Climate change is real. So is the energy crisis. We need new sources of energy. We need them now. People will always do what is the cheapest. Energy farming cannot undersell coal, oil and gas. Ignore the 'green' talk. Every day, the world dumps faster and faster. Do you want to change this? Do you truly want a tool to hammer at pollution?

Today - fusion will produce clean, green, abundant energy for planet Earth. If we can harness this natural process, we will change everything. That is the big idea. It is not a crazy idea. Each morning and across the world, bright men and women are trying to do this. We should celebrate their efforts. They are trying to save us all.

The fusion community is vast and it is growing. You can get involved. I have met many leaders and thinkers in it - and I can say they are some of the hardest working and smartest people I know. We share a vision for all mankind. We want to bring civilization into a new age: the age of fusion.

How to get there, what to do and the tools needed, will depend on all of us. It is hard to predict the future – but know that we can change this. There is a way forward.

Sincerely,
The Polywell Guy

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This page has executive summaries of everything on this blog. The plan is to update this page as posts are added. This should make the blog more user-friendly. Disclaimer: there will be mistakes. This is not peer reviewed material - and no one was paid to produce it. We are not perfect and we do not claim to be. This blog depends on you to find errors. Criticism is accepted – please comment, speak up and get involved - but please do not degenerate into name calling. This is hard stuff. Posts can take several months to outline, research and write, and, in general, the newer posts are superior to older ones.

The purpose of this blog is to educate the public. We are attempting to use the most accurate information available. We are also attempting to explain things in as simple a way as possible. Bear with us - topics can be unbelievably complex. Our goal is to be impartial - to present science as we find it, not as we would like it. That means admitting if this idea turns out to be a dud; as it may still be. Enjoy.

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2013:

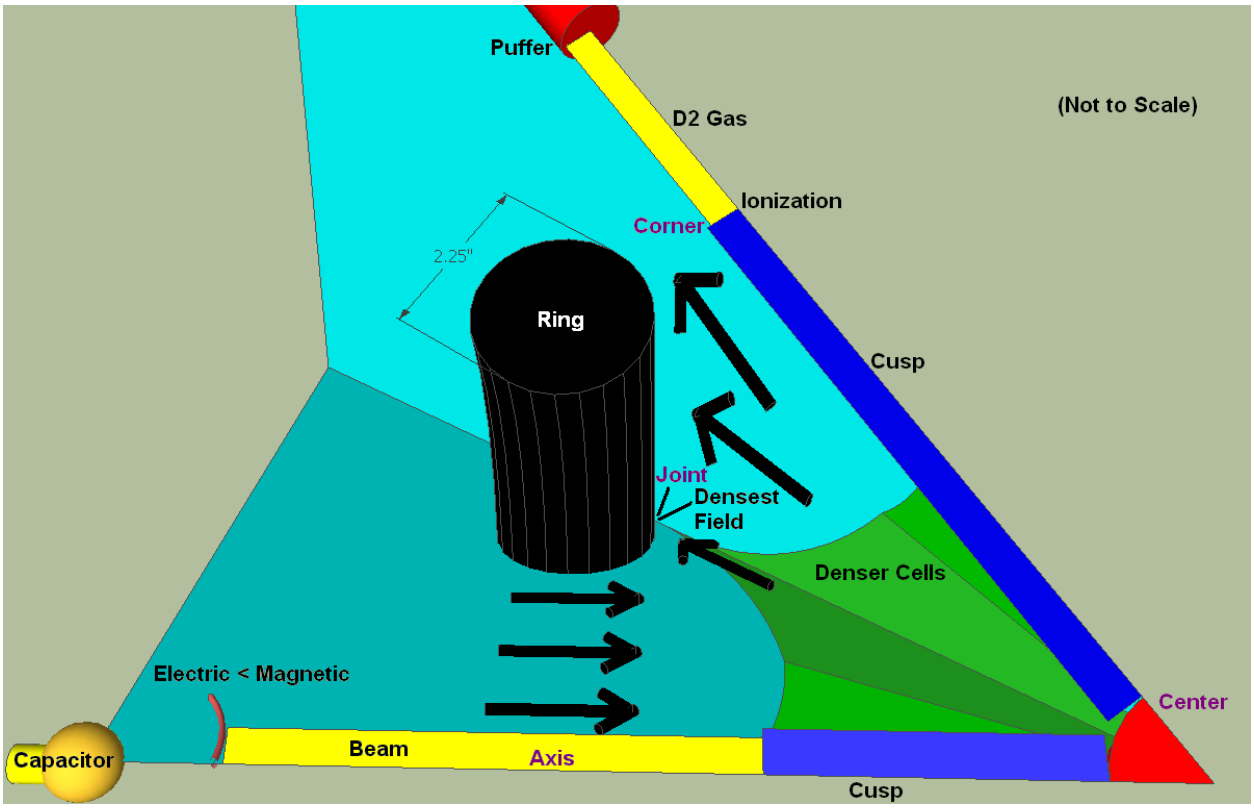
"Taking a Stab at Simulation" – Wednesday February 6, 2013

http://thepolywellblog.blogspot.com/2013/02/simulating-wb6.html

This post reviews what is needed for a comprehensive simulation of the polywell. It has four sections: using WB6 as a benchmark, analytical expressions, the magnetic field in WB6 and the particle-in-cell method. Any code is first validated by duplicating the WB6 results. The machine is outline, including: the geometry, power supply, feedstock and diagnostics. Operation is summarized in five steps: tank pump down, applying the cage field, electron trapping, gas puffing and the neutrons produced. The electron emitter and beam are modeled. Beam speed is strongly controlled by emitter placement and this impacts trapping. Regardless of emitter placement, the magnetic will overpower the electric field. Energy loss from the beam is shown to be insignificant. Estimates of the field at the joint, corner and axis show that ring design emphasizes uniform containment. The axis and corner fields are close in value. The number of electron trapped is estimated. The magnetic field model for one ring of WB6 is encoded into Excel and MATLAB. The excel model required using a trapezoid approximation.

