MULTICELL REACTORS

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A growing body of experimental evidence in this last decade has shown that some types of low-energy-induced nuclear reactions are possible. Key cathode characteristics considered important for these non-Joule heating reactions, as documented in a US patent application, are discussed. These concepts are incorporated into an electrolytic reactor system to encourage these reactions while discourage Joule heating of the electrolyte. However, even the more efficient reactor designs appear to have diminishing returns upon scale up. The MultiCell unit's unique design allows for repetitive replication of the unit (much like a component on a circuit board or computer chip) to acquire the desired power output while still maintaining the efficiency of the small MultiCell unit. The design uses a plurality of small cells arranged in an interconnected array, wherein each cell is characterized by having a relatively small cathode separated from a relatively large anode by a small gap.

1. Background

A small research group[a] has been investigating different methods for producing excess heat for several years now. We are now starting to see some success in our research. We use plasma, lasers, electromagnetic fields, contaminate defects, etc. in attempts to stimulate excess heat from cathodic reactions. The author researches in the area of creating *defects* or *sites* that may create excess heat in metal films. Generally, the cathodes are small and surrounded by a large anode. Surface contaminants and conditions, surface areas and perimeters, geometries, etc. are considered important in producing an efficient cell. Then scaling up through the replication of the cell unit into a plurality is done to produce larger quantities of power. These embodiments are documented in a recent patent application.[1]

A growing body of experimental evidence in this last decade has shown that some types of low-energy-induced nuclear (LEIN) reactions[b] are possible. These could be, and are thought to be by the group, the reactions referred to as non-Joule heating. One series of electrolytic experiments by Dr. Tadhiko Mizuno emitted

[a]The core group consists of five members Dennis Cravens, John Frick, Vince Golubic, Dennis Letts, and the author, Rod Gimpel.

[b]The more common term used is low-energy nuclear reactions (LENR). Its use was not as widely used when the patent application was filed. In a sense however, LEIN reactions may be a more desired term because it describes the sought situation where there is more energy generated than put into the system.

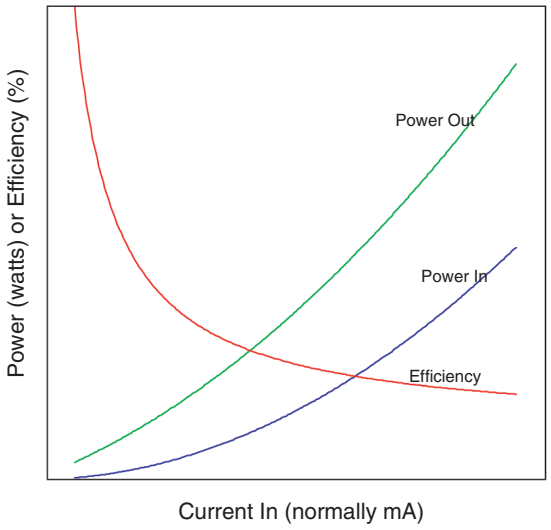

Figure 1. Non-Joule heating efficiency versus input current.

bursts of 10^5–10^6 neutrons at the cathode lasting up to 200 s.[2] Such experiments confirm the existence of the new reactions. Better theories may be developed that explain the non-Joule heating phenomena that have been observed but this does not change the results, embodiments, and claims documented within the patent application.

Unfortunately, most attempts to increase power yields have faltered when increasing input power or increasing the size and configuration of the cell. This is because increasingly disproportional amounts of the input power went into Joule heating of the cell and not into cathode boundary layers where the desired reactions occur. Joule-heating losses increase to the square of the applied voltage as shown in Fig. 1. Several designs and scale-up attempts have failed because the non-productive Joule heating quickly grew into overshadow the cathodic reactions.

Through the research of the group and others, we have concluded that further developments of and improvements in energy power systems utilizing electrolysis of liquid, plasma, or gas fluids are hampered by:

- an inability to scale-up because Joule-heating of the electrolyte (or proton/deuteron conductive media) becomes increasing dominant to the desired non-Joule heating processes;
- a lack of increased fluxes to heighten chances of non-Joule reaction at the cathode, and especially, in the cathode boundary layers where the desired non-Joule reactions take place;
- a lack of increased overpotential that drives the desired non-Joule reactions at the cathode, and especially, in the cathode boundary layers where the non-Joule reactions take place.

