FACES OF LENR

Part 5C: Design and Operation Principles of LENR Reactors

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Introduction to Part 5C

The subtitle of Part 5 is deliberate of course: "The design and operation principles of LENR reactors." This is too general, as at least three major different LENR operation mechanisms have been outlined in LENR technology. This could be put into the plural "designs and operations."

Mechanism 1 — Fission of nuclei is due to cracks induced by diffusion and lattice vibrations.

This is the fundamental process of electrolysis-based Pons-Fleischmann cells. Decisive tests were carried out by an Italian group led by Prof. Alberto Carpinteri.

This process is also found in geophysics as a slow, low-yield, but steady process in geochemical transmutations.

This crack-based process doesn't have a bright technical future despite the insightful improvement by Alexander Parkhomov. Actually, lattice vibration, and thus its acceleration, distorts the vacuum (ether) density around the nuclei (partly the Unruh-Davis effect), thus causing instability of the nuclei, leading to fission, and thus the release of new neutrons. They are in turn involved in fission reactions. Consequently, the fission stops after all the available reactor material is cracked. This is an interesting and valuable group of effects for academic research, but questionable as a useful device. The physical properties of the lattice as an alloy is important. (See Part 4.)

The catalytic process here is the very powerful crystal lattice vibration, thus a reduction of "ether density," which is not an existing concept in contemporary physics.

Mechanism 2 — Dusty plasma fusion: that is, catalytic fusion by rotating, electrically charged dust particles.

This process runs the energy generation of the whole Universe, in the thin halo, in the corona of stars. The dust is supplied by the omnipresent low-density interstellar dust.

Where the dust density is high, like in the Magellanic cloud, the Oort Cloud and other dust clouds, this process may run amok. They are the quasars, the most powerful explosions of the Universe. The source of their immense energy is shrouded in mystery for astronomers.

This process, first observed by Nikola Tesla in his carbon button experiments, has been forgotten and reinvented many times. Some examples are as follows: The Quantum Rabbit device, and the author's microwave, cavity-based, acoustically resonant reactors. It is easy to reproduce it in a kitchen microwave oven. Also Klimov's dusty reactors utilize the double spin field generated by the electrically charged, rotating dust particles.

The catalyst of the fusion process is the rotating dust particle in the plasma. Extreme transmutations are possible, but it is not the ideal method for heat production. (See Parts 2 and 3.)

The missing paradigm here is the concept of symmetry, that is, rotation in electrodynamics. The simplest field, a spin field, opens Pandora's box, because the generalized (extended) Lorentz force leads to teleportation, observed for example in Hutchison's experiments.

The concept of rotation in electrodynamics is vital in biology as well, because all active macromolecules are chiral in biology. (See Parts 2 and 3.)

Catalytic Fusion by Quasi-particles

Truly disruptive green energy innovations (Mechanism 3) are run by quasi-particles, like condensed plasmoids, and plasmon-polaritons. The principles of their formations and catalytic actions have been established in Parts 1, 2, 3 and 5B. Here we discuss only their practical applications through a handful of inventions. Readers who happen to read only this part first are wasting their time, because the operation principles of the LENR reactors must come first to understand their design principles.

The principles of operations and designs cannot be comprehended without understanding the previous parts, even with the many unknowns outlined there. Part 5B finished by outlining the spark and micro-discharge related research of Nikola Tesla.

Tesla published three known disruptive inventions:

1. The brushless AC motor and generator, the concept of rotating magnetic fields, the reliable workhorse of industry.
2. The concept of polyphase current distribution, thus the feasibility of huge power stations and electric power distribution without the colossal losses of DC networks.
3. The concept and engineering designs of longitudinal electromagnetic waves, now denied, though the patents are accessible. However, the work still contributed to the principles of radio engineering by demonstrating the engineering parts of a radio, power transmission without wires and remote control.

Tesla's fourth, immensely disruptive contribution was the utilization of condensed plasmoids in Geissler tubes. That work has been completely erased from his biographies, simply because it is still "wizardy" and can be understood only

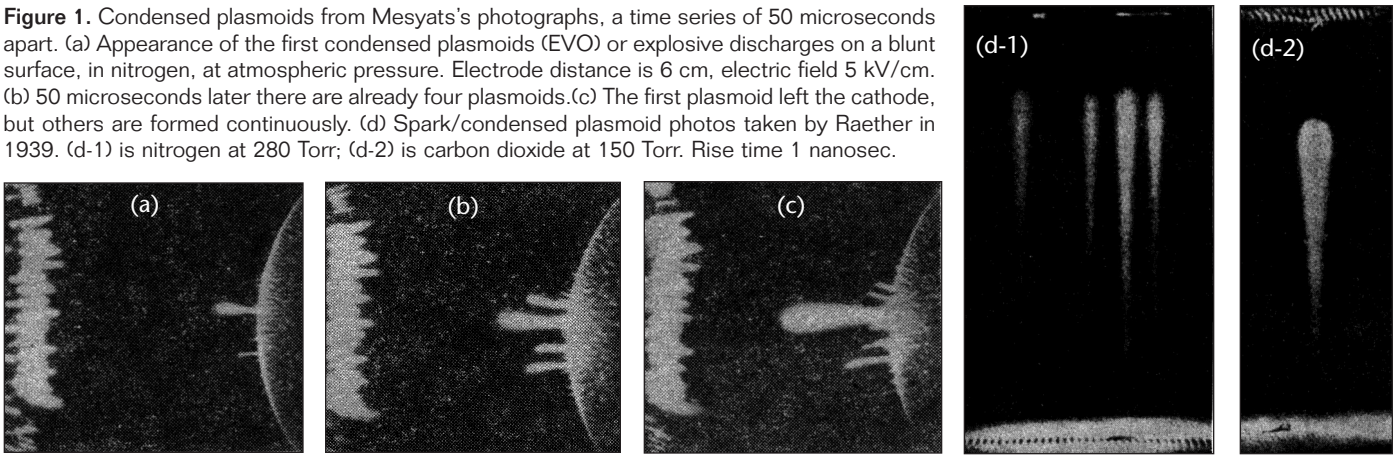


Figure 1. Condensed plasmoids from Mesyats's photographs, a time series of 50 microseconds apart. (a) Appearance of the first condensed plasmoids (EVO) or explosive discharges on a blunt surface, in nitrogen, at atmospheric pressure. Electrode distance is 6 cm, electric field 5 kV/cm. (b) 50 microseconds later there are already four plasmoids.(c) The first plasmoid left the cathode, but others are formed continuously. (d) Spark/condensed plasmoid photos taken by Raether in 1939. (d-1) is nitrogen at 280 Torr; (d-2) is carbon dioxide at 150 Torr. Rise time 1 nanosec.

by a handful of LENR researchers. (It is described in Part 5B.)

What is the real difficulty for us to grasp these concepts? How is it possible that the well documented, condensed plasmoid observations never made it even to the periphery of mainstream physics but academic plasmon polaritons did? The former is way out even from the outback "gray" area of textbook physics, while the latter lies just on the border. It is allowed to include them in small monographs, but not in major plasma physics textbooks.

There is a tough mental barrier in front of plasma physicists, two notions "set in stone":

a) Controlled fusion is possible only by thermonuclear processes, by fully ionized high-energy hydrogen isotopes. All the R&D funds (billions of dollars) are poured into this vast area. There are a number of innovative start-ups also sucking up millions of dollars.
b) The reverse of the above concept is also commonplace: It is impossible to make controlled fusion by weakly ionized plasma of any type. In fact, it is possible even in liquid deuterium with heavy muons (or pions)!

Are these ingrained statements backed by observations? Fortunately, there are convincing data sets on both areas. The data are in sharp contrast with the above statements. Unfortunately, opinion is stronger now than test data in this cursed area.

It is not clear for researchers that very sharp transients, electric sparks (under nanoseconds) and filamentary discharges are the source of new plasma phenomena. Our routine experience is still based on 50 (or 60) Hz sine wave discharge transients, or high-frequency low-voltage digital semiconductor devices based on crystalline semiconductors.

The range of parameters for these new phenomena are well beyond these known areas. These sparks are the consequence of dark discharge → spark or glow → arc transitions due to the negative slope of the voltage-current diagrams. It was possible to make them a hundred years ago, and Tesla mastered it in an efficient manner.

The tacit and false assumption that it cannot be different "out there" is crippling, paralyzing our creativity. In physics, each order of magnitude (in terms of pressure, temperature, conductivity, frequency, number of nucleons, or number of electrons bound in shells) always brings qualitative change as well. Also, the notion that spark (filamentary) discharge cannot be so different from the usual glow or steady-state arc discharge is dangerously false!

These are usually different qualitative changes in features. (The same applies to measurements or data acquisition as well.) For example, semiconductor-based digital power supplies, oscilloscopes, etc. frequently break down in the case of sharp electric pulses. Longitudinal electric waves are generated, and they polarize the semiconductors of the chips producing havoc. Only outmoded, hard-to-find devices based on vacuum tubes have a chance to survive.

This is only one (but a formidable one) of the problems when exploring this effect. The other is: how to make efficient high-voltage, high-frequency pulsed power supplies for the generation of plasma full of plasmoids?

Only half a dozen people have been able to make such devices for a century. A skill with mid-vacuum devices (gas discharge tubes) is necessary, including oil-free pumps, vacuum sealing, feed-through and pressure gauges. This technology became available after the pioneering work of Frank Penning at Philips (later at GE, Osram and Tungsram).

However, only Tesla had the necessary "open eye" to watch out for the "unexpected" for decades—from the 1890s up to the 1910s, when J. Norman Collie, J.J. Thomson *et al.* made the first transmutation experiments based on sparks in hydrogen.

The direct production of electricity (without intermediary heat engines) is a distant area from all previous LENR methods. The experience gained in Pons-Fleischmann cells, or dusty plasma reactors, is not of much help here. These areas are far from the borders of textbook plasma physics, and from each other as well. Therefore, the spark-based experimental work demands a different set of background skills and know-how than the other fields of LENR.

There are only a few photographs of the actual spark channel generation, where the leader is shown, the negatively charged pseudo-particle, the condensed plasmoid. Only Gennady Mesyats (Novosibirsk, in the 1970s), and the German Heinz Raether made a series of photographs with pico-second time frame resolution. (See Figures 1a-c.[1]) We shall return to the results of each condensed plasmoid generation experiment in Part 5D. Though they never investigated the catalytic features of condensed plasmoids, their immense electric charge became an established fact.

Now we describe their common operation principles and widely different engineering design solutions. The guide-

lines will be again, as always, the questions of David Nagel, laid down in *IE* #118.[2]

To rephrase the warnings again: from now on the mindset of mainstream physics, even of previous LENR research, is no longer enough. The active use of extended electrodynamics is always needed. The sharp electric pulses driving the discharge are essential; the properties of condensed plasmoids and plasmon polaritons must be known for any successful design and operation. Further, the knowledge around the formation and features of sparks and micro-discharges are useful. (See Part 5B.)

All inventions in this area have only fragmented information about their technical details. However, reading them will be like solving a crossword puzzle. The solution will emerge gradually, when the missing information is filled by adding the fragments learned by other inventions.

The "Above Water" Sparking Reactor

The fact that operational principles are above the design principles is illustrated in the reactor shown in Figure 2, by Parkhomov.

This reactor is still a research device, not yet a mature invention with sophisticated engineering. In principle, this reactor is better than the usual underwater sparking or cavitation machines, because the energy losses are less. The reactor itself is not a novelty. All arc smelters are the same. The novelty, the invention, is not in the design, but in its operation. That in turn depends on the power supply. This device cannot be used for a micron-size discharge gap, thus micro-discharges are ruled out. There are two useful discharge methods for large gaps.

a) Corona discharge with a microampere current, around atmospheric pressure. The yield is miniscule, and thus useless with the given reactor design (point to plane).
b) Transient arc discharge, preferably at atmospheric pressure is driven by relaxation oscillation. It may work with DC as well, because sparks are inherently "noisy." Further, the liquid surface is frothy with lots of droplets. They make dust fusion possible, too. Thus a number of transmutations crop up, also described in the patent application.

The hydrogen is there due to the water, and thus some excess heat is released.

In principle, this overall design is suitable to transmute molten metal, even molten sulfur (if it is not too deep, only some mm). The plasma gas can be hydrogen, even above atmospheric pressure, if some excess heat energy is expected.

No provision is made for acoustic plasma resonance, which is a definite shortcoming of the design. The plasma chamber resonance must be synchronized by triggering the power supply. No provision is made for the magnetic rotation of the plasma column (spin field generation), which may increase the yield further. These are the reasons why this device is suitable only for academic research (it is excellent for that), but not yet an invention for mass production.

The Moray Invention

Compared to the few eyewitness reports to Tesla's demonstration electric car, the Pierce-Arrow, T. Henry Moray had hundreds of documented demonstrations of his invention (or rather group of inventions) but the technical details are scant. It is certain that he used a very high voltage corona discharge; the cathode was a homemade PbS alloy with Cu, Al (probably to have a lower melting point). The reactor tube operated in a gas containing vapor, and it used oscillating circuits for generating power. In the generation of sparks and harvesting of excess electric energy, he used his own special diode, or "valve," which was able to open and close at high voltages with minimum losses. They were a kind of avalanche diode. This semiconductor-based invention was reinvented again by Janos Veres, who demonstrated it in front of this author several times. This is a modified Zener diode, which opens at about 400 V, closes at 300 V with negligible loss and is extremely fast. It is a sort of avalanche diode. It is produced occasionally during mass production of diodes, at the rate of 1 out of about 1000. The diodes are not tested in the factory for this fast opening capability. This invention was up for investment, but nobody was interested. (Semiconductor experts considered it impossible when they saw the demonstration device.)

The history of the Moray device is well documented, laid down in four consecutive brochures and a book, along with some technical details. The device cannot operate by textbook physics. The United States Patent Office (USPTO) did its best to reject it during a 20-year battle with tragic consequences. However, readers can comprehend its physics, its operation and design based on Parts 1, 2 and 5B. The energy producing tubes had a large surface, high voltage, high frequency, just as with the Tesla gas discharge tubes, as recalled by witnesses.

