Application of Magnetic Miles Impulse Control Technology to Low Energy Nuclear Reactions

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Summary:

This document outlines the current state of development for the Magnetic Miles Impulse Controller (MMIC) and its adaptation to low energy nuclear reaction (LENR) technology. The technology has two points of application, a generator of thermal energy that can be adapted to existing thermally powered electrical generators at the utility level, and also to the low energy remediation of nuclear waste materials, a process to reclaim nuclear waste materials by economic conversion to more benign materials. The following table summarizes the observed behavior of the MMIC in the LENR application in comparison to what has been reported in the literature by others.

Observed MMIC Behavior

Anomalous Behavior	**Reported LENR Behavior**	**Magnetic Miles Observations**
Production of excess heat	Up to 3.0 times applied energy as heat	2.5 times input energy as heat
Production of excess electrical energy	Speculative	1.18×10^4 times input energy as electrical energy
Production of excess hydrogen	Up to eight times expected amounts	Not measured, but copious amounts produced
Production of nuclear particles	X-rays at 300 keV., γ bursts, neutron flux detected	High intensity γ bursts detected
Transmutation of the electrode elements	Shift in atomic number higher or lower	Transmutation and half-life reduction observed

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I. Background

A. Low Energy Nuclear Reactions (LENR)

The original "cold fusion" reactions of Pons and Fleishmann[1] focused on fusing deuterium nuclei in a palladium electrode in an electrolytic cell[2]. The focus was similar to that of the hot fusion technology - the fusing of small nuclei into larger nuclei with the release of surplus nuclear binding energy. Since that time, many other processes have been shown to produce similar end results. This entire field of application is termed Low Energy Nuclear Reactions (LENR). Although experimental evidence abounds, the understanding of the process in terms of the accepted nuclear science of today, is limited. The table below illustrates the most common methods of producing a low energy nuclear reaction.

Table 1. Methods of Initiating LENR[3]

LENR Mechanisms	**Typical Reaction**	**Energy Forms**	**Industrial/Government Players**
LENR[4] (Classic)	Protons in Ni or deuterium in Pd. in an electrochemical cell.	Hot water	US Navy, Airbus
Cavitation[5]	Ni and D_2O bubble-jetting to Ni film.	Heat	Amoterra, Burst Labs, First Gate Energies, First Light Fusion
Laser Induced	Ni plus H plus an em, pulse	Heat	Brillouin Energy
Electric Discharge	C plus O in a carbon arc discharge produce Fe.	Heat, electrical, hydrogen, transmutation	Mitsubishi, Nissan, Toyota, Clean Planet
Temperature Driven	Ni plus Li isotope changes in a dry powder chamber.	Heat	Hydro Fusion Inc., Industrial Heat, Lattice Energy, Leonardo Corp., Neofire, Thermax

The solid-gaseous reactor, typified by the E-CAT device, has the material initially in solid form, but with the application of heat becomes a mixture of solid, liquid, and gas. Currently, heat is the only energy output from this type of device, but unsubstantiated claims[6] have been made suggesting that there is significant electrical output. This device is targeted to be a direct replacement for fossil fuel sources of energy where heat is used to drive steam turbines, etc., a utility level of application. The electric discharge offers an approach for commercialization that is

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[1] M. Fleishman, S. Pons; "Electrochemically Induces Nuclear Fusion of Deuterium"; Journal of Electroanalytical Chemistry and Interfacial Electrochemistry, Volume 287, Issue 2, 25 July 1990, Pages 293–348

[2] A deuterium nucleus consists of one proton and one neutron. The fusion of two deuterium nuclei forms a helium nucleus and an excess neutron. The neutron gives up its energy to the reacting mass in the form of heat.

[3] G. W. Draper, Dr. F. H. Ling; "LENRaries: A New Era of Renewable Energy", Anthropocene Institute, 2017, www.antropoceneinstitute.com

[4] The classic LENR reaction is the reaction in an electrochemical cell using Palladium electrodes in a "heavy water" electrolyte, or nickel electrodes in "light water" and a DC low voltage power source.

[5] Cavitation is an acoustic driven "bubble" that heats the entrapped vapor through resonant expansion and contraction. It is sometimes referred to as "sonoluminescence".

