FORGOTTEN INVENTIONS OF LENR

Part 2: The Four-and-a-Half Heresies

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Introduction

In Part 1, four LENR related heretical discoveries/inventions were introduced from the early 1900s:

1. Transmutation in gas discharges (experiments collected by S. Krivit[1])
Observation of helium and neon in a hydrogen atmosphere. The very notion of transmutation at low energies (some eV level) is a major heresy, and has the connotation of alchemy—bad science at its worst. There has been no change in this matter during the last hundred odd years, as the Pons-Fleischmann case has shown, or as biological transmutations are shunned[2] or geological transmutations are ignored.[3]

2. Reversal of potential (electromotive force) in interrupted arc discharge.
The observation of V. Mitkevich *et al.* in 1905 in St. Petersburg goes against the notion of conservation of electric charge, which is a fundamental law in all electrodynamics and electrostatic experiments. The other possibility to explain this effect is even worse: the law of energy conservation must be violated, or some other unknown form of energy is released from an unknown source.

Strange, unexplained severe instabilities such as self-generated oscillations have been observed in gas discharges repeatedly. Their energy source has not been identified. No spectroscopy has ever been performed in these tests, as no researcher in his right mind assumed transmutation behind the wild oscillations. Obviously, no energy balance tests were performed because an energy release has never been assumed to be the basis of these severe oscillations.

However, Mitkevich found evidence that voltage reversal (the cause of oscillations) is causally connected to the materials of electrodes. With mercury electrodes there is usually no reversal of potential. One could surmise that sputtering is necessary for the voltage reversal, or an eroded, uneven surface, on at least one electrode. (He did not state this clearly; it is just my conjecture.)

These heresies were connected later by an eccentric outsider: George Ohsawa, a diet guru, who firmly believed in biological transmutations. In his simple arc discharge experiments with graphite electrodes, he found a number of transmutations. In principle Mitkevich could have found the same transmutations in his experiments. However his "model of nature" ruled out the possibility of transmutation at all.

3. Felix Ehrenhaft in Vienna, started to test forces on tiny floating particles, such as colloids in liquid, and dust in gas. He found unexplained forces, driven by light. He tested forces on individual particles, but not in plasma—just in illuminated gas. He reported on a strange new world of magnetic monopoles and unusual "photophoretic" forces during his 50 odd years of experimental studies. However these new forces were not the fruits of Maxwellian (or Maxwell-Heaviside) electrodynamics.

Sputtering yields millions of tiny, sub-micron size particles, plasma emits light, and there are free electrons attached to floating, rotating particles. So there is just a vast, unexplored area out there, because dusty plasma research never touched (or dreamed of) Ehrenhaft's legacy.

4. Unaware of the above results, two inventors built disruptive inventions, producing unlimited amounts of electrical energy, apparently without fuel—Nikola Tesla and the young Thomas Henry (T.H.) Moray in the U.S., both of whom were quite far from mainstream science. This thinly disguised perpetual motion was immediately attacked from two sides, science and industry. Tesla was already an outcast despite his groundbreaking achievements; Moray was a lucky, but ignorant, amateur radio fan. They would not have been helped by reading the three previously mentioned papers. They were far away from academic research. For them details like transmutation, voltage reversal or colloidal dust were not relevant at all to electric energy production—which they achieved eventually.

There is a *fifth*, albeit less dangerous, "half heresy." Most researchers in the LENR field still believe that this discovery was made by Pons and Fleischmann in 1989. Electrolysis is the "host area" of LENR. Only heat can be generated. Transmutation takes place only in the bulk of a metal lattice, exclusively with hydrogen isotopes. Plasma is just another form of electrolyte for them.

The content of this review is contrary to this general view. Different aspects of LENR were detected in the early 1900s, in transient dusty plasma as a surface phenomena. Useful prototypes, producing electric energy, were demonstrated by Tesla and Moray by the 1930s. In later decades similar inventions resurfaced and then sank again.

None of them are documented well enough to rebuild them. However, from the remaining fragmented information, a rather coherent, testable chain of effects can be assembled. The fragmented and forgotten inventions of LENR are still a gold mine of valuable information in physics, and engineering solutions. The aim of Part 2 is to

arrange a number of these bits of neglected information into a logical, inspiring set, which later may pave the way for the field of LENR to be considered for an esteemed position in our technical society.

LENR Fusion: Dust and Electrode Edges as Catalyst

In order to fuse nuclei, and release energy, nuclei must be quite close to each other, within the range of the strong nuclear forces. However, Coulomb repulsion of like (positive) electrostatic charges of nuclei makes fusion technically difficult. High energies at extreme temperatures make this process possible, for example in hydrogen bombs, or in stars.

There is another path, less beaten: a strong local negative field (around electrons) can neutralize—*shield*—Coulomb repulsion. This is relatively easy to achieve on the surface of sharp edges of electrodes, or on the surface of charged dust particles in discharge plasma. Therefore this mechanism is described briefly. Then the transmutation effect is described on these charged surfaces based on this model, as a result of the elimination of Coulomb repulsion, thus facilitating local fusion. This charge shielding enabled by local high electron density is a *sort of catalytic process*, whereby the electron cloud is the active component.

Based on the above, the Mitkevich effect will be explained as a result of LENR fusion, which is not hot fusion, since neutron formation from light hydrogen (protium) is involved. This chain of fusion steps was outlined by Dr. Edmund Storms, but suspected by several other researchers.

Based on the above insight of voltage reversal in interrupted gas discharge, the Moray invention is scrutinized. Then other, transient dusty plasma-based, electricity-producing inventions will be described, to verify the LENR line of thought (most of them in Part 3 of this paper).

Before getting to the physics and engineering, there is another important point to clear beyond the Coulomb barrier: the "mental barrier."

Most researchers think that biological transmutation is *a priori* impossible, because energy released by fusion would kill plants or bacteria. They forget that the isotopes might contain more neutrons than usual in these transmutations, in some cases making them consume energy. That is fusion-transmutation which usually yields only a modest amount of energy release.

Further, there is another "built in" notion, that controlled fusion cannot be realized in small inexpensive devices, only in huge, "hot" devices. However, electrical energy-producing controlled fusion devices were table top size, moreover, they were manufactured in the price range of $1-10,000, and used ordinary hydrogen as fuel, sometimes as water.

A hot fusion device, whether it is inertially driven or magnetically confined, costs billion of dollars, uses tritium as fuel and is as large as a football field, so that it is never portable.

There is a trade off in principles. "Cold fusion" processes—seen as the Mitkevich effect—are quite complicated and self-organizing, especially with respect to their interrelated physical processes. They are not easy to fully grasp, as they consist of an array of interrelated effects, spanning several orders of magnitude in the scales of both time and size.

Hot fusion principles are simple to understand. However, they practically suit only bombs or stars, not the controlled manner of fusion.

The Practical Advantages of Dusty Plasma

Why are dust (nanometer-micrometer range) and sharp edges, like thin wires, so essential for *economic* LENR?

Why is transient, preferably resonant, dusty plasma the right environment? It is important to have a reasonable answer for these questions, because all the inventions are based on it.

There are two difficult issues at once:

a) Why is ordinary hydrogen also suitable as fuel?
b) Why are modest input energies enough for controlled LENR fusion?

The answer is outlined in a nutshell. (A more detailed process was described in a former paper,[4] and further details will be given in the Appendix, in Part 4.)

When the fuel is ordinary hydrogen, a neutron mediated chain of fusion reactions takes place, step by step. The process is most likely the series of steps shown in Table 1.

Overall, the chain of processes shown in Table 1 may yield

Table 1. When fuel is ordinary hydrogen, a neutron mediated chain of fusion reactions takes place.

$_1p^1 + _0e^{-1} + v \rightarrow _1n^0$ - 0.78 MeV	energy consuming neutron synthesis (Coulomb screening is necessary). This is the "bottle neck" process. Some neutrons may escape from the system, causing a net loss of energy.
$_1n^0 + _1p^1 \rightarrow _2D^1$ + 1.1 MeV	energy generating deuterium synthesis (Coulomb screening is not necessary). A proton-rich environment is necessary. The conditions are favorable on a surface, under a surface, or in a high pressure hydrogen plasma.
$_1p^1 + _0e^{-1} + _1p^1 \rightarrow _2D^1$ + ~1.9 MeV	This is also a deuterium generating process, but Coulomb screening is necessary. Its likelihood is less than the above two-body reaction between slow neutrons and protons.
$_1n^0 + _2D^1 \rightarrow _3H^1$ + 4 MeV	energy generating tritium synthesis (no Coulomb screening is necessary). Tritium is generated in a deuterium rich environment on surfaces of wires, dust, sharp edges, but in bulk plasma, too.
$_2D^1 + _1p^1 + _0e^{-1} \rightarrow _3H^1$ + ~6 MeV	In this three-body process tritium is generated, but Coulomb screening is necessary. Typically discharge eroded electrode surface or a dust surface catalyzes the process. Less likely than the above two-body fusion theories.
$_1p^1 + _2D^1 \rightarrow _3He^2$ + ~4 MeV	energy generating helium synthesis (Coulomb charge screening or shielding is necessary). The most favorable place is a highly charged surface or just beneath.

excess heat energy, if the neutron loss is negligible. The problem is similar to the "critical mass" condition of fission chains for heavy elements. Its bottleneck is the neutron synthesis from electrons and protons. There are further possible fusion steps, not described here, resulting in helium. Additional possibilities: as polyneutron formation, energy-consuming LENR fission reactions, and a host of other reactions involving heavier nuclei. These fusion reactions are quite different from "hot" fusion of deuterium and tritium, at very high energies. These "Storms" chains usually require catalysis, not in cracks, but on sharp edges, or dust in transient plasma.

There is some experimental evidence that thermal neutron production can take place when high voltage lightning hits the ground, and also in gas discharges.

Ernest Sternglass of Cornell University found in 1951 that neutrons streamed out of an X-ray tube, which was previously exposed to air—thus some water vapor as well. The finding surprised him, so the result was not published. It remained buried in the archives of Cornell University, until Max Fomitchev-Zamilov found it, and repeated the experiment as closely as possible. Indeed, he verified the fact of neutron generation, as well as the presence of deuterium and helium nuclei, with a mass spectrometer.[5]

There is another, barely known observation of Chris Mead *et al.*, who found that the isotope distribution of the mercury changes in a commercial compact fluorescent discharge tubes. The paper was published under the title "Unique Hg Stable Isotope Signatures of Compact Fluorescent Lamp-Sourced Hg."[6]

They tested the mercury isotope distribution in compact lamps, which are, after all, transient discharge tubes. They noted after 1,700 hrs, 3,600 hrs, and 16,000 hrs of service, the isotope distribution changes. There are many complicated interacting effects even in this simple tube, but it is noteworthy that ^{196}Hg isotope is enriched by about 20%, while the other five isotopes decrease after prolonged use. They made the tests with a sensitive mass spectrometer. They concluded that there is "an as yet unknown isotope effect among odd mass Hg isotopes."