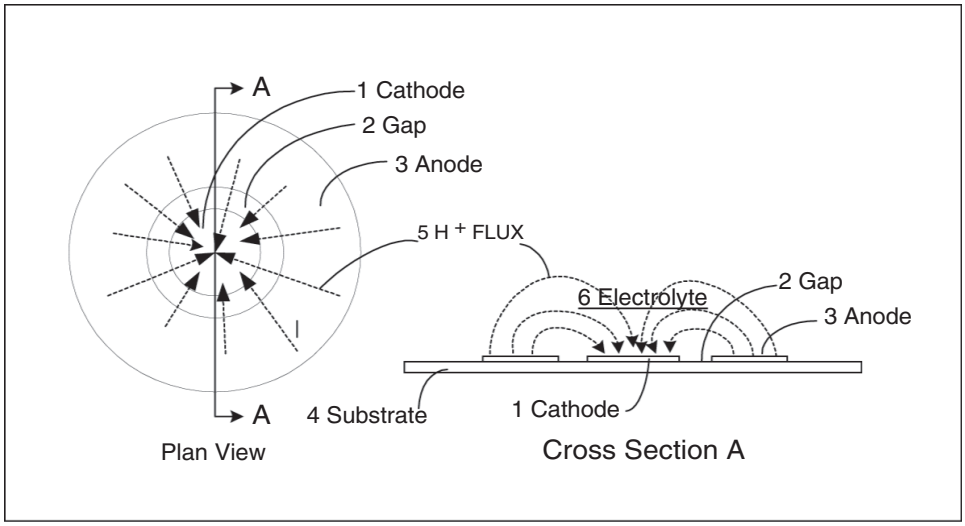

Figure 2. Basic MultiCell unit design.

2. Basic Design

The MultiCell is a small electrochemical cell designed to increase desired cathodic reactions in the electrolytic system/reactor and decreased Joule heating of electrolyte. The reactor's basic design involves a small unit, called a MultiCell unit. The MultiCell unit increases non-Joule heating efficiencies due its small size and a unique electrode construction having: a small cathode, a large anode, small gap, large cathode perimeter-to-surface area ratio, and symmetrical designs that synergistically increase the overpotential and desired cathodic reactions near the surface of the cathode while decreasing the less desired Joule-heating processes. The simplest MultiCell design is shown in Fig. 2. The MultiCell unit's unique design allows repetitive replication of the unit (much like a component on a circuit board or computer chip) to acquire the desired power output while still maintaining the efficiency of the small MultiCell unit. MultiCells have been immersed in an electrolyte bath to produce boiling water.

3. Object of the MultiCell Unit

The MultiCell design promotes a larger portion of the voltage drop to happen at or near the surface of cathodes. Focusing electrons and ions (protons/deuterons) into small areas and forcing them to flow through thin layers increases the flux, but it also increases the overvoltage (voltage drop) at and in the cathode surface boundary layers. *Tafel's law* (Eq. (1)) quantifies the relationship between flux and overpotential.

$$\eta = a + b \log_e I, \tag{1}$$

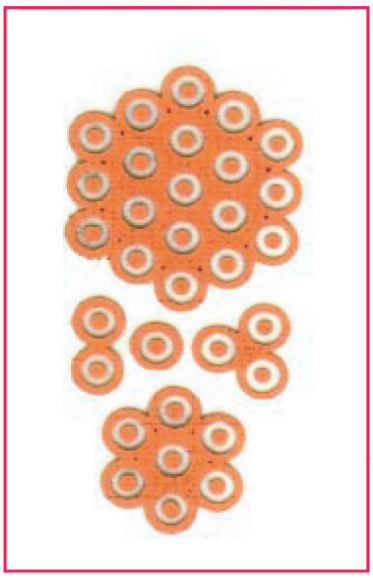

Figure 3. Replication of the MultiCell unit to increase power (actual photo).

where η is the overpotential in volts i the current density (electron flux, $e^-/m^2\,s$) or proton/deuteron flux ($H^+/m^2\,s$ or $D^+/m^2\,s$), and a and b are constants.