[6] M. Sharma et. al.; "Possibility of LENR Occurring in Electric Arc-Plasma; Preliminary Investigation of Anomalous Head Generation during Underwater Arcing using Carbon Electrodes"; International Conference on Inter Disciplinary Research in Engineering and Technology, 2016

both scalable to useable energy levels and controllable with suitable technology. The electric discharge process, though not necessarily aqueous, has heat and/or steam as an output. For the aqueous device, this limits its application to utility installations where steam driven turbines, etc. are the major energy conversion devices. It is not known if the anomalous production of hydrogen associated with the electrolytic and electric discharge processes, scales to industrial levels[7]. Brillouin Energy[8]'s process consists of forcing hydrogen into a nickel lattice through the use of their proprietary "Q Pulse" generator. Claims are that their nickel lattice is a highly-engineered product. The Brillouin device is not a discharge device, but works primarily in an electrolytic cell mode, along the lines of the original Pons and Fleishmann design. Hydrogen nuclei experience compression in nickel lattice using phonon vibrations in the fusion process.
AmoTerra[9] confines explosions of radioactive waste and proprietary materials that reduces radioactivity to near-background levels following combustion, gradually over several days. This technique has been confirmed by the Italian ENEA and is supported by the French CEA scientists as a serious candidate for treatment of waste stockpiles. Amoterra seems to be economical on a commercial scale.

First Gate's Sonofusion[10] is a plasma jet ejected when a bubble in D_2O acoustically driven to resonance, implodes. This jet, which lasts 100 picoseconds or less, is directed to a metal foil where fusion apparently occurs, with the resulting heat as output. Due to the level of sophistication of the LENR apparatus, trained technicians are required for its operation. Usage will likely be at the utility level (> 1 MW), limiting its use to large and small energy production facilities and situations where unavailability of alternate sources of energy makes this technology desirable. Final processes will likely be adapted to existing thermal generating stations and feed the energy grid in the normal manner.

B. Low Energy Nuclear Transformations

The LENR process has migrated to two camps of study, the original reaction proposed by Pons and Fleishmann, i.e. the nuclear fusion of small nuclei (typically hydrogen or deuterium), and Low Energy Nuclear Transformation (LENT), the nuclear transformation of heavier elements. LENT processes can be grouped into three variations, depending upon the technique used to achieve the change;

- Low Energy Isotope Transmutation[11]-LEIT-this process changes the ratio of isotopes in nuclear fuel, not he element itself.

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[7] S. Focardi, A. Rossi; "A New Energy Source from Nuclear Fusion"; J. Nuclear Physics, March 2010

[8] Brillouin Energy Corp; "Energy Generating Apparatus and Method"; US Patent Application, US 2015/0187444 A1.

[9] G. Vasperman; "27 Methods of Neutralizing or Disposing of Radioactive Waste"; http://freeenergynews.com/Directory/NuclearRemediation/Vesperman/

[10] Roger S. Stringham,"When Bubble Cavitation Becomes Sonofusion". in 237rd ACS National Meeting. 2009. Salt Lake City

[11] Low energy isotope transmutation is the changing of an elements' atomic weight without changing the element. Typically, this would involve the fusion of a nucleus with an elementary particle, such as a neutron or proton, followed by a subsequent decay. A successful example of this type of reaction is the Rossi- E-Cat reaction. The technology is based on the transmutation of one nickel isotope to another with the resulting excess energy being released as heat. The fuel for this device is a dry powder mixture of nickel, aluminum-lithium-hydride plus some additives. The ${}^{7}Li$ naturally present in the fuel is replaced by ${}^{6}Li$ in the ash. Similarly, ${}^{58}Ni$ and ${}^{60}Ni$ in the fuel have been largely replaced by ${}^{62}Ni$ through the reaction

$${}^{a}_{28}Ni + n \rightarrow {}^{a+1}_{28}Ni + \gamma$$

The reduction of ${}^{7}Li$ to ${}^{6}Li$ provides the neutron through the resonant absorption of a proton, with subsequent release of a thermal neutron

$${}^{7}_{3}Li + p + 2.5\ MeV \rightarrow {}^{7}_{4}Be + n$$

followed by

$${}^{7}_{4}Be + e \rightarrow {}^{6}_{3}Li + p + .86\ MeV$$

- Large Nucleus Nuclear Reactions -LNNR-This is the change of large nuclei which may or may not be the electrodes.
- Low Energy Waste Remediation[12,13]-LEWR-This process reduces the nuclear half-life of a radioactive material, rendering it environmentally inert in a much shorter period of time.

The table below illustrates some of the development activity surrounding the LENT process.