The most relevant test results are from T.N. Claytor of Los Alamos Lab, where the formation of tritium was observed in a deuterium plasma pulsed discharge. This will be elaborated in Part 3. The most important historical paper on transmutation of hydrogen into helium and neon by a pulsed high voltage discharge tube was published by Norman Collie *et. al*. in July 1914 in the Pr*oceedings of the Royal Society*.[1] The chain of transmutation discussed above was observed there, but of course they did not or could not describe this sequence of transmutation steps.

The removal of transmutations from the body of scientific observations was a tragedy, because all inventions are based on this sequence of events. All the inventors had to find out the details from scratch.

No textbook on transient discharge ever quotes these test results or others by Thomson, Soddy, etc. collected by Krivit.[1]

Textbooks or papers on transient gas discharge do not mention the feasibility of transmutation of hydrogen (or any other matter), while discussing a number of the electrode effects. There is not even a footnote.

To sum up the essence: this chain of fusion events does take place on and just under the surface of dust particles and edges of electrodes. (This was also noted by J. O'M. Bockris, that surface dendrites were necessary for transmutations in electrochemical tests.) The environment of these transmutations therefore is quite different from that of "hot fusion." While gamma radiation is observed there, in some reactions, there is none in the "cold" version. Otherwise all inventors would have died during the development process.

The removal of the transmutation effect in *transient* dusty gas discharges has robbed the opportunity of many potential inventors and developers.

The handful of inventors who eventually stumbled onto the energy-generating side of this effect speculated in vain about the fluctuation of ether, cosmos, vacuum, orgone, etc., and kept this "secret" to themselves. This is the human side of the slow development of this very important area. Even the hundred or so full time LENR researchers are unaware of this very efficient method to release substantial amounts of harmless fusion energy in a controlled manner.

Transient gas discharge is a more efficient and more versatile source of fusion energy than electrochemistry-based or steady state plasma-based methods.

A Complex Sequence of LENR Events…

The above outlined catalytic fusion concept is a radical departure not only from "hot" fusion, but also from the traditional cold fusion based on electrochemistry. There has been no research effort to find out the intricate technical parameters of the "Storms" chain.

No wonder there are so few test results about neutron generation and heavy hydrogen isotope formation in discharge tubes. First of all, according to the mainstream model, it is impossible, so it is not worth looking at it. On the other hand ultra-cold and thermal neutron detection and hydrogen mass spectroscopy are quite difficult and expensive. Tritium is easier to detect due to its radioactivity; helium is easier to detect due to its different mass spectrum, except in deuterium gas. However, helium has a different optical spectrum from deuterium.

Lack of in-depth experimental knowledge in this area has been especially harmful in LENR modeling.

Our first question is whether neutron production—fusion of protons and electrons—is possible. We ask because this process *consumes* energy, 0.78 MeV, in a single step. There are no intermediate states in between, it must be given at once: therefore it is a barrier. There is no "tunnel" to avoid this problem, to the best of our knowledge.

Gas discharges rarely exceed the overall 20 kV potential difference, but this difference is even less inside a gas discharge. Household gas discharge devices are run at even lower range. Where is the necessary million Volt range? This is the energy range of specially designed accelerators! (There is one exception though: Tesla reached up to about 2 MV with his resonant air core magnifying transformers, but those were bulky instruments!)

The answers are four-letter words: *dust* and *edge*. Dust is the uninvited guest of most discharges, and where there are electrodes, there might be edges, too. Dust and sharp edges on electrodes act as catalysts. Life is full of catalytic processes enabled by, for example, enzymes and vitamins. Yet mainstream "hot" fusion researchers never try to copy life, they use only brute force.

Let us deal with the dust first, and later with the edges. Although the two processes are different, they both serve the same purpose: to create neutrons in a catalytic way, on and beneath their surfaces. The collective oscillations of dust particles act in a strange way: they *magnify* electric fields within plasma oscillations.

This is like a magnifying lens for light rays: collects rays and amplifies intensity, without a significant energy investment. This electric field amplification process is not easy to grasp; it happens in the following sequence: Electrons of the plasma are very fast compared to the ions, but especially compared to dust particles, and sometimes they hit dust particles. So they are trapped beneath the dust surface, creating strong local electric fields. This negative field is exceptionally useful for Coulomb screening for the fusion of positive ions, and not only for the lightest nuclei! However, a steady state discharge plasma does not have a high potential difference; thus the average electron speed is low. MeV or keV range potentials are absent even at the peak of Maxwell's curve. However, acoustic oscillations make a big difference compared to steady state. Occasionally some dust particles may collect the fastest part of electrons under their surface even for steady state plasma, but the probability is low.

In the case of acoustically resonant dusty plasma, the high energy electron accumulation beneath the surface of dust particles are enhanced, thus transmutation/fusion may reach an already economic scale. This is the "magnifying lens effect," which makes oscillating dusty plasma useful. The dust or rough surface acts as a catalyst. Not all plasmas host LENR, for example when the electrodes are liquid metals, like mercury.

Acoustic Excitation of Dusty Plasma

When the plasma is excited acoustically, charged dust particles move along with the rest of the gas. Where the gas is compressed, the number of charged dust particles are high (at maximum pressure), but where the plasma is rarefied, their number, and thus the charge density, is lower.

There is a temporary potential difference between them and the positive ions, which further accelerate the electron cloud, hitting and charging dust particles to a very high potential, in the orders of MeV, even GeV. This is in essence the physical mechanism behind the "magnifying glass effect."

In practice, an acoustically excited, oscillating dusty plasma can be a powerful particle accelerator for the free electrons, as well as positive and negative ions. Very heavy charged dust particles are slow to move inside the plasma, due to their inertia. Thus this wave phenomenon makes possible the generation of huge temporary electric fields within a dusty plasma. The higher the pressure wave amplitude, the higher the accelerating potential, thus the higher the charge density on the surface of dust particles.

A plasma may start to oscillate due to an external exciting acoustic source—like a moving membrane of a speaker, or due to temperature differences or thermo-acoustic oscillations. The latter can be so powerful that they drive thermal engines and cryo refrigerators.

The "singing flame" Rijke tubes are fine examples of self-exciting resonant acoustic effects.

The third mechanism is the excitation of plasma by an external, time-dependent electric or magnetic field. (There are further a host of magneto-hydrodynamic plasma oscillation.) Thus excited dusty plasma is a very powerful accelerator for electrons, though the electron beam is not steady and homogeneous as particle physicists would like. However, in terms of investments versus accelerating fields, these table top plasma accelerators are second to none. Plasma Wakefield Accelerators, under development in the last two decades, may soon replace and overcome their gigantic predecessors, like SLAC, or the large Hadron Collider (LHC) at CERN.

Electrochemical cold fusion cells do not use the advantages of oscillating dusty plasma environment but they most likely use small local bubbles, and tiny plasmas inside them. Bockris warned several times that cell effectiveness depends on overpotential, in an exponential manner. This relates to the generation of small bubbles on the surface, where plasma effects may take place, but in a limited manner.

Steady state hydrogen or deuterium plasma has been used for loading Pd and Ni cathodes since the early 1990s but these bulky cathodes are not highly charged and the Coulomb screening inside a metal lattice is insignificant.

The key components of dusty plasma are the electron cloud, positive and/or negative ions and dust particles. However, non-ionized neutral gas makes the most plasma mass.

The presence of high mass (relative to ions) dust particles bring forth a series of new, self organizing collective and nonlinear behavior, like oscillations, resonances. The quality of the dust materials is important for several reasons, the first being their melting point. Even melted particles are of practical interest, but solid, non-conducting particles are the best traps for electrons and protons. In the hydrogen economy, the loading ability of the dust particle is the next important property of dust particles. The more hydrogen isotopes can be retained just under the surface, the better. Non-conductive carbon particles are good for this purpose, and some semiconductors, and of course palladium. However, palladium is too expensive to sputter away.

The non-linearity of the process is important. A negatively charged grain, when heated above a threshold, may emit all of its electrons due to thermionic effects, and it will be positively charged. As such, it will not attract positive ions anymore and fusion between positive ions will cease.

The charging of the dust grains by electrons and the neutralization of the surface charge by incoming positive ions is a dissipative phenomenon requiring constant but modest energy input.

Arc and glow, coronary discharges yield sputtering and dust. Capacitive or inductive discharges without electrodes, or microwave plasma, can be used to drive the dusty plasma only if dust is provided into the plasma.

In general, for dusty plasma the usual notions of pressure and temperature—as scalar quantities—are useless. They must be replaced by pressure and temperature tensors, for each plasma components. The temperature and pressure tensors must define/measure separately for each component, that is, electrons, ions, neutral particles and dust particles. In practice it is not possible to measure these components with our present technical limits.

High density (above atmospheric pressure) dusty plasmas have similar ion and electron temperatures, but the dust "temperature" is always different. All of the pressures and temperatures are functions of time and direction and there-

fore the notion of tensor is necessary.

There are several books and articles on the subject (see Reference 4), and if only one paper is considered, P.K. Shukla and B. Eliasson's review paper[7] is the most useful.

There is a warning though: the behavior of oscillating dusty plasma is so complex (hence its other name) that there is no real hope to describe them even by a numerical model.

Further, the authors of dusty plasma never consider LENR as a possible "side" effect. The published experimental investigation is usually at very low pressure and temperature. At atmospheric pressure, plasma diagnostics for the three components (electron cloud, ions and dust) are unsolved. Basically, trial and error is still the best method.

Neutron Synthesis on Charged Metal Edges

Felix Ehrenhaft was the first to see the strange effects of quasi particles, though this concept did not exist yet for half a century. Electron holes in semiconductors were the first and most important family members. Magnons, phonons, excitons, chiral fermions and plasmon polaritons soon followed. Polaritons are essentially waves of electrons, which behave collectively, like a particle. Helmholtz rings—smoke vortexes—are perhaps more familiar to the readers as quasi particles, which are easy to visualize.

Polaritons as electron waves may amass quite a significant potential, especially in resonant excitations. They may happen when they are limited by space (on the surface of small metal droplets) or when a field limits an electron cloud to a small area—like to a sharp edge. Thus the importance of surface quality emerges. Craters, edges, tips of needless are such places. A host of new phenomena emerges in the "world of tiny."

Resonant "surface plasmon polaritons" as quasi-particles were accepted into the mainstream body of science, but Ehrenhaft's particle attracting or repulsing "photophoretic force" was not. Maybe it is just a matter of ignorance. Ehrenhaft experimentally proved the existence of magnetic monopoles, but those were flatly rejected, because the magnetic unit of those charges was less than that predicted theoretically by P.A.M. Dirac. So physicists have been looking for it ever since as an elementary charge, not as it really exists in nature as a composite particle.

The neutron-producing capability of excited metal edges in hydrogen plasma has never been directly researched. By the 1960s when neutron detection became accessible, the Ehrenhaft legacy was ridiculed by the few who remembered him at all.

