

ANOMALOUS ELECTRICAL OUTPUT FROM ROOM-TEMPERATURE REACTORS.

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'Something's going on here, but you don't know what it is, do you, Mr. Jones?' Bob Dylan - Highway 61'

Abstract.

Some 200 years ago Edmund Becquerel discovered a new phenomenon, the photo-voltaic effect, a discovery that led eventually to the modern solar panel. A development curve that took 150 years. Towards the end of the 19th century Heinrich Hertz and some contemporaries discovered and studied the photo-electric effect, the liberation of electrons from metal surfaces when exposed to light, and Peltier published his work on thermo-electricity.

Frank Gordon and Harper Whitehouse may have added another new chapter to this story when they discovered and developed a device they call the Lattice Energy Converter (LEC)

Many iterations of the LEC device have demonstrated the spontaneous production of voltage and current for sustained periods. The device offers unusual simplicity and remarkable replicability. The current 'best hypothesis' is that a LEC converts the internal energy of gases like hydrogen or deuterium co-deposited with metals like iron, nickel, or palladium into ionizing radiation of some kind- and thus creates extractable electrical energy. Voltage and current increases with temperature, and the output is similar to that of a nuclear battery but without requiring normally radioactive components. The energy levels produced by the LEC are at present several orders of magnitude below those deemed commercially useful, but, the calculated flux of ionizing radiation necessary to match LEC output using a conventional nuclear battery would require the use of several curies of radi. But as this paper explains, this is not an accepted form of galvanism or a conventional electro-chemical effect, but something different to either.

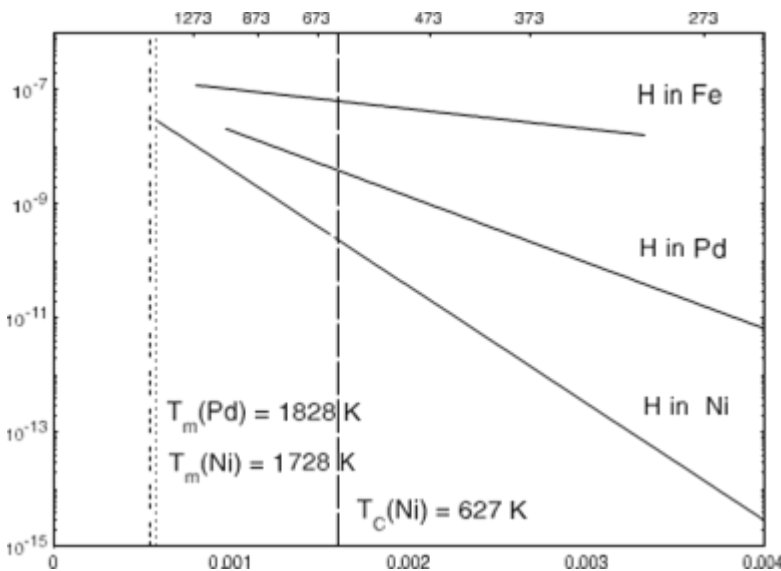
The Apparatus, summarised from a Description by Frank Gordon

A Lattice Energy Converter (LEC) converts the thermal energy of lattice vibration into ionizing radiation and electrical energy. The direct conversion of heat into electricity without the use of radioactive materials or mechanical means is a challenging yet promising method for the production of electrical energy. In its simplest implementation a LEC consists of a pair of electrodes separated by a gas at normal temperature and pressure (NTP). One electrode, called the working electrode (WE), is partly comprised of a hydrogen host material, such as iron, nickel, or palladium occluded with hydrogen or deuterium gas. The other electrode, called the counter electrode (CE), may be a common metal, such as copper, zinc, or brass. Experiments have established that when hydrogen host material is electrodeposited from an aqueous solution onto the WE it becomes 'active' and emits ionizing radiation. WE activity can be verified by in air by placing the WE in close proximity to a CE and connecting a digital voltmeter (DVM) between the two electrodes. If no spontaneous voltage is observed the WE is returned to the plating bath and more hydrogen host material is co-deposited on the WE. Multiple LEC configurations have been tested including tests where an external electrical voltage was applied between the working

electrode and the counter electrode as well as tests where the LEC self-initiates and self-sustains the production of a voltage and current in the absence of an applied external voltage and current. Prolonged tests of the system are undertaken in a hydrogen atmosphere where a sustained voltage may persist for long periods.