Table 2. Low Energy Nuclear Transformation Mechanisms

LENT Types	**Typical Reaction**	**Anticipated End Use**	**Industrial Players**
Low Energy Isotope Transmutation	Ni–Li isotope changes in a dry powder chamber	Heat	Hydro Fusion Inc., Industrial Heat, Lattice Energy, Leonardo Corp., Neofire, Thermax Ltd.
Large Nucleus Nuclear Reactions	Carbon/Oxygen to iron in an aqueous discharge	Heat, Material Processing	Mitsubishi, Nissan, Toyota, Clean Planet Inc.
Low Energy Waste Remediation	Decrease in half-life of uranium in hydrogen plasma	Waste Remediation	Mitsubishi, Amoterra, Lattice Energy, JWK

The difference between classical LENR and LENT is that, in the latter the target nucleus is large, whereas in the classic LENR the fusing particles are H or D nuclei. Mitsubishi[14] is working on nuclear waste remediation using an electrolytic process. They had developed foil permeation techniques by forcing deuterium with a radioactive waste through a metal foil. Yields were too small to be of commercial value; however, for the LEIT type of reaction, of which the Rossi E-Cat device[11], as a an example, only the atomic mass of the nuclear fuel changes, that is to say one isotope of nickel isotopes gets converted to another isotope of Ni, releasing some energy as slow neutrons, which can convert more nickel, or collide with other material to dissipate its' energy as heat. The fuel, nickel in this case, is still nickel, but with a differing isotope ratio from which it started.

LNNR reactions have been studied longer than the traditional electrochemical cell reactions. These reactions include the carbon rod electrodes in an electric arc. The production of iron for example, has been extensively studied and duplicated since its discovery in 1965. Although not strictly necessary, the LNNT reaction seems to favor the electric discharge method of initiating a nuclear reaction.

A third type of reaction is the low energy waste remediation reaction. In this process, radioactive wastes are subject to conditions, such as an extremely violent electric field that one would see at the focal point of a laser, or perhaps in a violent electric discharge. There is sufficient disruption in the nucleus of the waste material to cause it to undergo fission and break into smaller non-radioactive parts, eventually. Some researchers claim to get more energy out, than they put into the process. It perhaps is significant that the larger industrial players are putting major effort into developing this technology, especially in Japan. Amoterra, a Canadian company, seems to be

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[12] G. W. Draper, Dr. F. H. Ling; "LENRaries: A New Era of Renewable Energy", Anthropocene Institute, 2017, www.antropoceneinstitute.com,

[13] G. Vasperman; "27 Methods of Neutralizing or Disposing of Radioactive Waste"; http://freeenergynews.com/Directory/NuclearRemediation/Vesperman/

[14] Steven B. Krivit; "Mitsubishi Heavy Industries Continues Efforts to Commercialize LENR", New energy Times, July 13, 2016

about the closest to having a marketable technology. Recently[12], Draper addressed commercial interests in the field, claiming that their greatest need in order to get workable technology, was availability of reliable, independent test facilities. Most companies are small, with less than five employees, have been in business less than five years, and are capitalized with less than a million dollars. Draper states "unlike more reliable fission reactions, controlling LENR reactions has proven challenging. The most common reason why many LENR replications produce intermittent COP results is the lack of real-time control of the reactions. … LENR reactions are challenging to produce, much less control..."

C. Large Nucleus Nuclear Reactions by Electric Discharge

Whereas LENR is a process for fusing two or more small nuclei that comprise the nuclear fuel, typically in an electrolytic cell, LNNR requires the transformation of heavier elements, such as those forming the electrodes in an electrical discharge, into other elements. In a series of papers beginning in 2004, Dominico Cirillo[15,16,17,18] demonstrated the transmutation of metals in a water-based direct current discharge plasma. The table below lists some of the experimental results observed in aqueous electrical discharge LNNR.

Table 3. Observed Transmutation in Aqueous Discharge LNNR

Author	**Reaction Type**	**Electrodes**	**Reacting Products**	**Reaction Products**
Cirillo [15-18]	LNNR	W / Fe	W/ H	Re, Os, Au, Hf, Tm, Er, Yt
Biberian[19]	LNNR	W	W/ H	Unknown
Oshawa[20]	LNNR	Carbon	C, O	Fe
Brockris[21]	LNNR	Carbon	C, O	Fe, Mg, Pd, Ca, Al, Zn, Cu
Hanawa[22]	LNNR	Carbon	C, O	Cr, Mn, Fe, Co, Ni, Cu, Zn
Esko[23]	LNNR	Carbon	C, O	Fe, Si, Mg, Cu, Al, Ti, S, K
Sharma[24]	LNNR	Carbon	C, O	Unknown
Reiss[25]	LNNR, LEWR	Various	Various	Various
Dash[26]	LNNR, LEWR	U, Mo	U	α, γ, X-rays

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[15] Domenico Cirillo; "Slow Neutron Generation", Nov. 11-15, 2012, San Diego, California

[16] D. Corillo et. al.; "Experimental Evidence of a Neutron Flux Generation in a Plasma Discharge Electrolytic Cell"; Key Engineering Materials, vol. 495 (2012) pp 104-107

[17] D. Cirillo, V. Iorio; "Transmutation of metal at low energy in a confined plasma in water"; Eleventh International Conference on Condensed Matter Science, 12004, Marseille, France