The generation of the high energy electron waves means that their cumulative energy may reach the critical 0.78 MeV threshold level. Thus an electron wave plus a proton may form a slow neutron on the surface of an edge on a metal surface. Such an uneven surface may generate slow neutrons in oscillating hydrogen plasma. Here is where the separate legacies of Mitkevich, Ehrenhaft, Tesla, Moray, etc. come together.

Practically, thin wires with uneven surface, immersed in a pulsed hydrogen plasma, can be a source of neutron production. (This is the essence of the Claytor-Fowler effect, discussed later in Part 3.) Sputtering makes smooth surfaces rough, pitted with craters and dust, too. Alloys of non-dissolving crystalline metals, or composite conductors with nano- or micro-deposition, may make such strange surfaces. Inventors found them long before science had a name for them.

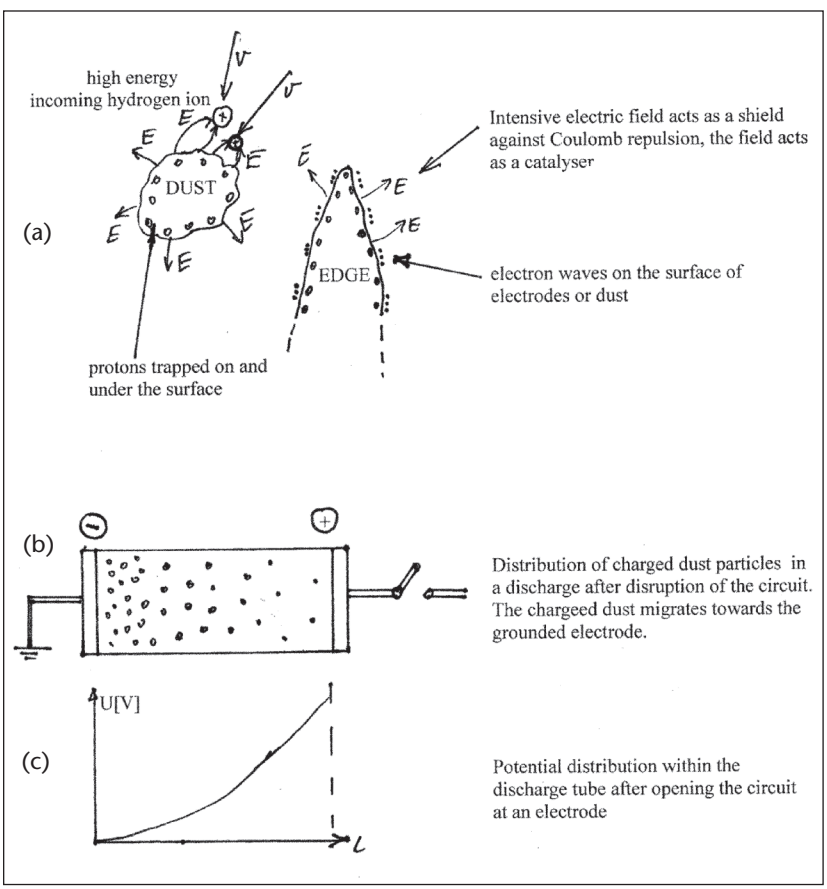

Figure 1. (a) Fusion on the surface of an electrically charged dust particle. The positive charge of the incoming ion is attracted by the negative dust particle/surface. (b) The uneven charged dust particle distribution in the tube. (c) Potential as a function of length.

Possible LENR Sequence with Dusty Plasma and Sharp Edges

Before we get to the electric energy-producing inventions, the connection between dusty plasma and transmutation must be outlined as it happens in practice.

Fusion of hydrogen isotopes with electrons or light nuclei may take place on and just under the surface of the charged dust. See Figure 1a.

In this case a neutral atom on the surface is approached by a high energy positive light ion. In a hydrogen isotope, a proton or deuteron hits a nuclei on the dust surface or just under it. The outer electron cloud around the surface material is ionized and then recombined. The events are identical with ion bombardment cases. Low intensity X-ray may follow this sequence of events.

There are at least three feasible chains of fusion events in transient dusty plasma (hydrogen rich plasma is preferred in all these reactions):

Path a: Neutrons are formed from proton+electron (plus neutrino) reactions, which in turn may take part in several reactions. The slower the neutron, the higher the probability of a neighboring nuclei immediately capturing it. This direction requires at least 0.78 MeV energy input. It is a problem with the neutron economy, if neutrons react only with the dust material, and they just change the isotope structure of the dust material.

Path b: Direct fusion of positive nuclei in the presence of a screening electrical field. If there is a simultaneous impact of two positive ions on the neighboring spot, they may fuse. This is a less likely event. Hydrogen, carbon, nitrogen and oxygen nuclei may fuse with relative ease. Nuclei heavier than iron are less likely to fuse, when plasma is maintained by a 1 kW input.

As in the dusty plasma oscillations, the electric field intensity may reach the GV/m order, all electrons can be removed from medium mass nuclei, perhaps up to argon, after which a hotter plasma is required. The best "host" material is carbon dust, but other oxides of metals with high melting points are also feasible.

Path c: Neutrons may form via another method, via a collective wave (oscillation) phenomenon on a conductive surface. Plasmon polariton resonance energies (0.78 MeV) might be enough to form neutrons with a proton in a nuclei, on the surface of a conductive dust particle, or the surface of sharp edges on an electrode.

If carbon particles are chosen in air atmosphere (Ohsawa type of fusion events), not much energy is released but when the plasma is mainly hydrogen or water vapor, a substantial amount of energy can be released, via controlled nuclear fusion, as historical examples have shown.

There is a further practical asset of resonant dust fusion—not only heat, but electrical, mechanical and even chemical energy (splitting of H_2O into hydrogen and oxygen) can be obtained. And all of them are released by small, portable, grid independent devices. Hot fusion is never meant to produce all the above sort of energies, and the usual electrochemical LENR methods are meant to produce heat only, which is the cheapest and least useful form of energy.

Present theoretical LENR models attempt to explain how Coulomb shielding and fusion of hydrogen isotopes take place during electrochemical processes. It is usually assumed that the technical environment is that of a regular or irregular metal lattice. Unfortunately these methods do not lead to a technical process which is economical, because the fusion rate is low. Moreover, in electrochemistry, the cathode surface rapidly changes due to deposition of unwanted pollutants from the electrolyte.

In dust fusion, this problem also exists but it is not always dangerous. For the quasi-particle neutron synthesis, the surface qualities (density of sharp edges/area) are crucial, but can be steady in a corona or glow discharge. Nevertheless, arc discharge surfaces are not controllable!

The Mitkevich Effect — An LENR Effect?

There are arguably good reasons to interpret the discharge tube potential reversing Mitkevich effect, as a consequence of energy release by LENR effects. The most probable sequence of events is the following:

— In the oscillating dusty plasma the accelerated electrons hit and charge dust particles, due to the high electric potential inside dust acoustic waves.

— Fusion of hydrogen isotopes takes place on the surface of charged particles and under it, due to the Coulomb charge screening of electrons, accumulated on the surface of dust particles. The same effect takes place on the uneven surface of metal electrodes, like sharp edges.

— Fusion heat, released without delay, heats plasma, in an uneven manner—where the dust grain density is the highest. Electrons are heated by the released LENR energy (Storms chain) and charge dust particles to an even higher potential. (This is a self-catalytic effect, or autocatalytic effect, with positive feedback.)

— Charged grain particles repulse each other and migrate towards both electrodes. Note that there is a time-dependent potential distribution within the plasma. This is not evenly distributed, and the potential drop is significant at the cathode and anode. This separates charges in the discharge!

— If the oscillating dusty plasma is in a (disrupted) electric circuit, charged dust particles tend to migrate toward both electrodes. However, when one electrode is disconnected, the particles can release their electric charge only on the connected electrode. The unconnected electrode is overcharged immediately, and repulses the rest of the charged dust particles. The connected electrode is at a lower (preferably ground) potential, thus the charged dust particles move—diffuse there—releasing their excess energy as electric energy. The charges migrate toward the electrode at the lower potential—at the unbroken conductor side. See Figure 1b-c. The original driving potential is thus reversed. The LENR-driven excess heat is turned into electric potential energy, and dumped into the electrode with the lower electric potential. A diode in the electric circuit does the task of circuit interruption. This circuit opening/discharge disruption must be done as soon as possible, otherwise electrons leave the dust particles and their potential energy is dissipated into heat.

There are a number of possible electric circuits, where the electric energy released by the Mitkevich effect may be captured. We shall see several examples for the extraction of electric energy, released by the LENR-driven Mitkevich effect. A number of inventions dealt with a similar problem of direct utilization of radioactive decay energy, mainly in the form of electric energy. In our case the problem is more difficult, because energy generation/extraction is periodic.

We shall look at a number of interesting arrangements: when the electrodes are asymmetric, or the chosen discharge is a high-voltage low-current cold cathode corona discharge, or a cold-cathode large-surface arc discharge or a small-surface hot-cathode arc discharge.

Note that the Mitkevich effect is like a "two stroke engine." In the first stroke by oscillating external energy generates plasma and LENR energy is released. In the second phase, the excess electric charge is extracted via a biased (interrupted) circuit. The interruption is necessary for a pulsed discharge; otherwise the excess energy appears only as heat, which is a less valuable form of energy. When the tube is part of an oscillating circuit, the potential difference of the circuit is reversed due to the migrating of charged dust particles (Mitkevich).

Usually the generated electric energy is captured by a capacitor, or in a resonant electric circuit. There are impor-

tant events at different scales of sizes:

(1) LENR—fusion, at nuclear sizes—femtometer, femtosecond range, due to the catalytic effect of Coulomb shielding.
(2) Dust grain charging and energy release at the nano or micrometer level on the surface and under it.
(3) Acoustic oscillations in the dusty plasma at the mm level, kHz-MHz range, strong internal electric fields are generated.
(4) Electric oscillations in the energy extracting circuits—cm size, kHz range.

The important technical parameters for dust fusion devices are sketchy. Inventors were not aware of the physical nature of the energy-producing effect, and they all wanted to keep the technical details to themselves. This is the eternal "catch 22" type of problem and one of the reasons all LENR-based great inventions have sunk so far. Since I have personal hands-on experience with "Patterson cell" electrolysis, AC low pressure and microwave driven high pressure dust fusion, later I shall describe my experience and personal history.

One Effect with Several Faces

Before getting to the technical details, let me mention the multi-faced application of a modest looking effect: when gases are heated, their pressure increases and where possible, they expand.

This is the humble foundation for a number of epoch making machines. Steam engines, internal combustion engines and external combustion engines come immediately to mind. However, gas and steam turbines and rocket engines have the same foundations. Moreover, single cycle engines—guns, submachine-guns, hand grenades and landmines and bombs—have the same physics.

Dusty fusion offers a similar range of practical inventions—except the weapons.

If the potential is so vast, why hasn't this effect had any widespread application? We had the partial answer from the book of Krivit,[1] when we saw that transmutation effects for transient arc discharges were discovered and published as long ago as 1907, repeatedly, but forgotten after 1914.