The Role of Co-deposition.

If suitable host metals are used during the electrolytic plating process, and particularly if it is prolonged, co-deposition of considerable amounts of hydrogen or deuterium will occur. The metal-hydrogen system [Fukai, 2005] and in particular the palladium-hydrogen system [Lewis 1967] have been studied for more than 150 years since St-C Deville and E Troost [1863] reported that hydrogen diffused rapidly through homogeneous plates of fused iron (Fe) and platinum (Pt). These surprising results led Thomas Graham, Master of the Royal Mint, to conduct a similar series of experiments with palladium (Pd). Three years later, Graham [1866] was the first to report the high rate at which hydrogen would diffuse through heated Pd and also that iron would occlude and retain hydrogen.



Diffusion studies of hydrogen in iron and steel are many, due to the commercial problem of hydrogen embrittlement. Despite this, the data scatter is large especially at low temperatures. Reasons for this may include hydrogen trapping by impurities, dislocations, grain boundary variables, micro-porosity or nano-cracking, faults already existing in the material or caused by thermal or electrolytic treatments.

1. (above) Diffusion of Interstitial Solutes in Metals (Mehrer)

2. (below) Frank Gordon - Typically simple LEC test apparatus of an outer iron tube containing a non-contact inner electrode, all made using commercial iron pipe fittings



Co-deposition of hydrogen/deuterium along with a suitable host metal plating on the working electrode surface is a necessary condition for the direct production of a voltage, around 250mV a micro-Ampere levels being typical for a small system like the one pictured here.

How Might it Work? Rout, Srinivasan et al.

The current working hypothesis of Frank Gordon/Harper Whitehouse is that the co-deposited surface emits radiation which ionises the free hydrogen between the WE and the counter electrode and that these ions separate into positive and negative species and impart a measurable voltage across the electrodes.

Some confirmation of this can be found in the work of Rout, Srinivasan et al (1994) quoted here, this group studied energetic emissions from palladium hydride. The energy levels appear to be small, it is able to affect radiographic films, but was not detectable using a Geiger counter.



Figure 3 – Looking for Emissions.

The absence of Geiger counts mentioned by Rout, Srinivasan has been confirmed by work in the NZC laboratory where we used high-grade pancake Geigers to detect emissions without success, comparing the counts for plated and un-plated brass sheet samples. There was a 2 cm air-gap between detector window and samples, which is certainly too far for them to detect very low energy emissions.

Rout et al found the fogging of X-Ray films was enhanced by application of an electric field of either polarity, but it was suppressed by a crossed magnetic field. These emissions were initially assumed to be of low energy (a few tens of electron volt electrons), but this possibility was ruled out as the emissions were able to pass through ten layers of paper. The major difference between paper (highest transmission), polyester foil (low transmission), and beryllium foil (no transmission) is the degree of porosity of the material. A small amount of hydrogen may pass through the filters, but hydrogen was found not to affect the film. The phenomena, though most easily reproducible in palladium, are perhaps more universal and may also be occurring when H₂/D₂ is loaded into other metals. All the mechanisms (known to us) which might have fogged the films, were considered and ruled out. Therefore they proposed that some new, unknown agency emitted from loaded palladium is responsible for fogging.

Simple, Cheap, Robust, Reliable? – The Lab Rat LEC.