[18] D. Cirillo, et. al.; "Water Plasma Modes of Nuclear Transmutations on the Metallic Cathode of a Plasma Discharge Electrolytic Cell", Key Engineering Materials, vol. 495, (2012) pp 124-128

[19] Jean-Paul Biberian, Mathieu Valat, Walter Sigaut, Pierre Clauzon, Jean-Francois Fauvarque; "Pressurized Plasma Electrolysis Experiments"; J. Condensed Matter Nucl. Sci., 15 (2015) 190-194

[20] The transmutation of carbon and oxygen in an electric carbon-carbon arc was originally reported by George Oshawa and reportedly produced a new iron alloy in economically producible quantities. Duplication of Osawa's work, using highly purified water and rigorous control of experimental variables, verified the production of iron in quantities one to two orders of magnitudes higher than were possible from the trace amounts of iron available in the electrodes. It was noted that when nitrogen gas was dissolved in the water (replacing oxygen), elemental iron was not observed as a reaction product. Spectroscopic evidence indicates the presence of Mg, Pd, Ca, Al, Zn, Fe and Cu. Recently, Sharma reported a net energy surplus using a carbon-carbon arc in an aqueous environment. Several reaction schemes have been proposed for the above of which the following is typical $2({}_{12}^{6}C + {}_{16}^{8}O) \rightarrow 2\,\mathrm{Si}_{28}^{14} \rightarrow Fe_{56}^{26} + \mathrm{He}_{4}^{2} + 56.55MeV$

[21] J. O'M. Brockris; "Early Contributions from Workers at Texas A&M University to (so called) Low Energy Nuclear Reactions"; J. New Energy, 4, 2, 1999, pp 40ff.

[22] T. Hanawa; "X-Ray Spectrometric Analysis of Carbon-Arc Products in Water"; Proc. ICCF-8 147-152 (2000)

[23] E. Esko. "Production of Metals from Non-Metallic Graphite", Infinite Energy, 78 42-43, 2008

[24] M. Sharma et. al.; "Possibility of LENR Occurring in Electric Arc-Plasma; Preliminary Investigation of Anomalous Head Generation During Underwater Arcing Using Carbon Electrodes"; International Conference on Inter Disciplinary Research in Engineering and Technology, 2016 [ICICRET 2016]

[25] H. R. Reiss: "Observation on the acceleration by and electromagnetic field of nuclear beta decay", Europhysics Letters Association, Vol. 81, No. 4, January 11, 2008

[26] J. Dash, et. al.; "Effects of Glow Discharge with Hydrogen Isotope Plasmas on Radioactivity of Uranium", Proc, ICCF-9, (ICENES,2002), p.122

As a process, aqueous electrical discharge phenomena offer a plethora of anomalous behaviors that have been reported[27] in the literature, and observed by Magnetic Miles during the course of development of their technology, as shown in the table below.

Table 4. Observed LNNR Behaviors

Anomalous Behavior	**Reported LENR Behavior**	**Magnetic Miles Observations**
Production of excess heat	Up to 300% of applied energy demonstrated	2.50 times input energy as heat
Production of excess electrical energy	Speculative	1.18 x 10^4 times input energy as electrical energy
Production of excess hydrogen	Up to eight times expected amounts	Not measured, but copious amounts produced
Production of neutrons or γ rays	E-Cat up to 300 keV x-rays	High intensity γ bursts detected
Transmutation of the electrode elements	Shift in atomic number higher or lower	Transmutation and half-life reduction observed

Not all of the reported behaviors are necessarily related to the LNNR process; however, the excess electrical current has been reported to be thermionic in nature, similar to that emitted by the heated cathode in vacuum tubes of the past. There are probably LNNR and LEWR reactions going on simultaneously in some of these scenarios.

II. Magnetic Miles Technology

A. Controlling the Process - Pulsed LNNR-MMIC Device

Little work has been published on power sources for LNNR that are pulsed or otherwise varied, in some controlled manner. Electrical discharge processes generally experience pulsed electric fields, but these are essentially an uncontrolled result of the discharge itself, sometimes governed by the internal resonant behavior of the entire apparatus. A few research groups have explored a pulsed approach however, the Correa's[28] had patents granted in the mid 1990'sfor a process they named "Pulsed Abnormal Glow Discharge". This centered around a low-pressure discharge tube, where the discharge is maintained in a so called cold state (unheated cathode) with electrical breakdown prevented by the application of an external electric field. Negative resistance and over-unity effects were claimed. Low energy nuclear reactions were not a focus point of their research.
Richard Reichmann and Karl-Ludwig Barth with Purratio Ag[29,30] developed a plasma torch using a capacitive discharge technique, in a hydrogen or water atmosphere. Over-unity heat production was claimed. That design allowed for the simultaneous application of a DC current and a short duration pulsed current to initiate a fusion event, claiming that the electron flow from the cathode, which was thermionic in origin, needed to be minimized. This maximizes the opportunity for hydrogen nuclei, lithium nuclei, etc., to impact the cathode, typically Th, Pd, Fe, Co, Ni, and a plethora of more exotic alloys. The cathode was either a pure metal or a coating on a metal grid.