Excel and MATLAB are compared against simple estimates and WB6 data, for benchmarking. Vector and energy density plots for a single ring, are generated.

The ring field is similar to the field made by two a-like poles placed close together. Therefore, the field points outward everywhere except through the rings themselves and the energy density is higher in machine center. It is suggested: that proper containment may balance the outward pointing fields and the magnetic mirror effect. This is not proven. The mathematical expression for all six rings is encoded into Excel and MATLAB. The field is modeled along three particle paths into machine center. These results are compared with expectations, estimates, single ring models and WB6 data for benchmarking. Vector and energy density plots for six rings are generated. Typical geometry, time steps and particles needed for a particle in cell simulation are given. The ion to electron ratio for WB6 is estimated at 0.98. The post concludes with nine suggestions for future work.



2012:

"The Public Plea" – Saturday October 20, 2012

http://thepolywellblog.blogspot.com/2012/10/the-public-plea.html

This post is a hodgepodge of ideas. First, is an attempt to write a “mission statement” for the community based on a survey of 409 posts on the talk-polywell implications thread. Quotes are included. Next, is a discussion of Bill Flints’ Polywell site and some highlights from the 2012 IEC conference. The fusor and the machine mechanism are both brief referenced. Machine scale up is discussed, using reaction cross sections and the volumetric fusion equation. Because of the Lawson criteria, efforts to raise machines’ efficiency as opposed to plasma density or heat, should be pursued. Efficiency may be raised by x-ray reflection, increasing electron and ion recirculation, reducing energy input, and using direct conversion to capture energy. Occam's razor is used to argue for this machine, as it currently makes fewer assumptions then other ideas. Lastly, a call for a MCNP simulation and dimensional analysis of the Polywell using eight dimensionless ratios, is made. The hope is that modes of operation, or a resonance condition, may be found.

“How It Works” – Monday September 10, 2012

http://thepolywellblog.blogspot.com/2012/09/how-it-works.html

This describes the proposed mechanism for polywell fusion in 9 steps, with citations, for WB6. First (1) the electrons are emitted using thermionic emission. Next (2) a Lorentz force pushes the electrons down a 12,500 voltage drop into the rings. Next, (3) the magnetic becomes greater than the electric component of the Lorentz force, and the electrons follow the field lines. (4) The electrons recirculate from the center to the 14 cusps and the motion is straight in the center and corkscrews tighter in the dense fields at the cusps. Under high density, the electron experiences a magnetic mirror and is reflected. Straight motion in the center scatters the electrons and leads to their eventual loss. (5) When billions of electrons are caught, they form a 10 kV point charge. (6) Uncharged deuterium gas is puffed towards the rings. (7) When the gas reaches the electron cloud it heats up past 16 eV and ionizes. (8) The ion experiences a Lorentz force, falls towards the cloud and builds up as much as 10,000 eV of energy. (9) If two ions collide, in the center, at 10 KeV, and they can fuse. The stated goal of NIF was to get the average plasma temperature over 10,000 eV under confinement. The fusion product should be too energized (multiple MeV’s) to be held by the fields. Other physical processes occur simultaneously with fusion, such as: x-ray generation, cyclotron radiation and columbic repulsion. Net power would mean minimizing these competing processes and raising reactor efficiency to lower Lawsons’ “critical temperature” for fusion. This post closes by discussing scale up through the cross section and volumetric fusion equation.

"The Physical Basis For The Polywell" - Monday July 30, 2012

http://thepolywellblog.blogspot.com/2012/07/the-physical-basis-for-polywell.html

This work explains much of the underlining physics of the Polywell idea, in conversational language. It is based off Dr. Bussards' last machine from the fall of 2005. The machine components are discussed: the cage, electron emitters, gas puffers and the rings. A model for $1/8^{th}$ of the rings is posited, with the joint, center, axis and corners listed as locations of interest. The rings are placed, such that, the joint and axis magnetic fields equal each other. The orientation of the ring current, magnetic and electric fields are then described; for this work all the north poles face inward. Next, the steps to turn on the machine are discussed – as adapted from Bussards' description. The device is turned on in five steps: by evacuating the chamber, turning on the cage voltage, turning on the electromagnetic rings, emitting electrons and finally puffing in deuterium gas. The physics of ionizing the gas are laid out next, followed by the equilibrating of electron temperature to ~2,500 eV. Critics argue that the electron and ion temperatures must all be within 5%.

From this description, the work shifts to simple models for the plasma and fields. A possible physical mechanism for the electron cloud to reject the ring field rings is mentioned. The number of electrons is approximated. The electric potential for a single electron is then estimated, across the middle of the device. This is based on one of five different electron cloud shapes in the middle: an infinitesimally small point, a small sphere, a large sphere, a 14 point star and a diamagnetic cloud. Next the magnetic field is modeled four points of interest: the center, joint, axis and corner. This model is used to predict the magnetic field strength as the rings are moved outwards. Specifically, the magnetic field, energy density and electron potential energy are all estimated. Unfortunately, the small magnetic moment of the electron means the magnetic field has a diminished role in its potential energy. Lastly, three other issues are also briefly examined. The first is the possibility of reaching the critical electron density to reduce x-ray losses; this is regarded as unlikely. The second is sparking inside the device; which was listed as occurring in Bussards' work. The last issue explores the theoretical upper bounds of how many x-rays could be reflected.