Unfortunately, this shows that overvoltage is less than proportional to the applied flux. This makes focusing the fluxes even more important, as the MultiCell does.

4. Cathode Materials and Morphology

A cathode substrate that can withstand the environment in the cell needs to be used. It is also felt that it should prevent leakage of hydrogen into the understructure, for example gold, copper, silver or platinum. A cathode size of less than $1\,cm^2$ is generally used.

We believe that "desired" heat-producing cathodic reactions happen in the surface of the cathode and not in the bulk of the cathode. We further believe that defects or sites in or on that surface are important in producing the desired reactions. The described embodiments were designed to validate these concepts, for example, they may use thin layers of palladium metal plated on a gold substrate cathode. Defects are formed on surface from the use of uranium, rhodium, and other elements. These give sites where hydrogen/deuterium can pair up and increase their chances to interact with themselves or atoms of the host electrode and environment. The sites are envisioned to provide areas where the hydrogen-recombination overpotential is high, which is considered important by some. Rare earth metals (e.g. cerium and lanthanum) are often used because they may provide a counter nuclear spin that helps in the coupling of hydrogen/deuterium.

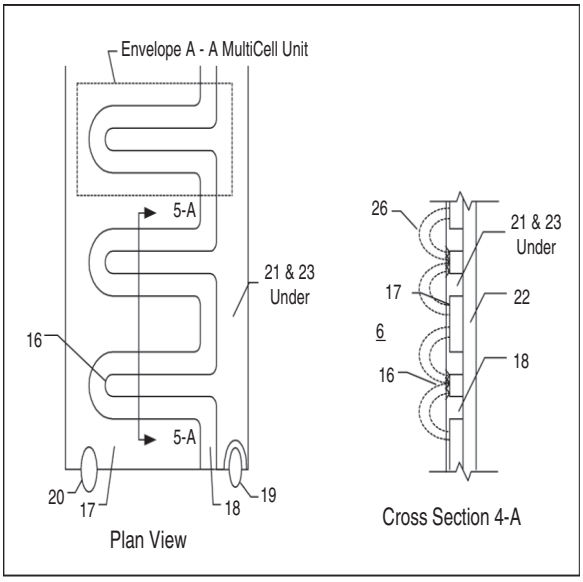

Figure 4. MultiCell non-circular pattern.

Palladium metal is often used as the anode. Using palladium limits the number of contaminates entering the electrolyte. Also, dissolution of the palladium from the anode can slowly plate out onto the cathode. This appears to be useful in the production of excess heat because it felt that it is the small crystal structures and contaminants and/or in the surface cathode are big contributors to the production of excess heat.

Cathode surfaces with corrugations, crevices, or large perimeter-to-surface area ratios are envisioned to increase edge-boundary layer reaction sites. Deposits of alternating thin layers of dissimilar electrically conductive materials, e.g. palladium and nickel, are being investigated.

5. Configurations

Figures 2 and 3 show the basic circular design. These designs can be constructed from plate stock or films onto a substrate. However, they tend to be more difficult construct than non-circular designs because they require construction in different planes to facilitate separation of the cathodes and anode(s). Whereas, the non-circular designs can be constructed form materials in the same plane. Figures 4 and 5(a) (taken from the patent application) show non-circular designs. The components of these are similar to the circular designs, except the cathode is long and slender. In Fig. 5(a) the cathode is constructed of connected dots in a row to increase the perimeter-to-surface area ratio.

