Fusion by Pseudo-Particles, Part 1
Past, Present and Future

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— Abstract —

There are urban legends and documented facts about mysterious fuel-free energy production devices witnessed during the last century. In Part 1 of this three-part series, a dozen of them are described along with their salient technical features, and about their known, and suspected, features. It seems that more low-energy nuclear devices in various forms have been demonstrated than previously thought. Thus the missing pieces in the puzzle are completed. Electrical energy-producing LENR devices were demonstrated by Tesla and Moray as early as in the 1920s. Papp demonstrated his noble gas plasma device in 1968. New technical solutions have emerged since then based on phonons, polaritons and charged nanodust particles, as pseudo-particles.

Part 2, forthcoming in Issue 108, will show the importance of charge screening by real and quasi-particle emergent properties.

Part 3, forthcoming in Issue 109, will show the historical parallel with the quasi-particle-based semiconductor and the LENR mystery, and describes another possible tectonic change in the future. Finally, the drawbacks and advantages of some inventions, and lines of development, are analyzed based on their physical properties, and compared to each other and outside challengers. According to Feynman, the most important word in physics is "atom." But the most *useful* concept may be "quasi-particle."

The Past

Martin Fleischmann and fellow researchers P.J. Hendra and A.J. McQuillan discovered "surface enhanced Raman scattering" in 1974. It is a strange and powerful amplification, a resonant process due to the collective oscillations of surface electrons. They behave like particles in a self-organized, "emergent" manner.

This phenomenon is somewhat similar to turbulence, when a collection of particles acquire new, unexpected properties which cannot be derived from their single-particle properties. Thus came the word "emergence."

Fleischmann realized the value of the collective oscillation, changing his view toward natural phenomena. In fact, he stumbled onto one member of a populous family of quasi-particles. His perception about a collective surface oscillation guided his research towards LENR phenomena in the area of electrolysis. He was not aware of its predecessors (the subject of this paper), who found and lost similar processes. Fleischmann made history by calling attention to a group of different nuclear phenomena.

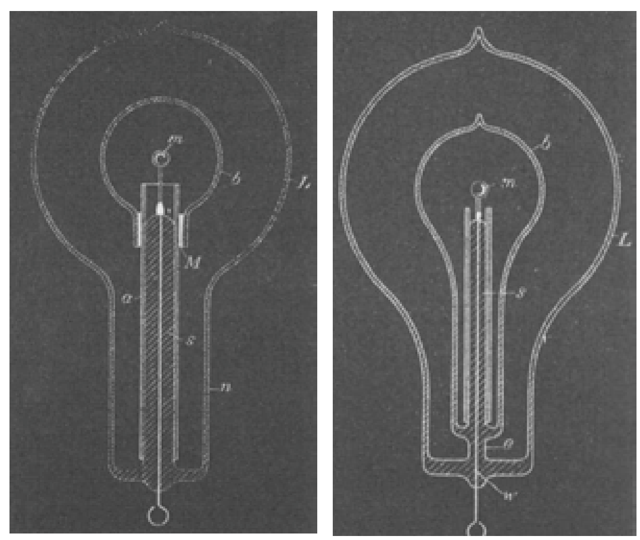

Figure 1. Spherical "carbon button" discharge tubes invented by Tesla in the 1890s. They were capacitively driven by polarization currents.

Tesla – Carbon Nanodust

There is a persistent urban legend about Nikola Tesla, the prolific Serbian inventor. According to some contemporaries, he developed an electric car in the 1930s. He converted a Pierce Arrow car removing its tailpipe. He claimed that his greatest achievement was not alternating current or the radio, but a high voltage tube which could produce energy and transmute materials. This story has usually been dismissed as nonsense. Now in the light of emerging LENR experience, this could have been true after all. He claimed "nature has stored up in the universe infinite energy" (Columbia College Lecture, New York, May 20, 1891).

Tesla demonstrated "carbon button lamps," spherical gas discharge devices in public lectures (London 1892, Philadelphia 1893, U.S. Patent 4,546,22/1891). These plasma devices were driven by high voltage polarization currents, which emitted suspiciously large amounts of light (U.S. Patent 593,138/1897, shown in Figure 1).

Carborundum (carbosilicate dust and/or carbon nanotubes) in a resonant plasma is a possible source of the LENR phenomena (discussed in Part 2). Some poor quality photographs of Tesla's spherical tubes were published in his legal records. Today the single-wire polarization current technology, which is required to resonate the plasma, has practically been forgotten, revived only by some amateur researchers. But our understanding of the principles of dusty plasma has been steadily growing in the last decade, and institutional science is finally catching up.

Tesla became an outcast in science by the 1930s. Physics was just over its "golden years." The mainstream was involved in quantum mechanics, and the golden years of nuclear physics was about to come 20 years later. No one has entered Tesla's footsteps ever since.

The closed-circuit plasma devices presently used are not suitable to exploit the dusty resonant plasma LENR process, as they cannot extract excess energy. RF and microwave driven plasma, developed decades later, were already workable methods but they exploit only excess heat. For direct extraction of electric energy, the single-wire technology is simple and straightforward. No wonder the same discovery has emerged again by using Tesla's single-wire invention.

Moray – Plasmon Polaritons in Microcavities

Henry Moray, a self-taught electrical technician in Salt Lake City, stumbled onto a strange effect as a radio amateur at the age of 15, in 1909. By 1911 the device illuminated a 5 - 10 Watt incandescent lamp, and did not improve until 1925 when it increased to about 70 Watts. By 1938, Moray demonstrated a device producing 4 - 5 kW electric energy several times. By the 1940s it rose to about 20 kW.

Moray modified a crystal radio, with the antenna serving as a high voltage low current power supply. His only patent (U.S. 2,460,707/1949) discloses a series of gas discharge tubes driven by Tesla-type single wire polarization currents. During decades of development, his multiple-tube device yielded 5 - 20 kW of electric energy, silently, continuously and without much heat. Moray's high frequency tubes of different designs emitted bluish light in the presence of high voltage sparks. The thin wires in the device and the sensitivity for one's vicinity to the power output of the device are telling signs of capacitively-driven discharge tubes.

T. Henry Moray in 1932.

According to his patent, Moray used a large surface, intermittently excited cathode, in a low pressure discharge tube. The cathode was made of "Moray metal," an alloy containing sulphur, aluminum, lead, etc. In a high voltage, low pressure environment, the cathode surface becomes large, spongy, and full of small, micron-sized cracks and cavities, like Swiss cheese. This can be a "nuclear active environment," a term coined by Edmund Storms. Metal dust particles and surface plasmons can be created at the nanometer scale, which are essential ingredients of some LENR processes. The tubes contained some water vapor, thus hydrogen, reading between the lines of his book and patent (*Sea of Energy in which the Earth Flows*, T. Henry Moray, 1st - 5th edition).

Moray kept a paranoid secrecy about the technical details of his "radiant energy" device, and had a long, futile fight with investors and partners, such as Carl and Henry Eyring, and the U.S. Patent Office. Though he lived until 1974, Moray never disclosed his invention, but kept on speculating copiously about the nature of the excess energy, resonances and plasma oscillations. Though dozens of people saw the working device, and half a dozen testified about it for a public notary, this invention is lost once and for all (see Figure 2).

Moray's device didn't require input from the grid, but a large antennae and grounding, as demonstrated several times in the deserts of Utah. The low current, high voltage, low power input from the antenna was enough to drive a first tube, which drove a second resonant tube with higher pressure, which fed the third-stage tubes, which yielded several kWs of electric power.

Moray skipped later aerials as a source of high voltage power input, so he could demonstrate a working device in a moving car, or in an aeroplane. He had to develop his own high voltage rectifying semiconductors, in itself an important achievement—and kept it secret. His cup-like voltage amplifier (not discussed here) is also a potentially useful and forgotten device.

But his spongy alloy—the "Moray metal"—was the essential site where presumably the low energy nuclear phenomena took place. Though it was not disclosed in detail in his patent, it might be reproducible today.

In retrospect there is a plausible explanation how a

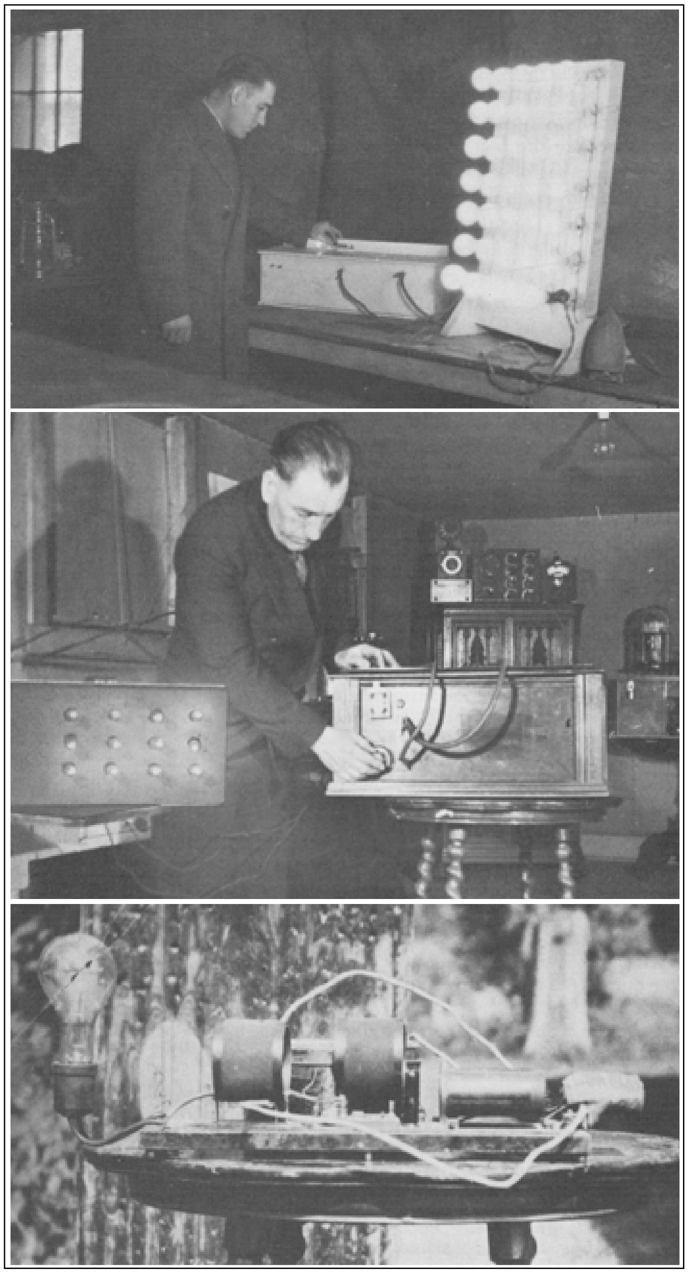

Figure 2. Demonstrations of the Moray device.

teenage crystal-radio fan in Utah stumbled onto an excess energy effect. Ostensibly he replaced the unreliable galenite crystal diode with a wire corona discharge tube, which was capable of rectifying, first at atmospheric pressure and later at lower pressures. The dry Utah desert air gave him a permanent advantage hard to find elsewhere: extreme high voltage between the aerials and the ground, up to 100 kV.

If the inner tube (the cathode) was made of a slightly roughened stainless steel, or a lead-sulphur galenite alloy with some surface protrusions and cavities—due to cathode bombardment—Moray created surface plasmon polaritons without being aware of it (see Appendix).

By tuning the modified detector radio circuit, Moray stumbled onto two distinct phenomena. First of all, the wire corona discharge tube became a sensitive microphone, and the resonant circuits amplified the acoustically modulated plasma oscillations; thus anyone could hear the noise of rain far away or the sound of a distant train. He proudly showed off this device, which might have already been a modified circuit.

Moreover, by tuning his radio into the frequency range of regular Trichel type negative corona oscillations Moray might have heard an unusually strong noise in the earphone. This aroused his curiosity enough to continue the experiments in 1909.

Hundreds of other radio amateurs might have got up to this stage, but apparently no further. (The author read a letter of a Hungarian crystal radio amateur who got into this stage in the early 1950s.)

Moray went further. He replaced the earphone with a 1 mm wide spark gap, having an electric output of about half a watt. This was much more than the ordinary output of the pin rectifier detector radio, having an output power only in the order of milliwatts. This was the fundamental setup that he showed to his teenage friends. It took him about ten years to figure out the relative importance of the different parameters. He reached the 50 - 100 W electric power output with an approximately 5 cm diameter gas discharge tube, having a cathode approximately 2 - 3 cm in diameter, whose material must have been "Moray metal." He certainly perfected one of the first R&D processes in nanotechnology. Lead, sulphur and aluminum in his alloy (a version of galenite crystal) served the same purpose as aluminum in the "Raney nickel" catalyst—to have a large surface. After some heating or cathode bombardment, these soft materials left the surface, leaving a number of sub-micron size cavities like Swiss cheese. This was the "nuclear active environment," due to the formation of a surface that was needle-like or cavity-like. Surface plasmon polariton resonances might have been generated by low power resonant electric circuits, excited by high voltage, high frequency electric fields, which in turn generated low energy nuclear phenomena. (The plausible mechanism of the polariton-based LENR will be discussed in Part 2, and more specifics of the Moray patent in Part 3.)

Thus Moray addressed the most important issue—reliability—like Tesla with his own "carbon button lamps." Other inventors discussed below were not so fortunate, as other inventions did not have such a good "engineering environment" as Tesla's volumetric, dust-based or Moray's surface-based LENR processes.

The next challenge, to increase power to the commercially interesting 10 - 20 kW range, took about 20 years.

One of Moray's insights must have been that a series of coupled resonant circuits need to be used for higher power output. But the tube required ever higher voltage input for lower frequencies—a real challenge.

Moray correctly noted that when excess energy is generated, "inertia sets in." That means the high frequency resonant electric circuits can drive sub-harmonic plasma oscillations in resonance. This is a typical feature of resonant ion acoustic oscillations, which were "discovered" decades later by mainstream scientists. (See Masana, R. and Daquq, M. 2012. "Energy Harvesting in the Super Harmonic Frequency Region of a Twin-well Oscillator," *J. of Appl. Phys.*, 111, 044501.)

Moray solved the high voltage input problem by rewiring the circuits, and switching to the Tesla-type single-wire technology (though he claimed he had discovered it independently).

The key element was a novel parabolic, cup-like amplifier or resonator, which is an engineering triumph itself. But he had to use high frequency, high voltage "Zener" type diodes to rectify the power impulses, to be fed to the cathodes. This was another engineering problem solved by refined germanium semiconductors.

Since he used tuned, resonant electric circuits and plasma resonances, Moray's device required some re-tuning after the initial warm up of the plasma, as several witnesses observed. The high voltage (100 kV), high frequency, capacitively driven ≈ 50 - 100 KHz device was very sensitive to de-tuning, that is to the touching of the aerials or even from someone getting very close to the device.

At first the walls of the glass plasma tubes were the source of water vapor via diffusion, providing a slow stream of hydrogen. Moray was aware of it, as we read between the lines of his books and stated clearly in his patent.

Since fine resonant tuning was essential for the device to produce energy, he was correctly convinced that resonance is a key to the production of energy. But the empty hypothesis of the oscillating Universe led nowhere.

As we shall see with other similar inventions below, the necessary scientific foundations were simply not available before Fleischmann's discovery: nanotechnology, quasi-particles, emergent multi-body interactions and low-energy nuclear phenomena. The theoretical and engineering challenges were as extreme then as they are today. The range of necessary topics is so wide and varied that in our goal-oriented, overly specialized science we cannot cope with such a technical and physical diversity. No wonder Tesla was considered to be a "wizard" of his time due to his reputation, but other researchers in this area were termed simply as crooks.

All these (and the following) inventions could have been of immense utility to mankind, but these ideas are very far from mainstream thinking. Consequently, mainstream thinking in this area is not remotely useful.

Since Moray's death in 1974, a great number of amateurs have unsuccessfully tried to repeat his work because they lacked the "right" starting point both in technical and theoretical grounds. Tesla at least made some attempts to describe the technical foundations of his invention. Thus we have his patents and lectures, with meaningful engineering ideas.

Moray left us much less, though he was also an exceptionally creative research engineer, facing extreme engineering, social and financial challenges.

In retrospect, it requires a sharp eye and open-mindedness to recognize and accept surface quality as a decisive factor in this area of research—as neither thermonuclear fusion (nor electrochemistry) demands or recognizes it as a factor worthy of consideration. This author went through it, as did Tadahiko Mizuno.

Mizuno remarked about the importance of surface features in his book (*Nuclear Transmutation: The Reality of Cold Fusion*, Infinite Energy Press, 1998). Though it is mentioned in the context of electrolysis, it applies here and to other inventions:

> When hydrogen is produced at a protrusion, the discharge reaction will be enhanced, the recombination reaction will be suppressed. . . (p. 103)
>
> You can heat up the lattice or expose it to a magnetic field; you can anneal the palladium [cathode] or alloy it to other materials. You can process the metal to make the surface smooth. Nothing will help. (p. 101)
>
> Near a protrusion discharge occurs more readily. . . which would yield hydrogen pressure reaching 10^{17} atmospheres. This far and away exceeds the 10^{11} atmospheres of pressure in the center of Sun. (p. 103)

This was a testable hypothesis with predictive capability. It was not followed.

Surface quality at nanoscale is very difficult to control and maintain in a gas discharge. As we shall see later, not all devices and processes are capable of maintaining it. Reproducibility and control are still a major concern for LENR, as well as the lack of a fresh stream of developers. Young kids no longer hang around crystal radios, as analogue long wave radios no longer exist.

Kids no longer make galenite crystals of their own (made of mainly sulphur and lead), mixing and melting them, learning with hands-on experience. Useful, down to Earth physics vanished for good.

The author has some remote experience with this technology, but it was just a string of quarrels. The sponsor and the engineers always wanted shortcuts and "compromises." They did not want a tall antenna because it is too dangerous, no sulphur and lead in the cathode material because they stink, no high voltage single-wire technology because it is "outdated" and dangerous, etc.

So after years of frustrating, endless rows, the project was a complete failure. The moral of the story: the Moray type of technology demands some uncompromising, extreme parameters, where no shortcuts are possible.

The underlying physics is absolutely alien to electrical engineers, who were raised in our conventional system of education.