"***A Green Sun" - Friday, July 6, 2012***

http://thepolywellblog.blogspot.com/2012/07/green-sun.html

This post is a review of a fictional novel about the Polywell, entitled: "A Green Sun". The book was published digitally on Amazon.com by Mr. Charles Grey in 2012. This post and summary will spoil the novels' story. The novel follows James McConnell,

a wealthy oil executive and Dr. Joliene Wu the head of a Polywell startup. The story is set in the spring and summer of 2013. The Ghawar oil field dries up and gasoline rises to 7.75 a gallon. This leads to riots and murder across America. The startup runs a 100 MW test and the machine works. McConnell uses the ultra-cheap energy to generate methanol from the air and water. The US government agrees to build Polywells in every major city to stabilize gas prices. The post gives general impressions of the novel and subjects the methanol production idea to general technical scrutiny, predicting a fixed price of 3.68 a gallon for methanol.

"Inventing the Impossible" - Sunday April 15, 2012

http://thepolywellblog.blogspot.com/2012/04/inventing-impossible.html

This post examines the history of inventing the airplane - considered impossible - as a guide in inventing fusion power. It opens by connecting the Polywell to magnetic mirrors, the Lorentz force, NIF and the fusor. The problems of x-ray cooling, thermalisation, a single prohibitory high temperature and neutrons are also mentioned. Flight was universally considered impossible. The public treated those who pursued it as cranks and a 100 years of failures supported this view. Today, the world sees the fusioneer in the same light. In 1893, Octave Chanute compiled every flying attempt in a book. Today, no such book, covering all ideas broadly and objectively, exists for fusion. He built a community of amateurs and organized general flying conferences. Otto Lilienthal's' 26 years of flying attempts is compared to Dr. Bussard 21 years of work on the Polywell. An analysis of why Sam Langley - who led the federally supported attempt – failed, is included. Langely did not focus on flying principals, fixed on high power machines, spent money on extraneous equipment, used faulty data and preformed few experiments.

The Wright brothers used simple cheap machines, had a fresh view, objectively questioned all information and performed many tests. They used dimensionless ratios and models, to simplify designs. They also argued extensively. Unexpected results, forced them to re-measure the lift tables. After success - they were ignored or chided by the military, the media and the public for several years. Flying news was only spread by word of mouth. It is argued that this would be true today; based on ideas in the book "The Purple Cow". The Wrights were also placid; and this helped people accept their ideas. Frank Lahms promotional work is also mentioned. Finally, a summary of 13 lessons for today's fusion researcher is included.

"The Startup" – Monday February 20, 2012

http://thepolywellblog.blogspot.com/2012/02/startup.html

This post explores a VC pitch. Demonstrating profitability after 7 years may be difficult. A case is made for urgency by the US military and government to build. If a machine was built, try running it with lots of low energy, tightly held electrons, few ions and ample space. The 2011 Iranian PIC simulation paper is explained, analyzed, and criticized. The work is poor. The design has too much metal. The paper does not address fusion, thermalization, the virtual anode or magnetic mirror theory. The Navy and Sydney groups are also briefly mentioned.

The 1989 patent expired and was re-filed in 2006. Since July 2011 this has been part of the prior art. Riders counter arguments are summarized. Next a six member team is suggested: a nuclear industry expert, a physicist, a marketer, a manager, a manufacturing specialist and a sales person. A prototype would need a vacuum chamber, vacuum pumps, puffer, fuel, electron guns, a neutron counter, a power supply, a coolant layer and the ring structure. Extras include: x-ray detector, a neutron recoil detector and a Thompson scattering laser detector. Device sizes are reviewed: Mark Suppes, (~6") Joe Khachan, (~6") WB-3, (~6") WB-6 (~12") and WB-7 (~12"). Planned devices: Joel Rogers, (~24") AEO Iran, (~24") and the Navy's WB-8 are mentioned. An argument for a larger prototype is made. A design based on the six sigma practices of eliminating variation using interchangeable parts is sketched. Rings are designed so spacing can be adjusted on the fly (moot point – rings should be spaced so the axis and joint fields equal). Seven suggestions are made for operating success: finding a resonance condition, using head on collisions, x-ray reflection, running electron rich, exploiting the ion charge, exploiting ion injection, (now a moot point) and using direct conversion.

The advantages of grouping terms into dimensionless ratios for experimentation are discussed. Two groups: the ion-to-electron ratio and the beta ratio are mentioned. Rayleigh's method and the Buckingham- Pi theorem are applied. Four ratios result and the Whiffleball number is considered as a possibility. A ratio of ion beam and electron cloud voltage is posited (now a moot point). A suggestion for mass and energy balances and the Lawson criteria is made. In Lawsons' 1956 paper: the rate of energy loss is compared to the fusion rate and a critical temperature where they intersect is argued. The fusor (1964) breaks this convention by fusing at a low temperature and pressure. If the loss rate is reduced, it may cross the fusion rate at a lower temperature – lowering the critical temperature needed for net power. The practical advantages of this are discussed. Diagnostics and plasma instabilities are listed as yet-to-be examined topics. An appendix, examines the size of an electron.

2011:

"Oh The Possibilities" – Saturday December 10, 2011.

http://thepolywellblog.blogspot.com/2011/12/have-little-imagination.html

This post has two parts: a business analysis and an engineering analysis that supports it. The business analysis forecast machine price point, durability, ideal environments and break in markets. The feasibility debate is framed as hinging on if there is a plasma structure in the center or not, and data is called for. Bussards' 1994 Navy report outlining an IEC power plant is mentioned. A price point of 91 cents and 16 cents a kilowatt-hour for a 1% efficient machine, fusing DD and PB11 respectively, is estimated. These cores are estimated to get about the same neutron flux as current pressurized water reactor fission cores, without a moderator. Market segments such as mobile generators, renewables, and isolated generation stations are mentioned. An emerging or high tech economy which is not dominated culturally, politically and economically by oil, gas, and coal is discussed as a launching environment. This is argued to be most fusion friendly.