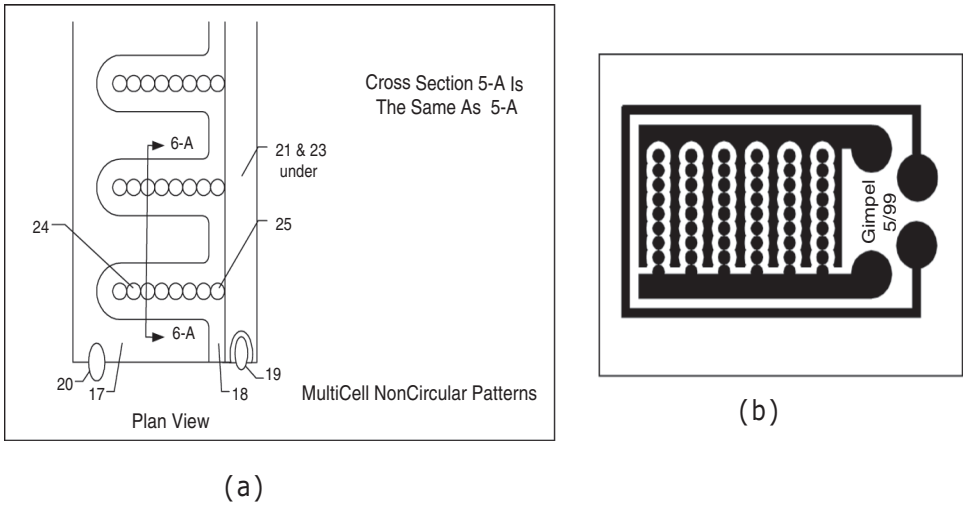

Figure 5. (a) MultiCell non-circular pattern; (b) an actual MultiCell (actual size).

6. Plasma Configuration

During operation of a MultiCell shown in Fig. 6 a blue glow or discharge can occur around the cathode (item 30 of Fig. 6). Notice the design is patterned after the non-circular MultiCell embodiment in where the cathode is smaller than the anode (see Fig. 4, envelope A). The blue glow does not happen until 50–100 V are applied. The exact voltage depends on configuration, electrolyte concentration, etc. While increasing voltage from zero, the current continues to increase until the blue glow or corona appears. Then the current sharply drops indicating a sharp increase in resistance. This marked decrease in resistance, when the plasma forms, implies that a significant voltage drop at the cathode surface boundary layers where the plasma forms. Figure 6 shows the operation and data collection of a plasma MultiCell unit as cited in the Patent Application. Unlike the other cells mentioned in this paper, this cell usually used light water instead of heavy water.

Experiments were run with this unit where high excess heat (>30%) were measured. Others have tried to measure its heat in flow-through calorimeters but it does not perform as well in such systems. This is because such systems require the cell to be run in at an enclosed cell with bath temperature around 50 °C. Whereas, the cell seems to performed best at higher, even boiling, temperatures.

Others, such as Tadahiko Mizuno, have also experimented with plasma. His original cell used larger plate cathodes. His latest cell now also uses a smaller cathode and larger anode design. The amount of hydrogen generated by an electrolytic cell is generally calculated by using Faraday's law. However, this is not correct for a plasma cell. The high temperatures and energies at the cathode break down water in disproportional amounts. Mizuno has measured where the excess hydrogen generation reaches more than 30% of energy input.[3]

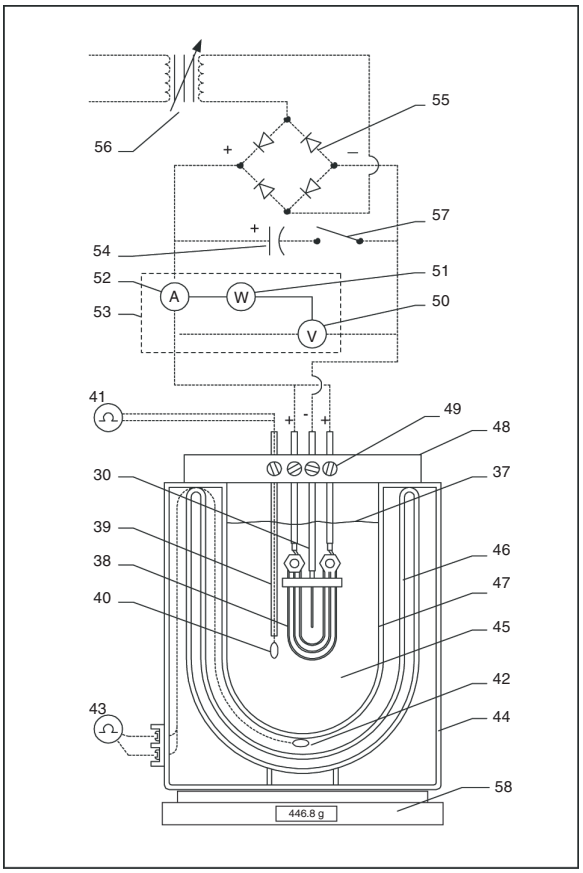

Figure 6. Process control, testing, and calorimetry apparatus for plasma MultiCell unit enbodiment.