Salt Lake City, Utah reminds people of LENR (cold fusion) and of the researchers Stanley Pons and Martin Fleischmann, and the year 1989. The city should commemorate Moray as well, and the date of the death of Joseph Papp because both made reliable, industrially applicable devices with direct electrical and mechanical energy output, in small, controllable, portable devices, arguably based on LENR. It is true that by 1989 they had faded from memory, but "cold fusion" returned via the back door, in a different technical setup, hopefully never to vanish again.

Moray had a small group of supporters who witnessed his experiments, among them Harvey Fletcher from Bell Laboratories and Carl Eyring. His brother, Henry Eyring, a local professor of chemistry, saw the demonstration too, but did not understand it. Therefore he vehemently denied even the existence of the excess energy effect, causing a loss of credibility for Moray. This eventually led to the demise of his invention. As a twist of history, Fleischmann and Pons worked on LENR in a building named after Henry Eyring. (Further in-depth analysis will follow in Part 3.)

What about the mainstream science of those years? In 1926, Germans Fritz Paneth and Kurt Peters realized that helium was "synthesized" in a spongy, white hot palladium tube, when light hydrogen was fed through it. This was the closest hit. (James Chadwick found the neutrons after a ten-year hunt in February 1932.)

Had they elaborated on the circumstances of their experiments—*e.g.*, temperature, surface quality and material testing—we would be smarter and better off today. A similar test was performed by Francesco Scaramuzzi in the Frascati Lab in 1989, when deuterium gas was led through hot titanium scraps and helium was observed. Unfortunately, the role of surface quality was not investigated with due diligence in these tests, but the "writing was on the wall." In the 1930s there were two working, advanced LENR devices producing electric energy. The fundamentals had already been presented by Tesla to his fellow engineers in the 1890s.

Papp – Charge Shielding by Chlorine Ions

Joseph Papp, a Hungarian-born inventor and a refugee of the 1956 Revolution, demonstrated his inert gas engine in California in 1968. His LENR engines were practically converted four-stroke internal combustion devices, but with sealed pistons, containing a mixture of water, rare gases and chlorine. The chain of collisions of inert gases (Xe, Kr, A, Ne and He) was a kind of impedance transformer. It worked like a whip with a gradually decreasing diameter. Even a modest initial wave velocity of the human hand at the thick end is enough to break the sound barrier at the thin end. Thus kicking a heavy Xe ion, a proton (at the end of a "lucky" collision chain) may produce a substantial energy (velocity). This process can yield an extremely distorted distribution of energy for the protons or deuterons in a plasma. Thus only a very small fraction of them had high energy. Some of the gas atoms were ionized, but most of the atoms were not ionized. There was another engineering trick: the introduction of some halides like chlorine, capable of forming negative ions, thus capable of charge shielding (screening or charge neutralizing if one prefers these expressions). Thus one proton with equilibrium velocity can have a good bonding and charge neutralization to a negative chlorine ion, forming a nearly neutral electrical bond. Then another proton, accelerated by a "lucky chain" of collisions, can have a high velocity, and fuse with the slow proton (or deuteron). This chain of events of a three-body interaction has a low (but not zero) probability, but that is exactly what is needed for controlled fusion. There were other minor engineering tricks as well, not discussed here, but the irreducible ingredients of a three-body interaction with charge shielding and non-equilibrium distribution are shown in Figure 3.

On the ill-fated first demonstration of the engine in Gardena, California, in November 1968, Richard Feynman, Nobel laureate and a veteran of the Manhattan Project, literally blew up the engine, killing one hopeful investor and severely injuring three other spectators. Feynman was convinced that Papp was nothing but a crook. He thought that controlled fusion can only be a thermonuclear one, which can take place only above a very high energy, consequently not in a small and cold piston of an engine. Thus Papp had to be a crook.

Indeed, Papp had a deceitful, paranoid personality, not trusting even his closest associates (see *Infinite Energy* #51 for details). Though he mastered a commanding hands-on experience with his technology, he was not much interested in the physical fundamentals. His first patent (U.S. 3,680,431/1972) contains some nonsense (like neutral electrons), but his third and most sophisticated patent (U.S. 4,428,193/1984) is crammed with a deliberately placed collection of misleading information, like the installation of high frequency magnetic field solenoids around the cylinders of his engines. He wanted to be rich and famous, and did everything to make it impossible. His former colleagues inherited this unfortunate characteristic. Fighting for his legacy, they keep on strangling each other, like the Rohner brothers, or Jim and Jake Sabori. (John Rohner's U.S. patent application is 2011/0113772.)

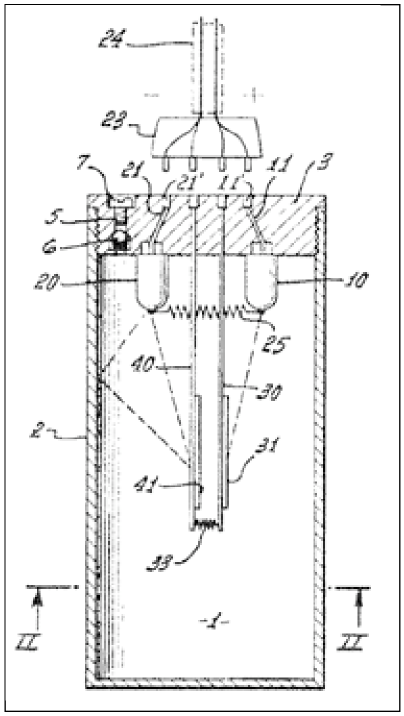

Figure 3. Joseph Papp's simplest invention—a gun with noble gas mixture.

The author has met some of Papp's former Hungarian co-workers, and received "original" blueprints, photographs, descriptions—mainly to mislead possible investors, and create a fog to mislead anyone who wants to repeat his experiments. Papp's ionization gas mixing device was clearly meant to impress (and deceive) possible investors.

His brother still lives in Hungary, but is ignorant of any technical details. According to former co-workers, Papp's father stumbled onto this phenomenon, and he was the source of the inspiration.

Jekkel – Plasmon Polaritons on Thin Silver Wires

Janos Jekkel, another Hungarian inventor and technician at the now defunct Electric Research Laboratories, stumbled onto a strange phenomenon when he wanted to build an electric oxy-gas welding torch. He wanted to dissociate superheated water molecules, simply shaking them apart by resonant high voltage, in high frequency electric fields.

He made a "T" shaped glass tube, superheated with high pressure steam (see Figure 4) and led the steam through two electrodes, made of micron thin silver wire "wool." There were roughly 20 kV, approx. 10 kHz series of one-sided sawtooth-shaped electric field pulses on the electrodes. When the device was switched on, Jekkel realized the difference between the small electric input, and the huge oxy-gas output. He kept on refining the engineering aspects of the design, because he had an internal combustion engine on his mind. The engineering challenge was to maintain the same pressure at both exit parts, which was crucial when he had to accelerate his car (a Moskvich 407).

During his experiments, the oxy-gas exploded twice, smashing all the windows of the neighbors. Jekkel claimed to have solved the problem of separating H_2 and O_2 gases with a solenoid and some permanent magnets. He got the fine silver wires from his lab, where he was in charge of developing a fast acting fuse (which he solved with these wires).

After three years of work, he made a partly successful 220 km maiden voyage to the village of Medgyes after several shorter trial runs. He was stopped and fined by a police patrol, because he had no gasoline tank. At that time, the price of Propane Butane gas was subsidized by the state, as most kitchen stoves run on it. Therefore it was not allowed to be used to run cars; they were supposed to run on gasoline, which was heavily taxed. Special permission was needed to run a car without gasoline, granted for only a few well connected persons.

On the way back, the main crankshaft broke since it was not meant to bear the brunt of oxy-gas explosions. He had to rent a car to pull him back home at a steep price.

Jekkel became fed up with the difficulties, took the engine apart and cannibalized the high voltage electronic power supply—the soul of the machine. Two decades later, when the "existing socialism" collapsed, a wealthy businessman offered financial help to rebuild the machine. (The author was part of the team.) After a few months, it became clear that Jekkel forgot all the important details. Since he had kept no logs, no documents, photographs, etc., Jekkel was unable to guide us. We tried stainless steel flat electrodes for months when he finally mentioned the thin silver wire mesh, but by then our budget and patience had run out.

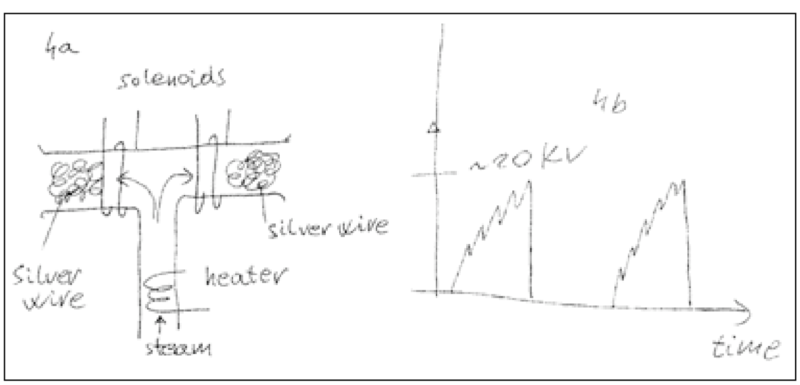

Figure 4. Schematic layout of the Jekkel tube and pulse shape.

In retrospect, we know that thin silver wire mesh might be the site of powerful plasmon polariton resonances—a fact not known at that time. Because all know-how about the electronic parameters of the resonant H_2O plasma smasher has been forgotten by now, there is no hope to revive this machine. Jekkel passed away on Christmas 2011. This author has met only one independent eyewitness, a former colleague who saw the device in action but he was not interested in the technical details.

Apart from the generation of nuclear energy by the resonant plasmon polariton method, there might be other physical mechanisms involved, and it might be of practical interest to test this possibility.

Gray – Plasmon Polaritons on Wire Mesh

There is another wire mesh invention producing excess energy, by Edwin Gray. Gray has a portfolio of three patents. The first one is 3,890,545 but only the last (U.S. Patent 4,595,975/1986) contains some useful information. His device is a transient arc generator. The excess energy drives a solenoid, which drives a special electric motor, where the stator consists of permanent magnets.

The real essence is in the fine wire mesh cathode, capable of generating volumetric and surface plasmons. In a rare interview, Gray boasted that he was capable of harnessing a series of very short, sharp bursts of excess energy, and these fed an oscillatory circuit.

As usual, he was a loner, keeping the most important details to himself and disclosing only partial details. As usual, he wanted to be very rich and very famous at the same time. As usual, he died penniless, and his work has been practically forgotten.

Shoulders – Plasmon Polaritons on Needle Tips

There is a similar strange effect, found by Ken Shoulders (U.S. Patent 5,018,180/1991, or 5,148,461/1992), which belongs here. The effect takes place on the tip of a needle in a transient plasma at low pressures. At a modest 500 V difference, a bunch of electrons and protons form an interesting particle cluster, which he called an "electrum validum," on the cathode tip, creating a hole on a fine aluminum or ceramic flat anode (or witness plate). The calculations yield an astonishing amount of excess energy, up to 90 times, and some transmutation effects as well; see Figure 5.

The small area of the needle tip creates an enormous electrical field strength and gradient which no linear or circular particle accelerator is able to generate. There is also a plasma wakefield acceleration, which collectively accelerates a wave of charged particles.

The gradually decreasing tapered surface of the metal tip generates polariton wave transients (besides other effects), which have an electric field amplitude increasing with time along its path toward the tip. These electric fields might be high enough to generate a number of neutrons via the $p + e^* \rightarrow n + \nu$ (Widom-Larsen type) process, where e^* is a wave of surface or volumetric electrons, a plasmon polariton, a virtual particle of high-effective mass. It is not clear yet whether the Shoulders process can be used for any direct technical application, but it is home to a number of fundamentally important pseudo-particle processes of extreme amplitude. No wonder it yields the high mass particle clusters, perhaps poly-neutrons, detected elsewhere by John Fisher and Richard Oriani (see *Infinite Energy* #94). The phenomenon is sensitive to pressure and gas quality. A similar process takes places in a less intense manner on the surface of thin deuterated nickel wires during high current transients. The tapered, conical pins are a sort of geometrical field intensity amplifier, yielding an unbeatable advantage of simplicity over other methods.

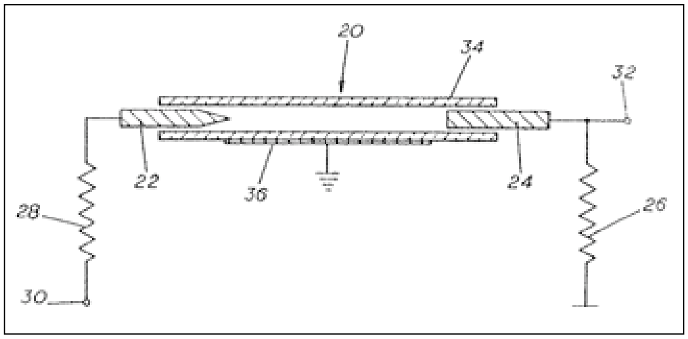

Figure 5. Shoulders' device in a patent figure.

Because this experimental method is inexpensive, even graduate students can work on it as truly fundamental research. However, it is very difficult to make a mathematical model of the interaction of the needle and the metal surface plasmon-polariton with the transient plasma.

The subject of "fusion by needles" also appears in an off mainstream D - T thermonuclear process developed by E.G. Bakhoum ("Very Small Scale Electrostatic-Confinement Fusion Apparatus," *IEEE Transactions on Plasma Science*, 37, October 2009, 2090-2097). The device, shown schematically in Figures 6a-b, successfully exceeded the ignition threshold near the tips; *i.e.* the product, plasma density · confinement time · kinetic energy exceeds $1.5 \cdot 10^{19}$ keV·sec/m^3. The needles are driven intermittently by a 100 kV power supply. Near the needle tips, the above triple product is about 10^{23} keV·sec/m^3, exceeding the break even condition, which has not been reached by other mainstream thermonuclear devices. This line of research has not been continued despite its merits. In my opinion this is the only good technical solution for the thermonuclear D - T process, which is oth-

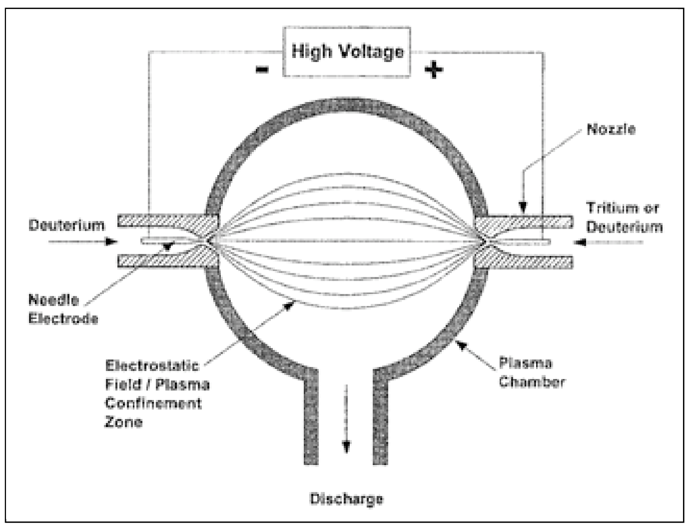

Figure 6a. E.G. Bakhoum's thermonuclear reactor concept built and successfully tested.

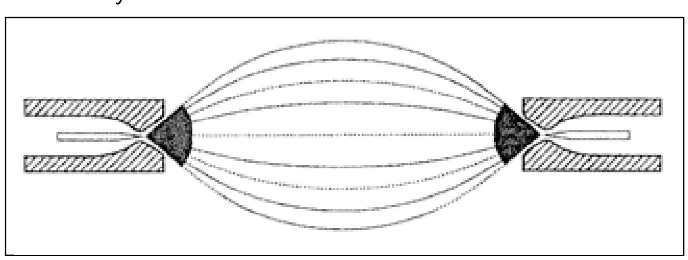
Figure 6b. The shaded area notes the region of ignition.

erwise faulty.

The useful nature of needles and cracks popped up by accident, as illustrated in other inventions described below.

Chernetsky – Plasmon Polaritons on Tapered Tips

Tapered, very sharp needles appear in four more discoveries. The first belongs to the renowned Russian plasma physicist, Alexander Chernetsky. The second belongs to the Canadian couple Alexandra and Paulo Correa. Both of them stumbled onto the excess energy generation by accident; both of them have published extensively about their discoveries; both have theorized extensively about the nature of their excess energy generation. According to this author both of them have missed the point, even the important aspects of the know-how.

Chernetsky used a low pressure, high frequency arc discharge to drive hydrogen plasma, which drove an inductively coupled circuit to the load. His sealed discharge tubes had symmetric circular molybdenum electrodes 0.8 cm in diameter. The current density had to reach a critical value, and it took several thousands of initial short arc pulses to "roughen up" the surface electrodes. His tubes had an inter-electrode volume of less than 1 cm^3. Otherwise the excess energy effect in the form of short, microsecond bursts did not appear.

In these tubes, hydrogen pressure is regulated by a getter, heated from an outside power source.

Chernetsky had a severe cathode erosion problem and his excess energy generation range of parameters was narrow.

He developed and demonstrated several devices, but he was a "heretic," and all his funds were cut off at the time of the collapse of the USSR. Though he teamed up with Andrei Sakharov, they missed the point. Sakharov suspected a vacuum energy fluctuation behind the voltage peaks, and bursts of excess energy. Chernetsky, a plasma theorist himself, worked hard with the equations of transient plasma oscillations, and derived the appearance of excess energy. However, he arbitrarily tampered with the signs of some terms to get the desired excess energy results.

But the real problem was the "fragility" of the tests results, like those of the early Pons-Fleischmann experiments. He published six papers (with colleagues Lichnikov and Popov) in Russian scientific journals, but after his death, his close associates did not continue this work.

Correa – Plasmon Polaritons on Needle Tips

The Correas stumbled onto this excess energy generation phenomena while clearing the surface of large, flat aluminum plates, in an argon atmosphere, using transient current impulses in abnormal glow → arc discharge transitions. The arc part should be cut as short as possible, because it hampers the phenomenon. The Correas have a wide patent portfolio, with extensive descriptions (see U.S. Patent 5,449,989/1995, or *Infinite Energy* #7 and #41).

This author has ten years of full time experience with both setups, extensive know-how and bitter disappointment with both approaches.