The US Army is identified as a first adopter. It has the personal, resources and the unbiased outlook to support efforts. Generators for bases need fuel. This represents vulnerable supply lines, price fluctuations and 70% of battlefield tonnage and could be changed. The city of Sana'a in Yemen is identified as a first adopter. The city of 2.1 million needs water, is not connected to the oil industry, is the national capital and has an existing pipeline to the sea. A fusion powered desalination project could be supported by the government. Mumbai India is discussed; the city has a technology, entertainment, and financial based economy, has nuclear research institutions and needs water. The steel and copper mining industries are discussed - steel because it benefits from a drop in coal prices. Implementation means an onsite reactor owned and serviced by a contractor.

The engineering analysis estimates ion collision energy, price, ring construction, reactor durability and method of particle injection. Fuels each have ideal voltages, cross sections and energy generated, which supports the idea that the reactor is tunable. This is enumerated for DT, PB11 and two DD reactions. Using these, twelve price points are calculated, for a worst, (20% fuel conversion, 1% energy capture) better (35% fuel conversion, 5% energy capture) and best (45% fuel conversion, 12% energy capture) case scenarios. From this - tritium is prohibitively expensive - even in unreasonable conditions (99.999% fuel conversion, 90% energy capture) the price

would be ~60 dollars a kilowatt hour. Pure deuterium is recommended and Boron is preferred for long term durability.

Material selection for the rings is discussed: graphite, 316 steel, neodymium, molybdenum, tungsten-carbide, silicon carbide, boron, Teflon and aluminum are all considered. Based on relative magnetic permeability, neutron activation, melting point, thermal conductivity, price and electrical conductivity – the case for stainless steel or tungsten-carbide is made. Reactor burnout due to embrittlement, transmutation and thermal stress is outlined. A basic analysis of neutron bombardment using the displacements per atom (dpa) equation is presented. Material cracking is a problem at 1 dpa. To apply this equation, cross section data for specific byproducts, materials and energies was recovered from the Los Alamos's nuclear information service. Data was incomplete, so only the neutron data was used (a worst case analysis). Cross sections are estimated by constituent material proportions. Dpa rates predicted, range from 0.0006 to 8.61 (a 1300 MW PWR fission core experiences 0 to 90 dpa). This analysis is very limited by not considering thermal stress, local chemistry and materials processing.

The time for electron fill up is estimated. Electron guns are modeled based on off the shelf products. The time is calculated based on the fuel, the voltage predicted, the ion to electron ratio and the number of guns. The machine is treated like it pulses for 100 microseconds up five minutes. A review of Nevins paper is called for – which argues pulsing, will not work. The ion injection analysis is unneeded.

"The 30 Second Elevator Speech" - Thursday, September 29, 2011

http://thepolywellblog.blogspot.com/2011/09/30-second-elevator-speech.html

This post is modeled after a 30 second business pitch for the polywell. A short history of literature is given and an appeal for research is made. The machine uses the Lorentz force to speed up hydrogen, slam it together and fuse it. Electrons - trapped in the middle of six magnetic mirrors – are used to make the voltage drop. Lots of other things happen in the center, but the ions can fuse. Under no configuration is this device radioactive free and a working reactor would still give off lots of heat. Seven criticisms are listed including: x-rays, thermalization, containment, cloud focusing, particle scattering, charge separation instabilities and neutrons. Nine ideas are listed to circumvent these problems, including: magnetic mirrors, an electron cloud magnetic field, an ion structure, efficient material recirculation, device pulsing, device tuning, energy collection, improved reactor design and increasing machine size. Next is a prediction on the polywells' future. The post closes with definitions of terminology and a recommended reading list.

"Modeling Some Real Results." – Wednesday July 20, 2011

http://thepolywellblog.blogspot.com/2011/07/modeling-some-real-results.html

This models the 2010 Sydney experimental paper and contains ideas similar to those in their 2011 modeling paper. But, this predates that paper by five months and is not peer reviewed. A ~6 cm Teflon device with 10 turns of copper wire was put ~30 cm away from an electron emitter in a bell jar at 0.015 torr. A probe, measuring electrons was in the ring center and 2,500 amps of direct current (at 450 volts) went into the rings. At full strength, the rings push apart with a ~0.2 Newton force. Tests explored how the trapping changed with chamber pressure, ring current and electron injection voltage. The use of Teflon, aluminum and 304 steel is critiqued. The ring design of ~21 mm spaced apart rings is critiqued for having excess metal (it is now known that rings are spaced so that the joint and axis fields equal.)

The physics of the electron for one test (ring current: 625 amps, pressure 15 mTorr, beam voltage: 15 KeV) is modeled. The electron is made using thermionic emission, feels an electrostatic Lorentz force pushing it the ~10 cm to the rings. The gas has a mean free path of ~6 meters. The average electron arrives at the rings in ~7.2 nanoseconds, going ~2.5E7 m/s and experiences a ~0.013 tesla field (per ring). First, the electron beam is treated as uniform. If it has 1 degree between the magnetic and velocity vectors, the magnetic is higher than the electric Lorentz force and the electrons are caught. Next, electron velocities are modeled like a spreading bell curve using a Wiener process, where an interaction takes 320 attoseconds and exchanges 3.2E-21 joules of energy. This predicts ~23 million interactions inside the beam before reaching the rings. The beam has a ~1 cm diameter with density of 1E8 electrons/cm^3 and is modeled over a 0.5 cm chunk. With a 3 degree difference, this predicts the slowest (~1.4E7 m/s) and fastest (~3.2E7 m/s) moving electrons will both be caught. Modeling is not done after fill up. The number of electron transits (~42,000) is found using a lifetime of 100 msec and a transit distance of ~6 cm. 155 volts measured in ring center means ~10 billion electrons were trapped.