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[27] D. W. Lindstrom, "Pulse-Controlled LENR - The Technology of Magnetic Miles LLC"; proprietary report prepared for Magnetic Miles, LLC, 2016

[28] P. Correa, A. Correa; "Electromechanical Transduction of Plasma Pulses"; US 5,416,391; May 16, 1995
P. Correa, A. Correa; "Energy Conversion Systems"; US 5,449,989; Sep. 12, 1995
P. Correa, A. Correa; "Direct Current Energized Pulse Generator Utilizing Autogenous Cyclical Pulsed Abnormal Glow Discharges"; US Patent US 5,502,354 Mar. 26, 1996

[29] Richard Reichmann, Karl-Ludwig Barth; "Method for Producing Thermal Energy"; CA 2621914 A1, 2007

[30] Richard Reichmann, Karl-Ludwig Barth; "Method for Producing Thermal Energy", WO 2007/08471 A2

The company is still in existence, and has an LNNR technology they have called "SolFire" that is in some rather vaguely defined state of development[31].

In previous reports[32,33], the application of the Magnetic Miles Impulse Control (MMIC) system to a discharge type LNNR was discussed at length. Table 5 is a summary of the observations based on the type of energy released.

Table 5. Magnetic Mile Impulse Controller in LNNR Application

Energy Source	Size of Effect	Source of Energy	Application
Low Frequency Electrical Pulses	Large	LNNT, LEWT, Non-Linear EM	Power utilities
Thermal Energy	Moderate	LNNT, LEWT, Joule Heating	Power utilities
High Frequency EM Radiation	Moderate-Large	LNNT, LEWT, Non-Linear EM	Unknown
Release of Nuclear Radiation	Unknown	LNNT, LEWT	Unknown
Anomalous Hydrogen Generation	Large	LNNT, LEWT, Non-Linear EM	Power utilities, transportation
Optical and UV Emissions	Large	Probably Plasma Chemistry	Plasma chemistry

The apparatus is characterized by a rise and fall in electrical energy levels in alignment with conventional thinking, however unexpected huge power surges in the apparatus occur in somewhat regular fashion. These surges have been termed "events" that may be associated with the anomalous, possibly LEWR behavior observed in the apparatus.

Several resonant frequencies were observed in the form of large low-frequency electromagnetic oscillations, ranging in frequency from the base resonance of the circuit itself at about 4 Hz., through the so called "Schumann[34]" resonances at about 7.8, 14.3, 20.8, 27.3 and 33.8 Hz. and to an internal circuit resonance of about 150 kHz. These electrical effects exhibit large energy levels, seemingly violate Kirchhoff's and Ohm's law. Joule heating effects[35] are seemingly absent or greatly reduced.

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[31] http://www.purratio.ag/PurratioAG%20eng/html/technologies.html

[32] D. W. Lindstrom, "Pulse-Controlled LENR - The Technology of Magnetic Miles LLC"; proprietary report prepared for Magnetic Miles LLC, 2016

[33] D. W. Lindstrom, "The Sheath Experiments"; proprietary report prepared for Magnetic Mile LLC, Stuart Florida, 2016

[34] https://en.wikipedia.org/wiki/Schumann_resonances

[35] Kirchhoff's law states that the sum of the currents entering a circuit must equal the sum of the currents leaving it; Ohm's law states that the resistance of a circuit is proportional to the voltage drop across it, and inversely proportional to the current flowing through it; Joule heating is a consequence of this, where the power converted to heat in a resistance is proportional to the square of the current multiplied by the resistance.