Magnifying lenses and acids were discovered in ancient Egypt, as well as discharge tubes for lighting (as shown in the reliefs of the temple wall in Dendera). They could have built telescopes, microscopes, glasses and gas discharge lamps, but never really bothered to utilize them. (The list of forgotten inventions is very long.)

The aim of this paper is to call the attention of the reader to the useful LENR facilitating features of dusty plasma. Therefore, I shortlist some of the various technical layouts where LENR fusion is suspected to drive the machine. The inventions are listed nearly in the time order they occurred.

Henry Moray

Though I regard Nikola Tesla as the inventor of the first electricity-producing LENR device, only indirect evidence was left to us about a demonstration in Buffalo, 1931. There he drove a Pierce Arrow electric car.

The secretive Moray unintentionally gave away more details, in his books[8] and his only patent, U.S. No. 2,460,707 (1949).

As it is always with great inventors, Moray stumbled into the excess electric energy generation by accident, as a young kid, around 1910. He noticed that something unexpected happened.

Moray was an ardent builder of detector radios, like many teenage kids were during the 1910s. In Utah, on the outskirts of Salt Lake City, he had a natural advantage: arid air. So his large, horizontal antenna was a permanent source of power, high voltage (up to 100 kV) but intermittent low current, of some micro-amperes; this is enough to power a small vacuum tube with a corona discharge.

Moray made a small wire corona discharge tube, inserted into the detector radio circuit. He probably had the original circuit (or a version of it) shown in Figure 2a, and the modified circuit shown in Figure 2b.

What happened was crucial: Moray heard a continuous stream of loud cracking in the earphones—that is, an *unusual excess power*, where there was no radio station. He kept on refining the system, until a small spark was run continuously, in the order of some Watts. In the meantime he learned to be an electro-technician, and after nearly two decades of no progress, improved his system considerably (after learning the skills of an electric engineer.)

In hindsight, Moray made several crucial improvements:

1. At an early stage, he switched to the Tesla "single-wire" which made it possible to generate the necessary high voltage to create an intermittent coronary discharge. (The circuit is shown in his patent.)
2. Developed a high current, high voltage germanium-based semiconductor solid-state rectifier, held in a semi parabolic cavity. (See Figure 2d.) This was his major breakthrough. He always hid this from spectators of his many public demonstrations. (He developed it further into an operational transistor. Thus he made a good radio receiver as well.)
3. Developed a cathode material, the "Moray metal," consisting of aluminum, copper, lead and sulphur. Maybe it helped to adsorb more hydrogen on the surface. Further, its uneven amorphous surface helped neutron formation by plasmon polariton resonances. (But this is admittedly a speculative idea!)
4. Developed a number of spark tubes, the "Moray valve," with strange, star shaped cathodes, and cavity like cathodes, shown in Figure 3.

Moray claimed that it is essential that ions smash the

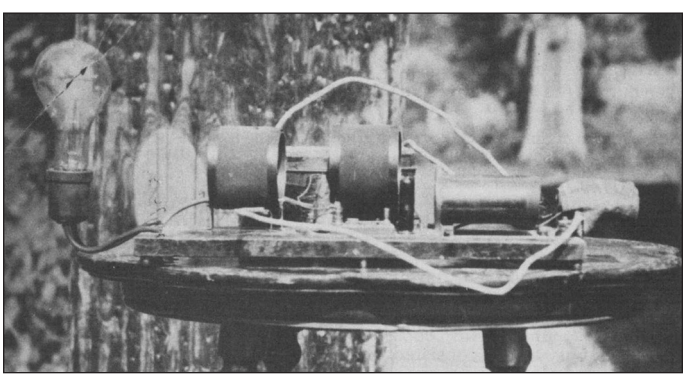

Photo 1. The only available photograph of an early Moray device. The power tube is hidden inside the coil of the inductors.

cathode at an angle, and not perpendicularly as the usual electrode arrangement.

He speculated widely about the physical nature of the energy source and about the importance of resonances in gas discharge. He agreed with Tesla's resonant aether hypothesis, lacking a better idea.

Moray fought continuously with investors, the U.S. Patent Office, and Eyring, the famous electrochemist, who thought the invention must be a fraud, as no excess energy can be released from plasma. He partnered, and then clashed with, many people, who could have been referred to as "frenemies." He died at the age of 94, without giving away his technology.

I have read and reread all of his books but I couldn't figure out the physical roots—lacking the lost knowledge of Collie, H.S. Patterson, Thomson, Winchester, etc., collected by Krivit,[1] and the rest discussed in Part 1.

The Moray story is a string of wonderful, but untold discoveries and human tragedies.

Before we look at relevant statements from his books, let me describe my initial gut objections about this and similar inventions.

Each breakthrough has two sides: a personal and technical. My first encounter with the Moray device and process happened in 1981 in an attic in Detroit. I worked at the Brookhaven National Lab, in the Department of Nuclear Safety, on leave from a similar lab in the Hungarian Academy of Science. (I had a one-and-a-half year research scholarship from the International Atomic Energy Agency. I was the first legal researcher in a U.S. nuclear research lab from behind the "iron curtain.")

An American colleague, Greg Slovik, invited me to visit Niagara Falls, and we stayed at his brother's house in Detroit. His brother was about to throw away his teenage journals (mostly *Popular Mechanics* and *National Geographic*). I asked his permission to browse through several cubic meters of old journals etc. Within ten minutes I found a small booklet about the Moray device, which immediately caught my attention. I became addicted since then, collecting info about this and similar devices and discoveries. I enjoyed extremely the open-minded, free-speech atmosphere of the U.S. after the stifling, tepid atmosphere of the Eastern Block.

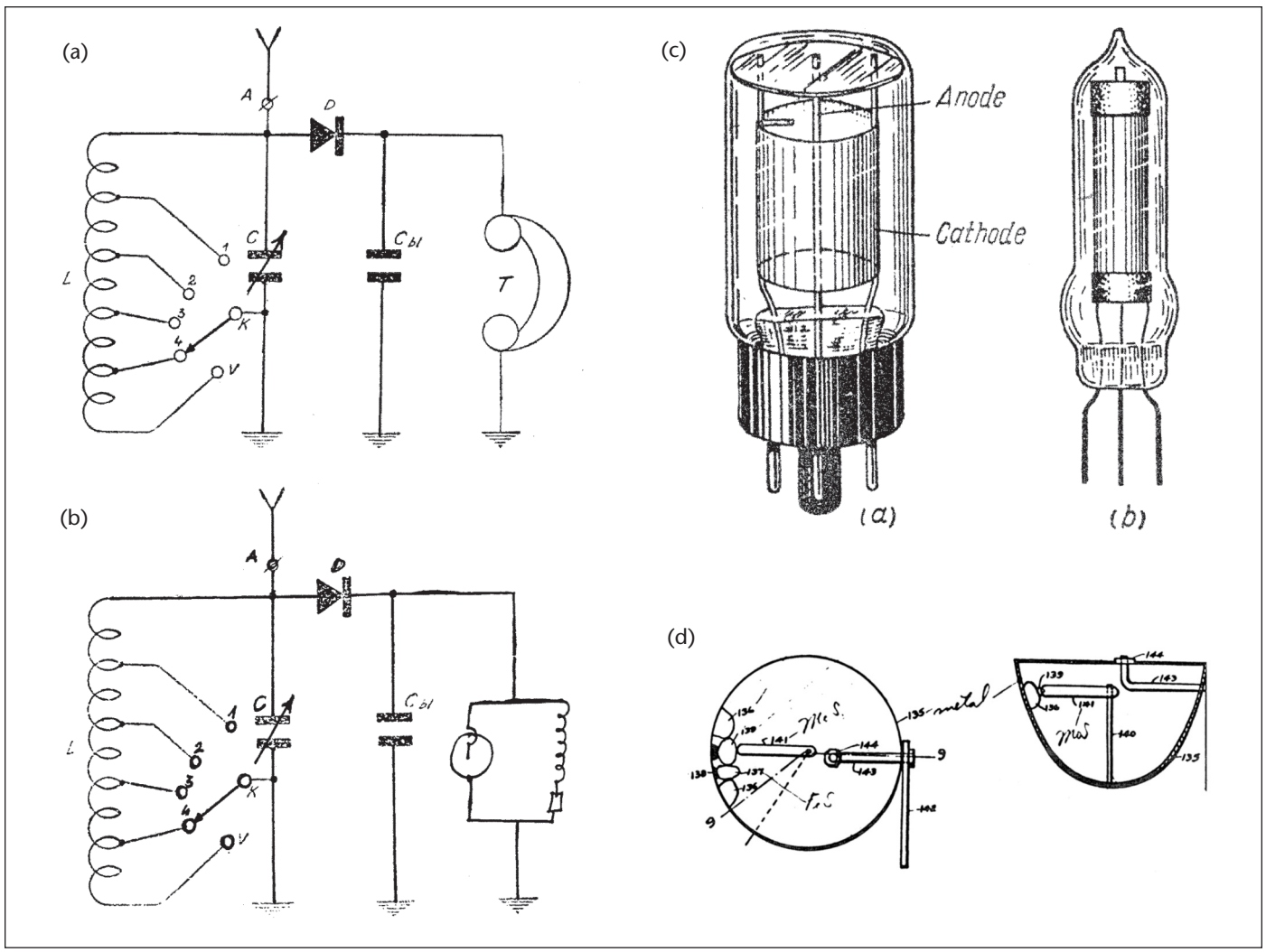

Figure 2. (a) One possible layout for a "crystal" or detector radio, advantageous for the Moray effect, since the high voltage of the antenna is not short circuited to the ground. The RF circuit is tuned by an inductor and by a C2 condenser. (b) The corona discharge tube in the radio circuit—the asymmetric geometry electrodes are an essential, but unknown, part of the system. The diodes were so-called pindiode or cat's whiskers, rather fragile, unreliable parts. They don't suit the need of high voltage, high current systems, but were good enough for the Mitkevich effect to appear. (c) Russian made corona stabilizer tubes for corona and glow discharge filled with hydrogen. (d) The cross section of the Moray detector or Moray "valve." In the 1930s it was an outstanding innovation, being a high-current high-frequency one, maybe high voltage, too?

I really felt freedom in practice, in all aspects of life—in the academic and political sense as well. It was an incredible feeling of liberation. In the brutal censorship of the Eastern Block, not a speck of information ever got to us about inventions like the Moray device or the Tesla electric car.

However, I became filled with doubts when I sank deep into the details of the description of the Moray device. In fact, I was not (yet) aware of the oppressive nature of science as an institution. I was not yet aware of the four forgotten/suppressed results already mentioned in this paper. (The transmutation during discharges was the worst case of oppression).

The source of energy was murky. I had already spent half a decade in nuclear energy research, written my Ph.D. on this subject, and read widely about energy sources, just out of curiosity. However, I had real difficulty with the Moray books.

It could not be driven by a "natural" source, like sun rays, because the device worked day and night, and its energy density was exceptionally high. How did 5-15 kW of electric energy come out of a shoe-box size device, without apparent heat as a side product? Unbelievable.