The paper indicated that electron trapping generally peaked at an ideal ring current – this supports a tunable machine. This observation is connected to magnetic mirror theory. The ratio of particle velocity and characteristic field length is compared to the electron gyroradius. When the ratio is higher than the radius, the mirror fails. As the ring current dissipates, the ratio falls. When the ratio is less than the radius, the mirror works and electron containment spikes, this supports a "peak" ring current. Next the mirror ratio (the ratio of the max and min magnetic fields) and loss cone concepts are discussed. FF Chen's textbook explanation and a difference between it and the

papers definition are included. Results suggest that lowering the pressure and raising electron injection voltage improves trapping. A price of $12,000 for equipment is estimated.

"If the Navy Gets Mixed Results: We Fund It." - Wednesday, April 20, 2011

http://thepolywellblog.blogspot.com/2011/04/if-navy-gets-mixed-results-we-fund-it.html

This post argues for Polywell funding based on the history of US magnetic confinement research. The MFTF was nine year, three fourths of a billion dollar machine that was cancelled by the Reagan administration the day it was finished. The DOE funded the idea without being totally sure it would work. An economic analysis of why government R&D budgets can be so narrowly focused is then included. As of January 2011 there is, an estimated 177 tokamak experiments either planned, decommissioned or currently operating, worldwide. The Polywell then is connected to the history of the fusors, magnetic mirrors, tokamaks and spheromaks. An argument for why funding the Polywell will be different from funding the MFTF is then made. The tenets of this argument are that the world has significantly changed since 1980, the need is great, the technology is mature, the competition to build is real and the potential payoff is huge.

"Response to comments." – Tuesday February 22, 2011

http://thepolywellblog.blogspot.com/2011/02/response-to-comments.html

Dan Tibbets, Carter, and Chrismb critiqued "The debate over electron behavior" and this response to their comments discusses electron trapping, motion, properties and the brillouin limit. Trapped ("inside") and untrapped ("outside") electrons are discussed. If the injection and escape energies are close - then electrons losses will likely be highest during injection. Irregularities in the magnetic field and columbic interactions ("knocking") are discussed as reasons for the electrons to become untrapped and cross the magnetic mirror line. For trapped electrons: low energy electrons occupy the low field center - while high energy electrons occupy the high field edges. If distances are less than the Debye length, knocking occurs; downscattering and upscattering the electrons. This model may be too simplistic. The electrons in WB6 are estimated using Coulomb's (5.5E11) and Gausses (8.5E11) law for a 10 Kv well at 35 cm.

The nuances of electron motion, electron drift, corkscrewing, the gyroradius and cyclotron radiation are interconnected and discussed. An error (electrostatic potential [volts] was called the electric field [volts/meter]) was found by Carter. Dr. Fitzpatrick's potential energy analysis of a magnetic mirror is reviewed. Modeling the Lorentz force and comparing pressures are both suggested as a means to analyze trapping. Data - a movie of electrons and ion behavior inside an experimental system - is called for, and Thompson scattering across a line is posited as a method for this. The possibility of a moving electron generating a mini-field which counters the ring field is discussed. The magnetic moment of a free standing electron (mass: ~9.1E-31 kilograms) is estimated (-9.3E-26 J/T) and if aligned in the WB6 field lowers the energy by ~1.2E-26 joules. The Stern-Gerlach experiment may counter this. The Brillouin limit, the maximum electrons density for a magnetically confined space is discussed, but ill-described. The appendix address if an electron will turn in a magnetic field.

"Spelling It All Out" – Thursday, February 10, 2011

http://thepolywellblog.blogspot.com/2011/02/our-big-problem.html

This post opens with a discussion of global warming and its connection to temperature rise, mass extinction and to large-scale food and water shortages. Bussard claimed that the energy recovered scales as the 5th of the machine radius and, if true, this post argues that the polywell will receive funding even if there is a small chance of this. Research is then connected to the energy, climate and economic issues discussed at the 2011 Davos conference. The post calls for experimental and theoretical investigation by the science community to determine if the polywell is viable. This would entail publication in existing science journals. The post calls on the internet community to raise the polywell's profile by critically thinking, connecting, and discussing the polywell. This concludes by laying out the seven guiding principles for this blog.

"Explaining the Counter Argument (Part II)." – Monday January 10, 2011

http://thepolywellblog.blogspot.com/2011/01/explaining-counter-argument-part-ii.html

This continues an explanation of "a general critique of internal-electrostatic confinement fusion systems" started in "Explaining the Counter Argument". New material starts in section E. Rider argues odd-angle ion collisions would prevail. Technically, there are four outcomes for ion-ion collision: coulomb repulsion, x-ray