The rest (99.99%) of Moray's technical data were lost, because the USPTO repeatedly turned down his whole set of inventions as being impossible. They recognized only hot

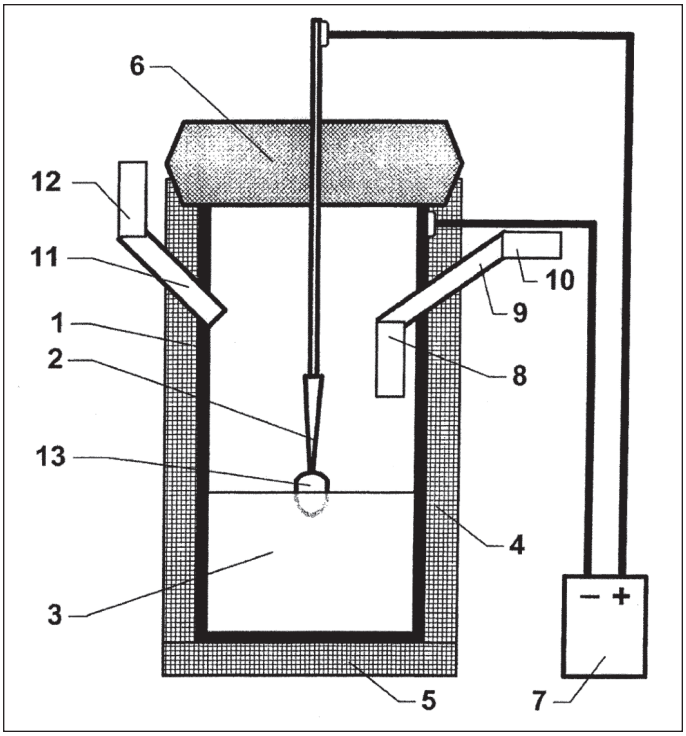


Figure 2. An "above water" corona/spark reactor by Parkhomov *et al.* The success of this reactor depends on the parameters of the operation, that of the power supply.

cathode-based tubes in the 1920s.

His only granted patent (U.S. 2,460,707) is a medical invention to kill bacteria and viruses with longitudinal electromagnetic waves. There might be some details of his energy producing tube hidden in the patent description. However, this assumption is speculative.

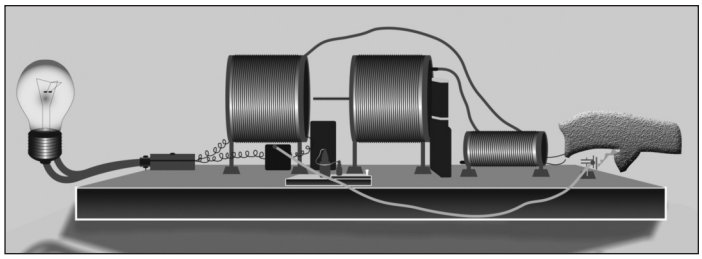


Figure 3. A drawing made of the Moray device based on the only surviving photograph. Note the coils. The power tube is hidden inside a coil.

No useful blueprint of the tube construction, or circuit, has remained. His books are loaded with long and empty speculations about the nature of an oscillating ether as a source of energy.

No one has replicated his 50 kW device so far, despite several separate efforts. These attempts were "inside the box" types, usually assuming radioactive semiconductor crystals as the source of energy. Today he wouldn't get even this patent—because killing viruses by longitudinal electromagnetic waves confronts the interest of big pharma. There are no documents about his medical success, only about the energy generation by gas discharge tubes. The fact that gas discharge was used comes also from eyewitnesses; they saw bluish light from his tubes, definite proof of gas discharge. No tube is shown with external magnetic coils in the patent. However, there is one remaining photo of the Moray device. It could be just a means of concealment. See Figure 3, redrawn based on the poor quality photograph.

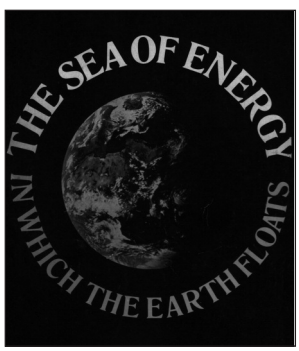


Figure 4. Moray's last book, *The Sea of Energy*, is mostly about the sad story of Moray's LENR reactor, and some vague speculations about the nature of "energy surges."

A few witnesses were allowed to peek into the wooden box hiding his device. They mentioned coils, resistors, capacitors and glowing discharge tubes, but not their specific arrangement. Moray's book *The Sea of Energy on which Earth Floats* is just a fragmented collection of deceptions and betrayals. See Figure 4.

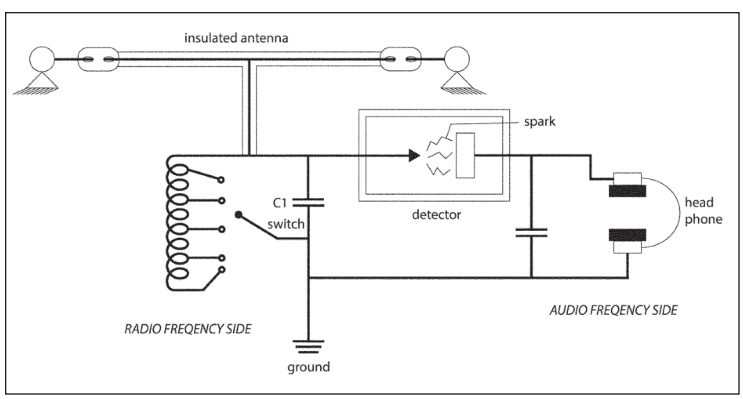


Figure 5a. The electric circuit of a crystal radio—one of several possibilities. The size of the antenna is smaller; the detector is bigger than in reality.

Reverse Engineering of the Moray Device

Just as with Tesla's discharge tubes in Part 5B and the Pierce-Arrow converted electric car, the reverse engineering of Moray's work is speculative, and subjective.

Readers may come to a different conclusion. But, in my opinion, a detector radio (crystal radio) is indeed a correct technical environment (but not the only one) to create excess electric energy by LENR—just by luck, with slight modification of the original circuit.

Building long wave radios (crystal radios) was fashionable from the 1910s up to the 1960s. They were ideal devices for teenagers to have "hands-on experience" with oscillating circuits, resonance and semiconductors. Literally, hundreds of thousands of radio amateurs built crystal (detector) radios over the decades, up to the 1960s, when long wave radio broadcast stations ceased; instead of amplitude modulation, frequency modulation took over.

Moray gave only a single sentence clue about the "aha" moment of the original discovery: "It was an unusual series of clicks in the headphone…"

The typical crystal radio is laid out in Figure 5a (which I also wrote about in *IE* #135[3]). The puzzle has kept me interested ever since. The first half of the riddle: why, out of hundreds of thousands of radio amateurs, did only Moray, in Salt Lake City, Utah find the excess energy effect? Did nobody else find it in the rest of the world? We shall have a tentative answer soon.

The second question: did Moray modify the original layout?

What follows is an even simpler layout than the one published in *IE* #135.[3]

At that time I assumed Moray used a linear wire corona discharge tube (just like the deuterium-tritium experiment by Tom Claylor at Los Alamos National Laboratory).

However, it would require deep insight by a teenage boy, without a plasma physics and LENR background, to build such a tube. Later, further insight is needed to modify the audio circuit, containing the headphone. It is not impossible, but less likely.

The most probable version seems to be the following: On the left side the RF resonant circuit, the tuning inductivity switch was not closed, and thus the variable capacitor C1 (Figure 5a) was charged to a high potential by the antenna. Moray used a long, horizontal, well insulated antenna for decades during his demonstrations, but later it became dispensable. This antenna provided a high voltage (1-50 kV) low current pulsed energy source due to the usual sunny weather in Utah. The antenna yielded a regular series of high voltage pulses due to a DC barrier discharge. It was in fact a dielectric barrier discharge through the rubber insulation. Moray improved this rubber later, but its composition has not been revealed. (It is mentioned in his book only once.) The long antenna wire even has some inductivity for high frequencies. The insulation is a barrier, letting some current intermittently flow through it at high potential. Thus a train of impulses reached the whisker. The low intensity atmospheric current charged the capacitor C1 in the same way as a relaxation oscillator in a

pulsed manner. This was his advantage over damp Europe! This seldom happens in Europe, maybe only during an approaching storm. This may happen when the tuning inductivity is not used, and switch S (Figure 5a) is thrown open, and thus C1 can be charged, as observed by eyewitnesses.

The next, critical, step is to let some sparks jump in the gap between the pin and the homemade galenite crystal when the sharp whisker wire was at some distance from the galenite crystal. Thus condensed plasmoids are created in the spark gap between the "cat's whisker," the pin and the semiconductor. If, and only if, there is damp air in the room, the water vapor is ionized due to the discharge, and there is hydrogen for the fusion. Thus the "eureka" moment is possible when the following three conditions are met simultaneously:

1. The S switch is open.
2. The cat's whisker is at a small distance from the galenite semiconducting, rectifying crystal surface, for example: while looking for a good spot.
3. There is some humidity near the crystal, for example due to breathing.

We always think that the "cat's whisker" touches the surface of the semiconductor. Indeed, this is the usual case. However, lucky accidents do happen. There is a cat's whisker type of diode shown in Figure 5b. (It is taken from a Soviet book for radio amateurs from the 1950s by V.G. Borisov.)

Though there are several more possible circuits, the simple circuit of Figure 5a continuously charges the pin from the antenna with pulses. A "room antenna" or poor grounding restricts the current to the cat's whisker. The pulsed discharges of the cat's whisker does the same task as Ken Shoulders' thyratron driven pulsing circuit, or Takaaki Matsumoto's underwater needle discharges [Part 5B], or Mesyat's explosive (spark) discharges.

Indeed, this process was reinvented over and over again by Tesla, Moray and others. Rapid pulses of high voltage are necessary for the needle to form condensed plasmoids, which happen to catalyze the fusion of hydrogen.

Obviously, point corona discharge has been studied systematically since the 1930s. Lichtenberg's figures have also been rediscovered, because they are the mixtures of plasma streamers and plasmoids. These studies, however, never involved oscillating circuits or studies of transmutations, or energy balance.

In the London College experiments up to 1914, Collie and coworkers studied transient spark/corona discharges at the same time as Tesla and Moray lived. They found transmutations, and published their test results in the *Proceedings of the Royal Society*.[4] However, there were no further steps to study oscillating circuits on X-ray film exposure, or current-time (charge) measurements.

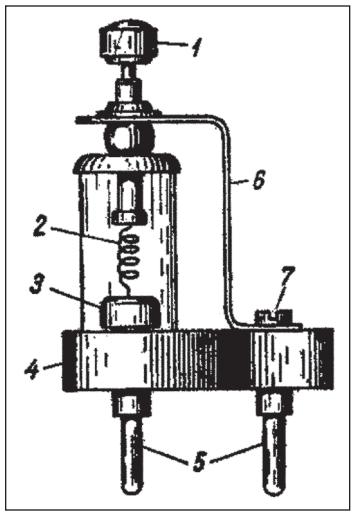


Figure 5b. The diode of the crystal radio—a metal tip and semiconducting lead sulfide, taken from a Russian book (Borisov).

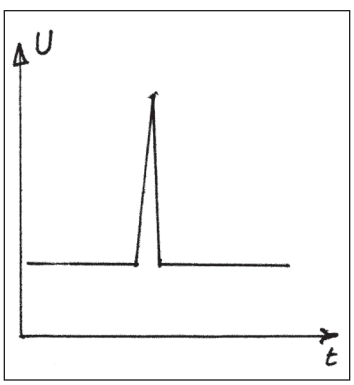


Figure 5c. A sharp short spike (overpotential) from the antenna as barrier discharge drives the spark in the diode gap.

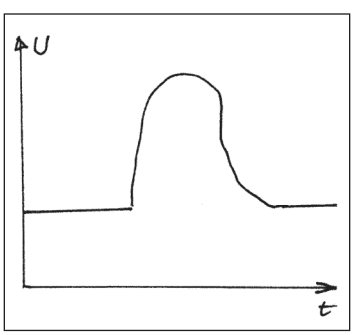


Figure 5d. Due to the spike, a potential step appears on the galenite crystal.

Micro-discharges, and filamentary discharges, are rich and multi-sided phenomena. They have never been studied at enough depth and detail. In fact, without grasping the meaning of rotational symmetry, the nature of quasi-particles and nuclear catalysis, it is not possible to comprehend their outstanding unusual, but useful features.

The Operation of the Moray Invention

Nevertheless, the fundamentals of catalytic fusion reactors can be learned on this device as well. Semiconductor technology grew out later from these roots (the crystalline semiconductor branch). Later, not only amplifiers (transistors) but also digital technology and computers, thus the software industry, grew from these roots.

So the modest, homemade, crystal-based amplitude modulation radio inspired and ignited fusion science and technology as well. It worked only for Tesla and Moray, on different paths of research (working in the shadow of vacuum tube, hot cathode electronics), up to the 1930s.

Let's see the assumed operation based on Figure 5a as a most probable circuit design. When the radio frequency circuit (left hand side) is left open, the tunable capacitor C1 ican be charged up to a considerable level, several hundreds of volts, maybe even kilovolts. Its potential is limited by the spark gap of the diode (Figure 5b), depending on the distance between the pin and the galenite. The insulated antenna, as a dielectric, sometimes delivers a spike in the potential. (See Figure 5c.)

On the anode side (galenite, PbS) crystal, only voltage/current spikes appear (Figure 5d). Note that this setup is not tuned to any radio station, in fact, it is harmful to close switch S, because it short circuits C1.

This setup serves as a relaxation oscillator driven by a high-voltage, and very low current, in the order of micro-pico amperes. (This amount of power is useless for power applications.)

On the right hand side of Figure 5a, there is the low-frequency (max. 10 kHz) audio circuit. The head phone is an inductivity, but biased by a small permanent magnet, to be able to generate acoustic waves by integrating the high-frequency (kHz only) parts of the radio broadcast. There is a deliberate mismatch between the frequencies of the two circuits to make possible the demodulation, or turning, of the long-wave amplitude modulated RF waves into lower frequency (some kHz) audio frequency.

For a radio set, the amount of energy to be extracted is

Figure 5e. The series of "clicks" in our experiments. They are not waves, but separate current pulses, as seen in Part 5A—most probably where young Moray heard these pulses in his headphones.

small, even from the nearby radio stations. The spark-based catalytic fusion, an explosion of condensed plasmoids, may yield a more powerful burst of electric charge, especially if a tube-like crystal detector is used, shown in Figure 5b.

For an open-air whisker–crystal system, the explosive energy of condensed plasmoids is modest or negligible. Thus the inclusion of the diode into a tube seems to be more than just useful; it is necessary.

For a closed tube of Figure 5b with some water vapor in it, the most probable voltage-time history is shown in Figure 5e.

It can be a series of clicks, stronger than that of a nearby radio station. These were the "clicks in the earphone" that aroused the curiosity of the eleven-year-old Moray in Salt Lake City. This gave him the motivation to study electrical engineering, which was a help him to a degree with grasping the meaning of resonant circuits.

The Challenges

Obviously, Moray wanted to understand the effect in order to increase the power. The concept of catalytic fusion was way beyond his grasp, or any of his contemporaries—for example, a certain patent examiner: Albert Einstein, or Rutherford, the first nuclear physicist, or Planck, who paved the way toward quantum physics.