It could not be fission of any material—as the critical mass, the radioactivity, neutron flux, lack of moderator, each prohibit it.

It could not be fusion either, as the fuel must be deuterium and tritium (so I knew then), and neither Moray, nor Tesla, had access to heavy hydrogen. Moreover, high voltage devices cannot make them, or so I thought.

I had no idea yet about the Storms' cycle in the early 1980s, nor the Widom-Larsen type of neutron synthesis, that is electron waves as pseudo-particles, and about pseudo particles in general.

Finally, I had a subjective objection: how did a teenage boy with no science background invent something with a modified detector radio, and tens of thousands of researchers with better education and better equipment did not? An accidental discovery involves only one thing at a time, not two or more. One cannot make an airplane or car by accident; it must be built according to a carefully planned concept! And what makes detector radios so special? I studied a number of books on the subject (mostly written in the 1950s) and I found nothing pointing to a special energy source. Why did no similar device ever emerge in Europe or

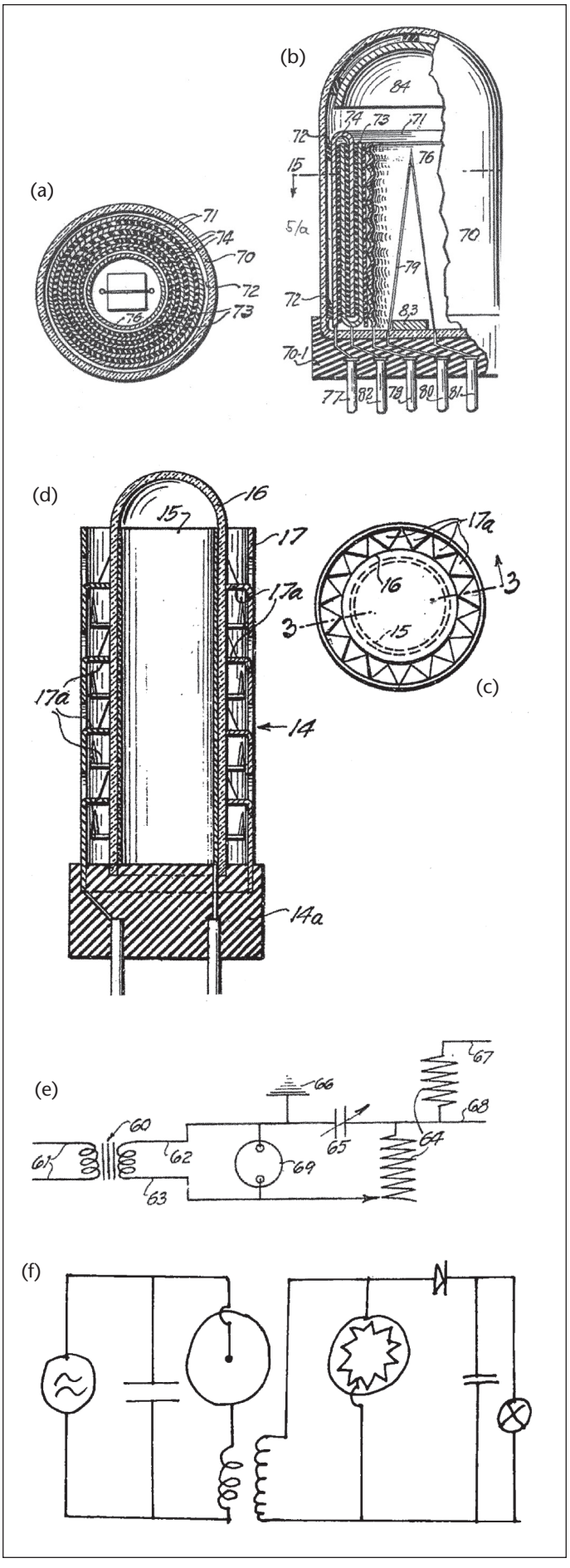

Figure 3. Possible layout of power-producing high-frequency Moray tubes, and their arrangement in a resonant electric circuit. Patent No. 2,460,707. (a) Vertical cut view of one of the "multi-walled" tubes. Perhaps the idea came from a glow discharge voltage stabilizer tube. All cylinders are connected with small capacitors, noted by eyewitnesses. Moray remarked that "it is advantageous to fill the tube with moist vapor. The tube acts as an oscillator for electric currents, and has an enormous capacity." (b) Horizontal cut view of the above tube; the coaxial cylindrical electrodes are visible. Is their material the Moray metal? The heating element (79) was not necessary, being a cold cathode discharge tube filled with gas. (c) The star shaped other "multi-walled" tube. When the internal multi-walled electrode is a cathode, the wall erosion is enhanced due to the inclined walls. Besides, they serve as efficient cavity cathodes as well. Horizontal cross section is shown. (d) Vertical cut view of the tube in (c). (e) The single-wire layout of the device. Ground is necessary. (f) A possible layout of the "closed-circuit" version of the device. There is a corona discharge tube in the primary circuit, serving as a capacitor. In the secondary circuit, the power-generating tube is the star-shaped oscillator tube.

Asia or in the U.S.?

What made the difference? The high voltage on the arial, the wire corona discharge tube, and probably some drops of water in the tube. Probably these together were the cornerstones.

Moray was afraid (and Tesla as well) that his valuable invention would be stolen. He was such a fool. He himself admitted that only two out of 100 of his discharge tubes worked properly. Instead of teamwork, he deliberately chose loneliness and secrecy, a sure path to oblivion. He didn't tell the "secret" to his own sons, so even having some parts of the machine, the sons got nowhere.

In hindsight, not a single scientist of his age (or a team of them) could have helped him solving the riddle of the energy source. Richard Feynman was just able to destroy Joseph Papp's inert gas engine in 1968, decades later (which also ran on LENR, but in a different technical solution).

Even the combined knowledge of Fermi, von Neumann, Heisenberg, Szilard, Teller, Wigner, Einstein, Oppenheimer, etc. was not enough to solve the riddle. The intricate complexity of dusty plasma oscillations in hydrogen was far beyond their knowledge.

How would a smart, intelligent person, like Abraham Lincoln, M. Faraday or J. Maxwell, interpret a flat screen TV, a smart phone, or a robot? Witchcraft of course. What else?

So the doom of Tesla and Moray, with their smart LENR inventions, was inevitable, because even friendly people suspected huge risks, or fraud in the strange devices. Of course the U.S. Patent Office flatly rejected the patent application, just like a perpetual motion machine, which is the laughing stock of examiners.

The Moray Device — Based on the Mitkevich Effect

Now let us see what is a likely setup for a detector radio based LENR reactor. In Figure 2a, one probable design (out of many) of a detector radio is shown, which may be the right technical setup for a lucky accident. The antenna is the source of high voltage (only in a desert), and there is a parallel, grounded, tunable oscillating circuit under it. This is the RF part. Next to it is the modulated audio frequency circuit, a must for all amplitude modulated radio, with an earphone, which is an inductor and a semiconductor diode (cat's whisker).

If a simple wire corona discharge tube is placed parallel, with the tunable RF circuit, as shown in Figure 2b, this in turn may drive the wire corona tube. The wire corona has a self-generating oscillation (Trichel pulses), when negative ions are present. (Hydrogen in vapor does this job.)

Thus if the parallel RF circuit is tuned to the frequency of the Trichel pulses, a resonant, high amplitude plasma oscillation starts. If it is a dusty plasma (using correct electrode materials), the conditions of LENR-based fusion effects are satisfied. When the voltage is reversed in the discharge tube—the Mitkevich effect—the diode acts as a circuit disruptor, and the electricity is captured in the condenser of the audio frequency circuit.

This energy is consumed by the earphone, as a loud hiss. In Figure 2c, Russian wire corona stabilizer tubes are shown as glow and corona discharge tubes (taken from a textbook in English).

These mass-produced corona stabilizer tubes were filled with hydrogen, from 16-80 Hgmm pressures; their "firing" or ignition voltage is around 900 V and their stabilized current is between 3-100 micro-amperes. (It takes about half a minute to get started.)

I am not sure at all that Moray had an "off the shelf" wire corona stabilizer tube, but it is easy to make from a metal plate and a wire, and it might be in an evacuated glass tube, sealed with wax.

The device seems to be simple, but works only in the desert of Utah, and nowhere else in the industrialized countries. In Utah the dampness of air is about 10-20%; everywhere else it is 50-70%, where the corona discharge tube can't be run from an arial. That was one of the unfair, unbeatable advantages of Moray—apart from his diligence and technical skill. No doubt, he was a lonely, tragic genius.

So how does Moray explain the working principles of his miraculous invention? Let me start with his last published paper, a transcript from a public lecture in 1962,[8e] at Valley State College.

Important Quotes from Moray

Moray said: "There can be no production of current electricity without an interruption of equilibrium. Whatever the quantity of [input] electricity, it will produce no kinetic energy if there is no disturbance of equilibrium...change of potential or electrical level."[8e] This was the very last written sentence of Moray about his technology, in a 1962 speech. He gave it away as his most important experience, or advice. This reminds me of Prof. Preparata, who shouted to the audience at ICCF6, at Lake Toya, "There is no result without transients!"

This is what Mitkevich also noted, that the discharge must be interrupted (disturbed) to have a potential reversing effect.

Moray said that "theories of operation are unimportant. For instance, the explanation of the backrush effect of condensers…as reservoirs for the distribution of energy."[8e]

Moray has termed Mitkevich's "reversal of electromotive force" as "backrush effect," which is equally suitable to describe the oscillation of interrupted dusty plasma.

He also had problems with the reliability of his device, which is so characteristic for LENR devices. He said, "we may make one hundred tubes, about two of these may meet all the requirements, the rest may fail to come up to standard. Sometimes none of them will operate, as they must have the critical balance and combined synchronous resonant action required."[8e]

In Figure 2b the simplest possible layout was shown. Decades later he made several improvements, as one can read between his lines.

He probably separated the Mitkevich effect into two different tubes since the gas discharge must be disturbed—that is to oscillate and interrupt—he made oscillation tubes. They were ostensibly corona discharge tubes at high voltage and low energy density in an oscillating circuit. They drove energy-producing tubes via a transformer that had higher plasma density and lower voltage to have the "backrush," the reverse of electromotive force. These tubes were of quite different construction, driven likely in an abnormal glow regime, which does not destroy electrodes as soon as an arc

discharge does.

He also used Tesla's "single wire" technology for years, to make high frequency, low current, and high voltage. However, it was very sensitive to capacitive tuning. A person touching any wire may de-tune the system out of resonance.

He used a cascade of energy-producing sub-units. One system drove a second, that in turn ran a more powerful third unit. So the system grew in complexity to reach a higher power output. Because the single wire system required grounding, it was not suitable for mobile applications, like cars. Later he developed a closed circuit system again. After several decades of development, the system became quite complex.

