mechanism: the reaction materials used in the reaction, whether they are

ferromagnetic, for instance, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

[021] FIG. 2A illustrates a simplified circuit representation of the coil 106 and FIG. 2B depicts an exemplary current induced in the coil 106 by the circuit 100. In FIG. 2A, the coil 106 is represented by an ideal inductor 202 of inductance L and an ideal resistor 204 of resistance R. The voltage applied across the coil 106 is represented by the power source 206 of voltage V. The current in the coil 106 as a function of time is depicted in FIG. 2B. $\tau = \frac{L}{R}$ is a time scale that measures the rate at which the current in the coil 106 increases. When the voltage V is applied to the coil 106, the current ramps up and quickly reaches the maximum value $\frac{V}{R}$ within a time period of 3τ - 5τ. Parameter τ sets the limit on how fast the current induced in the coil 106 can change in response to the applied voltage V.

[022] FIG. 3A illustrates the current, i, induced in the coil 106 as a function of time in response to the voltage V applied across the coil 106 as shown in FIG. 3b. The voltage V is switched on and off periodically. It is switched on for a time period of t_1 and then switched off for a time period of t_2, …, and switched on for a time period of t_{2i-1} and switched off for a time period of t_{2i+1}. The current induced in the coil 106 in response to the applied voltage V is shown in FIG. 3A. The current ramps up and drops down in response to the switching on and off of the voltage. Because the voltage is switched off before 5τ, the voltage is switched off before the current could reach the maximum value $\frac{V}{R}$. During t_2, the current drops down to zero more precipitously.

[023] FIG. 4 illustrates another variable current as a function of time. In FIG. 4, the direction of the current is reversed each time the current is turned on. For example, the voltage across the coil 106 is applied during time period t_1 and is turned off during time period t_2. The voltage is turned on again during time period t_3 but the polarity is reversed. As a result, the current in the coil 106 is positive during time period t_1 and negative during time period t_3. The current becomes positive again during time period t_5 and so on and so forth. The direction of the current dictates the direction of the magnetic field generated by the current under the right hand rule. When the direction of the current in the coil 106 is reversed, the direction of the magnetic field is reversed. By programming the controller 102, the time periods, t_1, t_2, t_3…, can be adjusted to produce a desired magnetic field according to specification.

[024] In FIG. 3A and FIG. 4, during time period t_1, t_3, t_5…, the current in the coil 106 does not reach the maximum value, $\frac{V}{R}$, before it is switched off. FIG. 5 illustrates a variable current supplied to the coil 106 that reaches the maximum value $\frac{V}{R}$ within approximately 5τ and maintains the maximum value for an extended time before it is switched off. After it is switched off, the current drops down to zero within a time period of 5τ. The current is turned off during time period t_2 and is turned back on during time period t_3. During time period t_3, the current stays at the maximum value, $\frac{V}{R}$, for a majority portion of the duration. When the current reaches the maximum value, the magnitude of the magnetic field induced by the current reaches its maximum and the maximum magnetic field is maintained for the majority portion of the duration. In some embodiments, the magnetic field is used as a triggering mechanism of an exothermic reaction. The magnitude, the polarity and/or the variability of the magnetic field are

characteristics or parameters that should be carefully determined in accordance to the re requirements of the exothermic reaction or reactor. Based on the requirements, the controller 102 can be programmed to control the H-Bridge Circuit 104 to supply the current to the coil 106 according to specification.

[025] To produce a magnetic field of a desired magnitude or polarity, the current in the coil 106 can be adjusted as well as the placement of the coil or coils 106. FIGS. 6A – 6D illustrate different placements of one or more coils 106. In FIG. 6A, a coil 106 is wrapped around a reactor 600 longitudinally. The magnetic field $\overrightarrow{B_1}$ produced by the current in the coil 106 runs parallel to the $\vec{x}$ axis. FIG. 6B illustrates a coil 106 configured to generate a desired magnetic field $\overrightarrow{B_2}$ along the $\vec{y}$ axis. The coil 106 is placed on top of the reactor 600.

[026] To enhance the strength of a magnetic field produced by a coil, multiple coils arranged in parallel can be used as shown in FIG. 6C and FIG. 6D. In FIG. 6C, a large coil 112 is wrapped around a reactor 600 longitudinally. Two small coils 114 and 116 are placed in parallel with the large coil 112, one on top of the reactor 600 and one beneath the reactor 600. The magnetic fields generated by the three parallel coils, $\overrightarrow{B_3}$, $\overrightarrow{B_4}$, $\overrightarrow{B_5}$, run parallel to the $\vec{y}$ axis and enhance each other. The total magnetic field is the vector summation of the three magnetic fields.

[027] FIG. 6D shows another configuration of multiple coils so arranged to generate a magnetic field of a desired magnitude and polarity. Around the reactor 600, the coils 118 and 120 are placed horizontally on top of and horizontally beneath the reactor 600 respectively, while the coils 122 and 124 are placed vertically to the right and vertically to the left of the reactor 600 respectively. The coils 118 and 120 produce magnetic fields

$\overrightarrow{B_6}$ and $\overrightarrow{B_7}$ that run parallel to the $\vec{y}$ axis. These two magnetic fields, $\overrightarrow{B_6}$ and $\overrightarrow{B_7}$, enhance each other. The sum of these two fields is $\overrightarrow{B_y} = \overrightarrow{B_6} + \overrightarrow{B_7}$. Along the $\vec{x}$ axis, the two vertically placed coils, 122 and 124, generate a magnetic field respectively. The sum of these two fields is $\overrightarrow{B_x} = \overrightarrow{B_8} + \overrightarrow{B_9}$. The two magnetic fields, $\overrightarrow{B_x}$ and $\overrightarrow{B_y}$, combine to yield a resultant magnetic field $\vec{B} = \overrightarrow{B_x} + \overrightarrow{B_y}$. This resultant magnetic field is designed to trigger an exothermic reaction in the reactor 600 in accordance to the requirements of the exothermic reaction or the reactor 600.