The most important and neglected feature of both effects has been the formation of very sharp tapered needles of nearly perfectly cylindrical symmetry on the cathodes. The formation of these needles deserves a separate research paper, because according to our knowledge of classical electrodynamics, they should not form. In the absence of these sharp needles, the sharp bursts generating current *cease altogether* when all the other conditions are the same. The molybdenum "needles" of Chernetsky's setup arise after hundreds of "roughening" current pulses. Tens of thousands of initial pulses are needed for the large area Correa cathodes (usually 64 cm^2). When the author tried an artificial grid of needles (spaced 0.5 - 1 mm apart with molybdenum needles, sharp blades, stainless steel mesh and brush), the bursts appeared immediately, but at lower voltage and current amplitudes. Higher current impulses quickly melted them. This technical nightmare of surface quality control made the author abandon the project, apart from personnel and financial difficulties.

Both Chernetsky and the Correas missed the importance of acoustic resonance. The excess energy released from a number of sharp metal tips, due to the apparent surface plasmon resonance, charge shielding and consequent fusion phenomena, was not efficiently coupled to the plasma. Consequently, the electric circuits extracting power did not work efficiently, though both of them desperately fought with this problem. The Correas even missed the importance of hydrogen as a fuel, though they (and we) noted that removing most of the water from the gas tube walls by baking them out reduces the extent of the effect, or ceases altogether.

All in all, the multiple needles on the electrodes are of major importance, and the effect has appeared and depended on the quality of the cathode surface, and not on the positive column or on the sharp electric gradient of the Faraday dark space as Chernetsky surmised.

The Correas tried small surface wire cathodes as well, with a higher electric field density, but in vain. The correlation between excess energy due to the cathode surface (needles), hydrogen gas and transient plasma discharges were beyond doubt. Certainly D_2 gas should have been looked at, but the lack of clear, reliable test results has prevented it. However, knowing the neutron generation capability of a high effective mass, high charge screening of surface plasmons and phonons, it is not a straightforward conclusion that only D gas or a D - T mixture can yield high outputs. Though a nuclear reaction can be just one of a number of possible and plausible models, it is a much cheaper testing ground than confinement-based hot fusion experiments.

This was the first series of events, when a correlation was found between the sharpness and number of needles, and craters with excess energy. The direction of excess current was also correlated with the location of the needles, or sharp-edged ring-shaped "craters."

A stereo microscope with a 50 power magnification was enough to observe the shape of the "moon-like" surface of the roughened electrodes. The Correas' device produced unusually shaped arc discharges, spherical near the cathode, conical towards the anode.

These phenomena have been marred by a number of "unknown unknowns." Therefore progress is inevitably slow and erratic if there is any at all (see Figures 7a-d).

Puharich, Meyer, Horvath – Plasmon Polaritons on Surface Protrusions in Ordinary Water

There are some light water inventions involving LENR. There is a third and fourth version of the "sharp needle on the cathode," albeit a more elusive one. Andrija Puharich (U.S. Patent 4,394,230/1983) and Stan Meyer used ordinary, room temperature tap water for electrolysis, but not with DC. They used high voltage, low current resonant driving electric circuits to obtain oxy-gas at excess energy levels. Meyer demonstrated his inventions on video several times. He did not disclose enough details in his series of patents to make a device that could be successfully repeated. Most probably he was unable to control the surface quality, and was not even aware where the energy was coming from.

Meyer was the archetype of secretive, paranoid and arrogant inventor, who was his own worst enemy. He died in a restaurant, exclaiming that he was poisoned, and then was duly forgotten. His invention is considered a hoax today by most (see U.S. Patent 4,936,961/1990).

Meyer's resonant "tap water splitter" is a simpler version of the Chernetsky-Correa invention, provided the cathode was properly roughened in two ways. It might have had several micron-sized hydrogen filled cavities as a site of the surface plasmon polaritons and/or a multitude of sharp needles or blade-like protrusions or dendrides serving the same purpose. Stainless steel containing nickel is a catalyst for splitting H_2 molecules, but "naked protons" were also generated during the ordinary electrolysis of the water.

Again the surface quality of the cathode is of immense importance, but invisible to the naked eye. Its proper preparation is not just "know-how," but the very essence of the invention. Without disclosing enough details to be repeatable by those "skilled in the art," these patents are worthless and should not have been granted.

Stainless steel can be etched with different acids and/or it can be treated by a high pressure arc discharge to "roughen up" the cathode surface to make grooves, cracks or needle-like protrusions, so when they are covered by small bubbles and inside them there is hydrogen plasma, the same "nuclear active environment" is generated as in the above Correa and Chernetsky devices. Even an indirect $p^+ + Ni \rightarrow Cu$ process may take place, like those described by Scaramuzzi, Piantelli, Rossi and Preparata.

Yet another version of a Ni-H electrolysis cell was made by the Australian (Hungarian born) Stephen Horváth. He went one step further than Meyer, having the cathode—a magnetizable stainless steel alloy—driven into magnetostrictive resonance. Magnetostriction is especially strong in Ni and some Ni alloys, and it is a simple way to generate phonons, and volumetric pressure waves, in the metal lattice. In case of a fine tuned resonance, when the frequency of exciting mag-

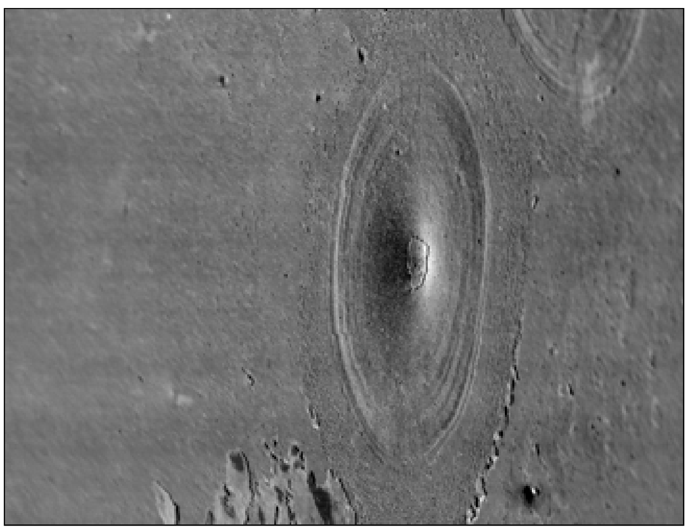

Figure 7a. The base of a sharp needle grown on the molybdenum cathode (broken during transportation).

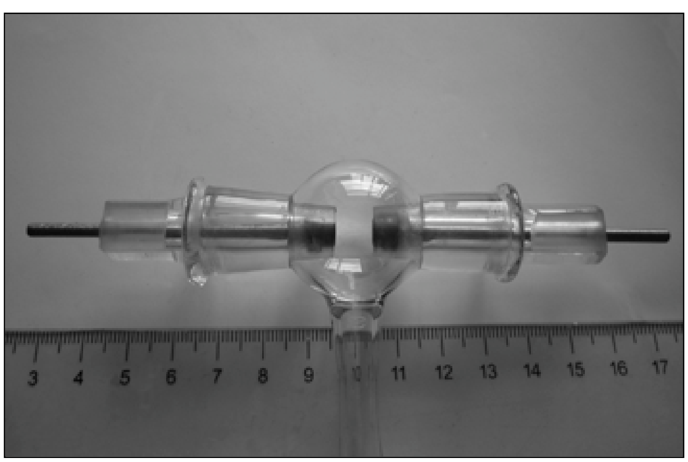

Figure 7b. A spherical Chernetsky tube with 8 mm diameter molybdenum electrodes. These electrodes are removable.

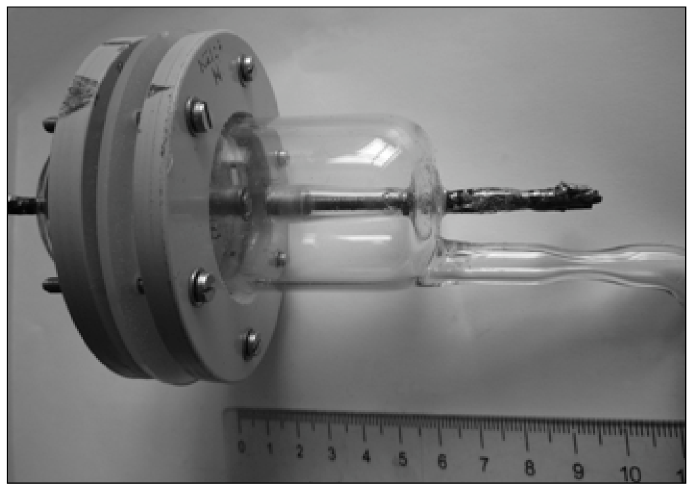

Figure 7c. Another Chernetsky tube, the same 8 mm diameter electrodes, but different shape of tube. There is no acoustic plasma resonance in this case.

Figure 7d. The author standing next to a Chernetsky-Correa test stand.

netic fields is the same as the mechanical vibration frequency of the cathode piece, the excitation energy is small and the process is efficient. Though these details are barely touched upon in his patent (U.S. Patent 3,980,053/1976), two of his investors, the Canadian-Hungarian Bela Kajdocsy and Mo Goldhaber spoke about it to the author, as part of the important know-how. A further useful feature of his cathode was that it had sharp edges to increase local electric fields, and to enlarge the surface of the cathode. This feature can be incorporated in electrolytic cathode designs, which are usually cylindrical or flat (except the Patterson cell).

However, the stainless steel (Ni-Fe-Cr alloy) is not ideal for bulk hydrogen loading, so most of the useful effects took place near the surface. Horváth, and some other technicians who tried to build his device, stumbled onto the usual effect. After some initial success, the excess energy disappeared.

Lacking a thorough understanding, and wasting money (ruining the investors), Horváth gave up this line of design. He now works on artificial muon induced fusion in Australia, to be discussed in Part 2.

There is a further version of the ordinary hydrogen loaded, Ni-alloy tube geometry electrolytic process, the "Joe cell." It is supposed to have resonant electric circuits for high frequency, high voltage excitation of the cathode. There are several embedded electrolytic tubular cells of carefully matched diameters and lengths. There are alkaline and acidic versions, and even pH neutral ones, like the Meyer cell. The Joe cell is the "layman's cold fusion" device. However, "cosmic energy" or "orgone energy" is mentioned as an energy source. No reliable, well-documented or repeatable experiments exist. The author is aware of some successful devices. They have performed well for a few days at the beginning and then suddenly turn into a highly wasteful cell, producing lots of ohmic losses and a brownish sludge on the cathode surface, apparently iron.

Phonons – Polaritons Inside Metal Hydrides

Phonons and plasmon polaritons are explicitly mentioned in the patent application of Robert E. Godes (2007/0206715) of Brillouin Technologies. The hydrogen loaded metal lattice is vibrated with ultrasound to induce lattice vibrations. The resulting added electron density waves are phonons, and pseudo-particles, which screen the charge of lattice hydrogen isotopes embedded in the cathode metal lattice.

The process takes place through several steps: p → D → T by neutron formation and neutron absorption. The plasma-based process is not discussed in detail in the patent application so it cannot be built by those "skilled in the art." The Brillouin patent application contains reference to phonons, and current induced polaritons as well.

This author has successful "hands on" experience with two systems of pulsed current induced polariton pseudo-particles endorsed by the late Italian professor, Giuliano Preparata. Our first setup was based on the Patterson cell with a large surface, and small spherical beads. The second flat, copper-palladium-nickel cathode setup worked well, with sudden current pulses. The beads were useless, apparently due to low current density. Phonons and volumetric polaritons (current transients) have lower frequencies, usually in the ultrasound frequency range. Therefore they are less economic than infrared induced polaritons in the order of tera and peta hertz. Moreover, phonons and current wave-induced volumetric polaritons require input energy, and power supplies. Infrared radiation-induced surface plasmon polaritons may induce self-sustaining heat generation by the positive feedback process of infrared-induced polariton resonance → heat generation → nuclear neutron capture → heat generation → infrared radiation induced (surface) polariton resonance chain with a positive feedback.

This process, termed as "heat after death," has been observed many times in recent years, but its connection to charge shielding or neutron generating pseudo-particles was not clearly explained.

One may surmise that the Ni - H_1 process of the late U.S. inventor James Patterson, and later followers of the Italian school, such as Piantelli and Rossi (WO2010/058288, US2011/0005506), used the same process, though it was usually shrouded in secrecy and mystery.

Esko, Egely – Dust Quasi-Particles

Not all the important work is hidden in secrecy and the fog of history. The important transmutation work of Ed Esko of Quantum Rabbit is well documented, and was published due to the existence of *Infinite Energy*. This work is based on a transient dusty plasma—arc discharge at low pressure without resonance. The cathode and anode consist of different metals, like copper or lead. The interesting feature is that they add different (pure) substances into the plasma chamber, like sulphur or lithium, and process them in a low pressure arc discharge. The result of these tests is a number of transmutation reactions, in the ppm range. Though these quantities are not yet in the commercial range, their scientific value is without any doubt; therefore they are duly ignored not only by the mainstream community (which is usual), but also by the small LENR community (which is sad). The Quantum Rabbit experiments were carefully documented. The test results were carefully measured with due scientific diligence, and the transmutation test results are far beyond the test error. Their main problem is that the test results are in irreconcilable contradiction to what mainstream physics teaches about the penetration of the Coulomb barrier.

There are some other inventions which can be related to LENR. The cavitation based (sonofusion) method of James Griggs is one example, but the hard data is so scarce, that there are question marks. Another candidate can be Casimir forces during bubble formation and collapse, but both phenomena can act simultaneously.

There are other similar "iffy" forgotten mysterious inventions in the field of "crypto technology," but less documented, therefore their evaluation would be very speculative.

There is another process and device fully disclosed by this author, based on resonant carbon nanodust plasma; see Figure 8 (and also *Infinite Energy* #102, video details: www.greentechinfo.eu).

Dust of Nature – Lightning

Mother Nature also provides some "freak" phenomena—slow neutron generation by lightning. These effects were independently noted by Brazilian, Indian and Russian researchers. The challenge is again, that according to the current mainstream wisdom, the usual 20 kV potential difference is simply not enough to create thermal neutrons; at least 0.7 MeV is needed. Lightning is considered an arc discharge, albeit a transient one. Instead, lightning is really a series of short current bursts or waves, which take place in a dusty environment, in ground-to-air discharges.

Geophysical Anomalies

There are some other geophysical anomalies awaiting explanation. There are unusually large concentrations of some noble metals on Earth like gold, platinum and silver. Why? These deposits cannot just form by some biological or volcanic process. In fact, they should be evenly distributed in the crust of Earth, like rare earth materials. In reality, rare earth materials are not rare at all just evenly distributed in a diluted density, as they were formed during some age old supernova eruptions. Thus the mountains of silver or other precious metals had to be literally "manufactured on the spot" where they were found and mined.

Ball lightning is sometimes considered as a candidate for a "natural cold fusion reactor." Indeed, it sometimes has an unusually long lifetime (up to even a minute) and very high thermal and electric output. The boiling off 10 - 20 liters of water from a bath tube, evaporating 1 - 2 kg copper or aluminium electric wires from walls or lifting off massive roofs from buildings shows that it has extremely high energy.

The author has spent several years with fieldwork collecting eyewitness reports and shooting documentary films about the absolutely curious damage patterns caused by ball lightnings, partly as a consultant to insurance companies. There are more than 500 written observations (in English) and eight hours of uncut video recording on our website, www.greentechinfo.eu. Based on this database and those collected by other field investigators, my opinion is that the primary mechanism of ball lightning has no relation to nuclear phenomena, whether it is "hot" or low energy. All LENR devices need some sort of carefully designed engineering hardware. The LENR process will not be sustained out of thin air, as ball lightning is.

As ball lightning occurs in nature, it cannot be described by present mainstream physics in classical or quantum models. There are over 150 theoretical models which attempt to describe it, but each of them has very severe shortcomings. The worst feature is that it cannot be created artificially, only something disappointingly, distantly similar to it.

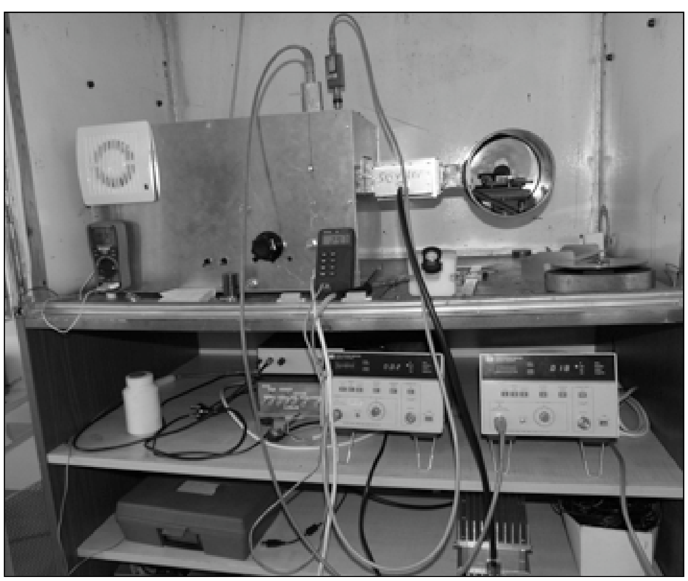

Figure 8. A carbon dust reactor of the author. The metal cylinder is the microwave resonator. There is a circulator between the waveguide and the resonant cylinder.

Interstellar Dust

It has been known since 1973 that 13 elements—O, Ne, Mg, Si, Ca, Ti, Kr, Sr, Te, Xe, Ba, Na and Sm—have a different isotope ratio depending on their source: the Earth's crust, solar or interstellar dust and materials. This shows that these elements are "manufactured" by different natural nuclear methods, even in cold interstellar dust.

There are similar problems with the synthesis of light elements, Li, Be, and B. Their abundance is higher in interstellar dust then in the solar system.

Polaritons in Biology?