Moray and Tesla made the road ahead always by trial and error: to increase the surface of the galenite crystal, to increase the amount of discharges, to find the proper power tube structure, pressure and gas composition, etc.

Moray never published the details of his device, hoping (in vain) for proper R&D funding to the very end of his life in 1974. By then, all major nuclear powers spent trillions of dollars on hot fusion military projects, and assumed they had mastered (hot) fusion physics. Spark-based, catalytic fusion, mastered by Tesla and Moray, was a totally incomprehensible, alien technology to them. The birth of LENR as a catalytic concept never took off from the lab of London College in the 1910s either. So the concept of controlled fusion became fatefully tied to the process of the H-bomb. To make it worse, the processes within the stars were also assumed to follow these hot fusion effects, lacking temperature data about the corona.

All the valuable know-how went to the grave with their deaths. They never revealed their technology. Moray never told it even to his sons. This was the third, but not the last, case when experience gained in catalytic controlled, low energy fusion was lost.

Moray's challenge was (among others) how to capture the electric energy released during the filamentary discharge. He had some rudimentary transient voltage measuring devices, such as a simple cathode ray device to help him.

Moray noted two things: Sometimes he observed very powerful, high amplitude voltage/current bursts, whose amplitude exceeded the voltage and power output amplitudes of the audio circuits by several orders of magnitude. He also observed increasing low-frequency voltage oscillations in the "low-frequency" audio circuit. He termed it with a parable. "Inertia sets in" when oscillations of the ether arrives. These are meaningless phrases. Moray never disclosed that he meant this for voltage and current oscillations.

In the fourth edition of *The Sea of Energy in Which the Earth Floats*, Moray writes (p. 45):

> This energy may come to the planets as oscillations similar to the oscillations and tides of the sea. The Radiant Energy tubes received this energy in surges which may last only a few microseconds, but the pressure (voltage) and the current in those surges are so large that sufficient energy is delivered to the equipment in resonance as to be unlimited and usable in multiple flashes and a magnitude which will compete with the light of the day.

These "bursts" were also observed by the author in the rather unreliable arc discharge devices of Correa and Chernetzky.

How Does Spark-Generated Catalytic LENR Work?

This section is written according to my lab experience. Some of the statements are speculative, because the diagnostics of condensed plasmoid catalysis does not exist yet. Nevertheless, they are based on actual observations of a similar circuit shown in Figure 5a.

It is very likely that two separate phenomena take place during the catalysis of condensed plamoids. One is based on short, nanosecond order disruptions. The other is a rather slow, continuous electron emission, when condensed plasmoids are in the "white" mode.

There is a regular series of small amplitude current bursts for the first one, shown in Part 5B, when under a sinusoid voltage the discharge current is a series of micro-discharges, or corona discharges even at zero voltages. There is no discharge at all at peak voltages. The intensity of the current peaks was not responsive to the voltage. Current peaks were observed only at high values of $\partial E(r,t)/\partial t$, but no current was observed at all when voltage peaked. The energy of these power bursts can be integrated (harnessed) with a resonant circuit, because they are active only in the above-mentioned phase of an oscillating circuit. (We may term this a "coherent state.")

During these current peaks, the condensed plasmoids are assumed to catalyze fusion only during increasing electric field phase. Thus the voltage amplitudes of the harvesting circuit current may increase only up to a maximum amplitude, then be maintained for awhile, driving the load. During these induced catalytic processes, condensed plasmoids seem to emit high velocity electrons. Electrons leaving the plasmoids are decelerated in the electric field, between the cathode and anode. Thus the tube acts as a gen-

erator. This happens only in the presence of hydrogen isotopes. This is the catalytic fusion principle behind all the inventions to be discussed here. These catalytic processes do not take place with high-mass inert gases, like neon or argon, as Jacques Dufour noted [Part 5a].

In the regulated, "tamed" or "triggered" catalysis of condensed plasmoids it is necessary to have the output in the form of potential energy, which is more economic than heat. If the shedding of excess energy electrons due to catalytic LENR is completely random, then one may extract heat only. There must be a delicate balance between the energy (velocity) of the ejected electrons and the voltage-electric gradient in the discharge tubes.

If the electrons have too high a velocity when leaving the condensed plasmoids, they will be decelerated to a degree when reaching the anode, but part of their energy will be dissipated as heat, thus lost when hitting the anode. (Instead of a "soft" landing, it is a "hard" landing.)

On the other hand, when their exit energy is too low when leaving the surface of condensed plasmoids, they will be turned away before reaching the surface of the anode, being at a higher potential, thus wasting their energy gain.

It is essential to choose, or "tune" to the frequency-dependent value of $\partial E(r,t)/\partial t$, when the catalytic intensity matches the voltage difference of the harvesting oscillatory frequency and voltage (electric field gradient).

Too low extraction frequency results in low intensity catalysis; most of the amount and velocity of ejected electrons are wasted. If the voltage amplitude of the harvesting circuit (the audio circuit in Figure 5a), is too low, the excess energy is wasted again when hitting the anode, as mentioned before. Thus the load coupled to this circuit must be decreased.

For too high frequency, and when the ohmic load is too much, there is again considerable waste—as most of the condensed plasmoids are triggered to catalyze fusion and emit electrons. These electrons carry the excess energy gained during catalytic fusion, as discussed in Part 5B. When the electric potential of the harvesting circuit is too small, it cannot decelerate all the kinetic energy. They cannot efficiently decelerate the electrons, leaving the condensed plasmoids with their excess energy.

The most difficult part is to deal with the deceleration of the charges, because they are embedded into a plasma. See Figure 5d as an analogy to the situation. A note to readers: The number of condensed plasmoids depends on a number of parameters, like the shape of the discharge tube, its materials, the plasma composition and the method of excitation, etc. They are not discussed here because it would far exceed the volume of this paper. (Later, we shall return to this subject in a different series of detailed papers.)

Setting this delicate balance between catalytic electron emission intensity (their number and kinetic energy) and their "harvesting" is a major design/operation task. It was for Tesla, Moray, etc. and for us as well.

Figure 5f may help the reader to grasp how and why to balance the rates of catalytic fusion and electric energy extraction. The mechanical analogy of triggered catalysis is illustrated on balls and tilted paths, matching the rate of catalysis and capture potentials at a given time.

α) Too high catalytic triggering rate makes the condensed plasmoids explode. Most energy is wasted before it is captured.
β) Proper generation and extraction level, long term sustained catalysis by condensed plasmoids. The energy generated is captured without much loss.
γ) Too low energy generation level, emitted electrons are few and have low energy, so they cannot climb up to the expected potential level.

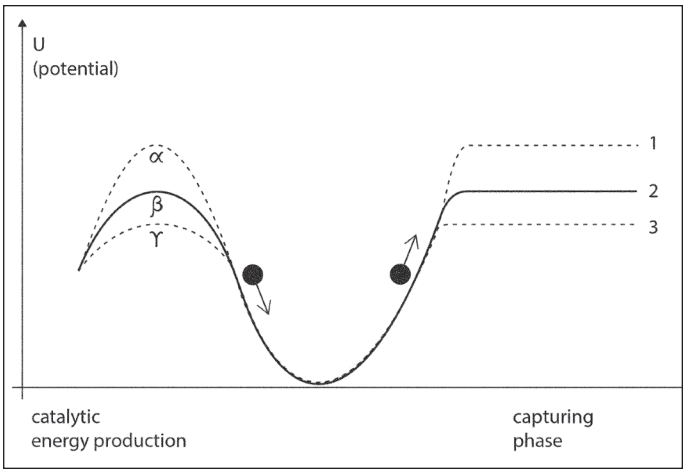


Figure 5f. The scheme of generation and harvesting of electric energy during a spark discharge in hydrogen.

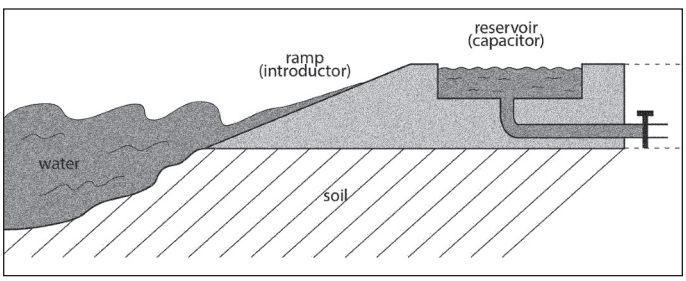


Figure 5g. The "sea of energy": the analogy by Moray about capturing the "waves of the universe." In fact these "surges" came from the exploding condensed plasmoids by triggering their catalysis, but not from the universe. This example is how to convert kinetic energy into useful potential energy.

Now let's see the other side, the harvesting or extraction side:

1) Electrons to be captured do not have enough energy to reach the capturing potential, and they return before capturing.
2) The properly maintained capturing potential level. The electrons just reach their highest potential. (Soft landing.)
3) Too high kinetic energy for capturing: most of the kinetic energy of the electrons released from the condensed plasmoids is wasted into heat. (Hard landing.)

In our experience, matching the production/extraction levels was possible only by trial and error. The number of free design and operation parameters is really bewildering. The task is a slow optimization process. The most important guideline is: measure the time-dependent potential of the harvesting circuit, and watch when its potential starts increasing despite a load. See Figure 6 as an example. This problem is a kind of "impedance matching." The engine throttle and the gearbox must be matched to the air resistance in a car. That event was caught on the oscilloscope in

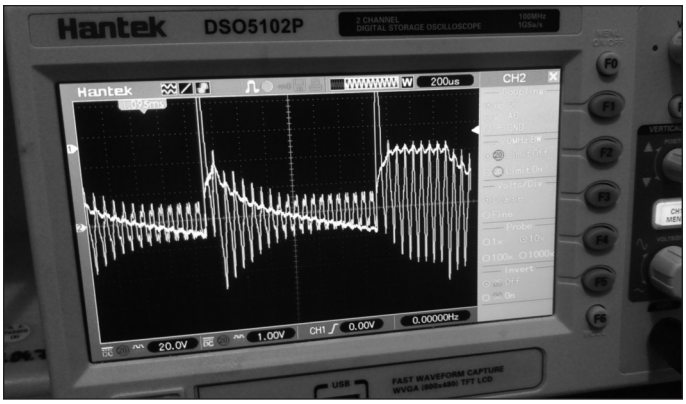


Figure 6. "Inertia kicks in" in our experiments. A successful capturing after two unsuccessful cycles, when the emitted electrons were not captured, but dissipated as current losses. Then the voltage amplitude of the harvesting circuit increases.

Figure 6, when the load was gradually decreased. Then came the proper matching, when the electron energy production was caught by the harvesting cycle, and its potential grew, instead of dissipated. After two unsuccessful cycles without capturing the excess energy, the "inertia kicks in," that is, generation/harvesting parameters are nearly optimal.

Moray, and Tesla, termed it "resilience of the Universe," when the generation/harvesting is matched perfectly, and this equilibrium between the amount of catalytic fusion and capturing/dissipation on ohmic load is maintained indefinitely. We have not had enough skill to maintain this ideal condition so far. The oscillation has an increasing or decreasing amplitude.

Moray made a sophisticated adaptive harvesting circuit to satisfy the need for changing load. Indeed, an electric car, for example, demands a changing power output. Thus the power production circuit (RF) and the harvesting circuit (audio frequency) must be matched continuously. However, a large battery pack at a pre-set harvesting voltage simplifies the production/extraction task for the operation of the LENR device. Such a LENR reactor and the excitation/extraction circuits reduce the size of a battery pack substantially. Thus an electric car/EVTOL airplane is lighter, cheaper and has a practically unlimited range. This is what makes the plasmon polariton and condensed plasmoid generation/controlled catalysis so important.

Thinking in terms of an analogy makes it easier to grasp the problems. Thus the extraction circuit is an analog to the ocean beach, when waves of different amplitude reach the coast. The capturing, extraction device is shown in Figure 5g, where a reservoir (capacitor) is fed intermittently by waves, and bled continuously. The water level in the reservoir depends on the time averaged wave energy and mass flux input and water output ratio.

This is simple, classical physics/engineering. This was Tesla's oscillating ether energy, and Moray's "sea of energy." The "water supply," the catalytic electron shedding by condensed plasmoids, is outside the realm of classical electrodynamics. (See Parts 1, 2, and 3.) It may be similar to the eddy current heating, or inductive heating, in plasma physics or metal heating. Also, capacitive plasma heating is a sort of analogy. Condensed plasmoid formations have the analogy of fluid ring vortexes as quasi-particles. Another analogy to the induced catalysis may be the twisting of a wet rug. Most of the liquid pours out just at the beginning of the twist. There is no more squeezed liquid out of the rug at the peak torque since it is nearly dry by then.

The novelty is: steady E, B fields do not initiate catalytic action, only transient ones, as discussed before. Thus filamentary discharge (corona, spark discharge) is necessary for the formation of condensed plasmoids, but to maintain their catalytic actions, changing external fields are also necessary as a function of time.

A plasma around the atmospheric density has its own acoustic oscillations, which depend on the ratio of discharge and inert volume. It is hopeless to calculate anything here based on textbook physics. The tuning, and matching all the frequencies to a common resonant frequency range, is an experimental problem, not a theoretical one at this early stage.

The Oscillating Universe Model

Through history, each discovery was made along an analogy model. Tesla imagined a dynamic, oscillating Universe as an inexhaustible source of energy. Moray, along the same line, assumed this energy was like the waves on a beach—hence the title of his book *The Sea of Energy*.

Both models were forgotten, because there was no clear experimental instruction on how to make it happen, or how to induce them.

The models and concepts are always very important. Some examples:

- Luigi Galvani's model of "animal magnetism" with contracting frog legs between different metals was met with ridicule. Only the experiments with Voltaic columns rehabilitated it, opening a new era.
- Faraday's "force field" concept met immediate stiff resistance. Only Maxwell's theory rehabilitated him.
- Oerstead's "white hot wire makes magnetic field" concept was rejected—this time with reason.

Tesla and Moray missed finding the causal relations between sparky plasma in hydrogen and the "energy surges."

Plasma physicists also missed realizing the qualitative difference between a Townsend discharge (avalanche ionization) and a sparky discharge, where highly charged, long-lived, pseudo-particles are formed. They utterly failed to realize its useful catalytic features.

The results (models) of Raether, Mesyats, Shoulders, Matsumoto, etc. completely escaped them, over and over.

This is one reason why the discoveries (models) of Tesla and Moray never made an inroad to practical devices, despite their importance.

Sometimes the condensed plasmoids not only catalyze, but also explode with a bang. This must be considered as a partial energy loss. These mini explosions are visible on the oscilloscope as current spikes, or isolated current spikes. (These bursts are visible sometimes on the pages of old textbooks in arc discharges, when raw data is shown.) See Figure 7.