[028] In yet another embodiment, a Helmholtz coil may be employed to generate a uniform magnetic field inside the reactor. The placement of the coil determines the orientation and polarity of the field. The Helmholtz coil is configured to generate a magnetic field of a desired magnitude to trigger an exothermic reaction.

[029] In the above description of FIGS. 6A -6D, the current supplied to the coils 106 is assumed to be the same, for the convenience of illustration. In some embodiments, the current supplied to the coils 106 may be different, depending on the desired strength, polarity and/or orientation of the magnetic field. For instance, in FIG. 6D, when the current supplied to the coil 118 and 120 is twice as large as the current supplied to the coil 122 and 124, the magnetic field $\overrightarrow{B_y}$ is twice as large as the magnetic field $\overrightarrow{B_x}$, yielding a resultant magnetic field $\vec{B}$ of a different orientation and magnitude.

[030] In the above description of FIGS. 6A – 6D, the magnetic fields generated by the coils 106 are static when the current supplied to various coils are DC. With AC currents, the generated magnetic fields are variable. The frequencies with which the magnetic fields shift directions and/or vary in magnitude are determined by the frequency of the AC currents. For example, an AC current of 50 Hz supplied to the coil 106 in FIG. 6A

will produce a sinusoidal magnetic field $\vec{B}$. The direction of the magnetic field $\vec{B}$ oscillates along the $\vec{x}$ axis at a frequency of 50 Hz.

[031] In some embodiments, the AC currents supplied to the different coils are phase-shifted relatively to each other. For example, in FIG. 6C, the AC current supplied to the coil 114 and 116, I_1, is 180° shifted from the AC current supplied to the coil 112, I_2, as shown in FIG. 7A. In one embodiment, the two AC currents are phase-locked to create a steadily oscillating magnetic field of the same frequency as the AC currents.

[032] In some embodiments, the currents supplied to the different coils may be phase-shifted relatively to each other and may be of different amplitudes. For example, as illustrated in FIG. 7B, the current supplied to the coil 114 and 116, I_1, and the current supplied to the coil 112, I_2, are phase-shifted 180° relatively to each other. Besides the difference in phase, the two currents, I_1 and I_2, also differ in amplitude. As a result, the resultant magnetic field differs from that shown in FIG. 7A, because the magnetic field generated by a current carrying coil is proportional to the amplitude of the current according to Ampere's law.

[033] In FIGS. 7A and 7B, two-phase currents are used to generate a desired magnetic field as a triggering mechanism of an exothermic reaction in the reactor 600. Multi-phase currents, e.g., currents supplied by a three-phase circuit, can be used to generate a rotating magnetic field. FIG. 7c shows a balanced three phase currents, I_1, I_2, and I_3. All three currents are of the same amplitude but each is 120° shifted from the next one. The magnetic field generated by the currents can be expressed as $\vec{B}(\sin\alpha t + \sin(\alpha t + 120) + \sin(\alpha t + 240))$ and is a rotating magnetic field.

[034] In some embodiments, a static magnetic field generated by a DC current supplied to the coil 106 shown in FIG. 6A can be used to trigger certain types of exothermic reactions in the reactor 600. The magnitude and/or the polarity of the magnetic field can be controlled by the current and the placement of the coil 106, in accordance to the requirements of the exothermic reaction.

[035] In some embodiments, an oscillating magnetic field generated by the AC current supplied to the coils 118, 120, 122, and 124 can be used to trigger a certain type of exothermic reactions. In some embodiments, a rotating magnetic field generated by a balanced three-phase current system supplied to the coils 112, 114, and 116 can be used as triggering mechanism.

[036] The present invention may be carried out in other specific ways than those herein set forth without departing from the scope and essential characteristics of the invention. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

Claims

What is claimed is:

1. A method for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction, the exothermic reactor comprising a vessel and one or more reaction materials, the reactor maintaining a pressure and a temperature and being surrounded by one or more coils, the method comprising:

    supplying a current to the one or more coils, wherein the strength of the current is determined based on a desired characteristic of the magnetic field; and

    switching off the current after a first time period;

    wherein the desired characteristic of the magnetic field and the first time period are determined to trigger the exothermic reaction and wherein the desired characteristic of the magnetic field and the first time period are dependent on the type of the exothermic reactor.

2. The method of claim 1, wherein the desired characteristic of the magnetic field is a desired strength of the magnetic field or a desired polarity of the magnetic field.

3. The method of claim 2, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field increases until the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

4. The method of claim 2, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field reaches the maximum when the current reaches the maximum before the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

5. The method of claim 1, further comprising supplying the current to the one or more coils after a second time period.

6. The method of claim 5, wherein the direction of the current is reversed.

7. The method of claim 5, wherein the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

8. The method of claim 6, wherein the frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction.

9. The method of claim 1, wherein a first coil of the one or more coils is parallel to a second coil of the one or more coils, and wherein the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil.

10. The method of claim 1, wherein a first coil of the one or more coils is perpendicular to a second coil of the one or more coils, and wherein a current running through the first coil and a current running through the second coil are turned on and off alternately.

11. The method of claim 10, wherein the current in the first coil and the current in the second coil are phase locked.

12. The method of claim 1, wherein the desired characteristic of the magnetic field and the first time period further depend on one or more of the following factors: the one or more reaction materials, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

13. An apparatus for inducing a magnetic field in an exothermic reactor to trigger an exothermic reaction, the exothermic reactor comprising a vessel, one or more

reaction materials, the exothermic reactor maintaining a temperature and a pressure, said apparatus comprising:

one or more coils positioned in the surround of the exothermic reactor;

one or more power supplies for supplying one or more currents to the one or more coils;

wherein the one or more power supplies are configured to:

supply the currents to the one or more coils, wherein the strength of each of the currents is determined based on a desired characteristic of the magnetic field; and

switch off the currents after a first time period;

wherein the desired characteristic of the magnetic field and the first time period are determined to trigger the exothermic reaction and wherein the desired characteristic of the magnetic field and the first time period are dependent on the type of the exothermic reactor.