Biological transmutation is perhaps the least-known and most ignored LENR phenomena. Due to the pioneering work of Louis Kervran, Vladimir Vysotskii and Alla Kornilova, the test results are compelling. The usual energy level (0.1 - 1 eV) of biological processes is hopelessly below the energy level of heavy ion collisions, where the formation of iron is observed:

> . . .an Englishman, William Prout, made a systematic study of the variations in calcium in incubating chicken eggs and found that when chicks hatched they contained four times more lime than was originally present in the egg and that, furthermore, the lime content of the shell had not changed. He concluded that there had to be an endogenous formation of lime from within the egg. This was long before scientists knew anything about the atom.
>
> Henri Spindler, a French scientist, became fascinated with how *Laminaria*, a variety of algae, seemed to be able to manufacture iodine. Searching for answers in half-forgotten literature on the dusty shelves of libraries, Spindler found that a German researcher by the name of Vogel had planted cress seeds in a container covered by a glass bell jar and fed them nothing but distilled water. A few months later when Vogel burned the adult plants, he found they contained twice the amount of sulfur which had been present in their seeds. Spindler also uncovered the fact that, soon after Vogel, two Britishers by the names of Lawes and Gilbert discovered at the famous Agricultural Research Institute at Rothamsted, England, that plants seemed to extract from the soil more elements than it contained.
>
> For seventeen years the Rothamsted researchers cropped a clover field, mowing it two or three times a year, and sowing it only every fourth year, without adding any fertilizer at all. This piece of land gave cuttings so abundant that it was estimated that if one had to add what had been removed in the period between the arrival of one swarm of seventeen-year locusts and another, it would be necessary to dump on the field over 5,700 pounds of lime, 2,700 pounds of magnesia, 4,700 pounds of potash, 2,700 pounds of phosphoric acid, and 5,700 pounds of nitrogen, or

more than ten tons of the products combined. Where had all these minerals come from?

> Delving deeper into the mystery, Spindler came across the work of a Hanoverian baron, Albrecht von Herzeele, who, in 1873, brought out a revolutionary new book, *The Origin of Inorganic Substances*, which offered proof that, far from simply absorbing matter from the soil and the air, living plants are continuously creating matter. During his lifetime von Herzeele made hundreds of analysis indicating that, in seeds sprouting in distillated water, the original content of potash, phosphorus, magnesium, calcium, and sulfur quite inexplicably increased.
>
> (From: *Alchemists in the Garden*, pp. 276-277)

Consequently either biological transmutation does not exist in nature, or some brand new phenomena may take place. Mainstream physics has the former opinion. This author has the opposite opinion. Therefore there is a need for an explanation.

Appendix: Polaritons, Plasmons

The usual definition of polaritons is described by several recent papers. They are charge waves propagating on the surface of a conductor. The definition applies to any conducting surface. Sometimes plasmons are used instead of polaritons, which is misleading. When there is a conducting plasma layer above the metal surface, a plasmon polariton is generated and we shall use this term.

> Plasmons—the collective oscillations of conduction electrons in metals—are capable of confining electromagnetic energy down to deep sub-wavelengths. They can also enhance the intensity of an incident light wave by several orders of magnitude. These phenomena are the main reason why the field of plasmonics is finding a wide range of applications that include single-molecule sensing, non-linear optics, and optical trapping of nanometer sized objects. Recently confined plasmons have been observed and spatially mapped in doped graphene.
>
> Electrostatic doping has actually been used to demonstrate plasmon frequency tunability and induced optical modulation in the TH_2 and infrared response of graphene.
>
> (From: S. Thongrattanasiri, I. Silviero, F.J.G de Abajo. 2012. "Plasmons in Electrostatically Doped Graphene,"*Appl. Phys. Lett.*, 100, 201105)

It is an important feature of these surface electron oscillations that their resonant frequency can be influenced by the geometric features of surface irregularities, like their size and shape. See the following papers: M. Najiminaini *et al.* 2012. "Nano Hole Structure with Improved Surface Plasmon Energy Matching Characteristics," *Appl. Phys. Lett.*, 100, 043105, and J. Nin *et al.* 2012 "Graphene Induced Tunability of Surface Plasmon Resonance," *Appl. Phys. Lett.*, 100, 061116.

These papers reiterate the "strong confinement and enhancement of electric fields near the vicinity of conductive nanoparticles." Further, "plasmon resonance wavelength. . .tunability, to a desired wavelength is greatly beneficial. This can be achieved by controlling the size, the shape, the material of the nanoparticles and the dielectric constant of the surrounding media."

Though optical plasmon wave generation is usually conducted on noble metal surfaces in air, our range of interest is different. Instead of air, ordinary water or heavy water, or dilute plasma covers the metal surface. This adds a further effective mass to the electron waves. It is worth noting, that a different surface quality is necessary to resonate with ordinary or heavy hydrogen plasma, as described above. This might plausibly explain why some surfaces work only with light water, and other systems only with heavy water, provided their surface contains irregularities of uniform size. Reading these and dozens of similar related papers, the role of surface irregularities are of primary importance in controlling the complicated electron-plasma coupled waves. Further details will be discussed in Parts 2 and 3.

Plasmon polaritons concern us because they behave as heavy, charged quasi-particles of small size, highly compressed electron waves coupled to plasma containing hydrogen isotopes. Because a million of them can be compressed in a wave or in a charged dust particle, or on the tip of a tapered needle, they have a useful charge screening capability. Thus they can mitigate Coulomb repulsion, and consequently act like a catalyzer in some nuclear reactions.

Their application will be elucidated in Part 2 of this paper. The aim of this paper is to widen the scope of LENR modelling, as dominant theories were usually restricted to the technology of deuterated metal lattice. All the inventions/discoveries in this part use some forms of these particles.

Part 2 will appear in Issue 108.

Part 3 will appear in Issue 109.

About the Author

George Egely graduated from the Technical University of Budapest (1973). He worked at the Nuclear Energy Research Lab of the Hungarian Academy of Science from 1974 to 1990. He was a guest researcher at CISE (Italy) in 1977 for three months, and at Brookhaven National Lab (U.S.) in 1981-82 for 16 months. He received his Ph.D. in 1982, on the subject of nuclear accidents of pressurized water reactors. Egely has compiled a large collection of ball lightning observations by eyewitnesses, and published a couple of semi-popular books on this subject. He is the author of three textbooks on the physics of "lost or forgotten" effects and inventions, and of several semi-popular books on the same subjects (in Hungarian). Since 1990 he has been a team leader in several small projects in alternative technologies. Some videos of these tests are posted online: www.greentechinfo.eu

*Email: egely@egely.hu

Fusion by Pseudo-Particles, Part 2
The Challenge of the Present

George Egely*

Fundamental Physical Concepts: Their Technical and Social Consequences

The need for renewable, inexpensive, pollution-free energy is apparent, and the solution is overdue. Devices based on multiple LENR processes are in the making. The advantages have already been detailed by Prof. David Nagel (*Infinite Energy* #103, "Potential Advantages and Impacts of LENR Generators of Thermal and Electrical Power and Energy"). Therefore an outline of possible physical concepts and techniques for building them is useful for the researchers in this field.

The mainstream school of thought in physics is a reductionist one. This Greek analytical method goes against the oriental, "holistic" view. So far it has been rather successful, shown by the history of science and technology. The simplest interaction is between two bodies, via force fields, or in a more extended form as chain reactions. But this kind of simplification is counterproductive for us, as shown below, and this is an understatement. In fact, it is devastating—especially in the field of fusion research.

To put it bluntly, the author will argue that muon-catalyzed fusion—as an example of three-body interactions—should be the fundamental physical and technical model, the driving force behind controlled fusion research. Further, the technical concepts of charge shielding and resonant processes should be emphasized as well. Together they make possible technically viable inventions, which are driven by the fusion process based on protons, instead of deuterons and tritons, as we have only protons in "unlimited" quantity, not deuterons and especially not tritons. The physical principles and their practical implementation is summed up in Table 1. The relevant technical processes and inventions were discussed in Part 1.

The well known $D + T \rightarrow He + n + \gamma$ (hot fusion) two-body reaction is technically sound, and proven beyond doubt. It is the fundamental process of the dreaded H-bomb. Its development in the U.S. carried a price tag of about $6 trillion—along with its means of delivery, like submarines, airplanes and rockets. The apparent destructive power impressed the corridors of power elsewhere, so the Russians, the Chinese and perhaps the British footed a similar bill.

The success of this two-body reaction gave pride and previously unknown access to nearly unlimited funding to physicists. The H-bomb mechanism has a trap, though, which is well known. The reactant D and T nuclei must have a very high temperature in order to overcome the Coulomb barrier. Edward Teller, S. Ulam and Andrei Sakharov came up with the right technical solution—to explode a small fission (plutonium) bomb to reach ignition. The need for this extremely high initial temperature still pervades the mind of mainstream fusion researchers, for both the inertial and the magnetic confinement line of R&D.

Bomb or Reactor — Not Both!

However, there is an essential, albeit neglected difference. In a good bomb all the fuel should be burned up as fast as possible, as in all explosive devices. Devices generating controlled energy obviously require a slow, gradual fuel consumption. Thus the fusion process should be slow, and non-explosive, so the door is wide open for a fundamentally different process and practical devices.

It is a grave mistake to forget this difference. There is an extreme price to be paid for ignoring it. Nearly all hot fusion (thermonuclear) designers are unaware of this distinction—they "like it hot."

Coulomb repulsion between light nuclei can be substantially reduced by a negative charge (if it is close to the reactants), thus reducing the repulsion, but it demands a three-body interaction at least.

In mainstream hot fusion devices, electrons do not shield the charge of any reactants; thus Coulomb repulsion is in its full force. The high temperature is a non-negotiable demand to overcome the repulsion forces between the two reactant nuclei, D and T.

The concept (not the hardware) of D – T fusion of the H-bomb became a real weapon of mass destruction, potentially wiping out not only towns or countries, while preventing a world economy of sustainable, pollution-free energy. New generations of hot fusion devices based on the D + T two-body reaction have always proven to be the "emperor's new fusion device." The "insiders" see them working, but the "outsiders" claim that they do not work. This author falls into this latter category. Money spent on hot fusion research is a waste of public money.

To put it in a different way, high-energy two-body interactions are suitable only for explosive fusion. They are fundamentally flawed for slow, controlled fusion with any meaningful economic use. On the contrary, charge-shielded (minimum) three-body fusion interactions are useless for explosions but suitable for LENR reactions. Constructing them requires engineering skill and insight, but this is the only feasible way to controlled nuclear reactions.

It is a pity that none of the textbooks written about controlled thermonuclear fusion describe the importance of charge shielding, which makes it possible for two protons to approach each other close enough that the attraction by strong interactions overcomes the reduced electrostatic repulsion. Instead, they come up with technically cumbersome "confinement" proposals, and with a non-renewable tritium reactant, both of which create more problems than it solves.

The sharp difference between the mindset of "power physics" versus "smart engineering" described in Part 1 is quite apparent here.

A Practical Model for LENR Developers

There is a way out, well-known to the mainstream. This is "muon-catalyzed fusion," known to those "skilled in the art," though its practical utility is in doubt. First, here is a glimpse at some relevant and sincere mainstream opinions:

Francis F. Chen, a veteran of thermonuclear fusion research, describes a series of unsuccessful attempts in his recent book, *An Indispensable Truth: How (Hot) Fusion Can Save the Planet* (Springer, 2011). The history is summed up under the title of "half a century of progress," where 200 Tokamak nuclear reactors were built, but none of them have ever reached the break-even threshold.

In Chapter 10, "Fusion Concepts of the Future," only two-body, "hot" reactions are considered, such as $p + B^{11} \rightarrow 3\alpha$; $He^3 + Li^6 \rightarrow 2\alpha + p$; $p + Li^6 \rightarrow He + \alpha$, etc., which are all above the 50 - 100 KeV ignition range.

Inertial confinement is treated from a distance in some pages, with a mild skepticism. "Cold fusion" and "muon fusion" are described under the subtitle "Hoaxes and Dead Ends." Are they?

In another book, *Plasma Physics and Nuclear Fusion Research*, Richard Gill (Academic Press, 1981, p. 31) openly states the mainstream view: "Plasma physics is not a pure academic exercise, although there are challenging fundamental problems to be solved. Neither is it a purely applied field which will earn money for the lucky holder of the right patent." The meaning is clear: Don't ever dare to think differently than the in-crowd does, or else. . .

In 2008, a $96 million device, the "national compact stellator," was thrown out during its construction at Princeton's Plasma Physics Lab without a blink of the eye (*Physics Today*, July 2008, p. 25).

Fusion research (and energy in general) is as much a social problem as a physical and engineering one. The indoctrination begins at school (see, "A Simple Facility for Teaching of Plasma Dynamics and Plasma Nuclear Fusion," *American Journal of Physics*, Vol. 56, #1, 1988, p. 62). When fusion is mentioned, the thermonuclear option is described, as if nothing else could exist. I referred to this mindset when I wrote about the "emperor's new fusion device."

Muons (negative heavy electrons) are capable of forming exotic atoms or exotic molecules between deuteron nuclei, or a muon may bind a molecule of tritium and deuteron, where fusion takes place. In heavy electrons, a molecule is formed where the equilibrium orbit (*i.e.*, the radius of oscillation) is much shorter than with the "ordinary" electron, so strong nuclear forces come into action (see Table 1-1 and 1-2).

Negative Muon-Catalyzed Fusion

It is an experimentally established fact that muons catalyze D – T fusion in a chain of as many as 150 - 200 reactions. The muon has an average life of about $2.2 \cdot 10^{-6}$ sec. Their creation requires about 5.3 GeV of energy (though its mass at

Table 1. Physical principles and their practical implementation.

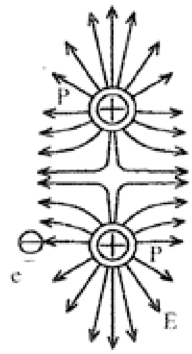

Table 1-1

Ordinary hydrogen plasma. Large electron-proton distance, weak shielding, strong Coulomb repulsion. Electron-proton binding energy ~1.5 eV, low. Fusion possible only at very high energies. (Neutrons are not shown.)

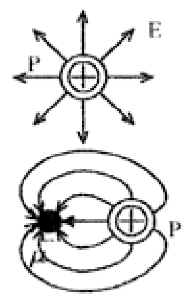

Table 1-2

Efficient charge shielding by heavy-electrons, called muons. Muon-proton distance is only some Angstroms, binding energy is ~200 keV. Approaching proton or deuterium is only slightly repulsed, cold temperature fusion is possible. (Neutrons are not shown.)

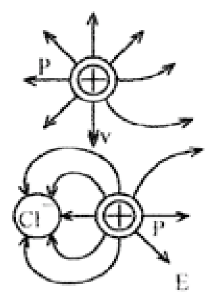

Table 1-3

Charge shielding by a heavy negative ion: J. Papp's solution. The shielding is partial, therefore the incoming proton must have a high velocity. Extreme local non-equilibrium.

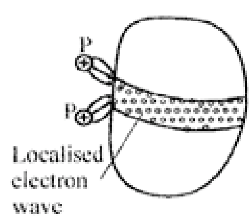

Table 1-4

The Coulomb repulsion of like protons, above the electron wave on the surface of a small surface. The density of electron wave must be very high to attain enough electric field intensity. (Neutrons are not shown.) Polyneutrons may form by this process also.

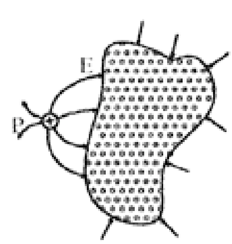

Table 1-5

For a charged dust particle, $p^+ + e^- + 0.7$ MeV = neutron+neutrino process is the most probable. Oscillating, resonant proton cloud, colliding with dust particle, is a reliable source of neutrons. Neutrons may interact with protons and surface nuclei.

rest is only 106 MeV). The process is not economic because even a 200 D - T fusion reaction yields only about 3.5 GeV of fusion energy (W.N. Cottingham, D.A. Greenwood, *Introduction to Nuclear Physics*, Cambridge Univ. Press, 2001). Thinking along this line is considered a dead end. This is the ultimate cold fusion since this reaction takes place preferentially in a liquid mixture of D - T. The reaction takes place in pure liquid deuterium, or in D - H mixtures, but not in pure liquid hydrogen.

The idea of heavy-electron (muon) catalyzed fusion was conceived by U.S. researchers, notably Louis Alvarez, but independently by bright Russian theorists like Igor Tamm, Yakov Zeldovich and Andrei Sakharov. But they never meant to create a device for that. Australia's Star Scientific Company, led by Hungarian-born Stephen Horvath, still sticks to the muon charge shielding as a technical solution. (An earlier U.S. patent was granted: 4,454,850/1984.)

However, the essence of this muon-catalyzed fusion process has important lessons for us. How are heavy ($m_\mu/m_e = 207$) muons able to catalyze a fusion in a liquid D - T mixture, at extremely cold temperatures? Due to its high mass, the muon gets so close to a nuclei, so that their charges screen and neutralize each other. The D - μ or T - μ doublet is electrically neutral even from a short distance of 100 - 200 femtometers, within the range of strong nuclear forces. Any such electrically neutral doublet can be approached by positive nuclei without significant Coulomb repulsion. (There is a similar idea behind the BlackLight Power Company of Mills.)

It is possible only due to the high mass of the (negative) muon. Why? Because both binding energies and distances depend on the scale of m_e/m_μ. Thus the characteristic distance between the D and T nuclei, or D - D nuclei, is reduced by a factor of ≈ 200. When an electron binds H isotopes into a molecule, their characteristic distance is about 1 Å (10^{-8} cm). This is reduced by a factor of 200 to about 500 fm, which is short enough for the strong interaction to start fusion, via tunnelling, in about 10^{12} sec. The characteristic energy scale of atomic, molecular physics with electrons is the Rydberg unit which is $m_e(e^2/4\pi\varepsilon_0)^2/2\pi\hbar^2 = 13.6$ eV while with muons it is 2.81 KeV. The liquid of this exotic heavy-hydrogen/heavy-electron has an extreme density, which cannot be attained by any confinement, or by any extreme engineering.

How does the heavy muon approach the nuclei, but does not fall into a nucleon despite the Coulomb attraction? Ostensibly it is due to the repulsing effect of strong vacuum fluctuations near the nuclei (due to the extreme density of the electric field). The light electron is repelled by vacuum fluctuations to a distance of about 1 Å, but the heavier muon gets much closer, due to its 207 fold inertia. Therefore it has a much better charge screening, and thus catalyzes a fusion reaction. These exotic atoms are extremely dense. Laser driven, X-ray driven or heavy ion driven D - T fuel pellets cannot be compressed with inertial confinement methods anywhere close to these extremes.

The mainstream view is that making (negative) muons requires too much energy so this kind of charge screening process is only of theoretical interest. Charged, emergent heavy pseudo-particles (the subject of this paper) are not the "weapons of choice" for thermonuclear engineering.