The LEC might be described as worryingly robust, since performance at some level seems not to be highly dependent on the choice of plating substrate for the WE, the plating electrolyte or its pH and the geometry used for the LEC. Frank Gordon and Antonio Di Stefano have successfully used 'straight' commercial hydrochloric acid at around 25%, with iron wire anodes, Alan Goldwater (USA) has used iron chloride, and other experimenters have used sodium hydrogen carbonate and

potassium hydroxide. Jean-Paul Biberian has replicated the LEC Effect using palladium and hydrogen and a further successful replication was performed by Andrew Erickson. The very preliminary and recent experiments carried out by the authors at the NetZeroChem (NZC)lab use a 19th iron century plating recipe consisting of 125 grams of ferrous sulphate, 125 grams of sodium citrate FeSO₄, and sufficient ammonia to take the pH up to around 10 when the salts are made up to 1750ml using distilled water. None of this work has actually suggested that distilled water or high purity chemicals are required. Plating substrates that eventually become part of the working electrode have included iron (as mild steel), copper, nickel, palladium and brass (copper, zinc, traces of tin, lead, silicon, iron). Anodes used for iron plating have varied from mild steel to softer iron as used in binding wire.

The low cost and safety demands of all these materials and the absence of any pressing requirement to use heavy water as an electrolyte carrier is just one of the features that could make replicating the LEC an ideal student project. The other important aspect of this is that the absence of any need for calorimetry – the calorimeter being replaced with a moderately expensive digital multimeter – means the equipment space calorimetry often demands and the usual extensive thermal equilibrium and calibration work needed are no longer required.

Replication Work, Jean-Paul Biberian. Brief quotes from LENR-forum.com. *

Frank asked me if I would try to reproduce his experiment. It took me a while to realize that it is not very complicated to do, so I did. My first attempt was with a 2mm Pd/Ag 10cm long rod inside a 6mm OD stainless steel tube. I put hydrogen in and nothing happened. I then did deposit a thin film of palladium by electrochemistry and re-did the experiment. This time a voltage appeared in hydrogen, and nothing under vacuum or in air. In order to amplify the phenomenon, I built two coaxial cylinders about 35mm in diameter and 10 cm long, then with hydrogen, the voltage went up to 640mV. An interesting point is that the voltage grows rapidly at the beginning and slowly afterwards. I measured the voltage with various resistors to check the power, and definitely, it is in the micro-Watt range. I pumped out the chamber to remove the hydrogen and put deuterium in. Under vacuum, the voltage decreased with time during pumping, and reached zero. When I introduced the deuterium, nothing happened, the voltage was zero. I thought that maybe deuterium is no good, so I switched back to hydrogen again. The voltage remained zero. Next day, the voltage appeared and kept growing. Definitely, it seems that the palladium film needs to be loaded with hydrogen to produce the effect. The first load is fast, but the second time it is slow. I could not continue this experiment because I needed the chamber for other purposes, but I plan to start again soon. This is not galvanic, because there is no contact between the two electrodes, there is only hydrogen gas and the palladium deposit is crucial.