14. The apparatus of claim 13, wherein the desired characteristic of the magnetic field is a desired strength of the magnetic field or a desired polarity of the magnetic field.

15. The apparatus of claim 14, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field increases until the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

16. The apparatus of claim 14, wherein, when the current is supplied to the one or more coils, the strength of the magnetic field reaches the maximum when the current reaches the maximum before the current is switched off, and wherein the first time period is determined based on the desired strength of the magnetic field and the current.

17. The apparatus of claim 13, further comprising supplying the current to the one or more coils after a second time period.

18. The apparatus of claim 17, wherein the direction of the current is reversed.

19. The apparatus of claim 17, wherein the current is turned on and off periodically with a predetermined frequency for triggering the exothermic reaction.

20. The apparatus of claim 18, wherein the frequency at which the direction of the current is reversed is determined for triggering the exothermic reaction.

21. The apparatus of claim 13, wherein a first coil of the one or more coils is parallel to a second coil of the one or more coils, and wherein the magnetic field generated by the first coil is aligned with the magnetic field generated by the second coil.

22. The apparatus of claim 13, wherein a first coil of the one or more coils is perpendicular to a second coil of the one or more coils, and wherein a current running through the first coil and a current running through the second coil are turned on and off alternately.

23. The apparatus of claim 22, wherein the current running through the first coil and the current running through the second coil are phase locked.

24. The apparatus of claim 14, wherein the desired characteristic of the magnetic field and the first time period further depends on one or more of the following factors: the one or more reaction materials, the temperature, the pressure, a substrate used for holding the one or more reaction materials, the shape of the exothermic reactor, and the size of the exothermic reaction.

Abstract

Methods and apparatus are disclosed for generating an electromagnetic field inside a reactor to trigger an exothermic reaction. The design and implementation of the electromagnetics are based on the requirements of a particular exothermic reaction or reactor. For example, the triggering mechanism of a particular exothermic reaction or reactor may require a magnetic field with a specific magnitude, polarity, and/or orientation.

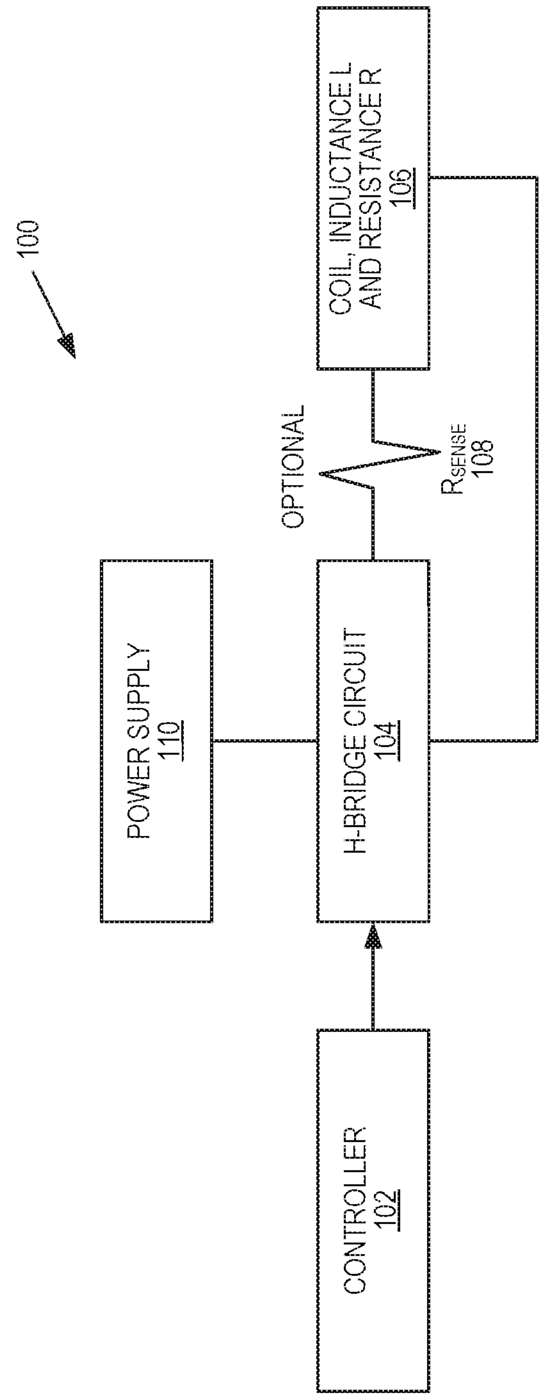
100
COIL, INDUCTANCE L
AND RESISTANCE R
106
OPTIONAL
R_{SENSE}
108
POWER SUPPLY
110
H-BRIDGE CIRCUIT
104
CONTROLLER
102