Moray reported: "Cost of Radiant Energy Power tubes now run quite high for a set of 29, which one unit requires, about $500 average for each tube. We must have tubes which will function as valves and some as oscillators and so on; each type tube must be in a certain position in each stage in the circuit, and they will not operate in any other position. They also must synchronize and balance perfectly for resonance."[8e]

He clearly describes the separated functions of the oscillator tube and the valve tube, which can be power-producing "backrush" tubes or just diode tubes, but he also used a semiconductor of his own design, made from Germanium: "a 100 lb unit can be made to deliver 300 kW…No shielding being required for Radiant Energy devices."[8e]

The power density is higher than that of internal combustion engines. Not requiring shielding is familiar in LENR, but not in hot fusion. Moray speculated widely about the nature of the energy source. He borrowed Tesla's "Radiant Energy" term, from a patent, submitted in 1901 (685,958), but they mean different physics from the same words.

Moray, unable to find a known energy source which drove his device, thought sometime that the universe had some oscillations (like vacuum energy) and he tapped it by tuning to the right frequencies. On other days he speculated that disassociation of matter yielded the released energy—just like fission.

Moray often quoted Tesla: "Throughout space there is energy…" He said, "Is this energy static or kinetic? If static, our hopes are in vain. If kinetic, and this we know it is for certain, then it is a mere question of time until man will succeed in attaching his machinery to the very wheelwork of nature."[8e] Moray continued, "This I have been able to do through the use of certain special valves [diodes, rectifiers] and oscillators…"[8e]

Moray described the plasma oscillations in the following sentences, which fit the Mitkevich effect: "When an elastic substance is subjected to strain and the set free, one of two things happen. The substance may slowly recover from the strain and gradually attain its natural state or the elastic recoil may carry it past its position of equilibrium and beyond, and cause it to execute a series of oscillations."[8e]

The Mitkevich effect is interpreted here as an elastic recoil which may carry past equilibrium and beyond. This is what he termed "rush" and "backrush." Moray further noted, "In other words, there may be a continuous flow of energy in one direction until the discharge is completed or an oscillating discharge may occur. That is, the first flow may be succeeded by a backrush and succeeding backrushes, the oscillations going on until the energy is either radiated or used up in the energizing of the conductors."[8e]

I have personal hands-on experience with these oscillations, in relation to the Correa and Chernetzky devices, discussed later. So these energy-producing oscillations are real.

These oscillations really come in as a series of Mitkevich potential reversals. However, they do not necessarily produce excess energy, in terms of electric energy. Very careful and arduous R&D is necessary to eliminate losses, to synchronize the input electric oscillator circuit with the acoustic plasma oscillations, and those with the impedance of the energy extracting circuit. This is a nightmare task, but Moray and apparently Tesla solved it, a hundred years ago. All later solutions have turned out to be inferior—unfortunately.

In my opinion, among the many inventive steps taken by Moray, the separation of mainly oscillating function and mainly energy-producing function was most important. We shall see later that Correa and Chernetzky, and the rest, did not separate the two functions.

Moray believed to the end of his life that radiant energy "means energy from the Cosmos, proceeding from a center in straight lines in every direction."[8e] Simple and wrong.

In my opinion, without the Storms fusion cycle—and slow neutron generation methods—there was no chance of understanding this useful but weird autocatalytic phenomena. (Without the work of Pons and Fleischmann that was impossible, because they restarted LENR research again from scratch.)

In the third phase of his experiments, Moray demonstrated a portable device where the circuit was closed.

"Radiant Energy...required that the device be given a test in an automobile (with no antenna or ground). Such a test was made by a continuous operation run from Salt Lake to Denver, Colorado, and back to Salt Lake City, over U.S. Highway 40...The device was operated for a total of 157 hours and 55 minutes...Close examination of the device disclosed that all parts were in perfect shape and could have been run indefinitely…It makes no difference whether one 50 W lamp is used or whether a 300 kW load is connected to the machine, the draft of current is adapted to the load. There is not a sound from the machine when in operation, there being no moving parts."[8e] Since the cat's whisker pin diodes had a limited threshold for current he developed a germanium-based diode, and perhaps an early transistor as well, for his radio system—which also sank into history.

Moray said: "It was June 24, 1925, that I discovered that by alloying Germanium with various substances, I was able to make a valve for a radio receiver..."[8e] Such a half ellipsoid shaped device is shown in his book,[8c] which is his longest, most detailed compilation. See Figure 2d.

This was always hidden in his fist, considered his biggest secret. Indeed, he took much trouble to develop it, but couldn't patent it either. Most probably he refers to this high current diode as the Moray valve. He tried to cooperate with the Bell Lab, but apparently, it didn't materialize.

Re-discovering the Mitkevich effect was not the end, but the beginning of a series of remarkable innovative steps.

Harnessing LENR in electric energy is more demanding than extracting heat, but oscillating plasma with charged dust particles makes them both possible.

Let us go over again, in Moray's words, the sequence of events: "Oscillations by synchronization are started in the first stage of the circuit of the device by exciting it with an

external power source…The circuit is then balanced through synchronization until the oscillations are sustained by harmonic coupling with the energies of the Universe."[8e]

This is again about tuning both the pulsing corona discharge tubes and the power producing tubes to their own oscillation frequencies. Then, "The reinforcing action of the harmonic coupling increases the amplitude of the oscillations until the peak pulses 'spill' over into the next stage through special detectors or valves which then prevent the return or feedback of the energy from the preceding stages."[8e] This sentence describes the power production, presumably through the Mitkevich process, when the voltage and current is reversed during the course of oscillation. The excess power is blocked, interrupted by his solid state, germanium-based diodes at one electrode (anode) of the tube. Maybe he used gas discharge diodes in the last power producing stage.

Moray said: "These oscillating pulsations drive each succeeding stage, which oscillate at a controlled frequency and which are again reinforced by harmonic coupling with the ever present energies of the Cosmos. That is, a first stage drives a second stage, the second stage drives a third and so on…"[8e] This clearly describes that this is a cascade device, like power amplifiers in audio technology with preamplifier, output amplifier.

Moray noted, "The special tubes which are the key to the successful operation of this device are specially constructed ionic, cold cathode tubes."[8e] Moray was secretive, but gave away some hints about the construction principles of his gas discharge tubes.

The Likely Structures and Operation of Moray Tubes

Moray refers to Tesla as the source of inspiration in his devices: "Tesla obtained a very high form of energy frequency resonance in some of his experiments. Resonance is one of the prerequisites to capture the energies of the Cosmos."[8e]

In the framework of LENR effects, the above sentences mean that resonant dust acoustic waves are necessary to release energy economically. Steady state dusty plasma is useless. Transient plasma may yield some transmutation/energy release, but it is not yet economic. However, the big issue is where to resonate the dusty plasma. Since there are oscillations everywhere in the different types of cold cathode discharge plasmas, are there really special frequencies where one can tune in "to the Cosmos"?

Moray wrote: "To detect or syphon radiant energy, it is necessary that it be transferred into the familiar potential of the kinetic energy of matter."[8e]

To me, this means that Moray separates the generation of oscillations and their amplification by RLC resonant circuits, and the power generation, by using a different cold cathode tube. Certainly it is possible that even the corona discharge tube makes some excess electric energy. After all this was his original, accidental discovery.

Moray fought with U.S. Patent Office for several decades on the "energy from the Cosmos" issue and noted "the U.S. Patent Office denied the existence of these energies, because no natural source of electrical wave energy was known to the examiner."[8e]

Indeed, now that the source of energy has been identified as LENR, we are not much better off. Moray wrote about oscillator tubes in the fifth edition of his book[8c] on page 209: "It is a system utilizing the principles of the wire corona with a concentric cylinder at different pressures...chemical reactions must take place when the oppositely charged molecular ions from an appropriate activated catalyst are accelerated against one another in the wire corona. It consists of a cylinder made of a suitable catalyst from which positive ions are emitted."

Moray had a special style in his writing. In the same sentence he wanted to hide and disclose details, where he himself was not sure. Therefore each of his sentences can be interpreted in at least half a dozen ways. Some people who read his books surmised that it was a "radioactive battery" or a device somehow tapping the fluctuations of vacuum energy. I interpret his sentences as an "instant" LENR effect in oscillating dust, just as in later devices which are more clearly described. They are based on the same physical effects, but lack the technical sophistication of Moray's device.

The special catalyst or electrode material is an alloy (probably slightly semiconducting), with the following published compositions by weight:

	Cu 5%	Pb 55%	S 30%	Al 10%
or	Cu 15%	Pb 55%	S 30%	

This alloy after bake-out and rolling may make a number of small cavities on its surface. This issue alone is a swamp, and it is easy to sink. Think about quality problems of Pd cathodes in P-F electrochemical cells! The Pb-S alloy is the traditional material for a simple semiconductor for early cat's whiskers.

Moray gives little guidance about the gas filling his tubes Though on page 230[8c] he dwells on the wonderful features of water, so hydrogen is there. In his only patent he also stresses the importance of water with the power-producing tube.

Concerning his real secret, the construction of the power producing tube, he is taciturn, opaque. On page 210[8c] we read: "…the circuit which set up in the circuit electrical pulsations corresponding to the energy waves captured by the interceptor and again kept from returning to the second outer circuit by 'multi-walled' valves. The final tubes act as energy pressure transmitters with a means to prevent shunting…by a special form of 'getter.'"

What is a "multi-walled" and "getter"? There is room for speculation. Without knowing the construction and operation of similar later inventions, the above sentences are empty and useless. Nevertheless, later he gave partial answers, hidden in obscure sentences, like the alchemists did.

There is another possible clue on page 213[8c]: "When a vibration of any kind strikes a boundary between two media of different vibratory impedances at an angle of less than 90 degrees, a transformation of vibratory rate may be changed into another vibratory rate. The Radiant Energy device therefore will continue to capture energy by resonance…as long as the 'keep alive' vibration of the cosmos continues to oscillate…Simple is it not? Just a case of the trapping of energy which is everywhere present…"

These loose descriptions alone are not enough to start. But dust and rough surface as a catalyst, driving LENR via Coulomb shielding, does help to make an intelligent, plausible outline of operating principles.

An abnormal cold cathode glow discharge satisfies the requirements of power production for the following reasons:

—It is rather efficient to maintain, as only a small power input is required. Pressure ranges from 10^{-3} Hgmm to 10 atm.
—Uniform sputtering for dust production from the surface. Slow, steady sputtering, with a very long life more than 10^4 hours without much change of tube properties.
—Current may vary by an order of magnitude.
—High ion current, in the negative glow region takes place. (Between the cathode dark space and Faraday dark space.)

The negative part of the voltage—current characteristics of the tube—helps the generation of relaxation oscillations, but discharge current should not run into high values (~1A), because of the destructive arc discharge.

So an assembly of concentrated, coaxial, tubular electrodes, is one possible construction, shown in Figure 3a, and Figure 3b as a cross section. They look similar to multi-walled stabilizer tubes, mass-produced since the 1930s.