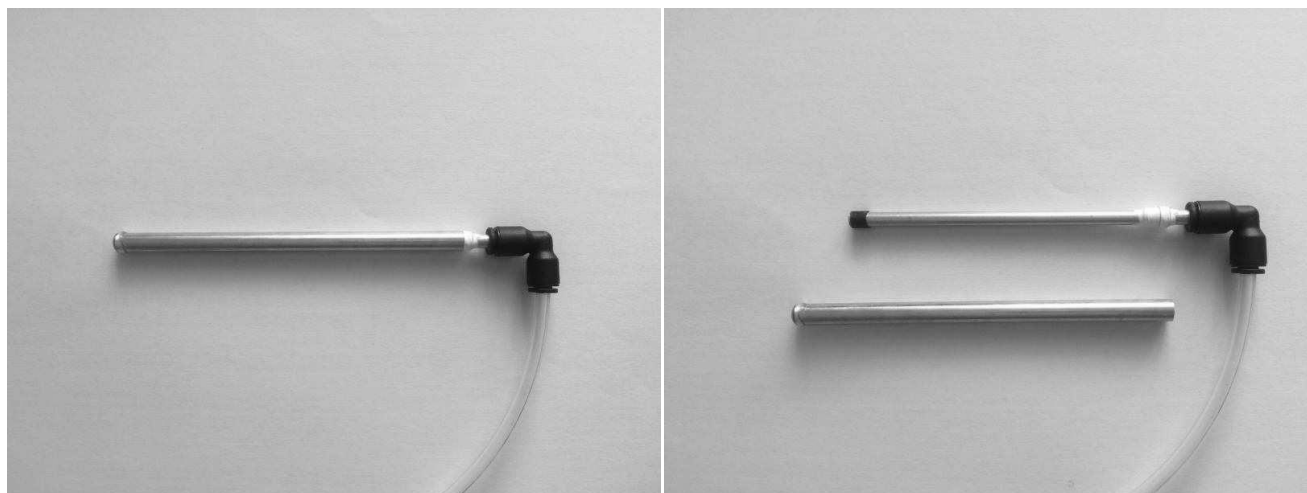
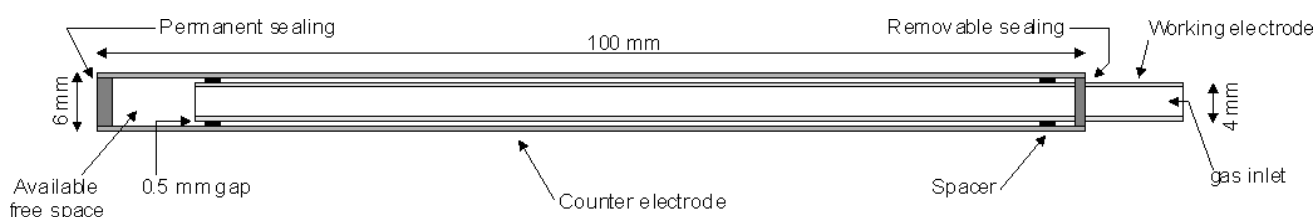
* Professor Biberian is due to speak on this work at IWAHLM 14 Assisi, 2021.

Replication Work, Antonio Di Stefano.

Di Stefano started planning a replication of the LEC device after seeing it described at the RNBE 2020 and ICCF-23 conferences and discussed on lenr-forum.com, attracted by its simplicity and apparently high reproducibility. The first concern was to exclude any parasitic effect due to electromagnetic interferences, noise, instrument drift and other conventional (but not obvious) effects. A series of control experiments were carried out before the actual replication, this also involved designing a simple structure that could be easily modified and reutilized in order to allow a wide variety of tests. Once this was built, the control experiments were performed, confirming the absence of undesired effects and the instrumentation sensitivity and noise level. This version of the

LEC is depicted in Fig. 4 below. Both electrodes are made from small diameter metal tubes (6 mm OD the outer one, 4 mm OD the inner one, both 1 mm thick): the working electrode (WE) can be electroplated, inserted in the counter electrode (CE) with a couple of rubber spacers, then the assembly can be sealed (with rubber fittings or epoxy). Given the dimensions, the gap between the two electrodes is 0.5 mm. The WE tube will also be used to evacuate and fill the device with hydrogen or other gases (the 4 mm tube can be directly fitted to many off-the-shelf pneumatic fittings). Different metal combinations are possible - 2 - (brass, copper and aluminium tested) and different gas pressures can be used, in order to verify how the generated voltage and current are affected.

Figure 4 – Di Stefano LEC.



Then the active electrode was created by plating it with iron, and the LEC was assembled and tested. The results obtained were almost identical to the ones reported by Frank Gordon, confirming the high reproducibility of this experiment and the reality of the underlying effect.

Control Tests.

The first step was to create LEC variants with identical mechanical structure to the final device, but without electroplating the WE. This provided a clear picture of the baseline behaviour. Three control devices made with a brass WE and three different CEs: brass, aluminium and copper were tested. The first tests were performed in air at atmospheric pressure, 23.9°C, 46% RH and subsequently using hydrogen. Main instrumentation was A Tektronix (Keithley) DMM6500 multimeter, a high precision device with customizable integration time and filtering. This was set to 10 MΩ impedance and an integration time of 20 ms and averaging of 100 samples. For some of these tests the inner tube (WE) is the same, and the outer tube (CE) is changed in order to test different metal pairs. The capacitance of all 3 variants was 30pF, suggesting that their geometry was identical. Measurements were made of the open circuit voltage using these clean and dry electrodes of different materials. In all cases the readings were as follows:-

- Brass-Brass: $0.01 \text{ mV} \pm 5 \text{ uV}$ • Brass-Aluminium: $0.01 \text{ mV} \pm 5 \text{ uV}$ • Brass-Copper: $0.01 \text{ mV} \pm 5 \text{ uV}$.