FIG. 1

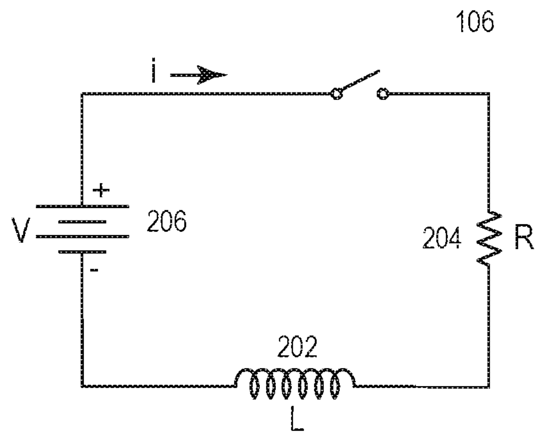

FIG. 2A

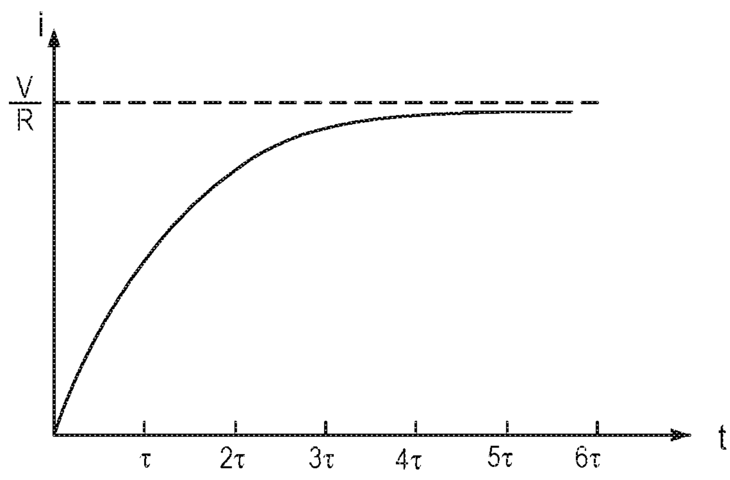

FIG. 2B

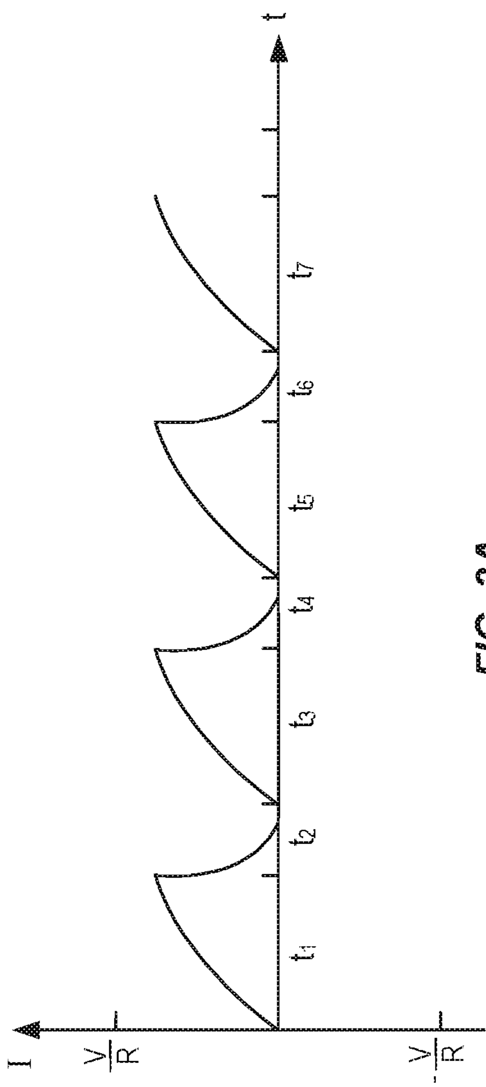

FIG. 3A

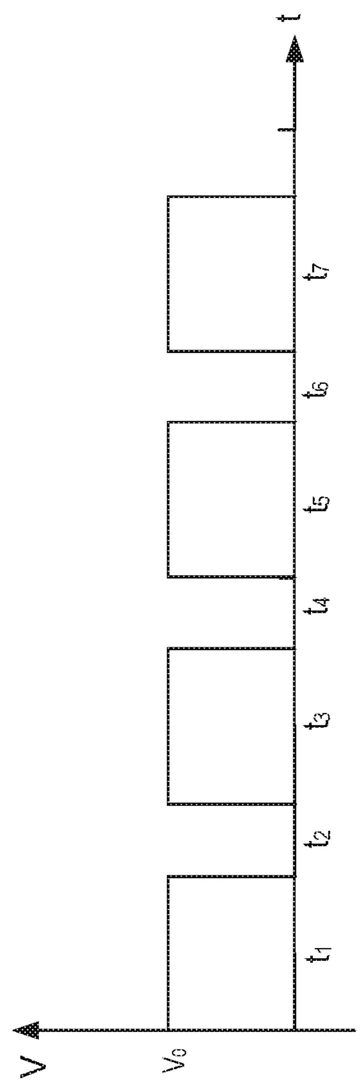

FIG. 3B

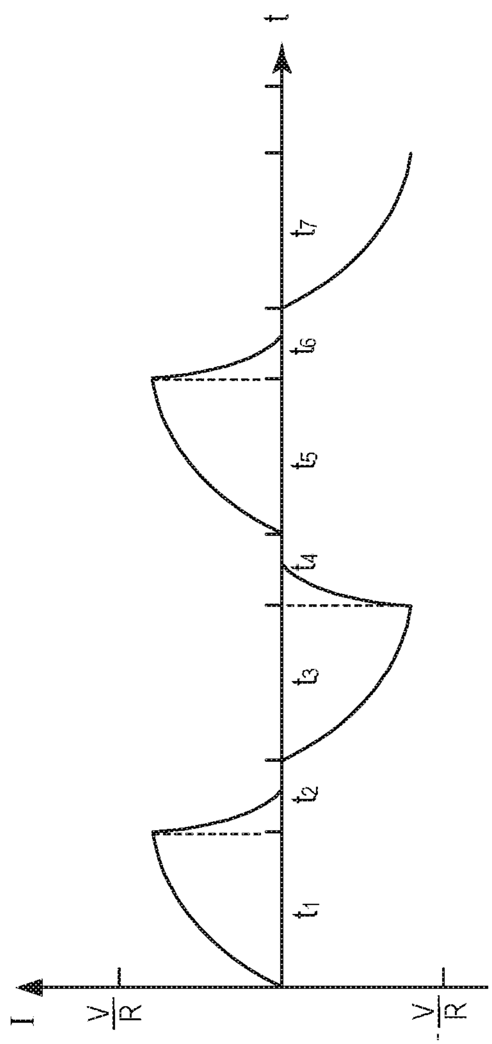

FIG. 4

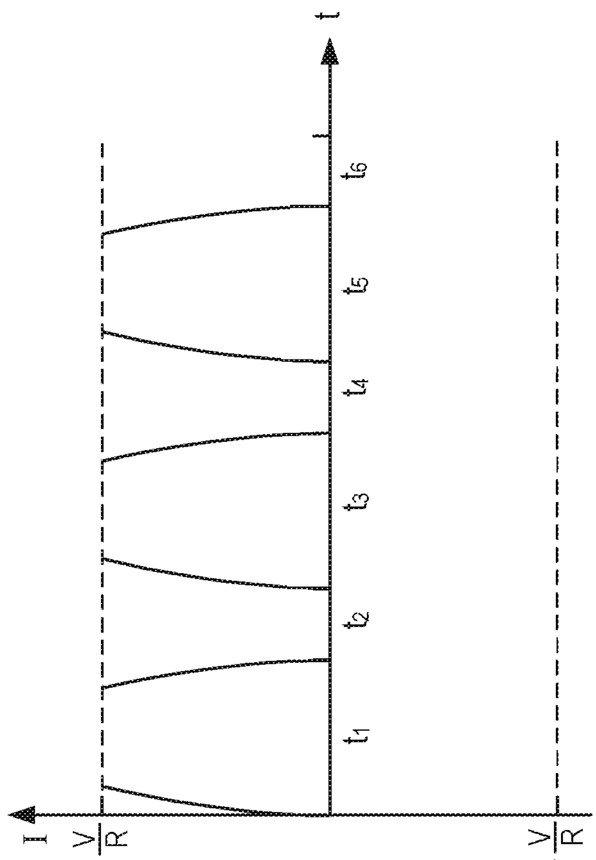

FIG. 5

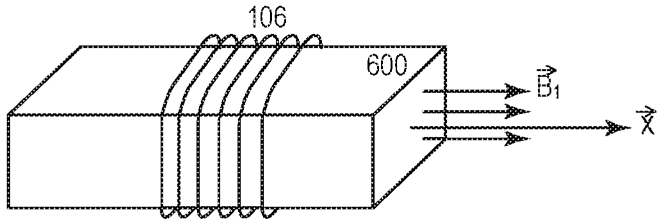

FIG. 6A

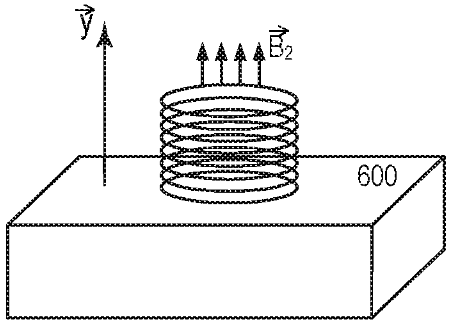

FIG. 6B

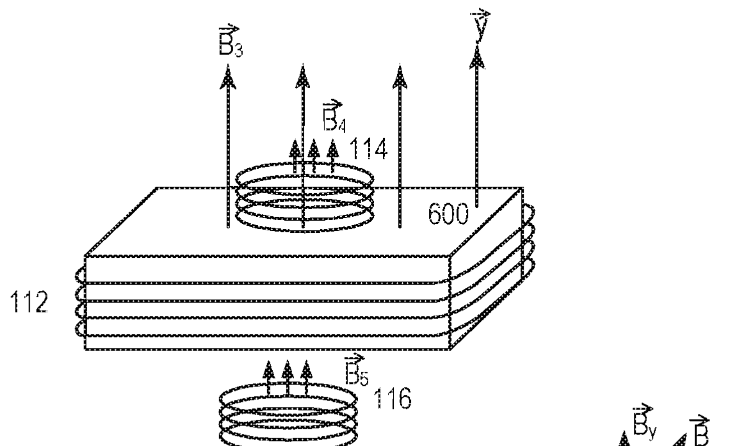

FIG. 6C

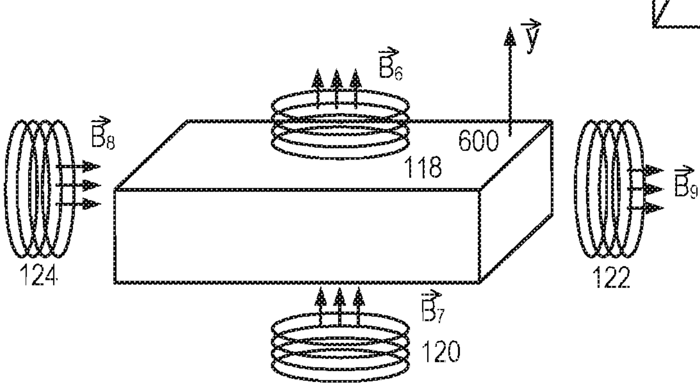

FIG. 6D

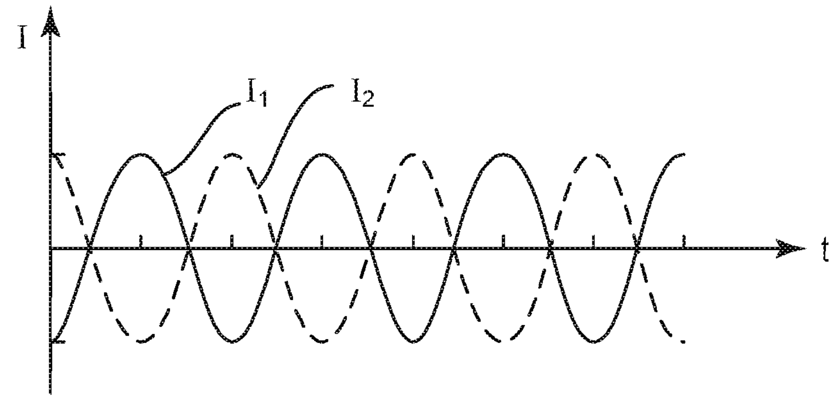

FIG. 7A

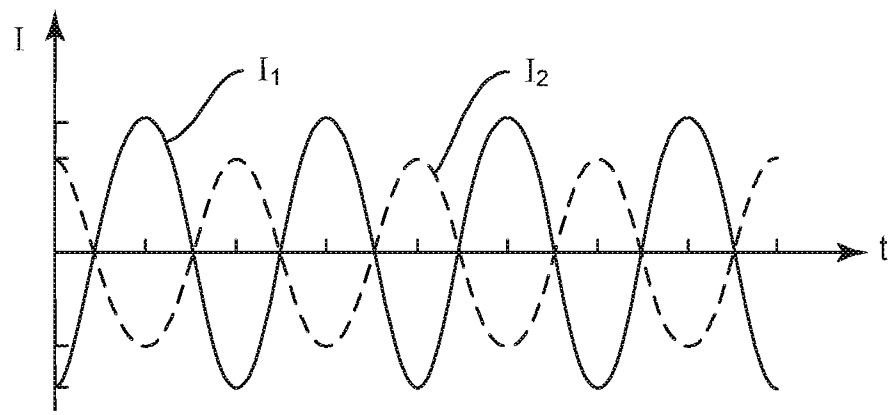

FIG. 7B

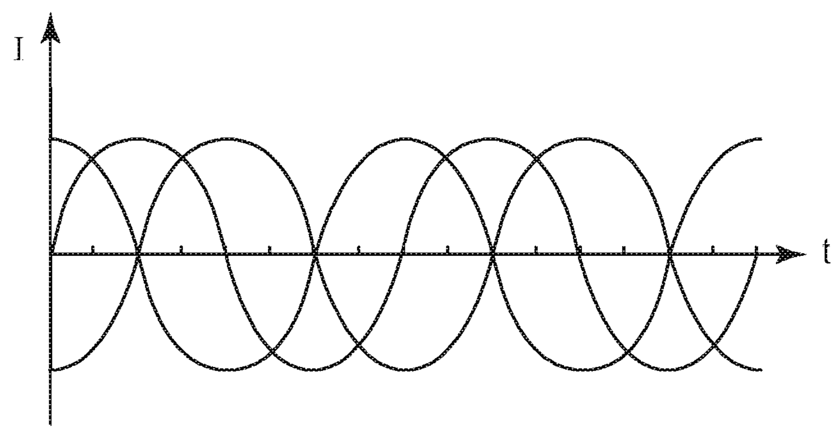

FIG. 7C

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS
First Named Inventor/Applicant Name:	Joseph A. Murray
Filer:	Justin Robert Nifong/Donna Donovan
Attorney Docket Number:	438/32/2 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 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	4	50	200
Miscellaneous-Filing:				
LATE FILING FEE FOR OATH OR DECLARATION	2051	1	80	80

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1065**

Electronic Acknowledgement Receipt

EFS ID:	38512568
Application Number:	16783497
International Application Number:	
Confirmation Number:	4990
Title of Invention:	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS
First Named Inventor/Applicant Name:	Joseph A. Murray
Customer Number:	76934
Filer:	Justin Robert Nifong/Donna Donovan
Filer Authorized By:	Justin Robert Nifong
Attorney Docket Number:	438/32/2 UTIL
Receipt Date:	06-FEB-2020
Filing Date:	
Time Stamp:	13:40:21
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1065
RAM confirmation Number	E202026D40549603
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	438-32-2UTIL-20200206-ADS.pdf	1256241 bc488f009b8d93b0485325e87a8cc19cd70b33cc	no	9