The same problem arises when neutrons are to be formed by forcing an electron into a proton. Vacuum fluctuations repel the light electron. But if it is a part of an electron cloud and bound tightly to it, it cannot be repelled easily: neutrons are formed, though ostensibly by electroweak interactions (Widom & Larsen).

However, amateur inventors (listed in Part 1) have accidentally stumbled onto several solutions. Instead of creating real heavy electrons, they created a wide variety of heavy virtual or pseudo-particles, which perform the same function (charge shielding) as heavy muons. All of these pseudo-particles have a negative charge, but usually not just a single electron but a multitude of them, and much heavier ones than a single electron or even a muon. The misconception in the mainstream view is that the quasi-particle must be in a closed orbit around the prospecting nuclei to be fused for a while in order to commence the fusion reaction.

Those inventors stumbled onto processes where an elusive pseudo-particle, usually a cloud or wave of tightly compressed electrons, does the same job, but without closed orbits. Such a dense pack may consist of millions of tightly compressed electrons and protons oscillating, and advancing in a coherent wave, usually on a conducting metal surface, or imprisoned in a solid, nanometer-sized dust particle. The former is termed broadly a "plasmon polariton"; the latter is a "dusty" or "complex" plasma. Both systems can be driven into resonance when the electron charge density is at its possible peak and when its field density and virtual or effective mass is heavy enough to have the same overall effect as that of a muon. These pseudo or "high effective mass" particles have been known to mainstream science for more than a decade. But neither phonons (volumetric electron waves) nor polaritons or nano-sized dust particles were considered of any use in nuclear phenomena because their charge shielding capability is of no use in their usual area of application.

Moreover, since the nuclear phenomenon which they induce is not accompanied by radioactive phenomena, the inventors did not think along this nuclear reaction line, (except for J. Papp). Lucky inventors did not understand the essence of micron or nano scale phenomena either on fine needle tips or inside small cracks on the surface of fine grain and dust. These are the usual sites of high-density, high effective mass electron waves.

Most probably Mizuno was the only researcher who stumbled onto proton induced electron waves in "proton conducting" ceramics as a special case.

Various pseudo-particle related charge-shielding phenomena are listed in Table 1. Most of them are based on pseudo-particles that are heavier than muons, whose most important feature is charge screening. However, these nuclear phenomena are never D + T processes, because tritium and deuterium were not available to inventors. In fact, all of their devices were based on ordinary hydrogen (or on even higher mass elements) as a "fuel," which is even more difficult for the mainstream view to accept. But there are other possible routes to achieve fusion than the high-energy D - T process, via an indirect process based on neutron generation and subsequent neutron capture processes, and/or H + D → He^3 type fusion with intense charge shielding.

What is a Plasmon Polariton?

There is quite a "fog" that consists of a "high effective mass" or "heavy" electron, and a further question is how to generate them usefully. The usual notion of a plasmon polariton or a resonant surface plasmon polariton is quite close to what we need to create. Let's try to clean up this fog, though in the appendix of Part 1 there was a partial introduction to the subject.

When an electromagnetic wave (usually infrared) hits a plain metal surface immersed in dilute (not fully ionized) hydrogen plasma, electron waves spread on the metal surface, and longitudinal charge density waves spread above it in the plasma. They are coupled by a high intensity electric field, but only inside the Debye shielding distance. The wave intensity is low for a large area metal plate, but good enough for, *e.g.*, a sensor in a pregnancy test. But when the surface area is small and permanent, like a thin wire, so that it cannot spread as a concentric plane wave (see Figures 1-6), the wave energy density may be high. This is interesting for us when we must approach the order of a MeV. (See this application as the blob of very thin silver wires of J. Jekkel in Part 1.) These waves are highly dispersive, and dissipative mainly due to the recombination between the ion cloud and the electron waves.

Tapered needle tips are even better than wires (see Figure 6) if we can get them (Correa, Chernetsky, Shoulders, Meyer). Even external, sharp-edged current pulses can excite them, not only thermal radiations. Zero dimensional objects (small, nanosized cavities) termed as quantum nanodots (Figure 4) or nano dust particles (Figure 5), are even better objects, since the energy of excitation cannot escape. With proper matching of cavity size, dust particle size and excitation frequency, giant amplitude electron wave oscillations are generated.

In Part 1 some of the "trade secrets" of several obscure, forgotten inventions were discussed, and their varied methods of plasmon wave generation were shown, along with their strengths and shortcomings. Resonances are vital in most of these wave generation processes, but these are standard engineering methods. The same applies to the generation of charged dusty plasma. The coherent wave feature in this case is the movement of trapped electrons on the surface of small dust particles.

Electron waves can be created in surface cavities (see Figure 4), cracks and protrusions of deuterated metals or in metal hydrides in "classical" electrolysis-based devices. In fact, the first two letters for low energy nuclear reaction come from the fact that in proton + electron or proton + deuteron reactions these high intensity charge waves are just catalyzers created by a small amount of resonant energy because they shield the Coulomb repulsion down to a technically acceptable low level.

Efficient coupling of the hydrogen plasma and electron waves can mediate gradual energy accumulation up to the required MeV order wave energy, which in turn can be used for inexpensive "local manufacturing" of slow neutrons. These low speed "cold" neutrons usually do not escape from

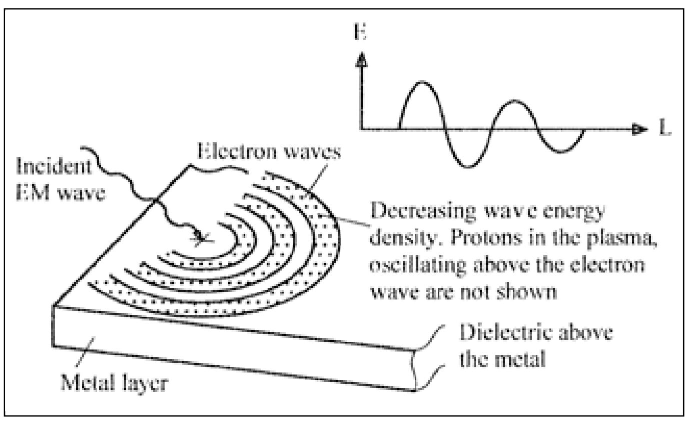

Figure 1. Plasmon polariton quasiparticles oscillating on and above a conducting infinite plane.

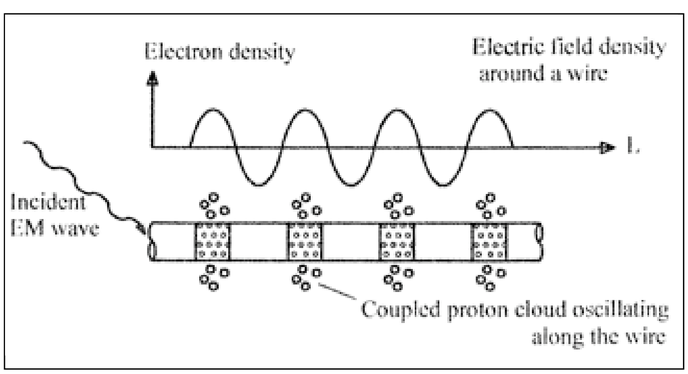

Figure 2. Infinite length, steady wave amplitude along a wire.

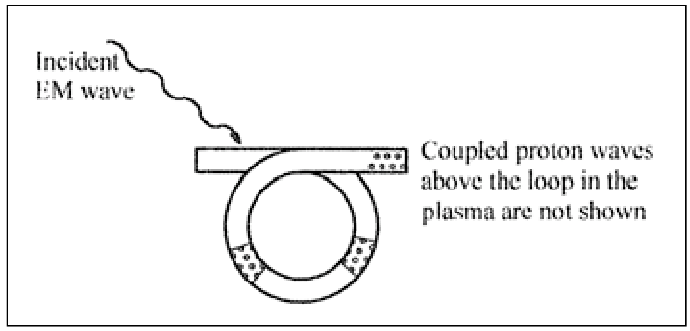

Figure 3. A piece of closed loop wire. Amplitudes could be increased by resonance, due to finite size.

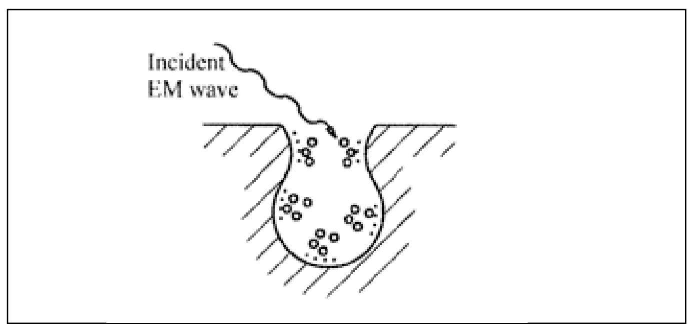

Figure 4. Resonant standing charge density waves within a cavity. Above them oscillate hydrogen (proton, deuterium, tritium) isotopes of a plasma.

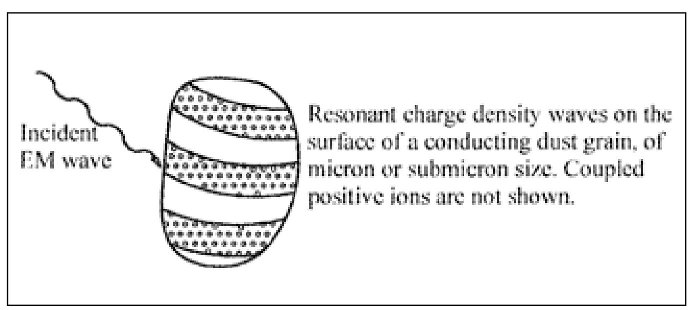

Figure 5. Case of an isolated conducting grain. Oscillating positive charges are not shown.

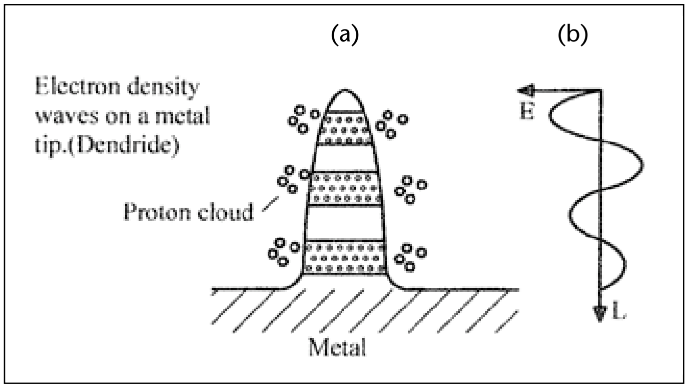

Figure 6. Electron waves along a tapered metal tip. Note the amplification effect along the tip.

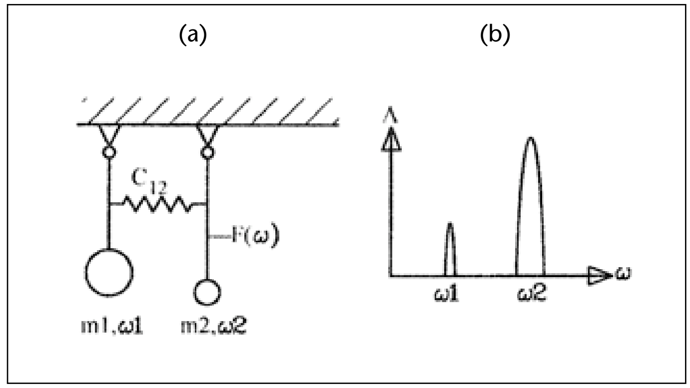

Figure 7. Coupled oscillators. The coupling spring constant C_{12} between the two pendulums is constant.

the device, because they have a very large reaction cross section, and thus react with the nearest nuclei. Consequently we don't need a high temperature or any confinement, like those in mainstream D - T thermonuclear monster devices. In our model, plasmon polaritons are tightly bound, coupled electron waves and proton (deuteron) waves in diluted, not fully ionized plasma. Their high inertia-high mass is the consequence of the high mass of the proton cloud, which oscillates, but at a smaller amplitude than the coupled electron wave. Now we have to describe the specifics.

Let us start with Papp's process, which stands out from the rest since it uses a negative ion, Cl^- for charge shielding, and a chain of inert gas atoms in impedance matched collisions to accelerate protons. Ostensibly, there are three possible separate events.

Some LENR Processes Using Quasi-particles

1) A fast proton accelerated by a "lucky chain" of collisions of rare gases hits an electron on the shell of the Cl^- ion, consequently creating a neutron: p + e- + 0.75 MeV → n + neutrino. Of course, the energy of a high speed Xe ion must be transferred with good efficiency to reach that goal. This step requires input energy, which is provided by a high-voltage spark between two conical electrodes. The 1 - 2 kV input voltage wouldn't be enough, but in a gas discharge at the "high-energy tail" of the Maxwell distribution, it is available for a few atoms. There are also acoustic focusing tricks in the invention to further boost this amplification effect.

2) When there is an inexpensive, continuous supply of low-speed, high cross-section neutrons, n + H → D + E, n + D → T + E, reactions may take place, none of them requiring input energy, but each of them producing energy E (as a combination of kinetic energy and electromagnetic radiation).

3) Due to the charge shielding capability of the Cl^- and the high speed protons, the $H_1{}^1 + D_1{}^2 \rightarrow He_2{}^3$ + E or $H_1{}^1 + T_3{}^1 \rightarrow He_4{}^2$ + E, reaction takes place. In this type of reaction, all features of the Papp process are necessary, that is, local charge shielding by Cl^- ion and local acceleration of protons.

The Cl^- ion is not a pseudo-particle. It is a heavy, negative ion but it does serve the same purpose as a pseudo-particle, or a muon, though it is not as effective for charge screening, and therefore it requires extra proton speed.

The rest of the processes, most inventions, use dense electron waves either formed on a surface or in a volume, listed in Table 1. Neutron generation with a pack of electrons is the first step of these inventions. Resonant, high-amplitude electron waves can be generated on a fine wire mesh (Jekkel, Gray), in small cracks or cavities (Moray, Puharich, Meyer), or on Ni surfaces, absorbed by light or heavy hydrogen (Patterson, Preparata, Piantelli, Celani, BARC, etc.).

When the energy of the electron wave is low, *e.g.* when it is excited by weak intensity infrared radiation, it may generate only low-amplitude surface plasmons, and then neutron generation does not start.

Lacking a minimum threshold level, the wave acts only as charge shielding. Then only heavy hydrogen reactions (D + D → He) may take place (Arata & Zhang). In order to utilize a light hydrogen isotope as a fuel, efficient charge shielding is necessary with high-amplitude, very intense electron waves.

Tips of fine needles (Shoulders, Chernetsky, Correa) have a double purpose. First of all, their potential difference may accelerate protons to some keV energy level and then it may hit the massive surface electron wave, where the acceleration by the continuously tapered tip is an amplifier, just like Papp's chain of collisions. This is the usual proton, electron → neutron reaction. However, now a whole wave of synchronously moving, accelerating electrons collides with the proton. This wave-like, high mass emergent pseudo-particle is of real technical use, relatively easy to produce, *e.g.* compared to "neutral beam heating." Using the charge shielding capability of extreme electric fields on the needle tip, H + D reactions may occur, along with D + D type reactions. The D might be generated *in situ* from n + p reactions, or added as fuel from outside. Wire mesh or needle tips can open access to light hydrogen as fuel, but it is not always economical. (There are usually few tips.)

Highly charged nanometer-sized dust particles serve the same purpose as needle tips, especially if loaded by electrons in an acoustically resonating plasma, but their number is higher, as they are present in the whole volume of the plasma (Tesla, Esko, Egely).

The combination of nano-meter length phenomena of electron density waves, charged dust particles and emergent features of pseudo-particles is a powerful, but hitherto neglected area of today's technology. The knowledge to drive them to the maximum level is extremely importance, and this is an understatement.

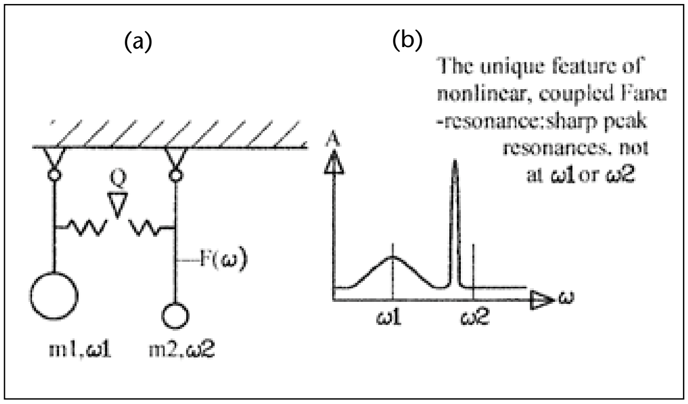

Figure 8. Coupled oscillators. The coupling strength is not constant, depends on the generated heat during LENR reactions. This is a simplified model.

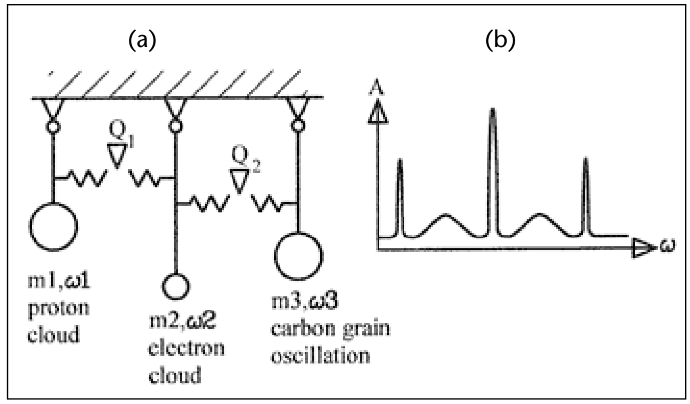

Figure 9. A more realistic picture of coupled, nonlinear Fano-resonances between the electron cloud, hydrogen isotope cloud and dust particle cloud.

The better the charge shielding is, the "colder" the different types of available fusion and neutron capturing processes are.

Mainstream thermonuclear fusion has an additional inherent problem. The reactants must have high energy to overcome Coulomb repulsion, but this adversely affects the reaction cross sections. It is difficult to make a good compromise because the ignition energy is in the range of minimum 15 keV for D - T mixtures, 80 keV for D - D reactions.