generation, fusion or pulverization. In Riders assumed machine, the core is ~0.0001% of the volume, so ion spends little time there. He uses a uniform effective density throughout. The virtual anode and Whiffleball effects would break this effective density assumption. Using the effective density, Rider finds the ion-ion collision time for isotropic plasma. Rider argues that the thermalization time is some multiple of the ion-ion collision time. He shows ion-ion collisions happening at 100 to 1,000 times faster than fusion (this is similar to other results) and argues that thermalization kills the machine. This result uses generic equations and assumes one collision velocity, quasineutrality, a uniform density and scattering independent of density and volume. Other effects such as of x-ray reflection, the virtual anode, and the Whiffle ball are not considered. He gives three reasons for the isotropic assumption: it is unlikely the ions will bounce straight back, the high energy ions will push into the low energy ions creating isotropic collisions and if the plasma was anisotropic, instabilities would form. If ions in the center space out due to columbic repulsion, the plasma is non-uniform, and the isotropic assumption may not hold. A measurement of the plasma density, temperature and, structure is called for. Based on this, the bell curve of ion energies is broken into 5 parts: too cold to fuse, between the fusion and injection energies, above the injection energy, in useless orbits, and too energized to be contained. The time for an ion to be lost due to upscattering is found, from a general IEC equation. The Sivukhin expression (which predicts how a particle slows down in a two species, isotropic, uniform energy cloud) is combined with the general IEC equation. This combination yields an equation for ion upscattering in two species plasma. It is noted that upscattering time depends on the mass and charge of the ions used. Based on this equation, Rider estimates that if the reactor thermalizes, ions will be lost very quickly.

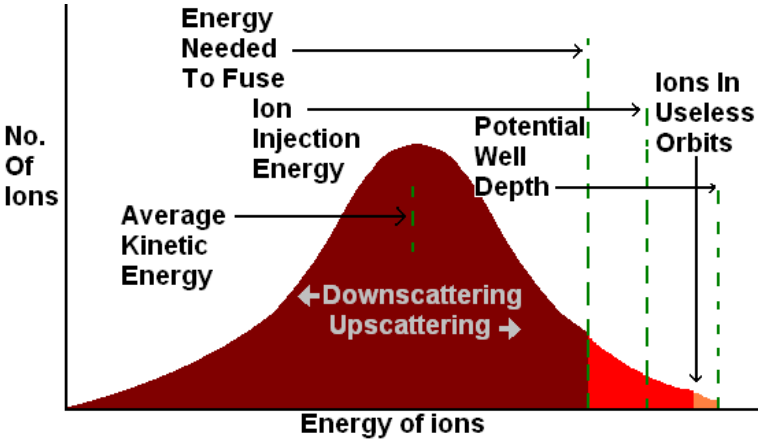
2010:

"We are now a community." - December 26, 2010

http://thepolywellblog.blogspot.com/2010/12/we-are-now-community.html

This post has a history of the amateur community, ('06 to '10) what this community can do, a call for research and links. Thousands of Polywellers formed this community, beginning in November 2006. In the spring and summer of 2007, articles were published and the talk-Polywell forum was created. Bussard got navy funding in August of 2007 and passed away that October. The navy team ran tests from January to late summer 2008. That fall, a Polywell idea was entered into Google's 10 to the 10th competition and Mark Suppes started work. He produced fusion, using a fusor, in

November 2009 and was on CNN in June 2010. The navy announced a ~12 million contract on September 11th 2009. The community is asked to investigate Rider's thesis. The post shifts to arguing for more research. The assumption: "fusion has been 20 years away for 30 years" is challenged because of the newest body of knowledge. Credit is offered to the tokomak, laser and, national lab scientists, engineers and mathematicians for making this possible. The internet is also cited as a way of speeding up research and redistributing knowledge. The post closes with an appeal for urgency.

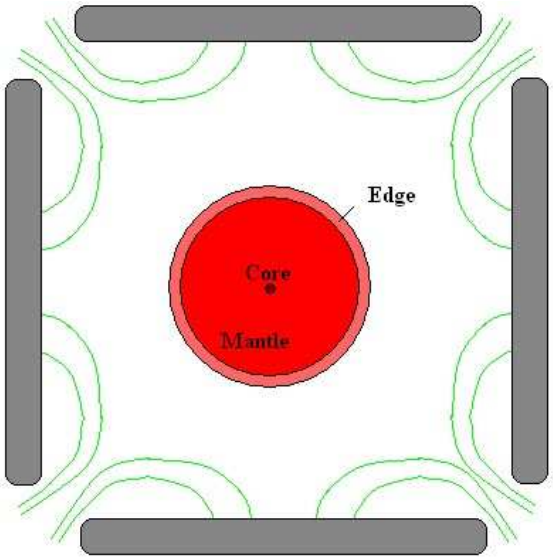


"Explaining the Counter Argument" - Sunday October 31, 2010

http://thepolywellblog.blogspot.com/2010/10/explaining-counter-argument.html

This post explains a chunk of “a general critique of internal-electrostatic confinement fusion systems” by Dr. Rider. Rider was a MIT grad student under Dr. Lawrence Lidsky in the mid 90's. The claim of different temperature and microwave compressed clouds is examined. The cloud is broken into three parts each with relative radii: a core (1 unit), a mantle (50 - 80 units) and an edge (100 units). Particle collisions - which degrade the focusing of the cloud - are about 10 to 100 times higher in the core then at the edges. Rider assumes the cloud focus remains constant - which he states as unlikely - and argues that fusion, x-rays, and scattering rates are independent of cloud density and volume. Rider assumes core behavior, energy and fuel is the same in all directions, uniform, and fully mixed. Rider also assumes the charge is uniformly mixed and this assumption is criticized. The rate of fusion power, independent of fuel density and per volume - is found - starting from a generic equation. The ion lifetime is then estimated. The amount of energy transferred, per volume, between ion clouds is expressed. Two cases are explored. In the first, ion temperatures are kept distinct by continually injecting new ions. An expression for injection is set equal to the ion cloud energy transfer expression - and from this it is found the ion cloud cannot vary more than 5% in temperature. This is critiqued by