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2		438-32-2UTIL-20200206-Application.pdf	100882 f2ffaf259c2c020c0dcea547f75224d194810556	yes	17

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	12
Claims	13	16
Abstract	17	17

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Drawings-other than black and white line drawings	438-32-2UTIL-20200206-Drawings.pdf	1031656 983cc68394637f49e2010a682fb375fb636e2223	no	7

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
4	Fee Worksheet (SB06)	fee-info.pdf	38313 a02fa43f78d237aef38ecc56c73132d7766f71d0	no	2

Warnings:

Information:

Total Files Size (in bytes): 2427092

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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)		
	Application Number	16783497
	Filing Date	2020-02-06
	First Named Inventor	Joseph A. Murray
	Art Unit	-
	Examiner Name	-
	Attorney Docket Number	438/32/2 UTIL

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	5958273	A	1999-09-28	Koch, et al.	
	2	5822669	A	1998-10-13	Okabayashi, et al.	

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code1	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20170094726	A1	2017-03-30	Elserman, et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number3	Country Code2 i	Kind Code4	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T5
	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

# INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number	16783497
	Filing Date	2020-02-06
	First Named Inventor	Joseph A. Murray
	Art Unit	-
	Examiner Name	-
	Attorney Docket Number	438/32/2 UTIL

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	PCT, International Search Report and Written Opinion in International Application No. PCT/US2018/045305 dated 03 January 2019	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*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	16783497