Therefore a search for production/extraction balance, an optimization, must take place between the input circuit causing discharge in the tube, and in the extraction circuit.

Further, the frequency of the harvesting circuit or extrac-

tion must be within a narrow range, having the proper electric gradient to trigger an optimum amount of catalysis in the plasmoids. Finally, the load (ohms resistance or impedance) must also be matched to limit the capturing, decelerating electric field intensity. (Other inventors, to be discussed later, solved this problem by different methods.)

Moray, unaware of the background physics, noted that he had to carefully choose/optimize the frequency and the voltage amplitude of the harvesting circuit. He built an elaborate regulating feedback circuit system, sketched only in his book by a block diagram, in a technically useless manner for us.

He wanted to show it off to his frequent visitors, but did not reveal the details: to have the cake and eat it at the same time. The USPTO repeatedly rejected this invention. It just cannot work, based on established textbook physics.

Nobody ever detected these mysterious oscillations of the Universe that Moray and Tesla assumed to drive their machines. Although they were fully aware of the importance of brush (filamentary) discharges to trigger them as a necessary condition, they were unable to work out the detailed step by step sequence in physics.

In fact it was Raether in the 1930s, then Mesyats in the 1970s, then Shoulders, who made the first meaningful steps by discovering and describing some features of "heavy electrons" ("exotic vacuum objecs," EVOs, as Shoulders termed it). Thus we stand again on giants' shoulders, now on Shoulders' shoulders.

How to Get Rid of the Antenna?

Moray must have realized that the need for the antenna and grounding is a severe drawback, as it is cumbersome, and makes the device immobile.

Eventually, he understood that it serves only as a high voltage electric pulse generator of rather irregular frequency. Tesla also fought for a long time to make high-voltage high-frequency switches, as alternators. He tried several electric and mechanical switches in the 1890s, and patented a string of them.

For Moray, the pulse generation breakthrough came on the June 24, 1925, according to the fourth edition of his book *The Sea of Energy* (p. 129). He found a germanium-based solid state electronic switch, where alloys of bismuth were also used, along with FeS. In fact, it was a threshold switch, an amorphous semiconductor. Moray filed a separate patent application under serial number 550611 in July 1931. The USPTO flatly rejected it, because, they assumed, only vacuum tubes can perform as switches, or amplifiers. Despite years of patient waiting, no patent was granted. The idea, and thus the whole apparatus, sank to the grave with Moray.

Decades later in 1966, a U.S. patent was granted to Stanford R. Ovshinsky, for the very same invention, under number 3,271,591.

Two years later, Ovshinsky published an experimental paper in *Physical Review Letters*[5] with an example of the high-frequency switch composition: 48% tellurium, 30% arsenic, 12% silicon, 10% germanium. (There are, in fact, an infinite amount of possible combinations.)

The solid state physics community was in an uproar and wanted the editors of *Physical Review Letters* to retract the paper, because Ovshinsky was not a solid state physicist, just an inventor.

Moray considered the small "Moray detector" as his most valuable invention. Moray never revealed it (like Veres, a Hungarian who re-discovered but didn't disclose it in the 2010s). He kept it in his pocket, allowing selected people to look into his device after demonstrations. Those inspectors saw tubes with a faint blush glow, coils, capacitors, but no hidden batteries.

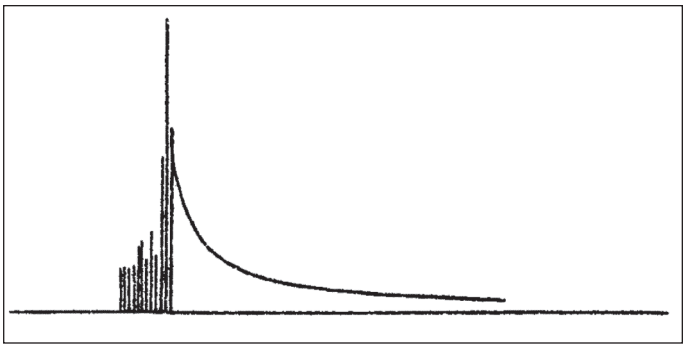


Figure 7. A series of sudden current bursts from a discharge tube in a glow/arc transition in an inductive circuit. (From J.M. Meek, J.D. Craggs, *Electrical Breakdown of Gases*, Clarendon Press, 1953, p. 467, Figure 12.17/b.)

This threshold switch drama sealed the fate of the Moray invention.

Had the Japanese bought the invention in the 1930s from Moray or Tesla, history would have been different. World War II, Pearl Harbor, etc. would have been unnecessary, because for them, World War II was a resource war for energy.

In an oscillating circuit (even if it contains gas discharge tubes), the input energy always dissipates. The current or voltage of these oscillations diminishes in a monotonous manner. These are "trumpet"-like exponential decay functions. "Surges," as Moray termed the increasing amplitudes, can be the consequences of energy generation. Gradual voltage increase may occur only when capacitors store energy in oscillation circuits, and there is a power source in the circuit.

In our tests, these amplitude surges were observed only in hydrogen or water vapor plasma. In dry air, as a control, no amplitude surges were observed.

The Moray device is like the car: a collection of cooperating inventions.

The portable version of the Moray device contained the following set of inventions:

1) The "valve," a high voltage amorphous semiconductor threshold switch. There is no such device in production today because there is no demand for it. Mosfets or insolated-gate bipolar transistors (IGBT) do not serve well here since their switching time is slow, and switch voltages are at max. 1 kV. Ken Shoulders used an ignition tube instead of this detector, because this yields high $\partial E(r,t)/\partial t$, which is necessary for the formation of condensed plasmoids and surface plasmons.

2) The Moray metal. This author tried, and failed, to reproduce a ductile, thin plate, containing sulphur and lead, Al and Cu. Maybe much more skill and patience is required. It may have served as the cathode or anode in his tube. Moray never published any details about his rubber invention, neither the composition nor its purpose. Any guess would be very speculative. My guess is that the antenna was insulated with this rubber, but it became obsolete with the invention of the Moray valve, the threshold switch.

3) The circuit layout of the three-stage cascade electric circuit. One stage (pulse formation, gas discharge tube for power production and a final energy extraction circuit) is not enough to make kilowatts. Therefore Moray used three units in a serial connection, to make about 50 kW output with a feedback. Thus after the first ignition, his device did not require an external power input.
4) The power tube construction was never shown in public. Only a sketchy drawing in Moray's only granted patent lets us make an intelligent guess.

The Moray device is the highest quality of all available (fragmented) descriptions of LENR reactors. Tesla probably used silicon carbide in his device, as that was his favorite in the 1890s.

The assumption of an external, hidden, unknown oscillatory energy source from the universe was a bitter compromise. It never helped them to have a better design, due to their lack of insight in physics. Despite this serious problem, they persevered by trial and error.

Plasma Composition

Tesla left no clear indication about his favorite plasma composition. At his sparky, high-voltage transformer demonstrations it was always atmospheric air, with varying degrees of humidity. In gas discharge tubes, he certainly had some oxygen, even at the price of burning the carbon content of his cathodes.

Moray, on the other hand, was clear about his preferred plasma medium: water vapor. He also mentioned a "special getter" material in his discharge tubes. Maybe its purpose was to absorb oxygen, released when the water plasma was split into hydrogen and oxygen.

As shown in Table 1 of Part 5B, whenever the chemical composition of the plasma was known explicitly, hydrogen was there—either as pure gas, or in the form of water vapor. However, no inventor ever used deuterium (or tritium). It was not available (for Moray and Tesla) or impractical, being more expensive than hydrogen.

Is it possible that water vapor is more favorable for condensed plasmoid formation than pure hydrogen?

Only Dufour's study (Part 5B) gives a hint: the charge emission was more intensive in deuterium gas, compared to hydrogen. There was no definitive study along the same line (spark based reactor chamber) to test the performance of various compositions for hydrogen/deuterium/vapor mixtures, not to speak of carbohydrates. This is a big problem because the behavior of these plasmas (their ability to form condensed plasmoids) is fundamental.

Likewise, a different internal combusion engine (ICE) is designed for gas and diesel fuel, and their thermodynamic cycle is distinctly different.

The same is expected here, in our case. The pressure range is seldom specified, if it all. The Correa and Chernetzky devices worked at very low pressures, well under a tenth of mercury millimeter, while all "water cars" were well above atmospheric pressure. This means that we must experiment with the pressure range of about five orders of magnitude, from 0.01 mercury mm to 10 bars. This requires quite different sealing, pumps and pressure gauges!

The operation of these devices are very different as well. While most of them run continuously (with a periodicity above 10 kHz), some, like the Horvath and Papp engines, are based on a series of low frequency acoustic explosions. The repetition rate also differs by orders of magnitudes. Note however, that there is no steady-state type device at all! All the devices (as shown in Table 1 of Part 5B) are based on repetitive, fast rising transient plasmas with high spatial and temporal electric field gradients containing hydrogen.

Thus readers are requested to always look out for microdischarges or spark discharges, being the area of $\partial E(r,t)/\partial t$; $\partial B(r,t)/\partial t$ high temporal and spatial gradients.

This corner of engineering parameters is not in use today. To get to this area, a large amount of know-how is required, to make such transients and to measure them.

For technically inexperienced people, only strings of failures are guaranteed.

I strongly recommend that interested readers should start a series of investigation along this line. Instead of an antenna, Shoulders used 2 kV short pulses and the switch was an ignition tube. Underwater sparking experiments also provide two important ingredients: a) short bursts and plasma formation around a tip; b) hydrogen in the plasma. Both are necessary, but sparks in the hydrogen gas/vapor atmosphere are more efficient. Interested readers may read more on the history of Moray's inventions and his ideas in my four-part IE series "Forgotten Inventions of LENR."[6]

All in all, both Tesla and Moray faced and solved three problems:

1. To form condensed plasmoids with efficient spark discharge.
2. To force the condensed plasmoids to catalyze fusion of hydrogen nuclei by transient external electric fields (perhaps also magnetic fields). This was termed the "white" mode.
3. To capture the high-energy electrons ejected from the condensed plasmoids in the form of potential electric energy. The condensed plasmoids sink into a passive, "dark" mode without an external excitation field. Eventually they decay, but their half-life depends on a number of parameters not yet clear at this time—like the composition of their materials, size, the material environment, temperature, etc. No one can calculate anything yet. The number of free parameters is astonishing, especially for the discharge tube (electrode material composition, electrode shape & size, composition of plasma, initial electric pulse shape and power, etc.). Intuition, perseverance, data acquisition, evaluation, etc. are all necessary.

Though the discussion of Tesla and Moray inventions was rather long, some additional reactors will come to verify over and over again the principles laid down previously.

The Spark-driven Horvath LENR Reactors

Hungarian born Stephen Horvath, living in Australia, made headlines in the local media about his "water car" in the 1980s (just as Papp, another Hungarian, did in California).

Of the two systems, Papp's reactor was better, because it was a closed system continuously producing deuterium and tritium with sparks. The Horvath LENR reactor is a hydrogen-based internal combustion system, letting the enriched deuterium and tritium leave through the tailpipe, which is a really bad engineering solution. While Papp had no idea

about the source of excess energy, Horvath was aware of it, but not to the details of the catalytic steps.

In Part 5D, more forgotten patents will be discussed. All granted U.S. patents involve underwater sparks. Most of them are less detailed than those discussed here. Readers will hopefully be able "to read between the lines" by then, to understand the devices better than the inventors did.

In his U.S. patent (4,454,850; 1984) Horvath claimed that his hydrogen/air ICE had a thermal efficiency of 39% when the LENR spark reactor was switched on, and only 18% when petrol driven. The dynamometer tests yielded 23 British horsepower for gasoline at 40 miles/hour equivalent speed and 1500 rev/sec, yet at the same parameters 30.7 BHP for hydrogen sparking LENR reactors.

He had the following arguments for the appearance of controlled nuclear fusion:

1. The helium content was 18 ppm permanently, while the background value was only 5.2 ppm. The data was taken by a Varian/Lexington leak detector—a mass spectrometer. Horvath's interpretation was:

$$D_1^2 + D_1^2 \rightarrow He_2^3 + n_0^1 + 3.27 \text{ MeV}$$

$$D_1^2 + D_1^2 \rightarrow T_1^3 + p_1^1 + 4.03 \text{ MeV}$$

Horvath considered these fusion reactions between deuterium nuclei, but he also proposed new hot fusion reactions, dismissed in hot fusion reactors, in the following manner:

$$D_1^2 + He_2^3 \rightarrow He_2^4 + p_1^1 + 18.3 \text{ MeV}$$

However, he ruled out the interactions of fast neutrons in any further reactions.

His nuclear reaction arguments are questionable because the density of deuterium is very low if it occurs only in a natural isotope distribution.

He shies away from the most important question: what is the deuterium enrichment process like? He speculates that the compression wave energy density is enough for the LENR process. The patent speculates:

> The electrical discharge also cause acceleration of the ionized deuterons in the hydrogen, which increases their energy...The total energy thus obtained is sufficient to cause the highly ionized deuterium in the hydrogen to undergo a controlled nuclear fusion with consequent liberation of energy…The fuel consumption is very much less than would be achieved by a normal combustion process.

2. Neutron radiations were tested by the activation of In^{115} foil (0.5 mm thick). Significant γ activity was measured by a sodium iodine scintillation crystal. Besides, neutron sensitive films were placed inside the reactor, indicating neutron activation (Kodak LR115 2B and 80-15 type 1B).

3. Tritium was measured in the condensed vapor of the exhaust with liquid scintillation methods (just as in the Claytor experiment at LANL).

In the Pons-Fleischmann LENR reactors, neutrons, helium and tritium are not always detected. This new process might be different, but it is not "real" hot fusion. The Lawson criteria is not met by orders of magnitude at these low temperatures.

The Strange Design of the Horvath Reactor

The cross section of the reactor is shown in Figure 8a (Figure 4 of the Horvath patent). There are two different sparking volumes, by two different sparking methods, according to the patent. There is an indirectly heated cathode (74) and anode (75) in the center, both of them flat and metallic. No effect of surface roughness is mentioned; is it part of the know-how?

The sparking takes place well above atmospheric pressure in hydrogen/air mixture. No specific cathode temperature is quoted, but the electron emission is enough for spark formation above 1000°C at 40 kV and 5-10 atmospheric pressure. On the (sharp) edges of the heated cathode, enough electrons can leave to form condensed plasmoids. This type of non-self-sustained (hot cathode) pulsed filamentary discharge has not been studied. This discharge area is to be found on the boundary of hot cathode pulsed arc discharge and corona discharge. It seems that an inventor has found something that plasma physicists have not even dreamed of.