The inventions mentioned in Part 1 do not have this problem. Due to their multi-body, high-intensity charge screening, the energy level of the reactants is in the order of chemical energies of some eV or even below. Thus high neutron or hydrogen nuclear resonant cross sections are maintained with relatively simple technical devices. Thus charge screening provided by pseudo-particles connects the dots for various inventions of Part 1. The list is not complete; maybe readers are familiar with other similar forgotten inventions or discoveries.

The mainstream concepts for controlled fusion are thermonuclear ones, the same as the H bomb. Both inertial and magnetic confinement require steps of extreme engineering. That is a proper solution for a weapon, but not sensible, and not economic for a controlled, slow process.

The year Papp died (1989), Pons and Fleischmann came up with the right approach—charge shielding for the reactants. With a further daring step, they proposed a different reaction of D - D. But even their high scientific reputation was not enough to change the mainstream view, apparently due to vested financial and moral interests.

But the Pons-Fleischmann charge screening idea has not yet been refined on the engineering side. The distances between neighboring deuterium nuclei are not smaller in a palladium lattice than in liquid deuterium. But deuterium (or hydrogen) in the lattice or on the lattice surface opens viable technical possibilities for efficient charge screening. Obviously, the simplest solution is to be sought. Apparently, the earliest solution is the simplest, and that was discovered and disclosed by Nikola Tesla, in 1890, for the resonant "carbon button lamp." It was already possible then, but it is a must today.

There is a sad general rule: If there is an important discovery, it is always far from the mainstream thinking, and there must be at least five to six independent discoveries before it is accepted (*e.g.* radio, semiconductors, the aeroplane, antibiotics). Controlled, charge shielded fusion has been discovered at least 10 times, over about 120 years, and still counting.

The merits of different quasi-particle related methods are even better understood, if they are compared to some other, innovative, off mainstream hot fusion technologies. Only one of Bakhoum was mentioned in Part 1. We remind the reader that none of the two mainstream thermonuclear technologies (inertial and magnetic confinement) uses charge shielding or resonance. Consequently there is a need for initial extreme heating (termed ignition), then for further heating before break-even is reached, which is not yet economic. A further problem is T breeding with a lithium blanket. It is unavoidable, but an unsolved challenge. It might be solved later though at a continuously working reactor which does not exist. So even if turbulent plasma energy losses would be solved for Tokamak, or extreme sphericity demands met for D - T fuel, pellets (which drives their price tag up to about $1 million each) there is the tritium breeding problem. A base load 24 hours seven days a week is necessary for the system to work economically. (The rate is now about 1 shot/day.)

It is no wonder that some people started to think along alternative technical solutions, but most researchers still stick to the D - T reactions (which is the ultimate source of problems).

Some Improvements on the D - T Reactions By Charge Shielding

To illustrate the merits of charge shielding, some "off mainstream" solutions are listed below. They induce some weak form of charge shielding for the D - T thermonuclear process:

a) The concept of R.W. Bussard, of electrostatic confinement and charge shielding, is better known as "polywell" (U.S. Pat. 4,826,646/1989 and 5,160,695/1992). The main idea is to shoot an electron beam into an ionized deuterium plasma to reduce Coulomb repulsion. Partial magnetic confinement is still used (Ioffe bars), but the emphasis is on electron cloud and ion acoustic oscillations, to reduce the mean free path of deuterons. The electrons are smeared in the reactor core. This technical step alone has meant a substantially smaller, therefore less expensive reactor. The U.S. Navy footed the research bill and the work was carried out in secret. They were not afraid of Russian industrial espionage, but the wrath of hot fusion researchers.

The concept worked and they reached a break-even point but due to the Iraq war, their budget was slashed, and no private funding was available. Bussard died shortly afterwards.

b) There is another unorthodox hot fusion concept of heating the deuterium by resonance, and not by a plutonium bomb or neutral beam accelerators or giant lasers. The patents of Philo Farnsworth (3,386,883, and Robert L. Hirsch 3,664.920/1972) work along this line. These examples have been quoted to show that either some charge shielding or resonant heating improves the design.

However, the combination of charge shielding and resonance is necessary for meaningful success.

Table 2 lists concepts according to the degree of charge shielding and acceptance. The better the charge shielding is, the smaller the chance that the science community accepts it.

Nuclear Active Environments

Apart from Ni and Pd metal, there are a number of exotic alloys which are capable of propagating high effective mass electron waves due to their unique composition, like Ce, Cu_2Si_2, UBe_{13}, UPt_3, URu_2Si_2, $CeRh_2Si_2$, etc. See the complete list in Ben Breed's insightful U.S. patent application (0122940/2009).

Resonant nano dust carbon plasma is the favorite of this author, following the footsteps of Tesla. The charged, oscillating nanoparticle does the charge screening job of an electron wave. It can be coerced into resonant oscillation. If the particle is conductive, like a carbon nanotube or nanodot, it can support surface plasmon polariton oscillations, and perhaps phonon oscillations.

The process is usually indirect, and several simultaneous processes are involved. Neutrons are formed as a first step, as a proton interacts with one of the electrons of a (resonant) electron wave (see Table 1-4, or with a dust particle, Table 1-5).

Fine wire mesh electrodes with high-frequency oscillations in ionized hydrogen are also active nuclear environments. Electron waves serve as charge shields; the problem is to have high charge density and frequent electron waves, or highly charged dust particles. This is the reason that even amateur experimenters stumbled onto various LENR reactions, without having any idea what was going on.

The elements of the puzzle were completed only as late as the early 21st century, where the background knowledge about electron density waves (polaritons, plasmons, dusty plasma) emerged with nanotechnology. By then, the isolated and partially disclosed inventions of Part 1 were forgotten. The mindset of a young aspiring researcher in nuclear physics is focused on high-energy, two-body interactions. Emerging charge waves or low energy charged dust particles are unheard "alien ideas." They are not only off the mainstream fusion research, but even outside the ideas of the small group of researchers on emergent nonlinear phenomena, like soliton waves.

Moray sought the help of contemporary scientists like Robert Millikan, Harvey Fletcher from Bell Labs, or Henry Eyring in vain. Tesla was too proud and hurt to talk to them. Thus both of them speculated that they found the energy of the oscillating Universe, a rather vogue notion. The very concepts of charge shielding to reduce Coulomb repulsion was a useless idea then, because the concept of fusion was not yet born when they demonstrated their inventions.

Table 2. The challenge of overcoming Coulomb repulsion.

	Mainstream	Off Mainstream	Off-Off Mainstream	Off^3 Mainstream
Theoretical Framework	Two-body D - T interactions; high temperature (thermonuclear).	Multi-body D - T interaction with weak charge screening and resonance.	Multi-body D - D interactions with mild charge and effective mass coupling	Multi-body e + p interactions with strongly localized mass and charge coupling
Usual Technical Solutions	Extreme heating inertial or magnetic confinement to satisfy the Lawson criteria.	Bussard Polywell, Farnsworth-Hirsch resonant heating. Interaction of a large volume of smeared electron cloud and deuteron cloud.	Classic Pons-Fleischmann: deuterated Pa lattice, DC current supply. Better versions: Patterson. Even better: Preparata, Scaramuzzi, Arata & Zhang, Rossi, Piantelli	See Part 1. Quasi-particle dominated territory + resonances. Local neutron production is dominant.
Result	Unsolvable for technical reasons, mainly for turbulent losses, troubles of tritium supply break-even impossible.	Sign of efficiency, maybe somewhere around break-even. Not portable, possible mass production, but not economic.	Sometimes better than break-even, even self-sustaining, unreliable due to quality control, not portable. Not suitable for mass production	Reliable, self- powered, several historical examples. Small, inexpensive units, portable devices Economic, suitable for mass production
Cost of Research So Far	≈ 200-300·$10^9$$	≈ 50·$10^6$$	≈ 50·$10^6$$	≈ 50·$10^6$$
	HOT FUSION		LOW ENERGY NUCLEAR REACTIONS	

They were truly ahead of their (and our) time.

But today, the details are clearer and fit together. There is a rich variety of possible LENR solutions and nuclear processes.

Charged dust particles are so perfect for charge shielding and so easy to create, that they even do well for the transmutation of heavy elements. The penetration of Coulomb barrier is technically uneconomical by other means, *e.g.* heavy ion collisions (see Table 1, Quantum Rabbit experiments, by E. Esko).

Fano Resonances

Readers familiar with the intricate details of oscillators may find the models in Figure 1 are oversimplified, a sort of linear "one mass, one spring" one tuned excitation frequency. Indeed, for plasmon polaritons, the oscillations are coupled ones, because incoming transversal infrared waves (or very sharp current pulses) might be the driving source. Moreover, it is a parametric coupled oscillation because the coupling electric field and plasma density do not depend solely on the power and frequency of the driving force. Heat generated during an LENR process during an oscillation (as shown in Figure 2) makes the system strongly nonlinear, and parametrically coupled. These systems can be driven into resonance at various frequencies, including both subharmonics and at much higher harmonics. Their resonant peaks are unique. They can be quite asymmetric and sharp, but sometimes rather broad, like the Fermi Ulam Pasta chains. One test result will be shown by Letts, Cravens and Hagelstein in Part 3.

These systems are fairly widespread in classical and quantum mechanics. They are termed "Fano resonances," commemorating Ugo Fano, who won a Nobel Prize for this interesting discovery.

The same applies to dusty (crystal) plasma resonances, shown schematically in Figure 3, where three major energy absorbing participants are shown: the electron cloud, the positive and negative ions, and the nanoparticles (see the review article by A. Mirosnichenko *et al.*, *Review of Modern Physics*, Vol. 82, July-September 2010, pp. 2257).

It is not a direct help for inventors and developers. It just outlines how strange, sharp resonances crop up all of a sudden seemingly out of nothing (see Figures 7, 8, 9).

Indeed, all the inventions mentioned in Part 1 contain a kind of Fano resonance, started just as lucky resonant effects observed by a prepared mind, like Tesla or Moray, etc. Some background information would help researchers of LENR to improve their engineering set-ups. Otherwise only luck helps.

Do we have to wait another hundred years when a teenage boy in the deserts of South Sudan, Ethiopia, Namibia or Mongolia will tinker again with the crystal detector radio of a long wave radio? Or can we learn from the lessons of forgotten inventions?

Luck is essential in science; we shouldn't be ashamed of it. In fact, these coupled parametric resonances are so complicated that it is impossible to build a good fusion reactor top-down, starting from scratch, with only theory at hand. It is futile to devise a good reactor just by listening to the theoretical lectures of famous professors of physics, like Feynmann, who blew up Papp's engine.

Though there are many open issues, rapidly developing nanotechnology is immensely helpful. Diagnostic tools are ready, and methods to grow and shape optimum nanoscale objects are improving. Nanotechnologists can help LENR because they want to prove their value and to increase their reputations. H-bomb designers had this opportunity 60 odd years ago and failed.

Certainly, a firm grasp of technology and theory would help the embattled LENR researchers, so we have to answer some questions before we are taken seriously.

Summing up the different methods by charge shielding by pseudo-particles, we have seen five major groups. They are listed by their method, the first known discoverer and the tentative date:

1) Resonant nanodust plasma (Tesla, 1890s)
2) Resonant nanocavities and plasma (Moray, 1920s)
3) Rare gas collision chain & chlorine (Papp, 1960s)
4) Needle tip amplification in plasma (Shoulders, 1980s)
5) High effective mass electron clusters with light or deuterated hydrogen metal lattice, electrolysis (Patterson, Mizuno, Pons & Fleischmann, 1990s, etc.)

Though these categories are subjective, they show that LENR processes are of wider scopes both in depth of time and physical formation than previously thought. Most probably the list is not complete. Each of these methods has advantages and drawbacks, summarized in Part 3. In general all are worthy of intensive study. (All the details are complicated and foggy.) All of their physical processes are more complicated then the simple high-energy two-body D - T collision processes.

The extra theoretical difficulties of charge shielding by pseudo-particles must be weighed against the gain of achieving its technical implementation. Further, better sub-categories and engineering ideas might emerge after intensive R&D efforts.

The identification of positive feedback loops for amplitude amplifications of coupled parametric resonant processes are quite a challenge, a nice task for open-eyed scientists. Though the roots of the LENR phenomena are very much older than the research of the 1990s, the historic role of Pons and Fleischmann is indisputable because all other attempts to establish this field have failed.

There are still a number of theoretical and technical questions to be answered, like:

- Are there direct $p^+ + e...e + p^+$ reactions (e...e notes the high effective mass electron cloud, regardless of its appearance as a surface wave or embedded in a solid nano particle)?
- Are poly-neutrons formed, and when and how many of them can exist?
- Are mass spectrometers proper tools to observe them?
- Are the present (mainstream) concepts of the nucleus and the atom good enough to deal with these not-so-new phenomena?

My tentative answer is that there are entirely new classes of interactions due to the possible appearance of poly-neutrons. Entirely new types of material may appear due to their neutron-rich nuclei. Therefore, present nuclear models may not always be usable. Moreover, two-body interactions lose their dominance; clouds of light nuclei may interact with clouds of electrons. These interactions are better treated by quasi-particle interactions as a distinctively different framework from two-body interactions. In this new arena, the fusion of medium sized nuclei—such as C, O, N—is possible at a very low energy level (of a few electron volts) at economic levels. Iwamura *et. al.* have solved this problem on a much smaller scale (U.S. patent application 0080903/2002).

The indoctrination level of this whole field is excessive. Only a number of mass-produced devices will change the present tragic situation. The present mainstream fusion is doubly cursed. The challenge is clear—to overcome the Coulomb barrier. However, the theoretical mainstream model is simply wrong: "dumb muscle" (thermonuclear). The technical solution for this erroneous theoretical answer is even worse; no resonance is used in any mainstream confinement-based solution (see Table 2).

This 50+ years of resistance to clear thinking in physics and engineering and biased intellectual property policy has already had devastating results in all aspects of our life on planet Earth.

It should be obvious by now to anybody with some technical background. Mainstream thermonuclear fusion is the wrong technical solution for the wrong theoretical framework (see Table 2 for a concise summary). At present it is too big to fail; it is driven not by results, but by the inertia of inter-government committees.

About the Author

George Egely graduated from the Technical University of Budapest (1973). He worked at the Nuclear Energy Research Lab of the Hungarian Academy of Science from 1974 to 1990. He was a guest researcher at CISE (Italy) in 1977 for three months, and at Brookhaven National Lab (U.S.) in 1981-82 for 16 months. He received his Ph.D. in 1982, on the subject of nuclear accidents of pressurized water reactors. Egely has compiled a large collection of ball lightning observations by eyewitnesses, and published a couple of semi-popular books on this subject. He is the author of three textbooks on the physics of "lost or forgotten" effects and inventions, and of several semi-popular books on the same subjects (in Hungarian). Since 1990 he has been a team leader in several small projects in alternative technologies. Some videos of these tests are posted online: www.greentechinfo.eu

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Fusion by Pseudo-Particles, Part 3

The Future and Lessons of (Quasi-Particle) History

George Egely*

Each pseudo or quasi-particle had its long fight for acceptance. Though semiconductors were known to exist by the 1880s, and the discovery of their rectification features commenced soon afterward, it was ignored by mainstream physics, meaning classical mechanics and Maxwellian electrodynamics. Semiconductor research was not even off mainstream, but off-off mainstream. Radioactivity was researched by the enthusiastic Curie couple, in filthy sheds. Even a generation later, in the 1920s, Wolfgang Pauli scorned semiconductors as "physics of dirt." Electron holes as quasi-particles did not storm physics departments. The idea reached industry and society a generation later in the early 1950s.

Similarly, dust particles and dusty plasma today are still a synonym of dirt, an unwanted byproduct from semiconductor manufacturing. Their practical utility is not yet apparent. It is an "alien" not only for the mainstream, but also for the off-off mainstream school of thought.

Today "real," analytically predictable, high-energy particle physics is the "mainstream." Emergent properties and multi-body interactions are not yet mainstream, although they are occasionally treatable by perturbation methods. Multi-body interactions yield "closed," analytical results only for a handful of symmetrical multi-body cases. They are not elegant, consequently not publishable in theoretical papers.

Influential makers of science policy don't think along the lines of "emergent," multi-body interactions, and endless series of committees and panel discussions have no room for weird quasi-particles, never did and never will. (They are highly educated experts, not just populist politicians.)

In fact, the longest, most expensive "civil war" of physics and science in general is already being fought along these trenches. On one side of the trenches are the well-equipped but poorly led armies of "thermonuclear fusionists," without using charge shielding and resonance. This is an unbelievably poor level of engineering, even by the standards of the worst engineering schools.

On the other side of the widest trench are the small, ill-equipped rebel army of "cold fusionists," mainly the followers of Pons and Fleischmann. Charge shielding, in the form of a deuterated palladium lattice, is on their flag. But it is still not good enough for victory.

An insignificant group of individual "guerrillas," mostly in the forgotten past, used different technical forms to make "high effective mass pseudo-particles." Consequently they had partial but little known victories from time to time but their greed, arrogance and extreme individualism made sure that they failed.

Even the thermonuclear fusion camp has its internal strife. There is some "friendly fire" between the inertial and magnetic confinement camps, but they become united to scorn the resonant Farnsworth Hirsh followers, the Russian "spheromaks," the Bussard polywell, or the focus fusion by Eric Lerner (U.S. Patent 7,482,607) using Joffe's bars, or the Stellator type of magnetic confinement, or G. Laberge's printer reactor (U.S. Patent 0198483/2006). This method is based on sudden adiabatic compression of the plasma by induced pressure waves with fast acting pistons. The fundamental engineering concept has come from laser printer injectors. The mainstream has exclusive access to friendly media, and a fresh supply of "cannon fodder"—troops from university indoctrination.

But thermonuclear fusion can't win against nature as it is because turbulent instabilities, eternal neutron losses, unavoidable heating inefficiencies are their worst and merciless enemies. (The recent fiasco of N.I.F. proves this point.) This "ghost army" of nature's forces will not let them win, no matter what they do.

So victory is likely on the rebels' side if they are willing to learn the skilled use of pseudo-particles. They may win partly because pseudo-particle research is by orders of magnitude less expensive than high energy thermonuclear fusion physics.

A lesson of science history is that electron holes as pseudo-particles in semiconductors have changed the methods of communication in epic proportions.

Phonons, polaritons, charged, oscillating dust particles, as pseudo-particles, have the same life changing potential for sustainable energy production in small, mobile, noiseless, inexpensive units. Phonons and plasmon polaritons are not new to science. (*Applied Physics Letters* and *IEEE Transactions on Plasma Physics* carries one or two new papers on these subjects in every issue.) But the practical application completely escapes researchers. Though nanotechnology is a rapidly expanding, and is now an accepted field of research, its workers are also unaware of the possible "gold rush" in their field.