	Filing Date	2020-02-06
	First Named Inventor	Joseph A. Murray
	Art Unit	-
	Examiner Name	-
	Attorney Docket Number	438/32/2 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)	2020-02-06
Name/Print	Justin R. Nifong	Registration Number	59389

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 438/32/2 PCT	**FOR FURTHER ACTION** see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. **PCT/US2018/045305**	International filing date *(day/month/year)* **06 August 2018 (06.08.2018)**	(Earliest) Priority Date *(day/month/year)* 07 August 2017 (07.08.2017)
Applicant **IH IP HOLDINGS LIMITED et al.**		

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 **3** 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/US2018/045305

A. CLASSIFICATION OF SUBJECT MATTER

B01J 8/02(2006.01)i, B01J 8/42(2006.01)i

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)
B01J 8/02; B01J 35/00; B01J 8/00; C23C 16/00; G03G 15/20; H05B 5/00; H05B 6/06; H05B 6/26; H05B 6/36; B01J 8/42

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: induction heating, reactor, coil, current, magnetic field, switch on/off

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5958273 A (KOCH, THEODORE A. et al.) 28 September 1999 See column 1, lines 39-42; and claim 3.	1,9,13,21
Y		2-8,10-12,14-20,22-24
Y	US 5822669 A (OKABAYASHI, EIJI et al.) 13 October 1998 See column 4, lines 30-32; and column 9, lines 60-62.	2-8,12,14-20,24
Y	US 2017-0094726 A1 (ULTIMAKER B.V.) 30 March 2017 See paragraphs [0002], [0016], [0017]; and figures 5, 6.	10,11,22,23
X	US 4579080 A (MARTIN, JOHN G. et al.) 01 April 1986 See claim 1, figures 8, 9.	1,9,13,21
A	WO 2017-036794 A1 (HALDOR TOPSOE A/S) 09 March 2017 See the whole document.	1-24