The external electric field is strange. The anode is star shaped (good for positive corona discharge), shown as (60) in the cross section of Figure 8b (Figure 5 of the patent), while the cathode (70) is cylindrical.

The anode is shown separately in Figure 8c (Figure 9 of the patent). Corona-arc or spark discharges are possible if edges (122) are sharp.

However, there is an unexpected twist in the story: the presence and the structure of the static magnetic field is a source of conflicting parameters.

First of all, the two sets of magnetic fields are nowhere perpendicular to the electric fields, thus Lorentz

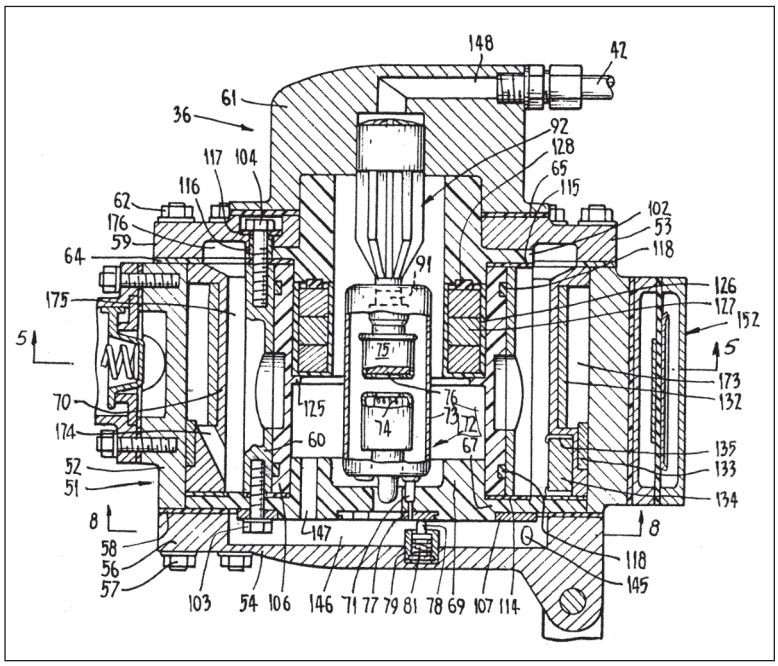


Figure 8a. The Horvath hydrogen sparking reactor cross section. Note heated cathode (74) and permanent magnets (174).

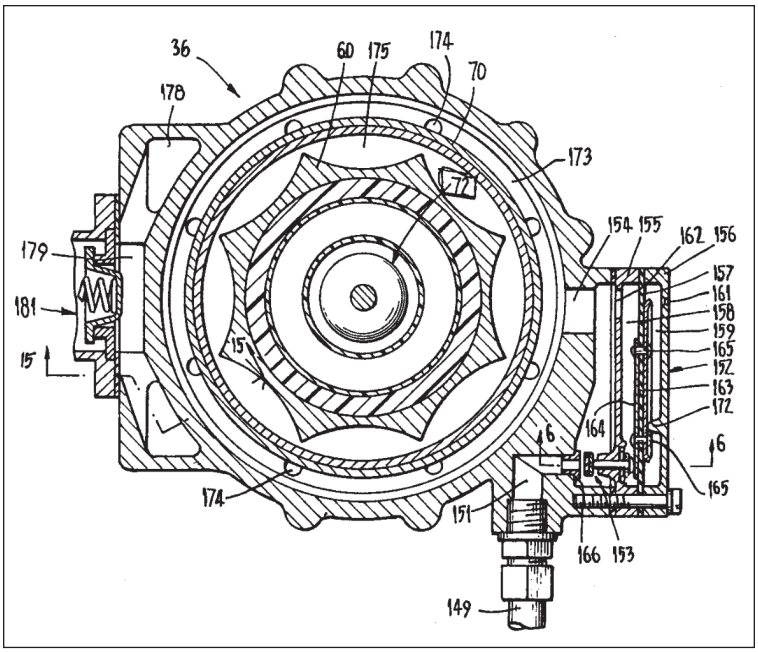


Figure 8b. Horizontal cross section of Figure 8a. Note the sharp edges of electrode (60).

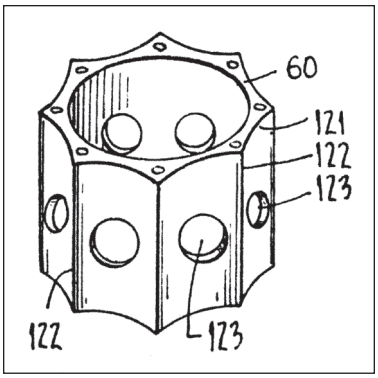


Figure 8c. Axonometric view of electrode (60) with sharp edges.

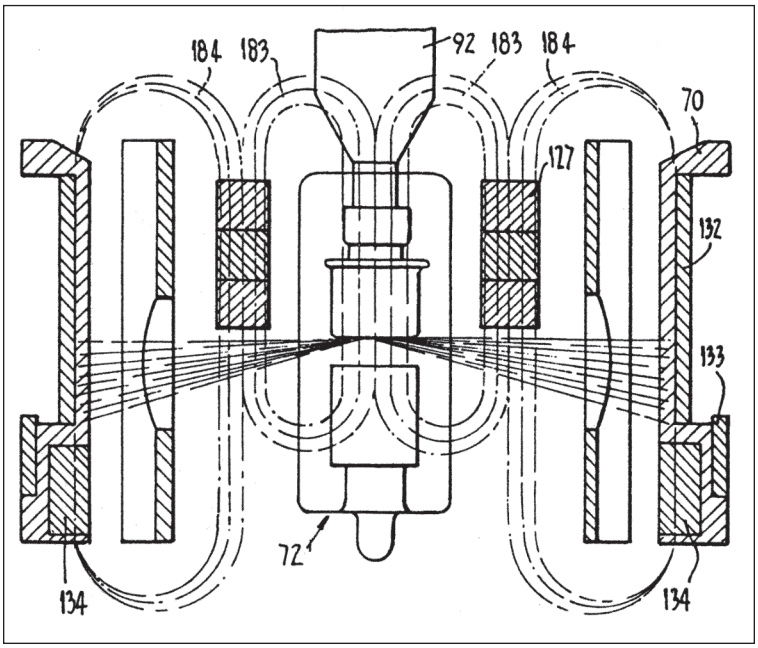


Figure 8d. The intricate magnetic field distribution inside the reactor. Neutron radiation is shown to spread radially, through a hole of the electrode (60).

forces/rotation is not generated. Between the axial electrodes (74, 75) the magnetic field is parallel to the electric field. (Although, ionization rate can be higher than usual by the rotation of electrons.) See Figure 8d (Figure 16 in the patent).

There is no magnetic field in the external, radial-annular electric field between electrodes (60, 70) if the description is correct. However, the unique features are already apparent by now: a hot cathode inner sparking chamber, a cold cathode outer sparking chamber.

Horvath gives a meaningless explanation for the presence of the magnetic field: "Magnetic field serves to accelerate the electrons which bombard the radiation tube anode."

Magnetic fields do not accelerate electrons, as we know, especially when the arc is parallel to the (accelerating) electric field.

Another enigma is the cathode temperature. If it is heated (as it is here), it heats the permanent magnets above their Curie point, and thus demagnetizes them.

Horvath certainly gets into internal contradictions here.

The salient, and the most important, consequence for us is in the statement: "Very high pulsating DC voltage is applied between the filament and anode 75 of the (inner) radiation tube...Typically the voltage between the filament and the anode will be 40 kV with a superimposed ripple of 2-4 kV…"

He talks about a radiation intensity of 3000 Roentgens/hour (quite a high value). However, the physical nature of this radiation is very murky. The patent states: "The creation of this high flux of photons is associated with release of large numbers of neutrons within the tungsten target of the radiation beam."

This "neutron radiation" is shown to spread radially from the anode.

I don't have personal hands-on experience with this apparatus, because the hydrogen/air mixture is highly explosive, very dangerous to use even for experienced staff.

Nevertheless, the "pulsed voltage" (without a specified frequency) is a feature of all LENR reactors in this part, as a necessary condition for condensed plasmoid generation. (See Part 1.) They can certainly catalyze from protons and electrons, neutrons, although with a -0.78 MeV energy investment. Then the newly formed neutrons may "pay back" the invested energy amply when fusing into deuterium, tritium, H_2^1 and H_3^1.

This is all about engineering skill, how to retain the reaction heat, and later to turn it into mechanical energy via the Carnot cycle of the ICE engine.

Horvath, Papp and Jekkel (all Hungarians and paranoids) followed this broad path. (Papp's engine was never used in a car, only made torque tests. Horvath's machine traveled only a few miles, because the hydrogen storage was not solved then. However, Jekkel's converted Moskvitch 407 did hit the road, and was caught and fined by the police due to illegal fuel usage—water.)

The Afterlife of the Horvath Reactor

Horvath offered his work to the Hungarian state at the end of the 1970s. My director at the Nuclear Energy Research Lab, Zoltán Gyimesi, flew to Australia to see the machine and meet Horvath. (It took a year for the preparation.) By the time he got to Australia, however, Horvath had sold the machine, so Horvath didn't show him anything. Then Horvath disappeared from the public eye for years.

When I, as a young research fellow working under Gyimesi, asked him about the technical description

Horvath provided, he just replied, "It is a state secret."

Knowing him, no wonder. He (and everybody in the @2000-person lab) was unable to make any sense of this invention. For each experienced researcher in our lab, reading this patent was a bewildering nonsense, yet it worked somehow! I am not aware how Horvath got the U.S. patent based on this shallow data. Were there sworn affidavits? Anyway, this expensive, but failed trip was quite embarrassing for Gyimesi. I remember there was only one meaningful question to him at a regular group leader meeting: "Did you at least see a real kangaroo?"

A Personal Assessment of the Horvath LENR Reactor

This reactor is certainly more than a discovery, but fell short of a sophisticated invention, where a host of auxiliary effects must be used skillfully (hence it is an invention). For example, it is not clear in the figures how the ring-shaped set of permanent magnets are cooled, because their field is irreversibly damaged even at half of the Curie point of phase change.

In general, the very reason and function of the complicated magnetic field is not defined. However, the same problem arises with the Papp and Jekkel inventions as well.

The role of acoustic shock waves is neglected in the description. The piston and combustion cylinders of the engine are kept separately in this reactor, if the patent description is correctly interpreted, but this important part is murky. (This was sloppiness on behalf of the patent examiner.) Papp definitely paid attention to the acoustics; the tips of the conical electrodes of his later patents are in the acoustic focus of the combustion chamber. In Jekkel's reactor, LENR fusion and oxygas combustion happen separately. From an engineering point of view: Why let deuterium and tritium burn in a chemical reaction and let them leave?

The next serious problem is the inadequate description of the electric circuit. A static description is inadequate; the shape of the current and potential transients ought to be provided, in order to be able to repeat the claimed fusion effects. This is clearly missing.

Dufour's Invention

The Jacques Dufour invention was previously discussed in Part 5A. This fusion device is a remake of Collie's discovery, of the 1910s at London College, forgotten by now, made as a simple spark reactor.

It is a simple sparking device in hydrogen from an engineering point of view, though the papers on the physical and nuclear after effects are well written.

Though the key Dufour paper[7] was written some 20 years ago and well documented in a refereed journal (*Fusion Technology*), it had zero impact. None of the recent, most detailed monographs on transient discharges has any reference to it. (See for instance Kip Thorne's *Modern Classical Physics CRC Handbook*, 2020.)

When Oersted, Ampere, Faraday, Hertz and Roentgen made their experiments in electrodynamics in the 19th century, they were repeated by their contemporaries by the hundreds! Now, a hundred years later, fundamental discoveries are always ignored!

Dufour's simple sparky reactor is shown in Figure 2c of Part 5B. It has a radial layout; the cathodes are four radial sets of thin copper wires. The sparks have a small volume compared to the whole volume of the reactor chamber. No interaction is assumed between the plasma oscillations and hydrogen gas, that is, resonant effects are ignored. Sparking is realized by a car ignition starter with about 30 kV. Sparks are always a set of short burst of currents, whereas some arcs can be maintained at steady state, and therefore the induction term of spin field generation applies.

Dufour's theoretical idea of fusion by a deep orbit is apparent in this design. Fast transients provided by sparks and plasma-gas interactions are not important there. The apparently incorrect theoretical model hampered the improvement of the engineering, so theory was detrimental to engineering. Thus the proverb is proven again: "Nothing is more practical than a good theory." Thus the generation of quasi-particles, catalysts of fusion, is ignored.

Nevertheless, the presence of fusion in hydrogen and deuterium is clearly, succinctly stated.

The Papp Inert Gas Engine (Mechanical Shock Waves)

The Joseph Papp LENR story and even a patent is published in *IE* #51. Papp was granted three patents (3,670,494/1972; 3,670,494/1972; 4,428,193/1984). The soul of the last version of the machine is made of quadruple conical high-voltage electrodes driven by high-voltage high-frequency pulses. The essence is partly the conical electrodes, as it was for Tesla and Shoulders. They were never thoroughly investigated in the discharge research. (Conical surfaces amplify the intensity of plasmon polaritons.) See Figure 9a (and also Photo 4, p. 19, Issue 136 of "Forgotten Inventions of LENR, Part 3"[6])

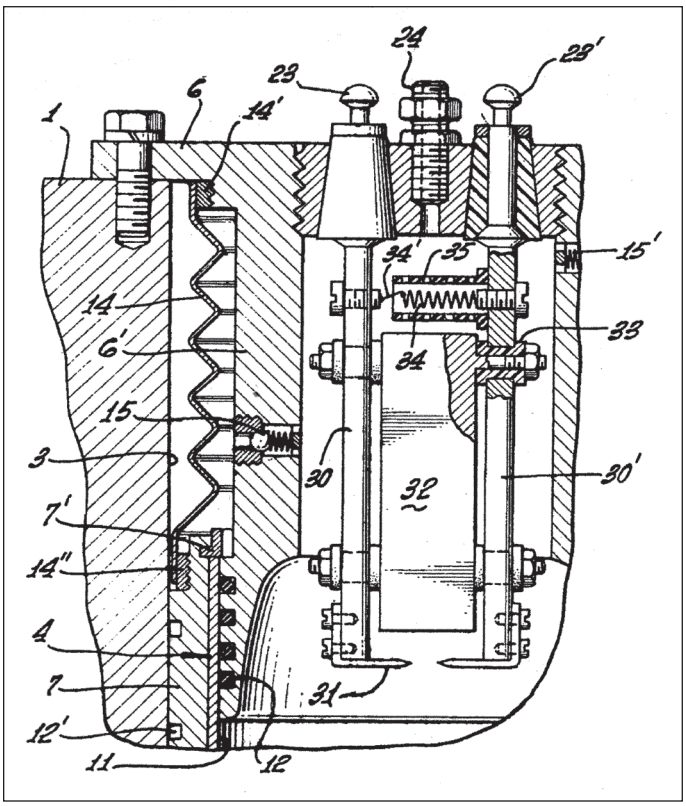


Figure 9a. The conical surface of the Papp electrodes, similar to Tesla's tube shown in Part 5B. The beneficial effects of conical electrodes were never investigated in gas discharge research.