Here is an excerpt from a Russian book:[9] "Some voltage stabilizer tubes contain more than one discharge gap in a single envelope. In one type of tube there are four discharge gaps, with external connections taken from each of the five electrodes so that a stabilized output in a multiple steps of 70 Volts up to the maximum of 280 Volts is obtainable. The largest cylinder is the cathode of the entire tube..."

The tube-shaped electrodes are probably capacitively coupled, and are at the same pressure. Their distance is in the order of some millimeters. It is practically Figures 14 and 15 of Moray's only patent, 2,460,707, herein as Figure 3a-b.

This is probably his "multi-walled" cold cathode, power producing ionic tube.

There is another sophisticated solution to the oscillators run by corona discharge. This tube is made with a number of cavity cathodes, shown in Figure 3c, and a cut section of Figure 3d, issued as an electro-therapeutic apparatus. (This way he didn't have to argue with the U.S.P.T.O. about the unknown energy source.)

The cavity cathodes are more efficient then flat-plate or wire cathodes, but sputtering is more pronounced. However, in this case it is useful now. It fulfills the above-mentioned description "at an angle less then 90 degrees," because in cavity cathodes shown in Figure 3c this criterion is satisfied. This was presumably one of his oscillator tubes.

Moray believed that energy is simply "captured" in the tubes from the "cosmos." Instant generation of LENR energy by catalysts in the form of electrons on dust particles was out of his range of knowledge.

In his patent, Moray uses a "single wire system," shown in Figure 3e. The first stage is driven by a low energy input, with a high voltage source. The same effect can be achieved by a closed circuit solution as well, outlined in Figure 3f.

Few people were allowed to have a look into his device. One of them, George R. Pyper, gave the following testimony on January 10, 1938: "He let me see inside this box and there was a high frequency transformer and some of his cold tubes and some condensers."

Anther witness described his detector, Figure 2c, which was held after the demo in his palm. High voltage, high current diodes were a sort of miracle then, but today they are "off-the-shelf" items.

Though Moray demonstrated the working device for years for engineers a dozen times, there was only one "scientific" demonstration to Dr. Knudson of Stanford University.[8c,p.117]

After several demonstrations "Knudson repeatedly threw the switch in and out, resulting in an inductive surge that burned out the device."

The same happened in 1968, when Joseph Papp had a demonstration, and Richard Feynman of CalTech blew up the demo device, by throwing the switches in and out (killing one spectator in the process). None of the witnesses found hidden wires or batteries.

Finally, in a strange twist of history, LENR research was kicked off by Pons and Fleischmann in Salt Lake City in 1989, where Moray lived and died. The ghost of LENR remained active there.

Chernetzky

Alexander Chernetzky, a renowned theoretical and experimental plasma physicist, stumbled across the excess energy effect by chance—as usual, while developing high power plasma-trons. He made this discovery in the 1970s. Actually, the Chernetzky papers are the "Rosetta Stone" of transient plasma LENR research. [See Figure 4.]

He developed numerous electrical circuits and hydrogen loaded, high current arc discharge tubes, where he could maintain occasionally some hundreds of Watts, occasionally KWs of excess electric energy. He published several papers (in Russian) about his findings, but only second and third rate journals accepted his papers. He published long theoretical papers on the subject, but only an error in a sign gave the explanation of excess energy, and LENR as an option was not considered.

The extreme irony of his situation was that he teamed up with Andrey Sakharov, a leading theoretical (and technical) expert behind the Soviet H-bomb. But Sakharov, who knew all there was to know about hot fusion, never gave a thought that plasma oscillations may facilitate fusion. He bought into the Tesla "aether oscillation" theory. Needless to say, vacuum oscillations really do exist. They are responsible for a number of weak effects: the Casimir force, Lamb's shift, Julian Schwinger's cavitation related sono-luminescence, etc.

Sakharov, who became a leading expert on cosmology, black holes and the oscillations of physical vacuums, speculated that this might be the root of the excess energy. But all technical predictions based on the vacuum fluctuation model have failed. Sakharov died early, and so did Chernetzky, in the last years of the Soviet Union. With the collapse of the USSR, during the Yeltsin era, scientists were literally hungry (they seldom got salaries). So his co-workers never bothered to continue this experimental line. (More about my personal experience in Part 3.)

Nearly at the end of Part 2, I must reassure the reader that excess energy-producing plasma oscillations do exist. Mitkevich noted it at the interruption of direct current arc, but Moray, Chernetzky, Correa, etc. observed it in a prolonged form, usually when the discharge tube was part of an oscillatory circuit. The Chernetzky and Correa circuits (to be discussed in more detail in Part 3) are similar to detector (crystal) radios in the sense that they consist of two coupled oscillating circuits.

We have seen these oscillations thousands of times in our lab, but we were unable to "tame" them. The arc discharge destroyed the electrodes in minutes, the ignition was unreliable, so were the oscillation amplitudes, too. The effect was there, but the reliability was weak. The fundamental influencing parameters are not yet understood.

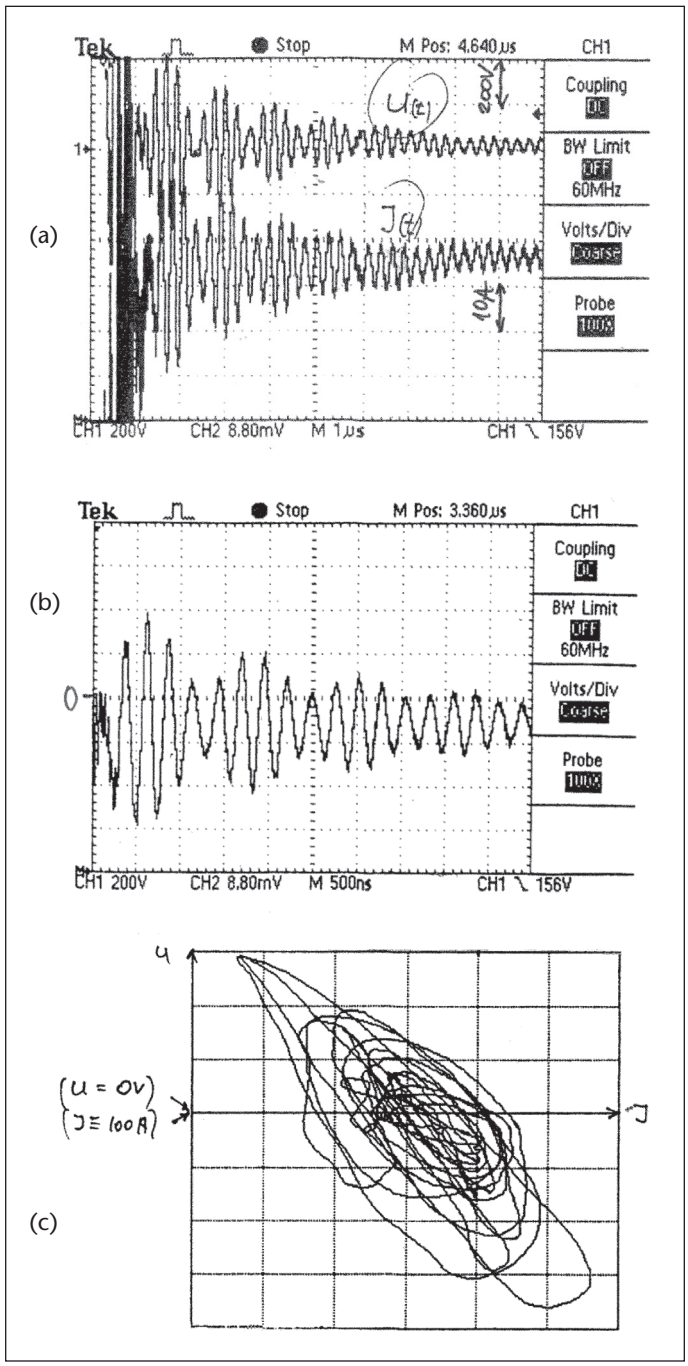

Figure 4. Some voltage and current transients, oscillations observed in arc discharge for the Chernetzky experiment. (a) Spontaneous instability during arc discharge as a function of time, when a capacitor was the power source. The upper curve is the voltage, the lower one is the decreasing current. The plasma was argon with water vapor. (b) When the same discharge tube is placed in an oscillation circuit, the oscillation amplitudes increase and the oscillations are prolonged. Current is shown as a function of time. (c) The same oscillation is shown as in (b), but current and tube voltage is plotted in a Lissajou-type parametric curve. The discharge acts as a generator in the lower right hand quarter, as voltage and currents are reversed. The rest is in a dissipative mode function of the oscillation.

Alexandra and Paolo Correa

Paolo Correa, a Canadian-Portugese biophysicist, stumbled onto the excess energy generating effect of transient glow/arc discharge by accident—again. He was cleaning a large metal plate by intermittent arc discharges. After some tens of thousands of discharges, he noticed that the roughened, large area metal surface "shot back." It took him years to research and develop further this effect and to carry out thousands of experiments. He developed a smart electric circuit, which made it possible to capture the bursts of electrical impulses generated in his large cathode area gas discharge tubes. He wrote long, descriptive patents (published by *Infinite Energy*) with numerous test results for different cathode materials, gas composition, and cathode areas.

I met him in person in Toronto, and visited his lab with the financial support of my sponsor. We wanted to cooperate somehow but he politely turned us down.

Nevertheless, we have tried to replicate his results in our lab, along with the Chernetzky layout.

Correa accepted Harold Aspden's line of thought at first, partially based on oscillating aether. It was later modified to include the effect of different acceleration of electrons and ions—to no avail. Then he supported J.B. Rhine's "Orgone Energy" ideas

There are a number of Correa patents. I shall quote only two which I read carefully, and translated into Hungarian. He used large, rough cathode surfaces, but no oscillating circuits. He was the first to discover the importance of sharp edges on the cathode, but the importance of hydrogen isotopes escaped his mind, so LENR was out of his sight. He found the electric energy-producing "reverse" kicks for glow and arc discharges respectively.

My bittersweet experience is the following. We have seen an occasional burst of energy for some of the input electric impulses for Chernetzky and Correa but they were not industrially applicable, reliable, repeatable excess energy bursts. Needless to say, it took more than two years to refine the test method for the power input and power output measurements for each individual pulses. For the Correa machine, it was controversial to make the "energy catching" circuit with accumulator banks. All in all, it took over three years to get the correct vacuum technology, the discharge tube construction and manufacturing, and the instrumentation. The Chernetzky/Correa devices are technically demanding and expensive for amateurs.

It was clear from the beginning that cathode erosion by periodic arc discharge is a major hindrance. Indeed, cathode roughening, having "zillions" of craters on the surface, was useful, but at a price: due to erosion, cathode material dust settled onto the glass walls of the tubes depositing a conductive layer. Further, after awhile the discharge channels were started from the back of the electrodes, not from the front. But the worst feature had been its unrepeatability.