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 January 2019 (03.01.2019)	**03 January 2019 (03.01.2019)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea
Facsimile No. +82-42-481-8578

Authorized officer
MIN, In Gyou
Telephone No. +82-42-481-3326

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2018/045305

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5958273 A	28/09/1999	CN 1060141 C	03/01/2001
		CN 1139912 A	08/01/1997
		EP 0742781 A1	20/11/1996
		EP 0742781 B1	29/09/2004
		US 6287531 B1	11/09/2001
		US 6315972 B1	13/11/2001
		WO 95-21126 A1	10/08/1995
US 5822669 A	13/10/1998	JP 09-062132 A	07/03/1997
		JP 09-106207 A	22/04/1997
		JP 3204052 B2	04/09/2001
		JP 3324351 B2	17/09/2002
US 2017-0094726 A1	30/03/2017	CN 107027208 A	08/08/2017
		EP 3148293 A1	29/03/2017
		EP 3148293 B1	07/03/2018
US 4579080 A	01/04/1986	EP 0147967 A2	10/07/1985
		EP 0147967 B1	26/08/1992
		JP 60-186013 A	21/09/1985
		KR 10-1985-0005146 A	21/08/1985
WO 2017-036794 A1	09/03/2017	EP 3341126 A1	04/07/2018
		US 2018-243711 A1	30/08/2018
		WO 2017-036794 A9	09/03/2017

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
NIFONG, Justin R.

NK Patent Law, PLLC 4917 Waters Edge Drive, Suite 275
Raleigh, NC 27606 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**03 January 2019 (03.01.2019)**

Applicant's or agent's file reference 438/32/2 PCT	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2018/045305	**06 August 2018 (06.08.2018)**	07 August 2017 (07.08.2017)

International Patent Classification (IPC) or both national classification and IPC

B01J 8/02(2006.01)i, B01J 8/42(2006.01)i

Applicant

IH IP HOLDINGS LIMITED et al.

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 43bis.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 66.1bis(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/KR	Date of completion of this opinion	Authorized officer
International Application Division Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	03 January 2019 (03.01.2019)	MIN, In Gyou Telephone No. +82-42-481-3326

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2018/045305

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established 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))

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:

   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 forming part of 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/US2018/045305

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

1. Statement

Novelty (N)	Claims	1-24	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-24	NO
Industrial applicability (IA)	Claims	1-24	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1 : US 5958273 A (KOCH, THEODORE A. et al.) 28 September 1999
D2 : US 5822669 A (OKABAYASHI, EIJI et al.) 13 October 1998
D3 : US 2017-0094726 A1 (ULTIMAKER B.V.) 30 March 2017

1. Novelty and Inventive Step

1.1. Claims 1-24

1.1.1. Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a method of using an induction heated reactor such as a fluid phase reaction apparatus for producing a chemical product from a reaction that at least initially requires heat-input, the fluid phase reaction apparatus comprising: A) an external reactor casing to contain reactants; B) a tubular induction heating coil positioned within said external casing; C) a first electrically non-conductive annular partition positioned within said induction heating coil; D) said first electrically non-conductive partition defining a reaction zone, said reaction zone being a region of high alternating magnetic field intensity within said induction heating coil and said reaction zone being in communication with said inlet port to receive fluid reactants and in communication with said outlet port to discharge fluids; and E) a source of alternating current electrical power connected to said induction heating coil for creating said region of high intensity alternating magnetic field in the reaction zone by alternating magnetic induction (see claim 3 in D1).

The subject matter of claim 1 differs from D1 in that the strength of a current is determined

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Box No. V

based on a desired characteristic of a magnetic field. However, the difference can be easily derived by repeated experiments practiced by a person skilled in the art, and no unexpected effect has been achieved compared to D1. Accordingly, claim 1 would have been obvious to a person skilled in the art from D1. Therefore, claim 1 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.1.2. Claim 9

Concerning the additional feature of claim 9, D1 discloses that as a current flows through this coil a magnetic field is created, wherein the magnetic field is substantially uniform within the coil and is directed substantially parallel to the axis of the coil (see column 1, lines 39-42 in D1).

Accordingly, claim 9 would have been obvious to a person skilled in the art from D1. Therefore, claim 9 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.1.3. Claims 2-8, 12

Concerning the additional features of claims 2-8 and 12, D1 discloses the alternating current (see claim 3 in D1). And D2, in the same technical field as D1, relates to a method of using an induction heat fusing device. As D2 discloses that as the size of the core increases, the magnetic field strength increases, even though the number of windings remains the same; basically, the switch-off time is determined by the voltage detection circuit; and by repeating this switching cycle, a high-frequency electrical current flows to the induction heating coil (43) (see column 4, lines 30-32; column 9, lines 60-62 in D2). Claims 3 and 4 differ from D1 and D2 in that the strength of the magnetic field increases or reaches the maximum until the current is switched off. However, the difference is merely one of several straightforward possibilities from which a person skilled in the art would select, in accordance with circumstances, without the exercise of inventive skill. The present invention and the prior art documents D1 and D2 relate to a method for inducing a magnetic field in an exothermic reactor. As those inventions are in the same technical field, a person skilled in the art would have easily combined D2 with D1.

Accordingly, claims 2-8 and 12 would have been obvious to a person skilled in the art from D1 and D2. Therefore, claims 2-8 and 12 are novel under PCT Article 33(2) but lack an

Continued on The Next Page

Supplemental Box

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

inventive step according to the combination of D1 and D2 under PCT Article 33(3).

1.1.4. Claims 10, 11

The additional feature of claim 10 is not explicitly disclosed in D1. However, D3, in the same technical field as D1, relates to a method of heating an inductive nozzle heating assembly. As D3 discloses that a device further comprises one or more sources of high frequency alternating current connected to the one or more coils such as a folded inductive coil member and a perpendicular positioned inductive coil member (see paragraphs [0002], [0016], [0017]; and figures 5, 6 in D3), the feature can be easily derived by a person skilled in the art from D3. The present invention and the prior art documents D1 and D3 relate to a method for inducing a magnetic field in an exothermic reactor. As those inventions are in the same technical field, a person skilled in the art would have easily combined D3 with D1.