This shows that un-plated and un-electrolysed components assembled into a LEC do not generate a spontaneous voltage, confirmation that the much higher voltages observed in a working LEC by Frank Gordon et al. are not due to galvanism or other common phenomena. These numbers can also be considered the noise floor of the instrumentation and setup for the voltage measurement. Finally current conductivity measurements were made between WE and CE terminals using DC voltages from -60 V to +60 V in 5 V steps. The conductivity was constant in each case despite varying the applied voltage and were as follows:-

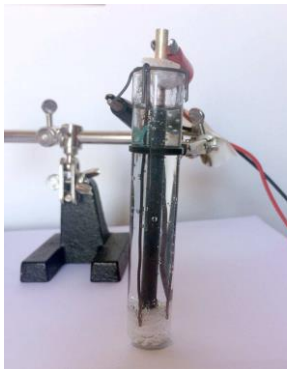
- Brass-Brass: $0 \text{ uA} \pm 0.5 \text{ nA}$ • Brass-Aluminium: $0 \text{ uA} \pm 0.5 \text{ nA}$ • Brass-Copper: $0 \text{ uA} \pm 0.5 \text{ nA}$

This shows the basic device structure does not conduct current, a second important confirmation that the working LEC does something unique, since it not only generates a voltage, but it is also able to conduct a current created spontaneously inside the device or one applied externally. Reducing internal pressure in the LEC using air or hydrogen (which made little difference) caused the conductivity to decrease, a phenomenon that is beautifully described in the first chapter of "Conduction of electricity through gases" by J.J. Thomson.

Tests on the active LEC

The device used for 'active' tests was exactly the same as the controls. The only difference is the co-deposition process, involving the plating of a thin layer of iron on the brass WE tube. This was done as follows. The working electrode was gently cleaned with fine abrasive paper and degreased with alcohol, then it was placed an electrolytic cell made from a test tube, with four 1 mm iron wires surrounding the WE. The iron wires were connected to positive voltage while the WE was connected to negative (ground). The electrolyte was 1/4 HCl 20%, 3/4 tap water. No ferrous salts were added, the Fe++ ions were directly obtained from the iron anode wires. The current was controlled by finely manually regulating the power supply voltage, following the regime described by Frank Gordon's and shown below.

Lab temperature was 26.4°C, 45%RH at the beginning of the process, 26.6°C, 51%RH at the end. At 15:30 the working electrode appeared as shown here (it became black quite abruptly).



The Electrolysis Regime			
Time	Current mA	Current /cm ²	Voltage
8.00-8.30	0.7	80 uA	0.167
8.35-9.05	1.7	190uA	0.254
9.05-12.00	16	1.8 mA	0.375
12.00-16.00	25	2.8 mA	0.450

After assembling each of the test LEC's the 10 MOhm impedance positive probe of the multimeter was connected to the WE, the negative to the CE. The voltage of device with the brass CE was -307 mV, the short circuit current was -2.4 uA. The voltage of the aluminium CE was 223 mV, and the current 1.5 uA. The voltage of the copper CE was -234 mV with a -0.69 uA short circuit current. The voltage of the brass CE increased slowly over time, so probably also with the other two metals higher figures would be obtained by extending the measurement time. During this experiment the

peak voltage with brass CE was about 330 mV. A considerable number of other measurements were taken, all of which confirmed that the device was operating in the same manner as the original LEC's build by Frank Gordon and Harper Whitehouse.

Additional Experiments by Di Stefano..