B. LNNR and LEWR Using the Magnetic Miles Impulse Control (MMIC) System

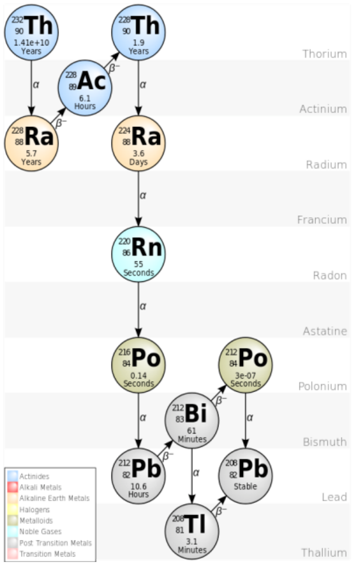

Figure 1 Decay of Thorium

Low energy nuclear waste remediation (LEWR) is the stimulation of nuclear fission in unwanted nuclear waste materials with low energy particles. Reviews written for the general audience are available[36,37]. The subject has been studied extensively with nuclear waste remediation in mind; laboratory demonstrations with uranium[38] in a low-pressure hydrogen plasma environment stimulated by electrical discharge showed an increase in α particle emissions by a factor of three, and for cesium[39], using a focused laser system where, changes were small but were linked to violent electromagnetic fluctuations. It was noted in an earlier document[40] that the need for an analysis of electrode composition before and after the exposure to the plasma discharge is a key indicator of whether or not a nuclear transmutation or decay rate alterations had occurred. Anode samples, cathode samples, and control samples from the electrical discharge apparatus were subject to Wavelength Dispersive X-Ray Fluorescence Spectrometry (WD-XRF) at an independent testing facility. The following table shows the presence of material change from the control specimen as indicated by the signal strength from X-Ray scattering. The ends of the electrodes (1/4" tungsten-thorium welding rods) not subjected to the electric discharge were treated as control samples.

Table 6. Electrode Analysis by WD-XRF

Element	Anode Change from Control	Cathode Change from Control	Reaction Type	Comments
Hf	0.0401	0.0318	LEWR	Hf levels increased by about 0.04%
Ta	0	0.0115	LNNR	perhaps slight increase at cathode
W	-0.1	-0.1	LEWR	drop of 0.1% indicated
Re	0.0207	-0.0051	-	inconclusive
Os	0	0.0264	LNNR	perhaps slight increase at cathode
Ir	-0.0288	-0.007	LNNR	slight drop indicated
Pt	-0.0084	-0.0037	LNNR	slight drop indicated
Tl	0.0849	0.0975	LEWR	Tl levels increased by about 0.08%
Pb	0.0106	0.0458	LEWR	Pb levels increased by about 0.02%
Bi	0	0.0128	LEWR	perhaps slight increase at cathode
Th	-0.08	-0.17	LEWR	Thorium level lower by about 0.2%
U	-0.0024	0.0031	-	inconclusive

From the data shown in Table 6, it is noted that the presence of hafnium (Hf) consistently increased by about 0.03%-0.04%, thallium levels consistently increased by about 0.08%, and lead increased

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[36] G. Vasperman; "27 Methods of Neutralizing or Disposing of Radioactive Waste"; http://freeenergynews.com/Directory/NuclearRemediation/Vesperman/

[37] G. Vasperman; "Radioactivity Neutralization Methods for Moab tailings", 2014, www.padrak.com/vesperman

[38] J. Dash, et. al; "Effects of Glow Discharge with Hydrogen Isotope Plasmas on Radioactivity of Uranium", Proc, ICCF-9, (ICENES,2002), p.122

[39] H. R. Reiss, "Accelerated Beta Decay for Disposal of Fission Fragment Wastes", Report for Grant #DE-FG02-96ER12195, March 6, 2000

[40] D. W. Lindstrom, "Pulse-Controlled LENR - The Technology of Magnetic Miles LLC"; proprietary report prepared for Magnetic Miles, LLC, 2016

by about 0.02%. The quantities of elements other than tungsten and thorium measured using the scattering technique are below the reliable measurement level for the instrumentation and must be regarded as indicators only. The presence of new elements (hafnium, thallium, and lead) indicates a naturally occurring fission reaction in the electrode. For example, from Wikipedia, the decay chain for ^{232}Th, the only naturally occurring isotope of thorium, results in ^{208}Pb, a stable isotope of lead with thallium being an intermediary reaction product. ^{182}W, ^{183}W, ^{184}W, and ^{186}W are the near stable isotopes of tungsten. These isotopes decay to hafnium isotopes with the emission of an α particles. The hafnium isotopes ^{177}Hf - ^{179}Hf are stable and naturally occurring.

Reiss[11] claims that intense electromagnetic disturbances can trigger decay of radioactive materials. An aqueous electrical discharge driven by the Magnetic Mile Impulse Controller is certainly chaotic and intense, and may account for the observed decrease in Thorium levels, and the subsequent increase in Pb, Tl, and perhaps Bi. This leads one to speculate that elements such as Hf, Pb, and Tl are the result of an accelerated fission process, shown above as an LEWR reaction, and other elements such as Ta and Os etc. are the result of a differing, perhaps non-fission LENR paths. The decrease in Pt and Ir is unexplained, but, if real, would likely be of the LNNR type. Further analysis under controlled conditions is required to verify this speculation.