The additional feature of claim 11 is not explicitly disclosed in D1 or D3. However, the currents phase locked in the first coil and the second coil are merely one of several straightforward possibilities from which a person skilled in the art would select, in accordance with circumstances, without the exercise of inventive skill.

Accordingly, claims 10 and 11 would have been obvious to a person skilled in the art from D1 and D3. Therefore, claims 10 and 11 are novel under PCT Article 33(2) but lack an inventive step according to the combination of D1 and D3 under PCT Article 33(3).

1.1.5. Claim 13

D1 discloses a fluid phase reaction apparatus for producing a chemical product from a reaction that at least initially requires heat-input comprising: A) an external reactor casing to contain reactants; B) a tubular induction heating coil positioned within said external casing; C) a first electrically non-conductive annular partition positioned within said induction heating coil; D) said first electrically non-conductive partition defining a reaction zone, said reaction zone being a region of high alternating magnetic field intensity within said induction heating coil and said reaction zone being in communication with said inlet port to receive fluid reactants and in communication with said outlet port to discharge fluids; and E) a source of alternating current electrical power connected to said induction heating coil for creating said region of high intensity alternating magnetic field in the reaction zone by alternating magnetic induction (see claim 3 in D1).

Continued on The Next Page

Supplemental Box

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

The subject matter of claim 13 differs from D1 in that the strength of a current is determined based on a desired characteristic of a magnetic field. However, the difference can be easily derived by repeated experiments practiced by a person skilled in the art, and no unexpected effect has been achieved compared to D1. Accordingly, claim 13 would have been obvious to a person skilled in the art from D1. Therefore, claim 13 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.1.6. Claim 21

Concerning the additional feature of claim 21, D1 discloses that as a current flows through this coil a magnetic field is created, wherein the magnetic field is substantially uniform within the coil and is directed substantially parallel to the axis of the coil (see column 1, lines 39-42 in D1).

Accordingly, claim 21 would have been obvious to a person skilled in the art from D1. Therefore, claim 21 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.1.7. Claims 14-20, 24

Concerning the additional features of claims 14-20 and 24, D1 discloses the alternating current (see claim 3 in D1). And D2, in the same technical field as D1, relates to a method of using an induction heat fusing device. As D2 discloses that as the size of the core increases, the magnetic field strength increases, even though the number of windings remains the same; basically, the switch-off time is determined by the voltage detection circuit; and by repeating this switching cycle, a high-frequency electrical current flows to the induction heating coil (43) (see column 4, lines 30-32; column 9, lines 60-62 in D2). Claims 15 and 16 differ from D1 and D2 in that the strength of the magnetic field increases or reaches the maximum until the current is switched off. However, the difference is merely one of several straightforward possibilities from which a person skilled in the art would select, in accordance with circumstances, without the exercise of inventive skill. The present invention and the prior art documents D1 and D2 relate to a method for inducing a magnetic field in an exothermic reactor. As those inventions are in the same technical field, a person skilled in the art would have easily combined D2 with D1.

Continued on The Next Page

Supplemental Box

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

Accordingly, claims 14-20 and 24 would have been obvious to a person skilled in the art from D1 and D2. Therefore, claims 14-20 and 24 are novel under PCT Article 33(2) but lack an inventive step according to the combination of D1 and D2 under PCT Article 33(3).

1.1.8. Claims 22, 23

The additional feature of claim 22 is not explicitly disclosed in D1. However, D3, in the same technical field as D1, relates to a method of heating an inductive nozzle heating assembly. As D3 discloses that a device further comprises one or more sources of high frequency alternating current connected to the one or more coils such as a folded inductive coil member and a perpendicular positioned inductive coil member (see paragraphs [0002], [0016], [0017]; and figures 5, 6 in D3), the feature can be easily derived by a person skilled in the art from D3. The present invention and the prior art documents D1 and D3 relate to a method for inducing a magnetic field in an exothermic reactor. As those inventions are in the same technical field, a person skilled in the art would have easily combined D3 with D1.

The additional feature of claim 23 is not explicitly disclosed in D1 or D3. However, the currents phase locked in the first coil and the second coil are merely one of several straightforward possibilities from which a person skilled in the art would select, in accordance with circumstances, without the exercise of inventive skill. Accordingly, claims 22 and 23 would have been obvious to a person skilled in the art from D1 and D3. Therefore, claims 22 and 23 are novel under PCT Article 33(2) but lack an inventive step according to the combination of D1 and D3 under PCT Article 33(3).

2. Industrial Applicability

Claims 1-24 meet the requirements of industrial applicability under PCT Article 33(4).

Electronic Acknowledgement Receipt

EFS ID:	38512785
Application Number:	16783497
International Application Number:	
Confirmation Number:	4990
Title of Invention:	METHODS AND APPARATUS FOR TRIGGERING EXOTHERMIC REACTIONS USING AC OR DC ELECTROMAGNETICS
First Named Inventor/Applicant Name:	Joseph A. Murray
Correspondence Address:	NK Patent Law - Industrial Heat - 4917 Waters Edge Drive Suite 275 Raleigh NC 27606 US 9193482194 eofficeaction@appcoll.com
Filer:	Justin Robert Nifong/Donna Donovan
Filer Authorized By:	Justin Robert Nifong
Attorney Docket Number:	438/32/2 UTIL
Receipt Date:	06-FEB-2020
Filing Date:	
Time Stamp:	13:49:29
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	Information Disclosure Statement (IDS) Form (SB08)	438-32-2UTIL-20200206-IDS.pdf	1035071 e1fed931ca7f7511edf53849e1fbde105c07d1d0	no	4
Warnings:					
Information:					
2	Non Patent Literature	438-32-2PCT-20190103-ISR-WO.pdf	1525052 e32a377577397e39856f53d8cf50dc5b3272632c	no	10
Warnings:					
Information:					
			Total Files Size (in bytes):	2560123	

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.