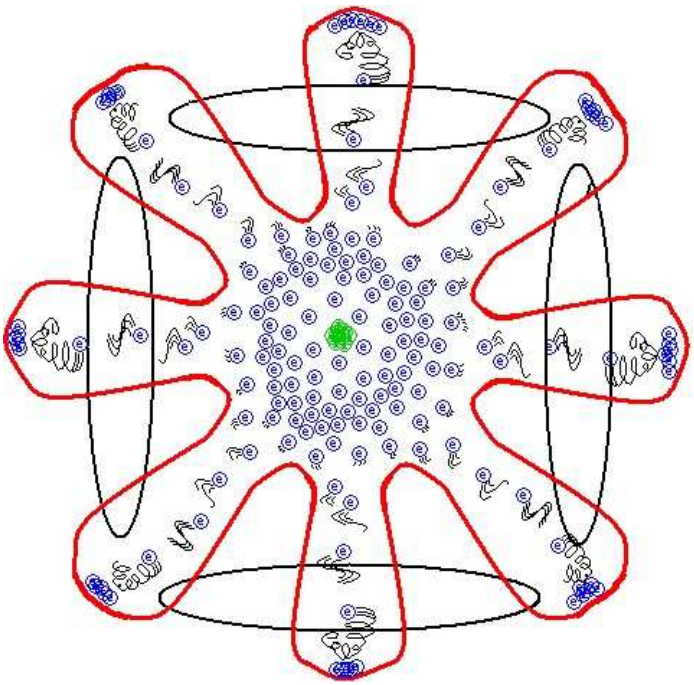
discussing other heat flows. In the second, the ions are kept artificially cold. A velocity for all collisions is assumed. The ion cloud energy transfer is divided by the fusion rate expression. Rider assumes that the transfer rate will be 1.4 times the energy generated. This analysis is critiqued.



"The Debate Over Electron Behavior." - Wednesday September 1, 2010

http://thepolywellblog.blogspot.com/2010/09/debate-over-electron-behavior.html

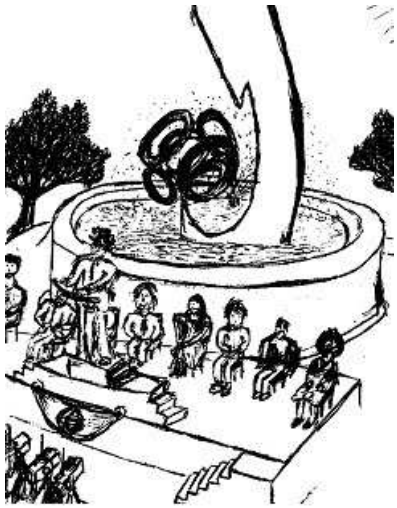
This examines electron behavior through the basics of the magnetic mirror and the Lorentz force. Disclaimer: this post has mistakes! The electrons recirculate from the 14 cusps to ring center. For a static electron, its magnetic moment will align it. When "kicked", it experiences a Lorentz force with the electrons in a denser field, having a higher potential and kinetic energy. This means tighter and faster electron corkscrewing at the dense field cusps. Magnetic mirrors are explained, using notes from the University of Texas. This assumes the fields are constant and the particles' total energy is constant. The electrons' electric and magnetic potential are compared with its' kinetic energy. This shows what regions of the machine, the electrons can and cannot occupy. The electron's magnetic moment is suggested as a counter to the ring fields (this seems unlikely, the moment may be too weak). Thomas Ligons' description of the virtual anode and low energy electrons in the center is quoted; with a call for a formal investigation into this.



"W.W.W.D. What Would Widgets Do?"- Monday, July 5, 2010

http://thepolywellblog.blogspot.com/2010/07/wwwd-what-would-widgets-do.html

This is a lighthearted, playful editorial about the effects of a new power source. The gulf oil spill and recent news events are linked together to the common problem of dirty energy. A widget, a fictitious invention that can produce cheap, clean, abundant, green electricity for five million dollars is purposed. A story of the widget is written, weaving the machine into the fabric of the US. Cheapness would economically drive many devices to switch to electricity. This would reduce, but not eliminate oil use, and impact drilling, fracking and tar sands. This could be used to desalinate water which would have political impacts across dry regions of the world. Cheap electricity could raise living standards and lead to human development in Africa. These changes would make America the wealthiest, cleanest and most respected nation on Earth.



"Transcript of Polywell Film" - Sunday, May 16, 2010

http://thepolywellblog.blogspot.com/2010/05/transcript.html

This post gives the highlights of a transcript for an "Interview with Thomas Ligon on The Polywell". The transcript is a 27 page document, with some errors. Its purpose is to be a viewing guide for the film.

"Conversations and updates on the Polywell" - Sunday, April 4, 2010

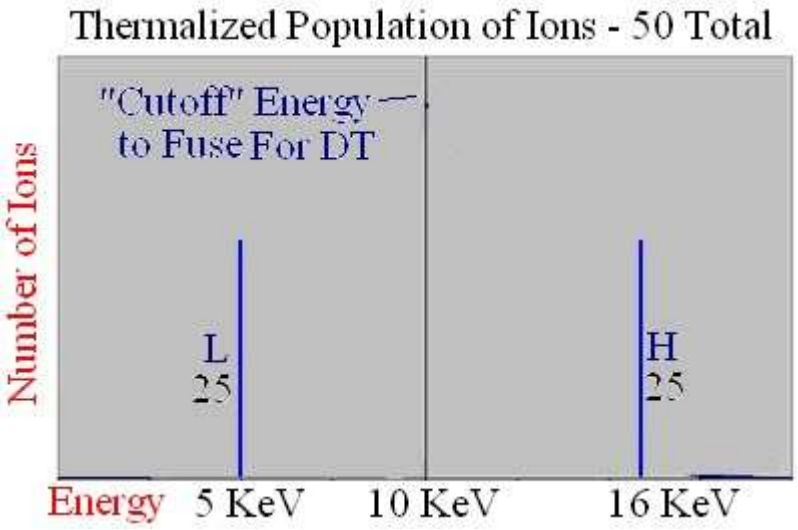
http://thepolywellblog.blogspot.com/2010/04/conversations-and-updates-on-polywell.html

This short post contains a link to a MSNBC article, design pictures and four questions about the polywell. The four questions answered are as follows. What are the connectors between the loops? Why does the design have so many holes? Is this designed used to heat water for energy capture? What is the build price? Lastly a comment is made on a 100 megawatt reactor.