Though it is always referred to as an inert gas engine, it actually was driven by hydrogen from the vapor of water in the sealed pistons. A small amount of α and β radiating substances were also in the piston. However, they are unable to penetrate through the metal casing. Only the γ radiation penetrated, but it has less ionization capability. There was no external magnetic coil around the reactors (cylinders) in the first two patents. They appear only in the third, and last, patent of 1984. It is curious. Only acid-proof steel alloys let magnetic fields penetrate them; ordinary stainless steels are magnetizable. In a sealed tube made of steel, no magnetic field penetrated into the piston itself (but vector potential will penetrate). The inert gas is a helpful auxiliary effect of momentum transfer from a large mass xenon atom to a low mass hydrogen atom, but it is not an essential part. Papp talked about an unpublished sparking fuel preparation device. (See Figure 9b.) The inert gas engine (one of several versions) is shown in Figure 9c.

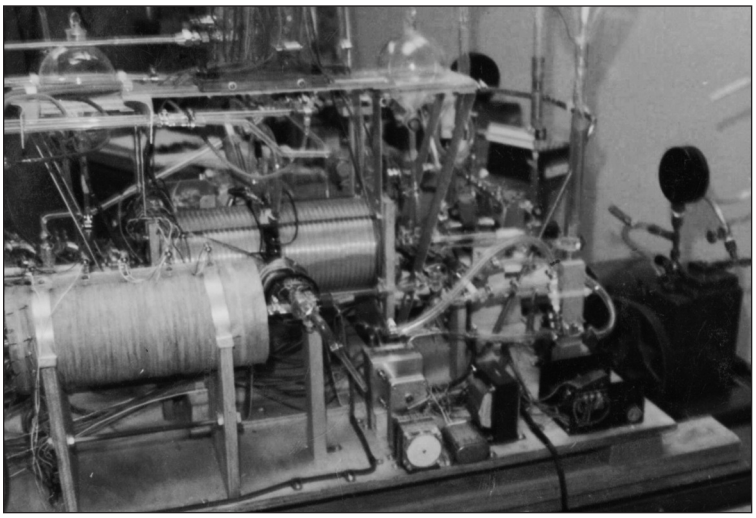


Figure 9b. An unpublished photograph showing the gas mixing and sparking device. Most probably it was not essential, just part of the show. The Penning gas type fuel does have advantages, but all other inventions work without it.

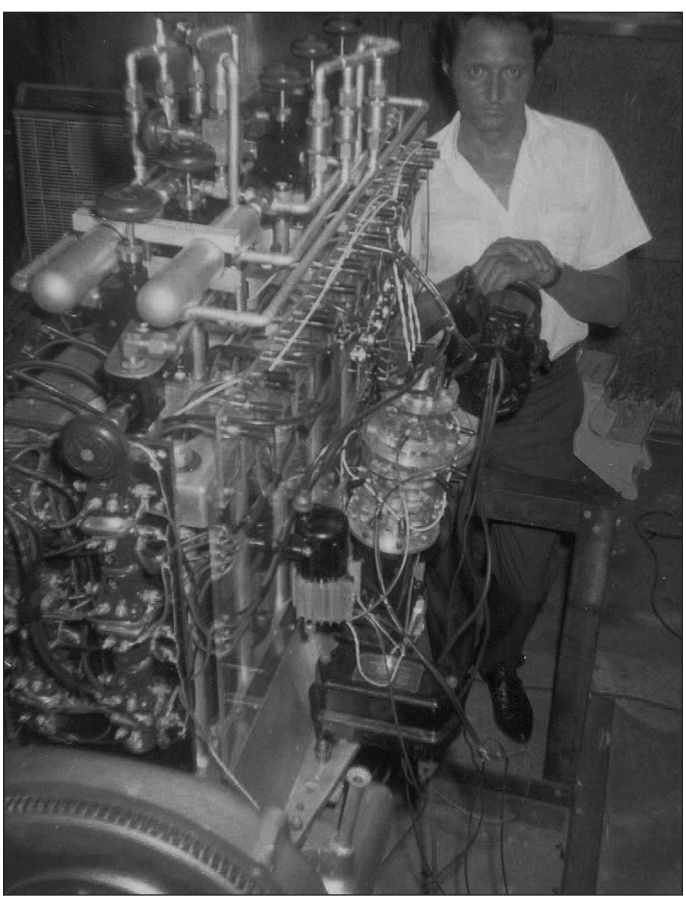


Figure 9c. One of several inert gas engines from the middle-aged Papp. There were only torque tests, but with independent witnesses.

Is the secret "fuel preparation device" some sort of polyneutron or condensed plasmoid device? Is it necessary at all? The answer is in the first patent (3,680,431), which is a deceptively simple device—a gun. It was not obvious to the patent examiners that they permitted a LENR reactor, and even Papp himself was not aware of it.

It is a pity that this asymmetric discharge device, shown in Figure 9d, escaped the attention of LENR researchers. Let's see what makes us believe that pulsed LENR is behind the shock waves. Is the inert gas mixture of any help? It is not used by other LENR reactor operations. Indeed, it is a good idea, because it is a sort of Penning gas. Penning gas mixtures (there are several of them) lower the discharge ignition voltage. Moreover, it makes discharges longer due to the metastable phase of the gases. Thus the ionization may last much longer than just for picoseconds, even for milliseconds. Inert gases have several metastable excitation levels at higher potentials than the ionization energy level of hydrogen. Thus hydrogen can be ionized for a longer than usual period. This is a lesson to be learned from this design!

The Evolution of the Papp Engine

The first Papp patent (3,680,431; 1972) is a detonator, and the irreducible simplicity is apparent. The common pattern with the rest of spark/plasmon polariton-based devices is also apparent.

In Figure 9e a cylinder is shown with two asymmetric electrodes (31, 41). This device would produce sparks only based on textbook physics, thus some heat, nothing else. However, contemporary video documents show extreme damage to the cylinder; when the load (a metal slug) was stuck, the cylinder exploded in a U.S. Army demonstration experiment. (*IE* has a DVD of it for sale, "The Papp Cannon Explosion of 1968.")

Something extraordinary happened that demands explanation. It is strange that the USPTO granted a patent for this device, because it is clear that it cannot work based on textbook physics.

There are two further unusual features in the device that may help comprehension. There is a spiral-shaped tungsten wire filament across the electrode plates (33), which is indeed important. Further, there are two vessels (10, 20) filled and sealed with radioactive materials, emitting α radiation. However, only X-rays and γ-rays can penetrate through the walls of the vessels (10, 20), so their utility is in doubt.

Since nobody repeated this experiment, to our best knowledge, the question of the use of the radioactive sources (parts 10, 20) will remain. (Photographs of the device do show them on later versions as well. Anyway, these radioactive materials are no longer available on the market due to

severe restrictions on their purchase.)

The gas composition of the Papp reactor was a subject of hot debate. The water and chlorine content was less than 1% in the "gun" type single-strike reactor, while argon was between 40% and 60%, xenon between 30-40%, neon between 6-8% in his first patent of 1972. Note that even a fraction of 1% of gas mixture makes a real difference in the shape of the Paschen curve! Therefore the composition of the gas mixture is not well specified, and practically useless.

The chlorine makes negative ions, which may help charge shielding between protons, but this is just a guess. Papp abandoned chlorine later. The unusual feature of inert gas mixtures were discovered by Penning at Philips, in the 1930s, and used in "neon tubes." Much later, they were investigated for plasma TV panels.[8] This multi-component mixture has never been studied; it is too complicated for science. Even a minute amount of inert gas in the mixture may change its properties!

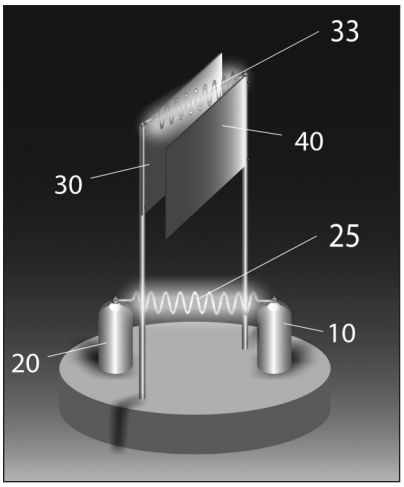


Figure 9d. Drawing from the first Papp patent. Note the asymmetric electrodes, the heating (shorting) wires and the radioactive material capsules.

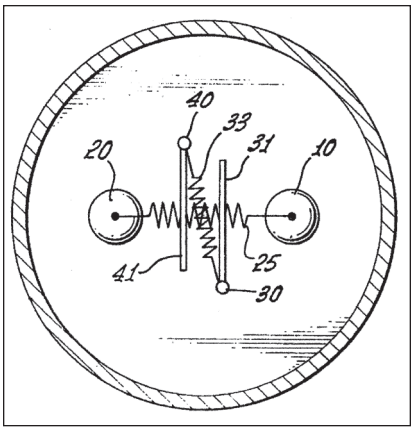


Figure 9e. Drawing of the most simple, flat, asymmetric electrode arrangement from the first patent. This method makes possible the fast movement of a plasma sheet along the flat electrodes, (plasmon polaritons) and the generation of sharp pulses, or sparks.

The starting pressure is less than 3 bars. In Papp's second patent, an engine without coils (3,670,494; 1972), the water content of the cylinder is increased significantly, by 10-25% of liquid water, which is left to evaporate. Besides water, 65% argon, 25% xenon and 10% neon is left. This "single-strike" or "gun" device is similar to the underwater explosion tests of Part 5B. Either titanium foils and wires were exploded, or just water droplets, in those French and Russian tests. Water vapor/inert gas mixtures were exploded in Papp's experiments in spark and arc discharges.

Repetitive explosions were used in the engine patent. Readers are reminded to review Part 5B, where the underwater explosions were characterized by transmutations—Urutskoev *et al.*; Matsumoto (also in Part 5A); Bogdanovich; Daviau *et al.* The Papp engine is just a sophisticated engineering improvement on these experiments.

The electrodes became conical just as in Tesla's tubes or Shoulders' tubes.

In his last patent (4,428,193; 1984), water as a gas constituent is not mentioned at all, only inert gases. This patent description is loaded with other nonsense as well, like the separation of inert gases (column 11, line 27-30). Therefore only the first patent will be discussed from now on, as the irreducible realization of LENR.

In Figure 9e two unusual features are apparent:

1. The asymmetric electrode plates (31, 41);
2. Tungsten coil (33), stretched between the electrodes (31, 41).

The latter is strange, as it short-circuits the electrodes in steady-state, making this setup clear nonsense at first glance.

Only reading the operation instructions may make some sense. The electrodes are fed by a DC current to heat the coil (33) to a red (or white) hot state. This partially ionizes the plasma, and makes neutrinos.

Then a sharp voltage pulse is given to the electrodes, of unspecified magnitude, by disrupting the heating current. Then two versions may happen:

1. The hot wire is evaporated. Then we have the generation of condensed plasmoids on the edges of the electrodes due to sparks, and dust fusion as well due to molten droplets of the tungsten wire. This is an efficient method, but cannot be used repeatedly.
2. Only condensed plasmoids plus plasmon polaritons are formed, based on catalytic fusion. (The tungsten wire is useless for repetitive application.)

Then inductivity of the tungsten coil (33) must have enough impedance to allow a significant potential difference build up between electrode plates (31, 41). Their edges must be sharp in order to yield a corona discharge, and then a spark-arc discharge.

Moreover, the transient discharge goes through the glow discharge regime as well, making the asymmetric plates (31, 41) the site of plasmon polariton waves.

The striking spatially asymmetric arrangement of the electrode plates makes it plausible, so this assumption is perhaps more than wishful thinking.

The process has the same symmetries as Tesla's spherical "carbon button" tube with a belt-like anode. The plasma is generated in a transient and moves along the electrode surfaces.

In the "serial sparks" engine patent, this further step ahead is visible. In the setup of Figure 9a, two asymmetric flat plates were used as electrodes, so the plasma must move along the plates. The conical electrodes are better, because the plasma wave intensity increases while moving along the cone towards the tip. This shape factor, or amplification effect, is not mentioned in plasma textbooks, though plasma sheets are discussed.

This effect was known to Tesla and Shoulders, as discussed in Part 5B. Papp used only one type of steel for his conical electrodes that he found particularly useful, but kept it a secret. Probably the work function of that particular alloy was remarkable. Note that hardening, electroplating, etc. may lower the work function considerably!

This intentional asymmetry of the electrode plates separates this invention from the usual textbook physics discharges, where plasma is usually generated between parallel planes symmetrically or in coaxial cylinders.

These transient plasmon waves may form on conical electrodes as well, apart from corona and spark discharge, producing condensed plasmoids. The effect seems to be stronger in the presence of inert gas mixtures than in hydrogen alone. The reduced symmetry of the electrode plate leads to the initiation of charge waves along them. This effect is useful for hydrogen, where catalytic fusion takes place.

As for the formation of quasi-stable condensed plasmoids, inert gases (even electronegative gases like chlorine) are perhaps beneficial. Many more experiments are needed in this area, because this is a huge unexplored range of parameters for discharge physics.

Of course, none of the inventors discussed here were aware of the physical foundations, or condensed plasmoids, etc. Thus nobody ever examined electrode surfaces later under polarized-light stereo microscopes to settle this question, to find traces of condensed plasmoids, or trasmutations in general.

The heated tungsten coil (22, 25) as an auxiliary heater nevertheless pre-ionizes the ambient gas, and yields low-energy neutrinos to help fusion (Parkhomov's criteria).

The partial pressure of water-vapor may yield enough hydrogen to make LENR fusion possible.

Later copycat patent applications like that of John Rohner (US20130167524A1; 2013) missed these important points, as did R.G. Britt (U.S. 3,977,191; 1976).

Papp had several public demonstrations, which is the only reason to include his device in this paper. The paranoid Papp had a fateful clash of egos with the arrogant Richard Feynman in 1968, where Feynman exploded the device, killing a bystander.

This fact alone is impossible without a powerful unknown energy source. Sparks alone do not explode on an ICE engine!

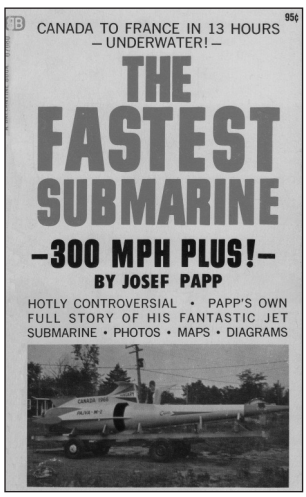


Figure 9f. Papp's book about the submarine.