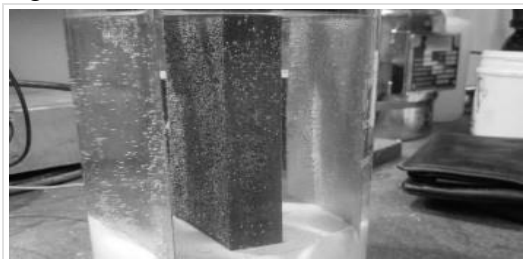
In order to verify the capability of the device to generate useful power/energy, the LEC was connected to a 100uF electrolytic capacitor, and the charging process was monitored. The capacitor was fully charged in about 90 seconds. The stored voltage was 309 mV, so the stored energy was 4.7 uJ. The time constant of the charging curve was 15 s. The time constant is equal to the RC product of the circuit, so the internal R of the LEC is about 150 kOhm. This is in good agreement with the load plot. Another test was done on the naked WE (in air), with a Geiger-Muller counter (LND712 tube, mica window, alpha sensitive), to check for emissions, no meaningful evidence of radiation was found.

Replication Work, Matt Lilley, Alan Smith

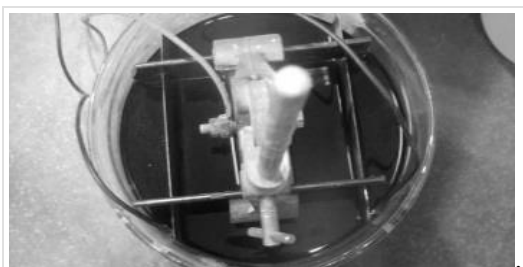
This replication effort in the NetZeroChem laboratory was only begun two weeks before writing this report, so though few, these results must be taken as very preliminary.

The first methodology decision made was to increase the LEC surface area by several orders of magnitude. Brass plates of 125 cm² were chosen as a substrate cathode material as brass is easily cut and shaped, it also takes soldered connections readily. The central anode is a substantial block of mild steel, and in this arrangement 2 cathodes can be plated simultaneously. The plating mix was, as described before iron sulphate, sodium citrate, ammonia, distilled water, pH 9.9.

Figures 6,7,8.



The brass plates chosen as the working electrode material were arranged with the substantial mild steel bar anode in a 2 litre borosilicate glass beaker for electrolysis. The arrangement is shown here (6) with plain water in the beaker for clarity.



The electrolysis regime and the electrolyte used are quite different to those used by other replicators, since the brass plates were exposed to a low average current for a period of 7 days. Total cathode surface area exposed to the electrolyte was 220 cm² and the typical total current supplied was 5W. A clamp was used to hold two slotted plastic spacers against the sides of the anode, the slots helped to hold the cathodes upright and at equal spacing from the central anode.



The brass plate cathodes were cleaned with 240 grit abrasive and then degreased with iso-propanol before being placed in the tank. Figure 8 shows the surface at a magnification of 300x approx) - the scratches are from the abrasive paper.

Figure 9.



Figure 10.

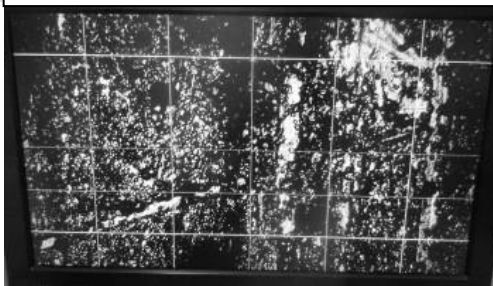


Figure 11.