The present state of affairs is a sad example of delusive indoctrination. Enormous effort has been spent on the elusive Higgs boson, which will yield no benefit for society, while pseudo-particle research, the research of emergence for multi-body interactions, lacks proper funding and fresh ideas.

Another area of pseudo-particle research has the potential of those two areas, namely of magnetic monopoles and magnetic currents. Rotating, charged ferromagnetic dust particles have the properties of South or North magnetic monopoles, as proven experimentally by the Austrian Felix Ehrenfest and the Russians Mikhailov and Mikhailova.

There are enormous fortunes to be made, followed by tectonic social changes from these other pseudo-particles. But change is not inevitable with the old mindset, where effort is wasted on useless "real" particles, and not enough opportunity is given to pseudo-particles.

In order to grasp the utility of the coupled plasmon-electron wave model, it will be useful to start from familiar ground.

The Benefit of Pseudo-Particles

The original Pons-Fleischmann idea was based on the hope that deuterium nuclei diffused into octahedral-tetrahedral sites will approach each other efficiently in the charge-shielded palladium metal lattice. Then the loading factor, endorsed by Michael McKubre, is indeed important.

However, in a static DC supply mode, the success rate and the reliability of these bulk-metal tests are low, as borne out by the experience of the last two decades. Mechanical vibrations of the metal lattice or current transients do improve the reliability and success but "surface contamination" ("poisoning") usually terminates good results. Though electrochemical deuterium loading is generally accepted and widespread within the LENR community, the underlying physical process is still debated.

Plasma based (*i.e.*, surface based) phenomena offer more pragmatic applications. J.P. Biberian offers a comprehensive opinion in his detailed review paper[1] of this field: "The use of gas phase instead of the original electrochemical system is certainly the future of the field. There is no longer the low temperature operational limitation as exists with electrolysis in water. On the other hand, the gas phase is a much cleaner environment that permits better control of materials. I believe that the most interesting system is the nickel hydrogen pair."

Gas (plasma) based inventions are as prevalent through the history of inventions (see Part 1 of this paper, *IE* #107) as electrolysis-based inventions. Even the nickel alloy (stainless steel) based invention of Stanley Meyer or S. Horváth might fall partly into this category, as some plasma might be generated in the hydrogen bubbles on the cathode during high current impulses.

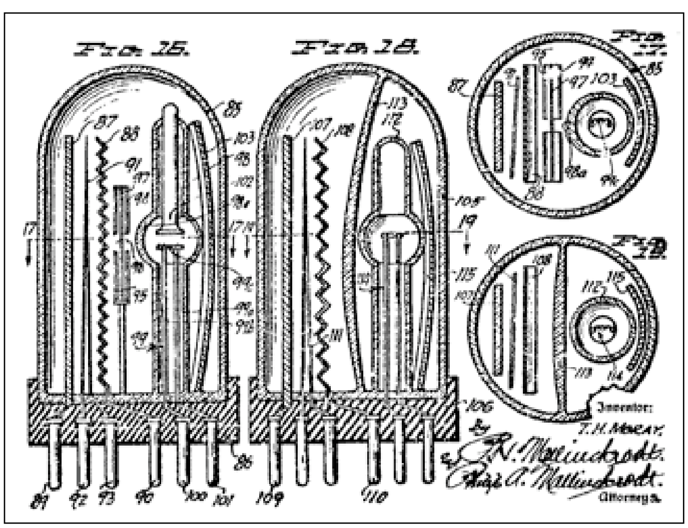


Figure 1. Cross sections of some Moray tubes.

LENR and Nanotechnology

Surface-based LENR inventions for electrolysis and plasma have the same reliability problem as bulk cathode methods, but it is easier to identify the important size and shape features of the surface. Moreover, rapidly evolving nanotechnology offers technical features previously unknown, like a dense matrix of sharp needles from metal or carbon cones grown for flat planet plasma TVs, or nanohole resonator arrays, etc.

Scanning electron microscopes yield better and better resolution and magnification of a surface, helping quality control. Mysterious "surface poisoning" might turn out to be nothing else but a damaged, razed, flat re-structured cathode surface. Only Paulo Correa carefully watched his cathode surface; Meyer, Puharich, Horváth and Chernetsky did not.

The recent paper by Moray King[2] is an excellent source of recent experimental evidence about the importance of surface quality. The patent application of Francesco Celani (U.S. 0124915/2012) is a really useful contribution in the LENR field. It is all about surface preparation. Contrary to the Rossi or Piantelli patent applications, the information in the Celani application can be understood, and surface quality control is described in terms of measurable parameters. It will be an historical patent.

Unfortunately the Moray patent (U.S. 2,460,707/1949) is not up to this quality. The cathode composition is listed as 5% copper, 55% lead, 30% sulphur, 10% aluminium. The molten copper aluminium alloy is the base metal, and then sulphur is added, then cooled, etc. The problem is that the surface texture is widely variable to heat treatment/refolding—as mechanical treatment. The folding/stretching treatment of this complex alloy has a double function. It acts partly as a catalyzer for decomposition of water, hydrogen, and molecular hydrogen, and a site for high effective mass plasmons—electron waves.[3]

The catalytic effects are significantly enhanced by bimetallic structures such as Ni-C or Cu-Al nanostructures.

The rapidly growing knowledge of nanotechnology helps us to appreciate the forgotten knowledge of past inventions, to clear the names of the inventors from the fog of ignorance.

The Moray tubes (see Figure 1) complicate further this foggy picture. There are sharp edges, large surface cathodes and anodes, and high voltages in this complex transient plasma tubes. To complicate this mess further, Moray claims in his other writings that the first stage of his device consisted of oscillating circuits only—with no plasma.

The explanation of the spectacular energy gain is of no use: "In my theory. . .electrons, protons, ions. . .they are portions of ether, that by some unknown means have become dissociated here and became electrically charged." The quasi-particle induced LENR model hopefully clears some of the thick fog.

Moray obviously chose high voltage, high frequency, low current plasma discharges in order to maintain surface quality. Correa, Chernetsky, Meyer and Horváth could not maintain it because surface erosion destroyed the grid of small needles, dendrites and cavities on the surface, and along with it the excess energy effect as well. Surface quality control in the nanometer range was a painful, hopeless wandering in the darkness for them. Dust is a more friendly medium, but not without its problems.

The importance of surface phenomena (thus its quality) is demonstrated further by the test results of Tadahiko Mizuno.[4] Mizuno clearly demonstrates in his paper that a transmutation process takes place at the surface within one micron depth at most, or even nearer the surface. John Bockris also noted the importance of surface needles—dendrites—for excess heat effects and the associated tritium production. Whenever these surface dendrites were removed by vigorous shaking of the electrolyte, the excess energy effect—tritium production—ceased. This is a good indication that needles and grooves on the surface enhance LENR phenomena, at least one technical form of it.

Mahadeva Srinivasan[5] arrives at a similar conclusion in his review paper "Wide-Ranging Studies on the Emission of Neutrons or Tritium by LENR Configurations: A Historical Review of the Early BARC Results." Srinivasan concludes that nuclear reactions seem to occur in highly localized "hot spots" and neutrons (if detected) are released in bursts. LENR reactions are more likely to take place at certain places on the surface and at certain times, periodically.

Srinivasan's fellow workers at BARC observed tritium production in Ni-H systems, "heat after death" phenomena and the lack of need for high hydrogen loading for excess heat for surface-dominated reactions.

These features are consistent with the polarization wave-coupled plasma wave model, which renders possible charge shielding by high effective mass quasi-particles, *i.e.* plasmon polariton coupled waves.

This tentative model offers a step-by step explanation of LENR devices discussed in Part 1.

The carbon dust device of Tesla and Egely, the copper-lead–sulphur "spongy cathode" of Moray, the needle and small cavity cathode devices of Shoulders, Correa, Chernetsky, etc., the micro or nanoparticle based devices of Piantelli, Rossi, Arata and Zhang all come under the same umbrella.

"Heat after death" is a runaway positive feedback effect in this model. Heat is created after the initial external excitation generating infrared waves. They in turn generate surface polarization waves on the surface, or resonances in a cavity. Thus these excited, high effective mass resonant electron waves generate neutrons by merging with protons, then deuterium, then tritium, then helium-4, releasing heat during these sub-steps.

The Role of Collective Oscillations

The "bottleneck" of these processes is neutron formation. The energy of the combined surface electron waves—proton cloud assembly, shown in Figures 1-7 in Part 2 of the paper—must reach a 0.75 MeV threshold level for the whole cloud. This is the salient point. It is not necessary for each individual proton-electron pair to have this high level. The sum of binding-oscillating energy of all proton-electron waves should reach this threshold, as this is a collective oscillation. It would indeed be difficult and energetically inefficient for single electron-proton pairs to form such a high energy. But tens of thousands of electron-proton pairs adding together their individual energy in a cooperative, coherent structure may easily reach this threshold level in a resonant process.

Continuous neutron generation is one major initial step of LENR phenomena. The ultracold neutrons react with other nuclei quite close to the surface; they seldom leave their generating environment, to say nothing of the reactor itself. This "branching anomaly" has been known from the beginning of the discovery of the LENR process and it is rather a blessing, not a curse. As LENR reactions are far less radioactive than mainstream thermonuclear reactions, they are more "user-friendly." Critics of the field, like Huizenga, used this fortunate effect to discredit the phenomena—still expecting the features of D-T thermonuclear reactions. But none of the several LENR reactions have intensive X-ray or gamma ray radiation. They are usually barely above the background level at all since slow neutrons have a high reaction cross section.

This is no wonder, since these fundamental phenomena and biological transmutations may take place even at room temperature. Most probably chiral media, the rotation of electrons above the surface of conducting nanoparticles, long molecules of carbohydrates and complicated, folded, conductive proteins are essential to transmutation and perhaps to energy production. Since life processes are more efficient and more sophisticated than anything we do with technology, no slow neutrons are expected to appear, *e.g.* around growing yeast cultures, capable of transmutations.

The neutron generation process is highly selective but only on a surface. Due to its resonant nature, a given cavity size can react either with deuterium or with ordinary hydrogen, but not with both. If the resonant cavity size distribution is not uniform, it may react with both hydrogen isotopes, but poorly, only at some isolated "hot spots," until it is destroyed by local heat. However, a mixture of D and H is suitable for such surfaces, as suggested by Edward Teller.

Cold worked, hard chips of titanium, full of sharp edges and cracks, or proper sized nickel alloy dust are ideal starting points for such plasma based experiments.

The combination of plasmon polaritons with a suitable surface quality offers a unified treatment for both past, forgotten inventions and for recent physics in nanotechnology. It helps to incorporate the useful technical features of these forgotten inventions, because this helps to establish a stronger probability of repeatability, and a better input/output power ratio. Moreover, the output in these revolutionary old devices can be electric energy as it was for Tesla and Moray.

The formation of neutrons, ostensibly through electroweak interactions (Widom-Larsen model) is only one among possible branches of LENR processes. The other, smaller branch is based on charge shielding and strong interactions. Here protons are involved in the reacting nuclei, in $D - D \rightarrow He^4$, or $p + D \rightarrow He^3$ type reactions for energy production. There are other reactions between heavier nuclei, causing transmutation phenomena; some are fusions, others fissions. Usually a combination of all the above phenomena takes place, as heavy ionized atoms may oscillate among the protons also.

Can we do away altogether with single protons and have only argon or neon "fuel" for the plasma? The Correas had such an environment but it had always been contaminated by some water, thus hydrogen, diffusing through the glass walls of their discharge tubes. Even He or Ne may be used as a fuel as for Papp, but it is inefficient and therefore technically useless.

It is important to note that each of the technical solutions is able to generate neutrons. Only the dusty plasma and surface plasmon polariton processes are really collective oscillations. Papp's collision chain/negative ion charge shielding is a somewhat unique process, broadly fitting into the LENR process since it has no plasmon polaritons.

Direct Experimental Proof

A major disadvantage of these processes is that it is difficult to test them directly. Though the study of surface plasmons on flat gold or silver plates, or in glass embedded colloids, is common and widespread in mainstream science, it is rare in diluted hydrogen or deuterium plasma. The only exception is the test of Peter Hagelstein, Dennis Letts and Dennis Cravens,[6] who induced surface plasmon polaritons on a palladium surface by the beat frequency of two lasers directed toward the same small spot. The lasers were tuneable in the optical range of petaHz, therefore their difference or beat frequency is in the infrared (terahertz) range. By carefully adjusting the beat frequency, they noted some distinguishable resonant frequencies, where local excess heat was produced.

It was noteworthy that a very small amount of input energy for the surface wave excitation was enough to induce local excess LENR heat energy, but by orders of magnitude higher. This was a smart, well-designed experiment. Unfortunately it got less attention then it deserves.

Sharp energy producing resonant peaks were observed at 8.4 THz, 14.5 THz, 14.75 THz, 15.3 THz, and a broad resonant peak between 20.0 THz and 21.4 THz, showing the characteristic features of Fano resonances discussed in Part 2. They have also noted the influence of the surface quality of the cathode, since different sites produced wildly varying amounts of excess heat.

In fact, this idea can be used to create a diagnostic tool for electrolysis only. By radiating a very small spot in a given infrared spectra (or a controlled part of the spectra), it is possible to identify the excess energy generation capability of a surface. A collimated infrared beam transmitted by a flexible optical fiber would do the same job. The amount of locally produced excess heat can be measured by infrared thermometers.

Lasers are not economic tools for the excitation of large surfaces, but infrared radiation does the job, as was noted by Focardi, Scaramuzzi, Celani, Rossi, Piantelli, Arata and Zhang, just to name some researchers. Transient electric field excitation is another practical method, but not good for diagnostics.

The Letts-Cravens-Hagelstein experiment provides a deep insight into the resonant nature of the LENR excitation process. If there is no resonant excitation of surface plasmons (or volumetric phonons), there is no appreciable result in the form of excess heat or transmutation.

Unfortunately the method cannot be applied to transient plasma-based processes, because the generated heat is measured in a time integrated way, over a large area or volume.

The Winner is. . .

There is no definite result at the time of writing, because the race for mass production is just about to start. Therefore bookkeepers, the real judges of any race in the economy, are not working yet. The opinion is therefore my own, based on "hands on" experience.

Frankly, there is not much future for any devices based on electrolysis. It is due to problems of quality control, *e.g.* surface roughness, width depth and length control of cracks, and the site of surface plasmons. Bulk palladium devices are out of the question, partly because of their high price, partly because of their weak, unreliable performance. Thin film, Ni layer devices might be of academic, but not practical, interest.

Tera-peta hertz frequency, 200 - 600°C plasmon polaritons are more economic to make than less frequent volumetric phonons. A more favorable economic output is expected starting from mid-temperature range (~200°C) $Ni\text{-}H_1{}^1$ systems for heat production. These are micron or nano sized grain particles heated just under the "heat after death" temperature (400°C) in order to be able to control the process. Any higher temperature is not a really good solution. I favor carbon nanodust territory (dust acoustic resonance), a field of carbon nanoparticles and charge shielding by two simultaneous processes, shown in Table 1-4 and 1-5 in Part 2.

Papp's process is the most suitable for mechanical work. Although it is meant to replace internal combustion engines, its future is not guaranteed because direct electrical energy generation is a more straightforward solution on board the newly developed electric cars.

In this field the carbon-based Tesla process and the "Swiss cheese" cathode Moray process compete with each other. The latter one is less efficient and requires a very high input voltage, not accessible by present conventional technology. Its only advantage is its reliability and durability, as cathode erosion is not significant. (It is a resonant process, using low-current; see Figure 1.)

The Gray, Jekkel-oxy-gas, Correa or Chernetzky processes are quite cumbersome. Thus an insight to the features of charge shielding and quasi-particles, and multi-body interactions, gives some clue to the economy of these processes.

There are two dark horses in this race (one is based on another quasi-particle, the magnon, which is generated by transient magnetic phenomena). The forgotten inventions of Hubbard, Hans Coler and some other researchers give definite hope for direct energy production by resonant magnetic circuits. (These are not permanent magnet motors—which are a dead end street, except perhaps the Yildiz motor. My guess, based on some firsthand experience, is that the Tesla legacy can be competitive here.)

The Competitors

The first competitor is the so-called "monothermal cell," usually simple solid-state devices producing a low voltage low current. The effect was discovered about 20 times during the last century, but always went into oblivion. This device consists of two electrodes of different materials, with a semiconducting material between them. The electric field creates a preferential direction of charges in the semiconductor due to the difference of contact potential. The charge may be an electron, or a quasi-particle—an electron hole. The thermal noise and/or vacuum fluctuations are the source of the electric energy. The random oscillations of the real and pseudo charges are rectified by the internal electric field established between the electrodes of different materials.

The current density is in the order of micro amperes/cm^2, though it can be substantially increased with proper technological development. The output is intermittent, though after a few minutes the semiconductor filled cell becomes "tired" due to excess charges building up in the vicinity of the electrodes. The power production of the cell recovers after the load is switched off for awhile.

The author and his colleague, J. Szamosközi, have about ten years of experience with the system. Our electrodes were made of either copper-aluminium or copper-carbon. The semiconductor material was selected out of thousands of household materials: poorly conducting plastic materials (antistatic plastic), glues and paints, mixed with different fine grain powders.

The technical challenge is to spread this semiconducting material evenly in a thin layer between the electrodes. This thickness is usually in the order of 50 - 100 micrometers. If it is thinner, a slight technical error may cause a short circuit in the cell. But if the semiconductor is thicker than about 100 micrometers, the electric field between them is too weak, and the cell resistance is too high. Thus the overall output is reduced.

It is not easy to find a suitable material, as most paints deteriorate or dry after a few weeks and plastic materials tend to lose their conductivity as they age.

Silicon-based semiconductors must be doped to have a proper conductivity, and are expensive and fragile to make. Organic semiconductors are promising for these applications although they are not available for amateur researchers.

We have even used brake (hydraulic) fluid in thin layers, as it is easy to spread, and with a thin insulating mesh, large surface areas can be established.

A typical cell is shown in Figure 2, taken from a German patent application by Eckhart Kaufmann in 2009 (DE 10/2009017961), using copper-zinc electrodes.