After about a two-day rest for the tubes, the results were good, but by the third day, the effect vanished completely. In hindsight, my guess is that water diffused slowly into the borosilicate tubes. When we baked out the tubes at about 150°C, the results were worse, as water disappeared. There was no excess energy burst. Despite my hands-on experience

with Pons-Fleischmann electrolytic cells, I was unable to connect the dots. The palladium cathode-based "cold fusion" seemed to be so far away from the Correa-Chernetzky-Moray-Tesla gas discharge effect, like a plant and an animal. Both of them are living, consisting of cells but yet vastly different.

Despite the frequent disappointments, we have started a Chernetzky project trusting the similar physical features, that is the transient arc discharge has identical physics behind the excess electric energy burst in both cases. In addition the same vacuum technology made the technical achievement of both projects simpler.

The Chernetzky project yielded the same disappointments. Though occasional bursts of excess energy were observed, even the direction of the excess current was not repeatable. Sometimes it helped the input current; other times the direction of the current changed, and the burst of energy overcame the input current. Sometimes excess energy appeared at the cathode and sometimes at the anode. The surface had to be rough here, too, in order to have any effect.

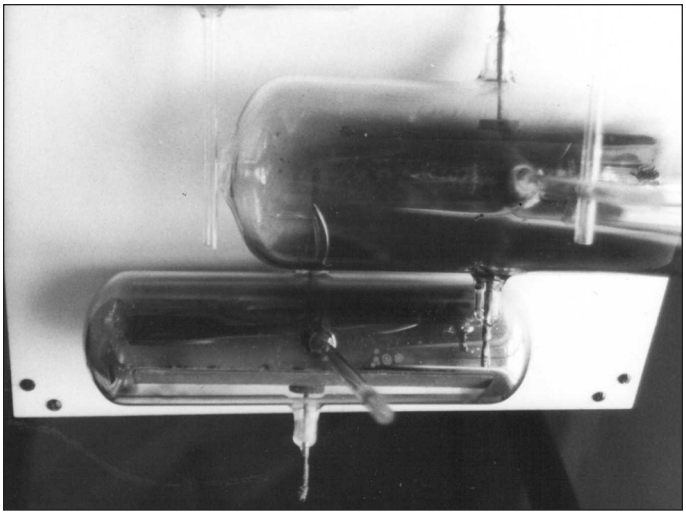

Photo 2. Two large-surface-area Corea tubes. Note the aluminum oxide dust on the glass surface.

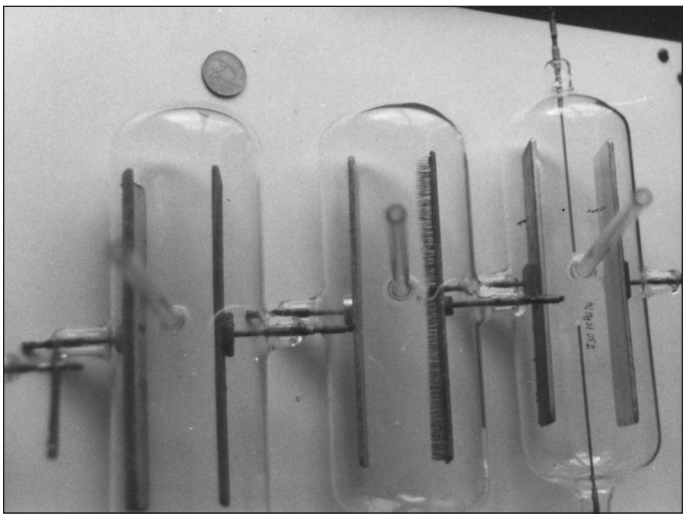

Photo 3. Large-surface-area unused Correa tubes. The middle one contains a number of pins in order to study the Shoulders effect. The last tube in the middle has auxiliary electrodes. They serve as anodes. On the left hand side the cathode is curved. The coin above is roughly 3-cm diameter. All the cathodes are of 64 cm^2 area.

I made two major personal mistakes. First of all, I was unable to identify the nature, and the source, of excess energy. I bought into the false "vacuum oscillation model."

I regarded Tesla and Sakharov so highly as researchers that I blindly accepted their ideas. Later, when the vacuum oscillation model became absolutely untenable and fruitless, I assumed that energy is not conserved. Under other conditions, this might be so, but not in a transient gas discharge. I have not found the slightest reference to LENR in the vast literature on the wide ranges of gas discharge.

The second major mistake was personal. I could not persuade the engineer in charge (Istvan Csonka) to tune the Chernetzky device into high-amplitude resonant mode.

After years of empty rows, I left the team, which collapsed soon after.

My million dollar lesson has been: do not use arc discharge, because erosion destroys the cathode surface and it has a very poor efficiency. There are only two possible ways out.

The "Moray path"—high voltage, low current, high frequency corona or glow discharge, for excess energy production. Microwave driven plasma, dust added in a controlled manner, for transmutation, and heat generation without electrodes.

These two methods are different paths to LENR. The "Moray path" is more likely to be restricted to neutron synthesis on a surface, but water vapor and/or hydrogen must be present in the discharge tube. The discharge ought to be

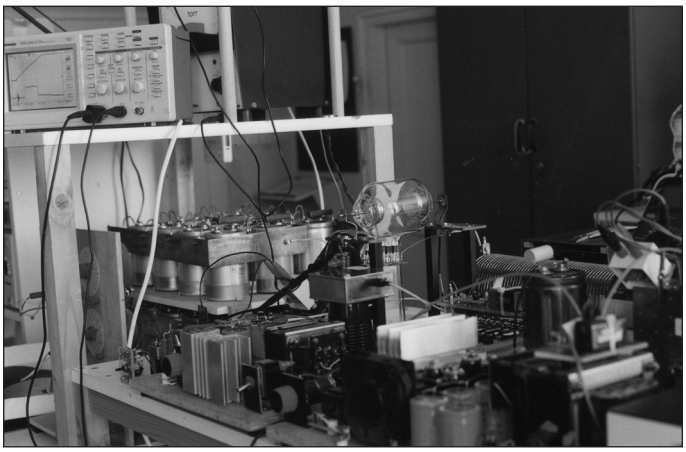

Photo 4. An experimental stand. Note the condenser bank and the air core inductor. A small area core tube is mounted on top.

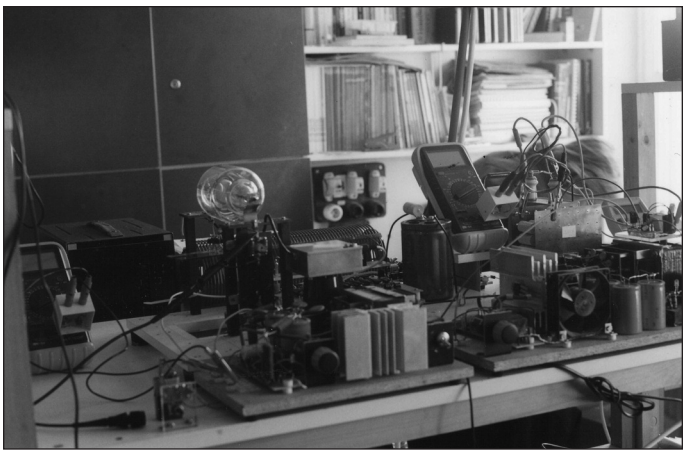

Photo 5. The same test stand as Photo 4, from the other side.

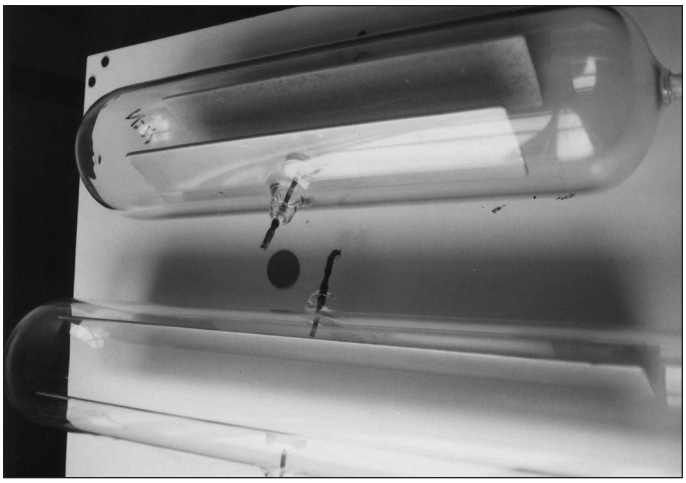

Photo 6. 120 cm^2 cathode area Core tubes.

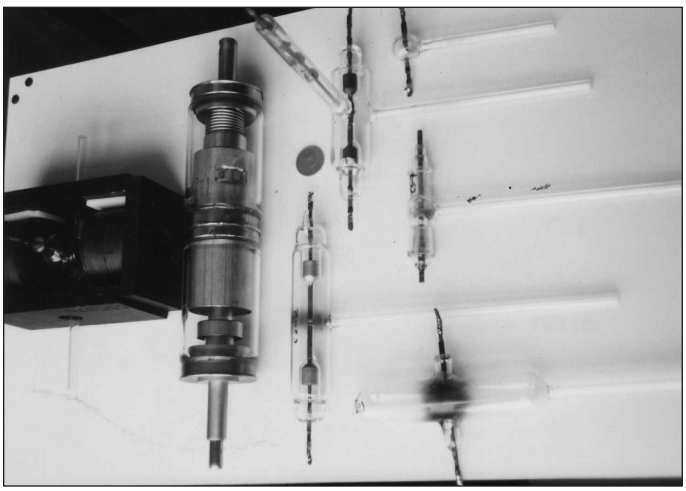

Photo 7. Small area Chernetzky tubes. Note the dust on the glass surface. There is one tube surrounded by ceramic magnets. The magnetic field had no advantage.

uniform, cold glow or coronary discharge. The latter intrinsically provides 100 kHz pulses, if an electronegative gas is present, like hydrogen or oxygen or Cl.

Several present theoretical models might fit into this process, like "zero momentum light element reaction" of J.P. Wallace,[3] the "heavy electron" collective oscillation model of Widom and Larsen. In general, Edmund Storms' model[10] shows a gradual build up of He via hydrogen, deuterium, tritium/He_3[2], He_3[2].

Such processes have been reported by Max Fomitchev-Zamilov at ICCF20.[5]

Neutrons, He and some deuterium were measured in the Wendt and Irion Tungsten wire explosion. This is also true of the Sternglass experiments where the plasma was made of H_2 and HCl. The plasma was generated at 20 kV and 30 mA.

Moray used a much higher voltage, and probably less current, but that parameter range is unexplored today. It is quite possible that higher potentials and lower currents of corona discharge are more economic for neutron synthesis, as well as his large area of rough surface electrodes.

In the Moray demonstrations, observers noted the presence of the smell of ozone, bluish light in the discharge tubes, and thin wires, even for high power outputs (above 5 kW), meaning that its currents were very low.

In Part 3 the Chernetzky and Correa devices and test results will be detailed and analyzed. The background fuel cycle will be discussed, along with other independent discoveries and inventions with the same root.

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Part 3 is scheduled to appear in Issue 136.

Part 4 is scheduled to appear in Issue 137.