Interested readers are invited to repeat this simple looking experiment. The energy of the piston-slug can be absorbed by a sand sack hinged as a pendulum, instead of calorimetry. An alternative way is to measure the height of upward jump after an explosion.

This energy balance test is easier than an isoperibolic calorimeter. The control experiment can be done with inert gas, or nitrogen, without water/hydrogen. It is likely that Papp had no clue as to the origin of the energy source, since he never used heavy water in his experiments. The radioactive sources are most probably useless as they don't fit into the common pattern of other similar experiments.

According to Papp's brother, who lived in Tatabánya, Hungary, it was their father who somehow discovered this effect, while working at the physics lab (KFKI) of the Hungarian Academy of Sciences.

Papp wrote a book about his early work on a very fast, single-person submarine in *The Fastest Submarine* (Figure 9f).[9] It is a shocking book, but no useful technical details are disclosed. According to the photographs of the books, this LENR-based submarine was indeed built. LENR energy was used to heat the cone of the machine white hot, so a thin vapor layer arose around the submarine. This eliminated friction, and it moved underwater as if it were moving in air. (See photos and a schematic of the submarine in Figures 9g-l.)

When I wrote the four-part history of LENR devices, this book had already been on my shelf for years but I chose not to mention it. It seems so incredible that a single person was able to build such an ultra-fast submarine, while none of the major naval powers could do it. This was similar to the case of the first steam turbine driven ship in a sense, the "Turbinia" built by Parsons, a brilliant British inventor. That ship just left all the reciprocating piston based steam ships in complete shame at a major British naval demonstration. (All those ships became obsolete.)

Papp made a major pubic relations mistake not to demonstrate his submarine on a shorter, safer distance. (He wanted both fame and wealth immediately, which is a recipe for failure.)

Now the pulsed spark/plasmon polariton-based devices are hopefully acceptable to readers. Even the reverse engineering of his propulsion system is possible in principle. It was based on the principle of the German V-1 rocket (World War II), pulsed combustion rocket (ramjet). Here water was sucked in, and a spark was exploded in vapor/inert gas mixture in a separate chamber. The expansion of this plasma threw the water backward at high speed (momentum), working like a ramjet rocket. The Graneau underwater explosion device worked on the same principle, but without the acoustical resonant chamber, and without the advantage of metastable Penning gases. Heating the cone of the submarine to a white hot temperature yields the Leidenfrost effect, the formation of a thin steam layer. This reduced the drag significantly, thus made possible the 300 miles/h speed under water without propellers, by "rocket" propulsion.

The inscription in Hungarian is clearly visible on the tail of the submarine. The "cica" means "little cat," the nickname of his wife (Figure 9h).

According to Papp, the submarine failed and sank near the French coast, and he barely escaped and survived.

Finally, it is difficult to understand his electronics but the pulsed high-voltage electric pulse formation is certain. (See Part 1 to understand the need for it.) To see the theoretical background on condensed plasmoids, there are papers on condensed plasmoids in *IE* by Shoulders (#61, 70) and E.H. Lewis (#83, 145, 147).

The *Journal of Applied Physics* has been an outstanding source on plasmon polariton resonance for the last decade, along with *Applied Physics Letters*. None of these papers dwell on LENR-related catalytic transmutations because they were never investigated in their experiments.

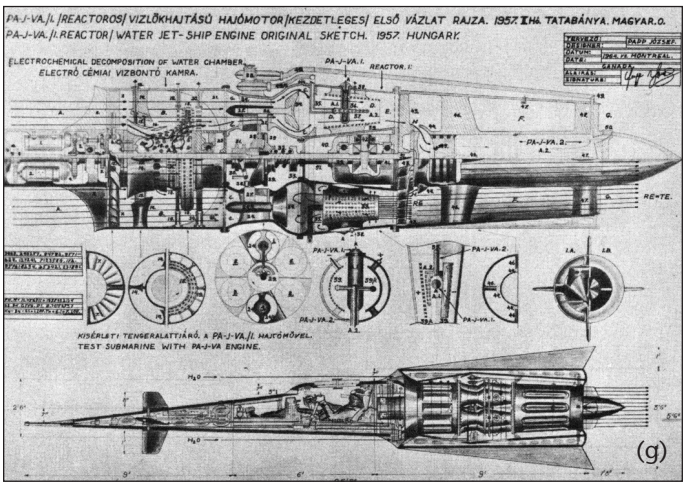
Significant improvement might be achieved by the combination of the above method with the Ohmasa gas. That is, when the ordinary vapor is replaced by the HHO gas, that is oxygas made with cavitation, and partially with deuterium. This "imported" high-density catalyst is better than the locally made catalysts, and condensed plasmoids.

The Colman Dust Bed Cathode RF Device

The British invention by Harold Colman and Ronald Seddon

Gillespie (U. K. 763,062; 1956) is an oddity.

The device is an RF driven, dust bed cathode discharge tube, and it consists of several layers of different molecules, and crystals. The cathode, ZnO, is also a semiconductor. It consists of a loose bed of crystals, thus small corona discharges can be maintained in the quartz discharge tube. The fine different types of crystals are incorrectly specified, but one of them yields only water from its crystals. This is the only hot discharge tube well above Parkhomov's temperature threshold. There is an external magnetic field with peri-



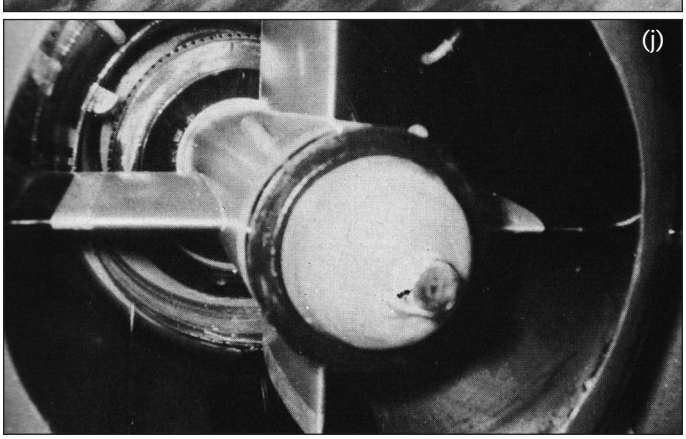


Figure 9g-l. (g) First blueprint of the submarine, drawn in 1957, in Tatabánya, Hungary. (h) The submarine on the trailer. "Cica" was the nickname of Papp's wife. (It means "pussycat.") (i) The "ramjet" engine, driven by LENR. (j) A test run of the submarine is driving into the water. (k) The back of the midget submarine. Note the lack of propellers, as it was driven by a pulsed jet, that is ram jet propulsion. (l) The submarine is on a small trailer, to be taken to an underwater test.

odic fields perpendicular to the tube. The patent application was "sold" as a battery to the examiner.

The discharge tube must be heated nearly white hot at first, and then the system is self-running like a battery.

The inventors mention α and β radiation, which can't get through the quartz glass—except by teleportation.

There is a parabolic reflector focused on the tube made of lead. Is it a protection from heat, UV or γ-rays? Nobody has successfully recreated this device.

Despite its oddities, transient sparks, water vapor and cavity cathode are there. Though a quite unusual construction, it fits to the line of LENR reactors. In fact, it is similar to the Arata and Patterson "floating bed" cathodes by analogy. None of the technical parameters are given so it will take significant patience to repeat it. More details about it are in my previous historical review on forgotten patents (Part 3).[6]

Jekkel's Oxygas Reactor

The device of Janos Jekkel is the simplest LENR reactor yielding high pressure oxygas. The reactor is a T-shaped glass, and superheated steam is pumped through it. There are two irregular blobs as electrodes, made of very thin silver wire yielding a corona discharge. The power supply yields high-voltage one-sided pulses (20-30 kV.)

The horizontal part of the T tube is inside a solenoid, and thus not only the electric field changes rapidly (~ 20 kHz),

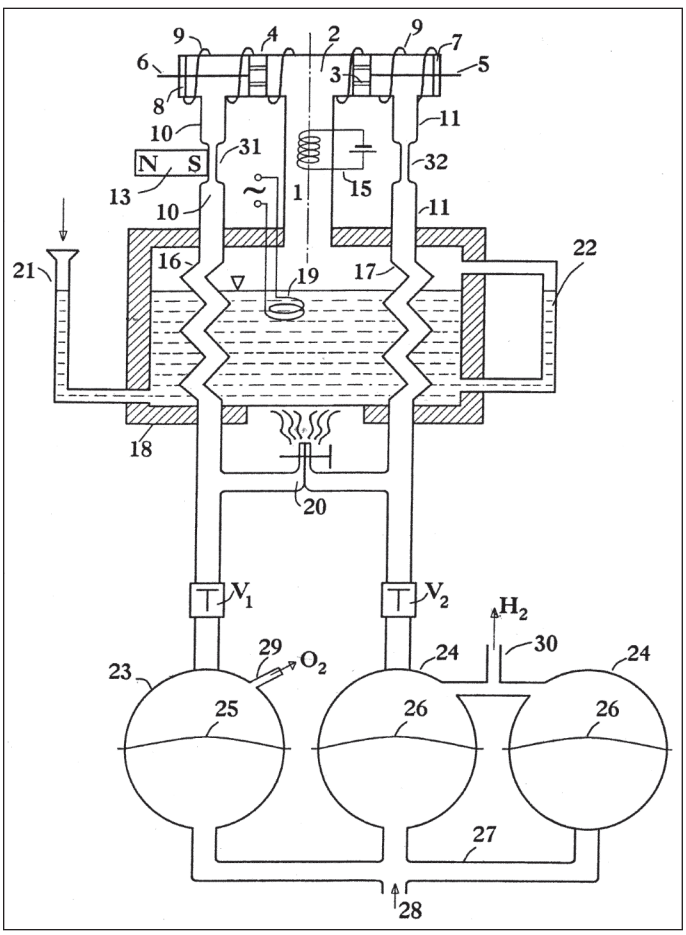


Figure 10. The hydraulic tube circuit layout of Jekkel's water splitter. The electronic circuit was lost in time, but it yielded high-voltage, one-sided pulses.

but a coaxial magnetic field as well. The explosion was prevented (not always) by keeping the ratio of oxygas about 3% under the explosion limit. Jekkel claimed he was able to separate oxygen and hydrogen plasma with strong neodymium magnets, but this is doubtful. Nevertheless, this device is relatively simple to make.

The inventor found this effect again just by luck, and worked on it in secrecy for years.

The Layout of Jekkel's Device

The scheme is shown in Figure 10. The T-shaped discharge tube is on the top. The saturated vapor rises in the vertical part of the T tube (1). The corona discharge takes place at the joining of the two legs of the tube (2). The electrodes (3, 4) are made of fine silver wire, connected to the high voltage (20-30 kV) power supply via feed through (5, 6). The horizontal tube is closed at the ends by plugs (7, 8). There is an external solenoid (9) around the horizontal tube section. The vapor is superheated by a wire (15). Though the bulk of the water is warmed near to boiling point with a burner (20), there is a floating electrical heater (19), to make "on demand" saturated vapor.

The LENR reactor is the upper, horizontal section of the T tube. The microdischarges and condensed plasmoid/polariton formation takes place within the mesh shaped electrodes (3, 4).

These electrodes were irregular blobs, though several layers of fine silver/titanium mesh will do better job.

The molecules split to H_2 and O_2 due to the excess heat of LENR in superheated water.

Now the murky part comes: Jekkel claimed that he was able to separate hydrogen from oxygen with a strong permanent magnet (13, at the neck 31). He claimed dozens of times that this was his big discovery (after the excess heat) which made possible the separation of hydrogen from oxygen. Thus it is possible to maintain the same pressure at both legs of the T-shaped splitter. This way the oxygas always had the same H_2/O_2 rate.

Personally, I am skeptical about this claim. I would do the separation with a porous ceramic, because only hydrogen can diffuse through it, the oxygen cannot. This separation with a magnet was necessary to avoid a high amount of oxygas in the tube, because it explodes with the sparks. (His machine blew up twice.)

The third technical insight was to maintain equal pressure and mass flux at both wire electrodes. This was made possible with the membrane systems (25, 26, 27). Thus hydrogen and oxygen leave the system at the same pressure.

At inlet 28, nitrogen or air maintained the same pressure. The water vessel had heat insulation (18).

There were two heat exchangers (16, 17) to recover the heat from overheated water. The liquid water was removed at V1, V2 separators, and returned with pumps (not shown) via 21 to the liquid container (18).

Though Jekkel worked for years to improve the device, he never documented or photographed anything, fearing that police would arrest him. (Propane gas driven cars were strictly forbidden, and a policeman is unable to distinguish between methane gas and water vapor. None of them are allowed because they are not taxable.)

He found the excess heat/splitting effect by sheer luck. He was under the false impression that he could remember it

and repeat it. He failed when the opportunity came.

It is easy to recognize the design similarities between the Papp and Horvath engines. They were driven by low frequency sparks, which in turn generated heat, thus splitting the water vapor. The pulsed corona discharge of Jekkel's device produced hydrogen and separable oxygen. In principle, it would be suitable to drive fuel-cell cars (like Toyota) instead of simple combustion-shock waves as in the Papp engine.

Gray's Corona Discharge Tube

The Edwin Gray device (U.S. 4,661,747; 1987) is based on the same principles as Jekkel's steam splitter. The Gray tube contains two coaxial wire mesh cathodes of unspecified thickness and mesh distances.

This can be suitable for transient corona discharge (regular Trichel pulses) at about 20-50kV. The anode is also a cylindrical rod. The gas composition and its pressure, and electrode material, are not specified, thus it is one of the sloppiest granted patents of the USPTO.

The gas certainly contains some hydrogen. Is it pure hydrogen, or water vapor just as with Papp and Jekkel?

The gap between the mesh electrodes is about 5 cm if atmospheric gas is used. The external mesh is about 10 cm in diameter, judged by the only photograph I had access to. A high voltage, steep inductive voltage kick operates the tube. It is not known whether this coil is outside, coaxially around the glass tube walls. (Gray was just as secretive as Papp.)

The Gray system is practically identical to the Jekkel system regarding the method of initiating fusion in a corona discharge system. It takes two steps:

1. Formation of condensed plasmoids by a row of micro-discharges along a fine wire mesh, described in Part 1.
2. The plasmoids are "activated" from the "dark," inactive EVO to a white EVO state (Shoulders' terminology).

In the active state, they probably rotate as individual pearls due to the very nature of spin-type fields.