Figures 3a and 3b are photographs of one of our experimental cells with copper-carbon electrodes. The semiconductor is a "fine-tuned" industrial glue mixture. This is the sixth generation of such a cell. Each new cell doubled the electric output of the earlier one. The 10 cm^2 electrode area is able to flash a small LED every 10 seconds. The previous cell was able to flash after a 50 second delay period. The typical cell voltage is about 0.5 V, thus it is not the electrochemical contact potential difference.

The effect clearly violates the second principle of thermodynamics as it is stated in the textbooks, which claims that due to irreversibility one cannot gain energy with the help of "Maxwell's demon." That is, we cannot separate and accumulate fast and slow particles in a gas, and thus create a temperature difference. However, this principle holds only for electrically neutral particles, not for the charged ones we use, even if they are quasi-particles. The monothermal cell is in fact a Maxwell's demon.

The "monothermal" cell theory was established for electrolytes by the late Romanian inventor and theorist Nicolae V. Karpen. Figures 4a and 4b are two photographs of Karpen's devices in the 1940s. They have constantly produced electricity ever since in the National Technical Museum of Bucharest, continuously driving a small torsion pendulum. There has been no sign of deterioration of the gold-platinum electrodes since then because the effect is not based on stored electrochemical energy. Figure 4b is a close-up of a Karpen cell. (Note the similarity to a Pons-Fleischmann cell.) The Karpen theory was later extended to semiconductors by M. Marinescu, but both scientists had an "icy" rejection of their work (like LENR). Thus their work is barely known except to Romanian electrochemists.

Magnon-Based Devices

For most "established" opinions all these LENR and monothermal devices are heresy. But they pale compared to what comes next.

From time to time amateur researchers stumble into an unusual, mostly resonant effect, when electricity is produced

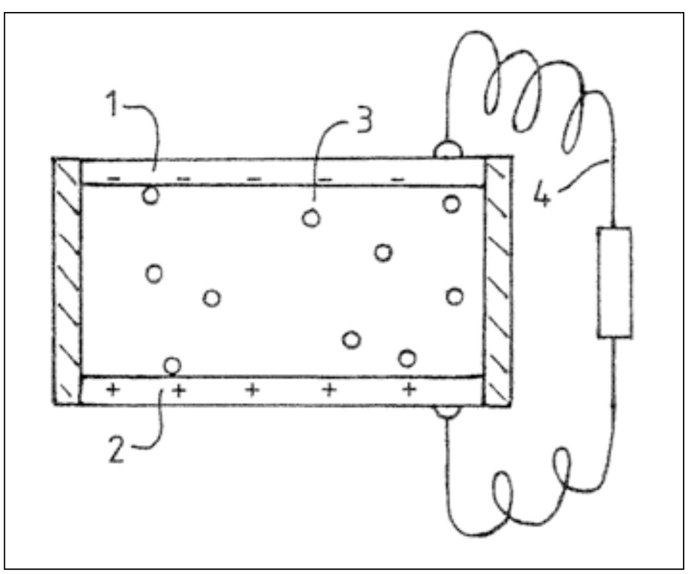
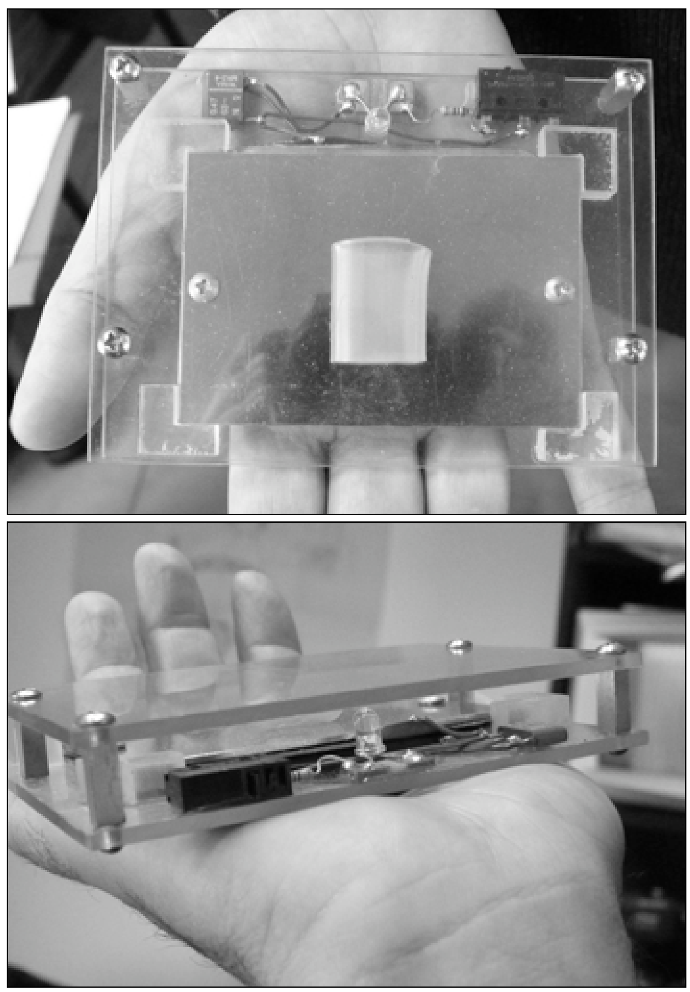


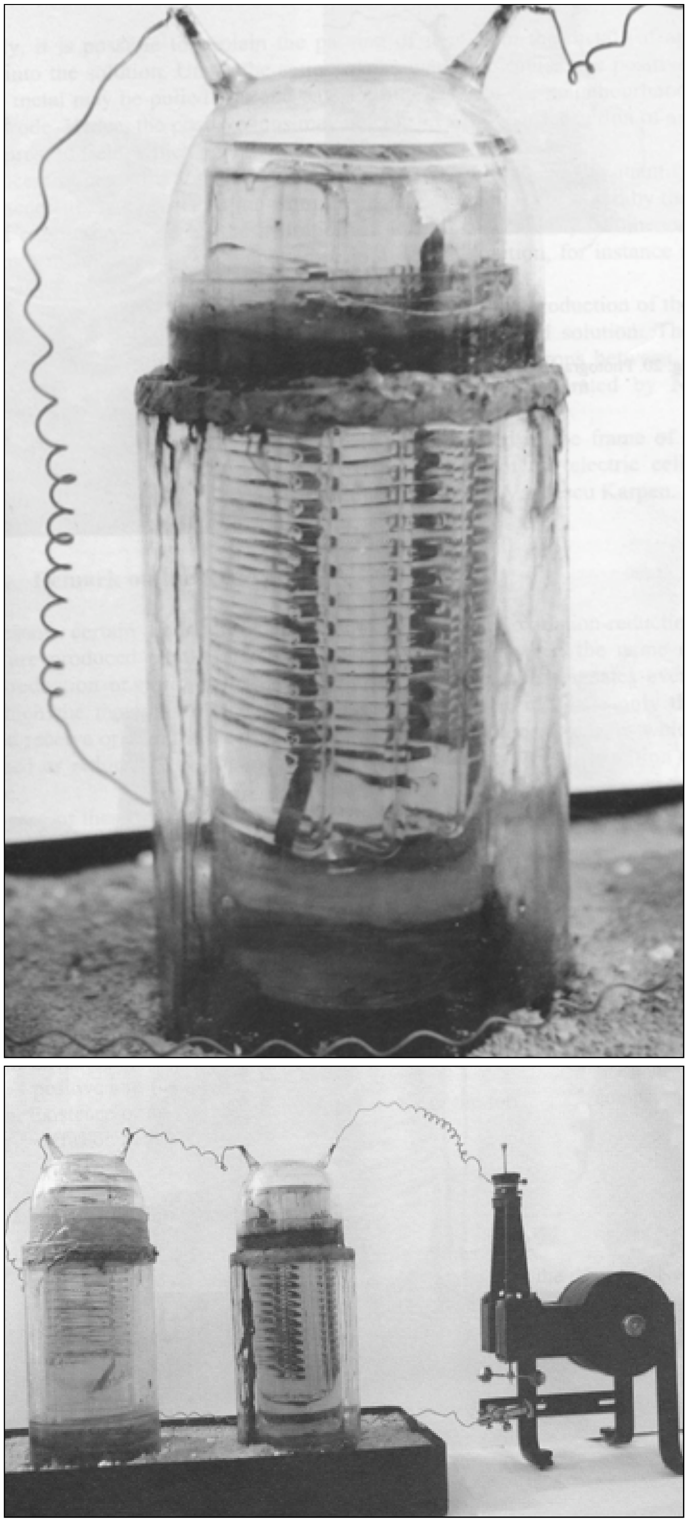
Figure 2. Schematics of a unitherm cell.



Figures 3a and 3b. One of our cells in the author's hand.

apparently out of nothing. Usually only fragmented information is available and these devices seldom get patented. The very cautiously worded U.S. patent for Gunderson is the exception, not the rule (8,093,869/2012, Apparatus for Generating Electricity Utilising Non-destructive Interference of Energy).

From a distance, the author is involved in the re-development of such a device, called the "Hubbard resonant transformer" (see Figure 5). So far only a small amount of excess energy has been measured. The parameter range where the resonant excess energy appears is narrow. It took years of work to find it. Obviously most readers will dismiss this since it violates the energy conservation principle.



Figures 4a and 4b. Electrolytic cells by Karpen yielding a small amount of electric energy.

Let me remind the readers how science works as an institution. The energy conservation principle was established by a German physician, Meyer, who made this statement for closed thermodynamic systems. He was considered then as a fool and an outsider. His papers were not published by the established journals in the 1820s.

Then, due to Helmholtz, the idea has been excessively generalized even to systems which were not carefully tested due to the extreme technical challenge of measuring all the necessary parameters at the same time. For example, 50 Hz resonant, noisy, iron core transformers were found to yield too much heat, but heat output is usually not measured automatically. Dissipation losses are believed to be equal to the generated heat. However, some transformers "poorly designed" and in a non-linear ferro-resonant mode of operation do yield excess heat or vanish heat. The subject deserves a separate paper. Only magnons as quasi-particles are of interest here.

Another well-known, eye-catching phenomenon, where the conservation of energy is apparently violated but never mentioned, is the tornado. The tornado, and the dust devil in arid areas, are typically rare, self-organizing phenomena, where physical models and computer software are unreliable. Mathematical models notoriously break down and fail to predict or even to simulate these effects, despite the best efforts.

Data fed from real life events provide reliable initial and boundary conditions. However, in simulations tornadoes stop in a couple of seconds, whereas in real life this kind of vortex might exist for hours without losing its energy content while destroying houses or sucking up small lakes and rivers.

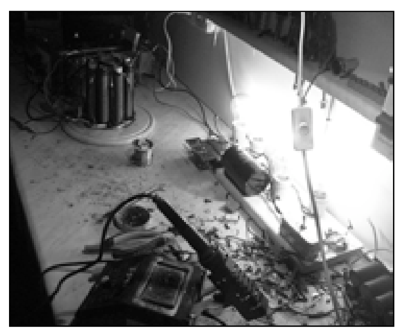


Figure 5. A resonant experimental Hubbard transformer with Ohmic load, under development.

Our tornadoes are short-lived compared to those in other planets. The most famous is the big red eye of Jupiter discovered by G. Cassini in 1665. It has been rotating along smaller vortexes ever since. Saturn and Uranus also have such permanent vortexes. Even Venus has two of them. It is worth knowing that these giant gas planets emit much more heat than they absorb.

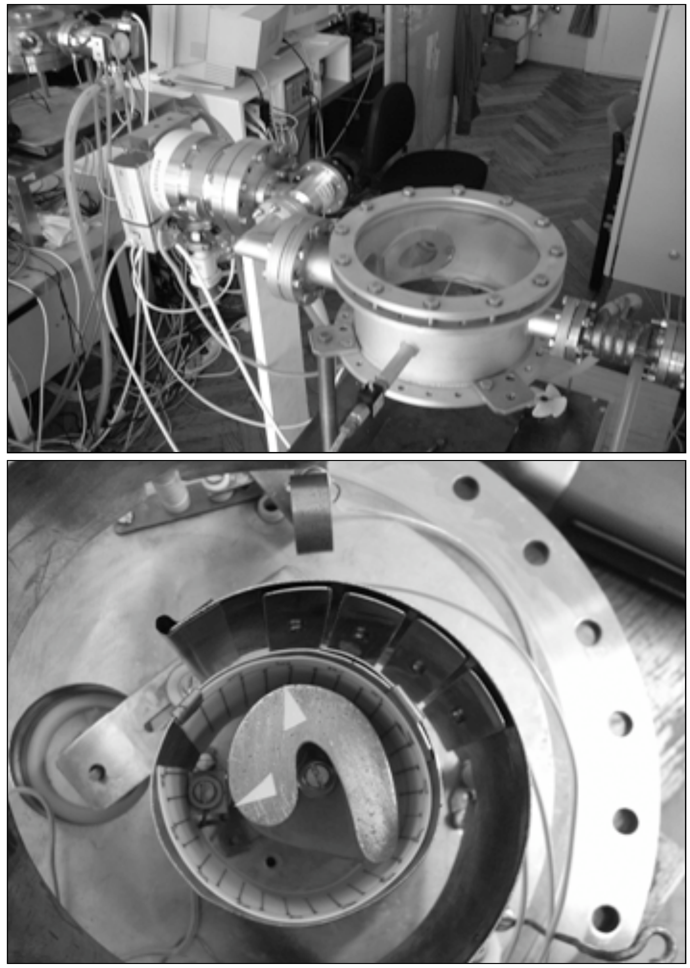
The spiral galaxies have anomalous movements (hence the need for dark matter and dark energy), yet spherical and globular galaxies behave according to textbooks.

Modified Newtonian dynamics has been suggested to avoid the need for dark matter.

Trout are good swimmers in fast mountain streams. In fact, they are so good that they do not move at all, yet they are not swept away by the fast rivers. Their secret is a tornado-like flow around their body as discovered by an Austrian forester, Viktor Schauberger. There are some modern followers, too.

Figure 6. A "good" electron beam penetrating a repulsive electric field.

Figure 7. The same set-up with a slightly different incident angle. The beam is repulsed at zero potential.



Figures 8a and 8b. The electron tornado vacuum chamber from outside and from inside.

The excellent mass produced sack-less vacuum cleaner by Dyson is a good example for an industrial application. But he had to build 5,127 experimental models to find the "right" parameters when the "cyclone" works "miraculously." Otherwise it is of little use.

Another remarkable invention was worked out by Harry Schoell in Florida (Cyclon Power Technologies Inc.) It is a flame/steam cyclone with up to 46% mechanical efficiency. Considering the necessary losses, it is about 20% better then what is allowed by textbook physics.

Indian inventor Somender Singh patented a vortex-based internal combustion engine (U.S. Patent 6,237,579), which has also an unusually high efficiency.

This author and his team have developed an electron beam tornado based on the same principle. There is no room here for the details, but a properly formed electron beam may penetrate a repulsive electric field up to 180-200 V potential difference, provided the beam travels in spiral electric and magnetic fields. In Figure 6 a "correct" parameter set is shown, when the beam penetrates the repulsive field.

In Figure 7 the beam bounces back from the same field because the angle of approach is not correct. The vacuum vessel is shown in Figure 8. More photos can be seen on the website www.greentechinfo.eu .

There are a wide range of renewable energy production technologies where there is no fuel and thus no pollution.

LENR is the best candidate though. However, none of the present established old or "renewable" technologies are good enough for our needs.

Hot fusion, solar or wind, uranium based reactors are not mentioned here because they are uncompetitive with quasi-particle based light element fusion (or neutron capture if you prefer).

Not so long ago, light water experiments were used by "cold fusion" researchers as control experiments, because they were convinced that nothing happens there. Their tacit assumption was that a D + D reaction, and charge shielding by the bulk palladium lattice, drive a fusion reaction. It turned out that shielding is nearly as weak as that in the Tokamak plasma. But quasi-particles will come to the rescue—for those who are able to use them.

Epilogue

The first theoretical paper on the possibility of neutron capture and nuclear transmutation was written by G. Gamow in 1935.[7] Julian Schwinger, the most original U.S. physicist, suggested this mechanism again to no avail in the early 1990s. There is a need to translate these ideas into inventions. There is no hint of how to do it here on Earth in a machine. The quasi-particle-based LENR devices of Tesla and

Moray were witnessed by dozens of people, but became forgotten by the time Schwinger formulated his theory.

The existence of magnetic monopoles (as a fine example of a quasi-particle) was discovered by Felix Ehrenhaft in the 1920s witnessed by dozens and published in several papers. V.F. Mikhailov re-discovered them to no avail. This subject is ignored by mainstream science.

Monothermal cells violating the second principle of thermodynamics have been discovered and forgotten dozens of times.

A forgotten Korean researcher, Hyung Chick Pyun, discovered by accident a semiconducting organic polymer, containing polyacetylen, in 1967. This could be an excellent application for an electron hole-based monothermal cell. Later the American Alan MacDiarmid got the Nobel Prize for the discovery, but the monothermal energy producing effect is still unknown.

Powerful tornadoes are well-known here on Earth and on other giant gas planets, but their energy-producing capability have escaped the attention of researchers. Although this effect is utilized in the Dyson vacuum cleaner and the Schoell cyclon lawn mower, even their inventors are not aware that they violate the First Law of Thermodynamics. Each method is capable of producing "infinite energy."

When Arctic ice is melting, the economy is tethering partly due to high energy prices as resources are dwindling, pollution chokes half of China. Isn't it time to think "outside of the box"?

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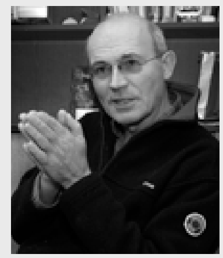
About the Author



George Egely graduated from the Technical University of Budapest (1973). He worked at the Nuclear Energy Research Lab of the Hungarian Academy of Science from 1974 to 1990. He was a guest researcher at CISE (Italy) in 1977 for three months, and at Brookhaven National Lab (U.S.) in 1981-82 for 16 months. He received his Ph.D. in 1982, on the subject of nuclear accidents of pressurized water reactors. Egely has compiled a large collection of ball lightning observations by eyewitnesses, and published a couple of semi-popular books on this subject. He is the author of three textbooks on the physics of "lost or forgotten" effects and inventions, and of several semi-popular books on the same subjects (in Hungarian). Since 1990 he has been a team leader in several small projects in alternative technologies. Some videos of these tests are posted online: www.greentechinfo.eu

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