C. Thermionic Current

One can think of the Magnetic Miles device as a three-terminal device, where one terminal goes to the battery positive terminal, the second goes to the battery negative terminal, and the third connects the cathode of the spark gap. This is illustrated conceptually in Figure 2. Experimental evidence corroborated by others[15-18] demonstrates the existence of large currents thought to be of cathodic origin. Recent evidence [41] raises questions regarding the origin of the thermionic current. Figure 3a is the battery current independently [42] measured for the MMIC in the motor configuration. This configuration lacks the spark discharge shown in Figure 2, however large current spikes appeared at the leading and trailing edges of an oscillatory pulse.

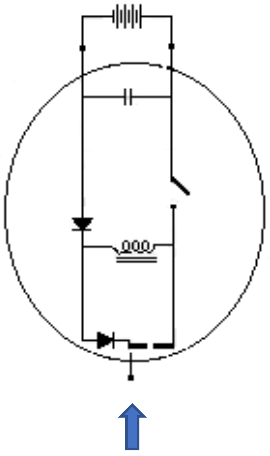

Figure 2 Simplified MMIC Circuitry

The gap current is defined as the difference between the cathode current and the anode current. This is shown in Figure 3b. There is a similarity between the battery current to and from the motor, and the gap current, but the magnitudes of the currents are vastly different.

Figures 4 is the negative battery current; similarity in current form is noted there also. This similarity in form between the motor current and the spark gap and battery current raises questions about the assumption of the gap current being thermionic in origin.

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[41] This experiment was performed on February 6, 2017 using two inductors in parallel.

[42] T. A. Haskew; "Magnetic Miles Motor Testing", University of Alabama – Electromechanical Laboratory, Nov 19, 2012

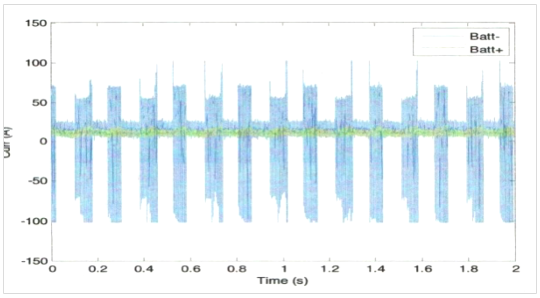

Figure 3a Battery Current (no spark gap)