This is a major difference from chemical catalysts, like platinum or palladium. These metals are always active when their surface is properly prepared. Condensed plasmoids or EVOs must be kept in an active state with dynamic external electric and magnetic fields, as rot $S(t) \sim \partial E(t)/\partial t + \partial B(t)/\partial t + \ldots$

This continuous need for activation might be one reason why this process was rarely discovered.

The reader may recognize the same pattern in the principles of these inventions by now, despite the many other unknown factors.

A saw-tooth type voltage is necessary to keep it going continuously. A spark or micro-discharge is needed for the catalytic condensed plasmoid formation, and a growing E(t) electric field (and a similar magnetic field) to maintain the catalytic fusion.

This pattern is seen for Tesla, Moray, Horvath, Papp, Jekkel, Colman and now for Gray. None of these inventions can be reproduced at will from the fragmentary documents they left behind. However, the mechanism emerges from the fragments of previous research and inventions, just as a crossword puzzle with the help of fundamental research by Raether, Shoulders, Mesyats, Matsumoto, etc.

Both the concepts of condensed plasmoids and spin field are needed simultaneously to maintain catalytic LENR of hydrogen isotopes.

It seems that all of the above inventions used "ordinary" hydrogen, not heavy water. Most of them never had access to it; it was not available (but known to exist). Only Ohmasa used it in his gas and transmutation experiments with cavitating vapor bubbles.

Though the quality of the Gray patent disclosure is really awful, it also confirms the need for transient filamentary discharges as an emerging pattern. Therefore it was included in the row of useful patents.

Gray leaped ahead of Jekkel's oxygas machine by one important step. He extracted the generated energy in electrical form, a better idea than its chemical form. A schematic Gray tube is shown in Figure 11a, while in Figure 11b the scheme of Jekkel's tube is shown. The pulsed voltage generation/capturing device of Gray is shown in Figure 11c.

In Gray's tube, the cathode is shown as a double coaxial mesh, galvanically connected to each other. The anode is a metal rod or cylinder connected by a spark gap to an R resistor, and then to a load. The double cathode mesh is excited by a pulsed high-voltage power supply, and the other terminal is connected to the cylindrical anode. There is a spark gap above this anode, and it is connected to another electrode. (In fact, this is a triode configuration.) Therefore the anode rod, or cylinder, is a cathode for the upper anode connected by a resistor to a load. This seems to be complicated at first sight, but each part has a function, and is irreducible. This system is perhaps the simplest one to demonstrate the required parts when the excess fusion driven energy is extracted as electrical energy.

The double walled mesh also acts as a cavity cathode. It has a higher efficiency than a single layer grid due to the emission of secondary electrons. (In principle several layers can be used).

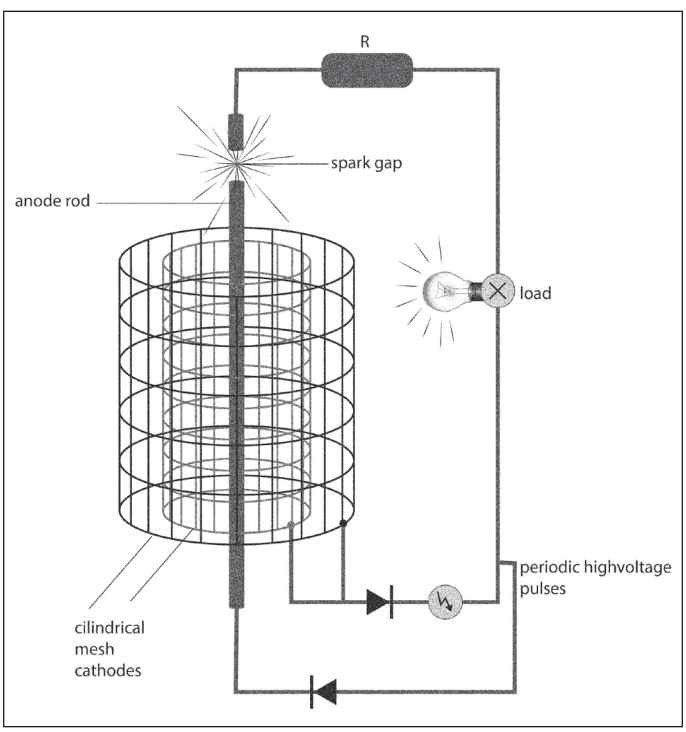


Figure 11a. Gray's corona discharge tube, reconstructed from the patent description.

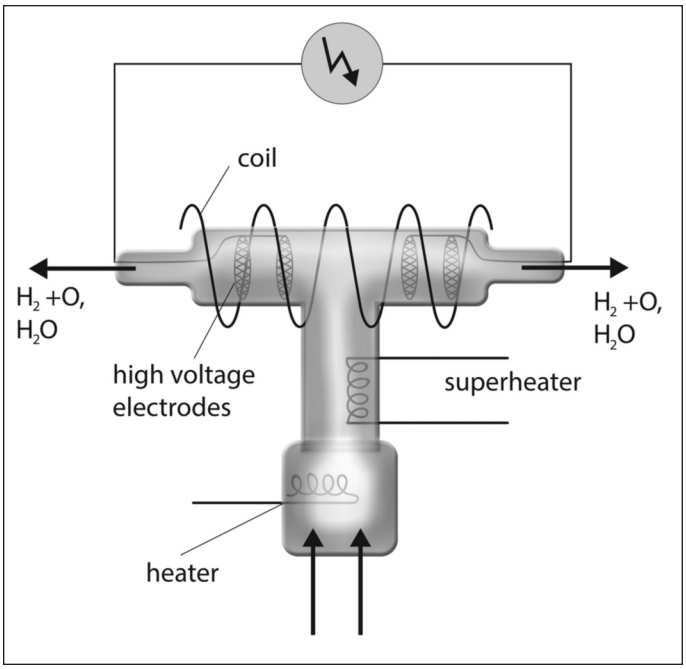


Figure 11b. Jekkel's steam splitter sparking device, reconstructed from the information given by the inventor.

The Probable Nuclear Processes in the Gray, Jekkel, Papp, *et al.* LENR Reactors

As noted before, the excess energy released by the most probable fusion processes turns this energy into heat, and not X-ray or γ-ray radiation. The catalyzed processes by condensed plasmoids are assumed to be the following:

$_1p^1 + e^{-1} + \nu \rightarrow {}_1n^0$ - 0.78 MeV(endotherm)
$_1n^0 + {}_1p^1 \rightarrow {}_2D^1$ + 1.1 MeV
$_1p1 + e^{-1} + \nu + {}_1p^1 \rightarrow {}_2D^1$ + ~1.9 MeV
(this three-body process is doubtful)
$_1n^0 + {}_2D^1 \rightarrow {}_3H^1$ + ~4 MeV (Claytor process)
$_1n^0 + {}_2D^1 \rightarrow {}_3He^2$ + ~4 MeV
(observed in electrolytic LENR)

These possible reactions were outlined by Edmund Storms. They may take place simultaneously on the wire of the coaxial cathode mesh. Storms assumed that they took place in the cracks of a palladium cathode. Here the site is definitely the wire surface as the cause of the catalytic transient, intermittent corona discharge and surface polariton waves.

The fuel is definitely hydrogen and deuterium, and the method is microsparking, or arcing, as verified by Claytor. The catalysts are either or both plasmon-electron waves and condensed plasmoids as quasi-particles, so the most important conclusion for the design of these reactors is: make sure the formation of micro-discharges by providing small sharp conducting edges on the electrode surfaces. There is a viable way to create nano needles or microneedles "en masse," because they were used in flat panel plasma TV screens (pioneered by Shoulders). This technology was fully developed by Samsung for flat screen plasma displays. This company was only one step away (by using hydrogen) from mass-producing catalytic fusion devices. Although it was known that plasma TVs ooze heat, no calorimatry tests were done.

These processes never take place in DC plasmas, as shown in many experiments. This is the most important conclusion regarding the operation of these reactors. Further, no glow or arc discharge is allowed, because it is a waste of input energy. At last—make sure to remove the generated charges either as a capacitive harvesting (Correa), or as a resonant circuit (Moray).

The rapidly changing electric and magnetic fields, thus spin fields, are required further for the catalytic fusion process. The heat energy released in the process—here comes a novelty—is turned into the kinetic energy of a single electron if the previously mentioned Zuppero-Dolan process happens. This is definitely not a Carnot process so its efficiency can be higher than 30%. Moreover, the cathode is not heated, as for example, the Moray tubes were cold. (Corona discharge, being non-equilibrium, yields room temperature cold plasma, and therefore the cathode has a long life.)

The Storms reactions family require hydrogen isotopes which must therefore be absorbed to the cathode surface. Consequently, changing the polarity of the cathode is detrimental.

Once the electrons acquire the fusion energy, as kinetic energy, they must be slowed down by a back potential, as discussed previously.

In most cases, this excess electron energy is turned into heat, or by breaking the chemical bonds of the H_2O molecule into oxygas. This is the result of underwater sparking devices, for example: of Stanley Meyer (U.S. Patent 4,936,961; 1990); Horvath (3,954,592; 1976); Puharich 4,394,230; 1983).

Excess energy harvesting is simple with low efficiency for underwater processes due to the quenching of the plasma. Jekkel's method is more efficient, as it happens in super-

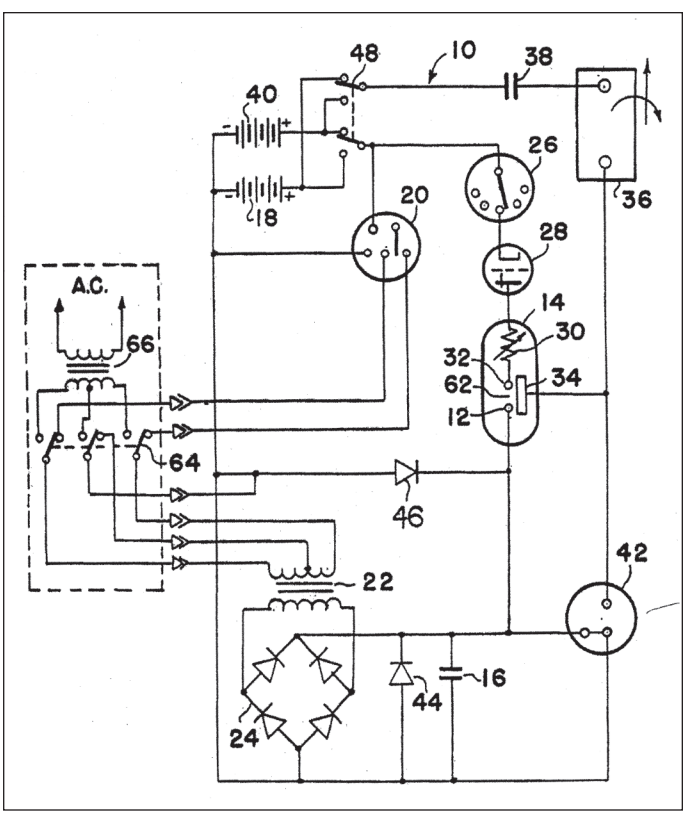


Figure 11c. The input/output circuit for the Gray device. Note that both sub circuits use inductive elements.

heated steam, not under water, where most of the input energy is wasted to maintain the plasma state. It is strange and counter-intuitive to design LENR reactors with a liquid phase. A four-phase process (liquid, vapor, superheated gas and plasma) is energetically wasteful, and does not offer any engineering advantage. I strongly discourage using liquid or even a saturated vapor phase in reactor designs.

In Gray's tube, the kinetic energy of the electrons is decelerated on the inner anode cylinder at a floating potential. Thus it is charged gradually to a higher electric potential. The potential difference between the cathode mesh and the anode increases, slowing down incoming electrons. This potential energy must be tapped periodically. This is done by a spark gap as a switch.

Moray solved this problem with his oscillating circuit, mentioned before.

Despite the foggy description, the Gray tube contains all the essential parts for corona induced catalytic fusion. The gain is extracted via a spark gap as valuable electric current.

It seems that only the catalytic fusion is the novelty. The different technical solutions of harvesting it are already textbook physics. However, even that requires painful and careful R&D.

Correa and Chernetzky Transient Arc Devices

All the devices so far, and the origin of the next two devices are also due to serendipity and strenuous efforts. The history and the author's hands-on experience were detailed in the aforementioned four part series.[6]

For both devices, the electrodes in the discharge tubes had to be "broken"/roughened. These sharp, crater-like edges made possible the creation of a sudden discharge: from glow to arc.

The heating effect of arc pulses made both inventions impractical due to immense melting, and sputtering erosion. The design of these plasma LENR reactors was careless.

Nevertheless, the extraction of excess electric energy was possible for awhile. The Correa device was driven by relaxation oscillations, and the Chernetzky device with a high frequency (up from some kHz to MHz range) AC power supply. Did they have a bias DC potential? It was implicit in Chernetzky's paper.

Both devices made possible the simultaneous presence of plasmon waves and condensed plasmoids.

The large-surface area Correa tubes and small-surface area Chernetzky tubes were run at a very low pressure, under one millibar. Therefore expensive oil vacuum pumps and fittings were required, making progress very slow, a real technical nightmare.

Despite these troubles, the pattern emerged as years went by: high excess energy current peaks were induced at voltage transients, as if they were power generators. These current bursts were mass ejections of electrons—just as with all previous devices.

The Chernetzky device was run only in hydrogen and argon, but in the latter case water vapor was always there. LENR as a possible energy source was rejected by the financial backer of the project at that time, so hydrogen gas was not allowed for the Correa tubes. (Nevertheless, water diffused through the large surface area of the tubes). However, this authoritarian ban sealed the fate of the project.

Correa's extraction method is fundamentally flawed. This is a lesson to be learned! He used a capacitance to capture the "burst," but only the first one. He was not aware that condensed plasmoids were formed, and they catalyzed LENR reactions (fusion) by external $\partial E(r,t)/\partial t$ pulses in a hydrogen atmosphere. He firmly rejected all other models apart from his "ether oscillations." Thus the condensed plasmoids can be "milked" several times, not only once. Thus he missed about 90-95% of the excess electric energy.

Both Moray and Tesla complained that they were unable to get to "perfect resonance" with nature when the electric energy production can be maintained indefinitely merely by external field excitation. We can get 8-10 consecutive wave pockets with a gradually diminishing yield in our very simple system. This is not a theoretical limit. The number of wave pockets can be increased by improved circuit resonance tuning. Chernetzky used a resonant extraction circuit with better success but no technical details have ever been published.

The final conclusion is that LENR was the cause of excess energy generation, yet both inventors expected vacuum oscillations behind the observed excess energy (so did Tesla and Moray).

Part 5D will continue in Issue 159 with the LENR-related forgotten patents, including mechanical ones, and describe the only published test by the most renowned researcher in academic gas discharge.

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