7. Methods of Producing MultiCell Electrically Conductive Patterns

The patent application also discloses developed and demonstrated methods to efficiently and accurately produce metal patterns on electrically non-conductive materials with the use of an ink-jet printer device. The technique uses an ink-jet printer with special inks containing soluble palladium (or other catalyzing metal) compounds to produce the desired patterns or pictures on paper or other materials. Then the palladium compounds are reduced to metallic palladium (see Fig. 7). Finally, electroless (e.g. nickel, cobalt, copper, gold, platinum and palladium) plating solutions are used to deposit metal films over the metallic palladium patterns (see Fig. 8). Even though the palladium metal (or other similar material) is in low concentration, it acts as a catalyst and provides the sites needed for the electroless metal process to begin. The deposited metal then acts as its own catalyst and continues the plating process. Other layers of different metals can then be deposited on

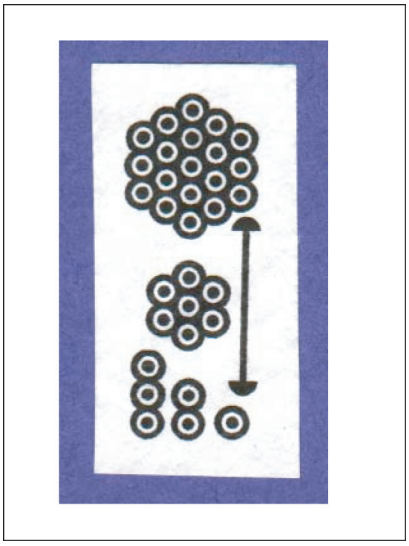

Figure 7. Palladium metal pattern produced by ink-jet printer (actual size).

the metal patterns using standard electrolytic and/or electroless metal depositing techniques.

Using different metal solutions applied as different "colored inks" can make alloys and contaminants of varying composition. One of the "colored inks" can be a reductant that develops the sprayed pattern. This can be repeated until the desired thickness is obtained.

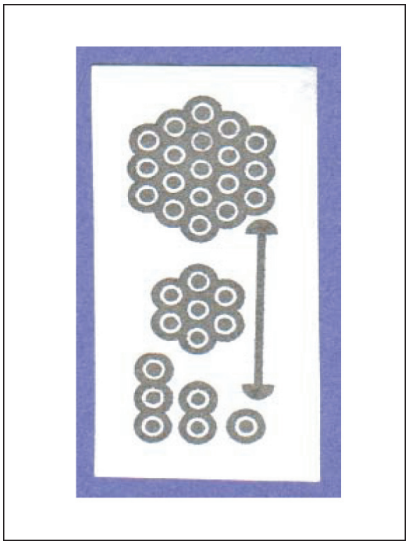

Figure 8. Nickel plated onto palladium pattern.

There are manufactured glass and ceramic glazes that contain palladium, copper, silver, gold, and platinum, etc. compounds that can be applied like paint. When heated, the organic compounds in these paints reduce the compounds to elemental metals. Hand applying, silk-screening, or other methods can be used to apply the paints in the desired patterns to the substrate. Appling a thinned solution of palladium paint can produce a catalyzed pattern like the above-cited technique prior to performing electroless plating.

8. Conclusion

MultiCell concepts have yielded good results and further developments appear promising and will continue. However, development is slow because of the shoestring budgets of the group. Most of the funds come from the "day jobs" salaries of the group.

References

1. R.F. Gimpel, D.J. Cravens, J.S. Frick, V.F. Golubic and D.G. Letts, *MultiCell Reactors, 20 June 2000*, US Patent Office Patent Application Serial No. 09/597,650.
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3. T. Mizuno, T. Akimoto and T. Ohmori, in *Generation of Heat and Products During Plasma Electrolysis, Paper and Presentation, Proceedings of the 10th International Conference on Cold Fusion, Cambridge, Massachusetts, USA, 24–29 August 2003.*