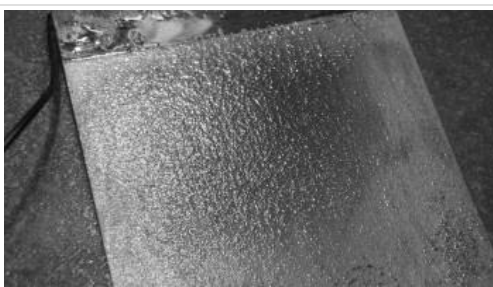
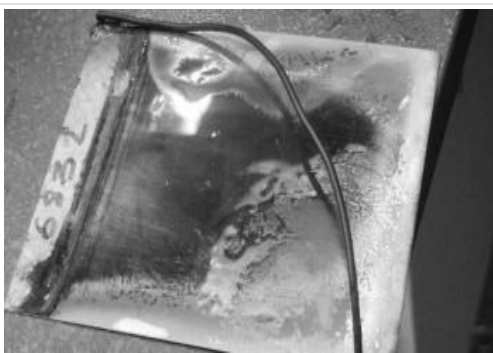


Figure 12.



After 7 hours in the plating tank the side of the cathode facing the anode had an obvious coating of iron (9), but was also beginning to develop black patches, which are probably magnetite, Fe^3O_4 . In other work Smith has noted the tendency of electrolytically formed anodic magnetite which often consists of clumped nanoparticles to down-convert into hematite, Fe_2O_3 within minutes when exposed to air, especially when using acidic electrolytes. This was one of the reasons for choosing an alkaline electrolyte which seems to passivate the surface somewhat.

This microscope shot, at 300x magnification (10) shows one of these 'dark zones' on the cathode, the black particles are firmly adhered and cannot be resolved at this magnification.

After 7 days in the tank the plating has a rather coarse and 'gravelly' surface, but the plating seems to have good adhesion. The rationale behind the long plating time was that it would maximise both plating thickness and hydrogen occlusion. This latter supposition has yet to be proven.

As can be seen in (12) here, there was some 'bleed over' with plating also present around the edges of the side facing away from the anode. Whether plating –even partially –on both sides of the WE is helpful or not is at the present time unknown, but will be accurately determined in future experiments. It was found in a rapid test that 2 WE's face-to face would output 127mV.

The freshly plated cathode, now the 'WE' was removed from the tank, rinsed in cold mains water and again in distilled water, then gently dried with paper towels. Connecting the WE and an unplated but otherwise identical counter electrode (the CE) to the Victor 8155 DMM while they were separated by around 30 cm. gave a max reading of >2 mV which was taken to be the 'noise' floor from surrounding equipment. This was confirmed by connecting the DMM to two more untouched but otherwise identical brass plates which also gave also gave a >2 mV reading.

The next thing was to stack the WE and CE plates on top of each other in air, not in hydrogen, with the heavily plated side of the WE facing the CE, using 0.9mm microscope slides as spacers. This gave a peak reading of 350mV which over the next hour dropped down to 250mV. The benchtop DMM readings were double checked with a hand-held clamp-meter known to be very accurate. Both meters were in agreement. Recovery time from a short circuit was not more than 5 seconds.



Figure 13. Bench DMM and on 'control' meter...not at the same exact moment- but they agreed very closely throughout. Much more closely than they do here.

After 90 minutes -with these plates in air, not hydrogen – the reading was 270mV. At this point the WE was put back into the plating tank with voltage as before, in order to prevent potential corrosion of the iron plating. Unfortunately the next morning the whole area electricity grid went down for 12 hours, so no further experiments were possible. Further experiments have been conducted, and will be published when ready. The reason for some (hopefully) artefactual oddities discovered in control experiments and also preliminary calibration work on a more advanced DMM are current priorities.

Findings so far are that when a WE and CE are separated for some time (say 30 minutes) the output recovers only slowly, taking 20-30 minutes to return to its pre separation level. It was also found that the closer the WE/CE were, the higher the output, but that even a very thin polythene sheet placed between them instantly reduced the output to zero. The best spacers in terms of performance are both very thin, and very porous, lightweight fly-screen nylon mesh being the most effective separator tested so far. Adding some small lead weights to the top of the stack also improved output and stability by keeping the electrodes flat and thus closer together. The table below might also be of interest, it shows the output vs recovery time for a WE/CE pair in air after short circuiting them with an earthed wire, the intention being to drain away any residual charge etc.

TIME -seconds	OUTPUT mV.
0	100mV (instantly)
30	140
60	132
90	146
120	152
150	158
180	152

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