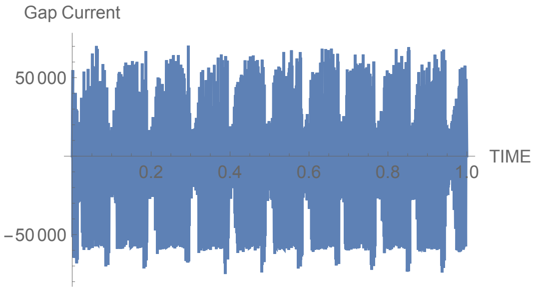

Figure 3b Spark Gap Current

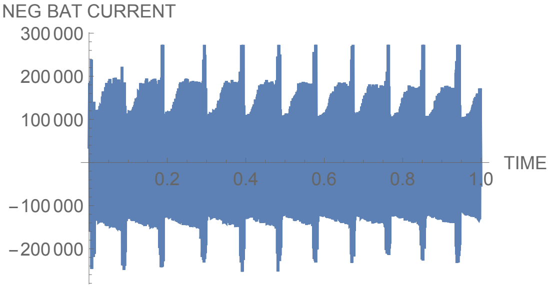

Figure 4 Negative Battery Current

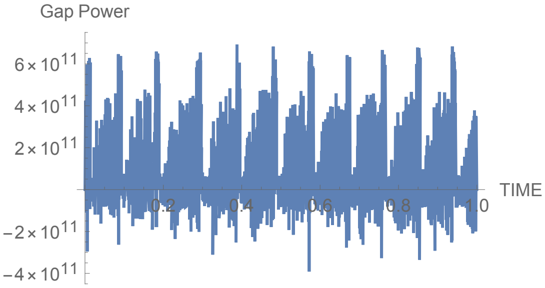

Figure 5 Power Across Gap

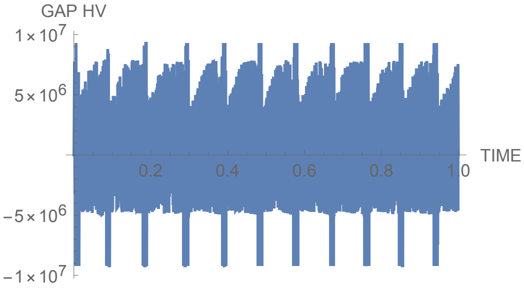

Figure 6 Voltage Across Spark Gap

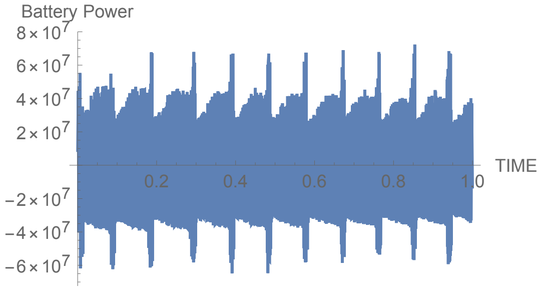

Figure 7 Power Drawn from Battery

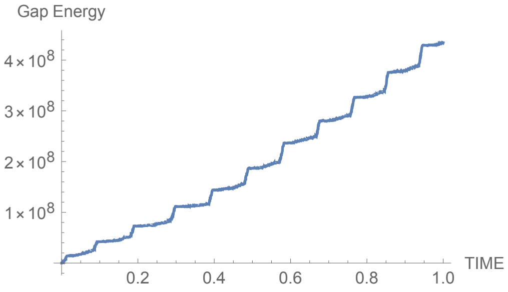

Figure 8 Spark Gap Energy

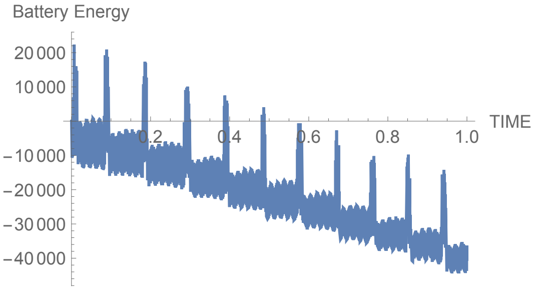

Figure 9 Energy from Battery

Figure 6 gives the voltage across the spark gap, having peaks of about eight million volts. Multiplying this by the spark gap current of Figure 3b gives the instantaneous power levels in the gap in excess of 600 billion watts. The net energy entering the spark gap, which is the energy flowing out of the anode minus the energy entering at the cathode, is given in Figure 8. This is the time integral of the power in Figure 5. The slope of the graph in Figure 8, the average net power at the gap is about 4.36 x 10^8 watts (436 megawatts). A similar procedure can be used to calculate the power drawn from the battery. The slope of the graph for energy drawn from the battery is about 36,900 watts (36.9 kilowatts). Dividing the average net power at the gap by the average power flow from the battery gives the average coefficient of performance for the apparatus which, in this case, is about 10,000 (averaged over one second). All measurements were made with calibrated instrumentation; data was sampled 800,000 per second.

Table 7 shows the average values of a few of the experimentally measured parameters. The average values are comparable to the results of others [15-18]. The coefficient of performance with regard to the gap power, as compared to the power drawn from the battery, is about 1.18 x 10^4. Further work is need to determine if this can be maintained for longer time periods. It does point to the need for investigation into LENR's electrical output, since it seems to be significantly higher than heat output normally sought after.

Table 7. Peak and Average Electrical Properties

Property	**Peak Value**	**Average Value**
Battery Pos. Current	-246,000 275,000	-133.2 Amps
Battery Neg. Current	-246,000 275,000	-154.2 Amps
Battery Voltage	+290 +200	249.4 Volts
Anode Current	+54,000 -53,000	365.2 Amps
Cathode Current	+26,000 -49,300	-121.7 Amps
Gap Voltage	-9.43x106 9.11x106	3166.4 Volts
Gap Current	71,400 74,600	-239.4 Amps
Gap Power = Slope of Gap Energy vs time graph	6.8 x 10^{11}	4.36 x 10^8 watts
Battery Power = slope of battery energy vs time graph	6.8 x 10^7	36.9 x 10^3 watts
$\text{Coefficient of Performance} = \frac{\text{Gap Power}}{\text{Battery Power}}$	3.9 x 10^6	1.18 10^4

D. Future Developments

Magnetic Miles LLC has, over the course of the past eleven years, developed a technology that is applicable to the LENR industry. It is very unique because it demonstrates the possibility of generating heat and electrical energy via the LENR mechanisms that is far greater that the energy inputs required to drive the process in a controllable manner. The heat energy generated by LENR is two or more times that supplied to the reaction; for short term excursions, the gain in electrical energy is 1.18 x 10^4. It does this in a controlled manner, where the output parameters of the LENR are controlled by the operating characteristics of the MMIC device. The next step is to explore and expand the basic controlled LENR technology to the point where it can be transferred to the utility level power generation industry and to expand the nuclear waste remediation technologies to the point that the appropriate industrial entities that have the capability, in terms of engineering and manufacturing know-how, can take it and develop the technology for their own applications. When completed, the new technology will make existing fossil fuel and nuclear power generation technologies obsolete, and will provide a proven fast and cost effective method for cleaning up existing nuclear contamination.