"A very simple model for the polywell to spark discussion" - Monday, January 4, 2010

http://thepolywellblog.blogspot.com/2010/01/very-simple-model-for-polywell-to-spark.html

This post is a rudimentary discussion of a population of 25 high energy ions, 25 low energy ions and 50 electrons inside the machine. Between these three groups, there are six interactions possible. Using this simple system and statistics, this post shows that only six percent of interactions would result in fusion. The post then assigns energy to each interaction: 10.8 MeV for a fusion reaction, -0.011 MeV for a high-energy-ion-electron interaction and -0.003 MeV for a low-energy-ion-electron interaction. Using these energies, probabilities, and a random number generator an excel model is created. The machine energy is plotted over time. How the energies for a high energy ion and a fusion reaction were assigned, is discussed in the appendix. An estimate for the number of electrons in WB-6 is included.

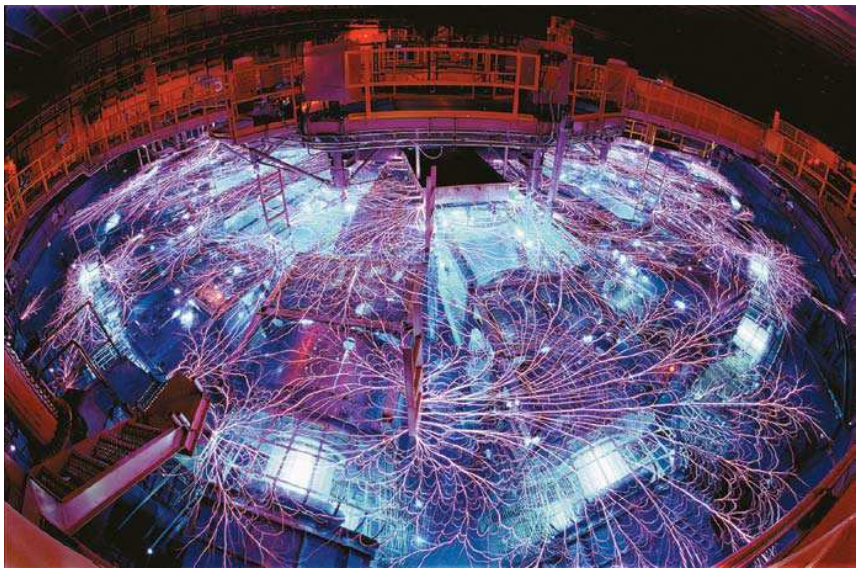


2009:

"Concise Questions and Answers about the Polywell" - Sunday, December 13, 2009

http://thepolywellblog.blogspot.com/2009/12/concise-questions-answers-about.html

This post contains researched responses to questions by Mark. His interest was in Boron and Lithium fusion as well as the Z-Pinch machine. The response starts with Thomas Ligon's description of the Boron fusion and the direct conversion method for energy capture. The direct conversion idea has a theoretical efficiency of 80% energy conversion. The post reviews the D2 and DT reaction, cross sections, the volumetric fusion equation, x-ray cooling and the lithium reaction. The post closes by mentioning Dr. Todd Rider and Dr. Richard Nebels work.



“Extended Interview with Thomas Ligon About The Polywell” - Sunday, December 13, 2009

http://thepolywellblog.blogspot.com/2009/12/extended-interview-with-thomas-ligon.html

This post summarizes the film an “Interview with Thomas Ligon on the Polywell”. There are 27 topics discussed and a link to a film is included at the end of the post.

“Questions & Answers with Thomas Ligon On the Polywell” - Tuesday, October 20, 2009

http://thepolywellblog.blogspot.com/2009/10/questions-answers-with-thomas-ligon-on.html

Thomas Ligon was an employee for Dr. Bussard from 1996 to 2001. This post contains his answers to emailed questions; the questions are as followed. What is your formal background in? When did you start and leave the company? Can you offer a history of events at Bussards' company? What was it like working with Dr. Bussard? What is the idea behind the polywell? Where did the research stand when you left? What major problems had been solved, what remained? What is the biggest technical challenge and advantage facing the polywell? What are your thoughts on Dr. Bussards claimed data? What form do you see the research taking? What will a final machine might look like?

"The Polywell: The World's Most Important Invention You Have Never Heard Of" - Sunday, October 11, 2009

http://thepolywellblog.blogspot.com/2009/10/polywell-worlds-most-important.html

This post offers an overview of fusor research, Bussards story, his machine claims, a summary of criticisms and a summary of the latest research. The post opens with Dr. Bussards work with the fusor in the 60's and 70's. The fusor uses a voltage drop - made by cages - to slam ions together. The problem with the fusor is that the cages leak energy so fast that the machine will never make power. The polywell innovation was to use six magnetic to trap electrons and make the voltage drop that way. Success also emphasized efficient recirculation with a limit on conduction losses. Bussard claimed that in 2005, he got fusion at a rate 100,000 times better than previous Fusors. Bussard passed away two years later. The post discusses criticism from Dr. Todd Rider, from 1994. Three issues discussed were x-ray cooling off the cloud too fast, neutrons damaging the machine and particles going to a bell curve of energy. The post closes with a summary of research developments to that point.