

The amazing discovery of Cold Fog Explosions.....

Extracting Intermolecular Bond Energy From Water

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Abstract

When a small amount of energy from a high voltage capacitor is discharged through a few cubic-centimeters of water, a strong explosion results which cannot be explained with thermodynamic nor electrodynamic forces. The 90-year history of unusual water arc explosions and their technological applications is reviewed. Three years ago it was discovered that what explodes is not the liquid water plasma but a quantity of dense cold fog generated in the plasma. The paper examines the science of this phenomenon.

It is concluded that tiny fog droplets contain less intermolecular bond energy, per unit mass, than bulk water. The energy difference is liberated quantum mechanically when the fog is created and sets up strong repulsion forces between the fog droplets. The extracted bond energy, which appears as kinetic energy of the fog, was deposited in the water during condensation in the clouds. It is argued that the heat of condensation is transformed to bond energy so that the explosions are actually fueled by concentrated solar energy which heated the vapor in the atmosphere. The extraction of internal water energy does not contribute to environmental pollution nor to global warming.

History of Water Arc Explosions

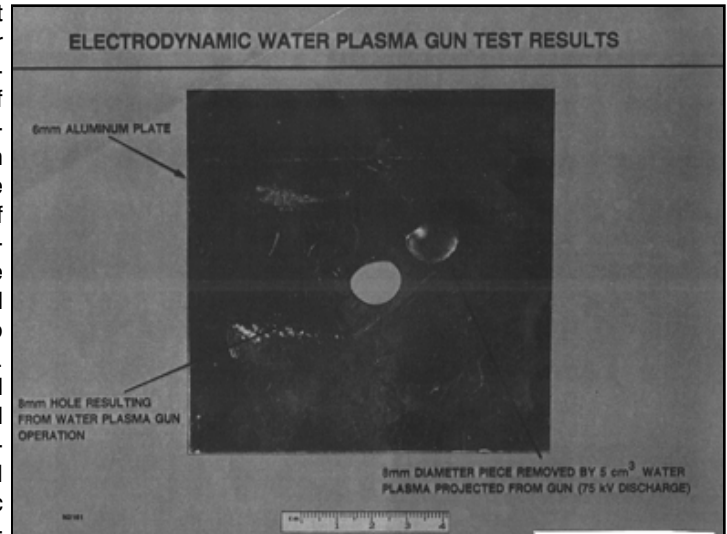
The energy we are liberating from ordinary room temperature water is set free by an electric arc in the water which causes an explosion. It is now known that what explodes is not liquid water but cold fog. There is a ninety year history of experiments with water arc explosions. It began in 1907 when Trowbridge [1], at Harvard University, passed a long electric arc through water-laden air. This produced a cloud of white fog. Trowbridge discovered another effect which has a bearing on fog explosions. He stretched a sheet of paper alongside his sparks of more than 50 cm length and found that at every corner and forking of the lightning-like discharge, holes were punched through the paper without any burning or charring. It took eighty years until experiments of this kind were repeated in the Massachusetts Institute of Technology and revealed that thunder was not the result of heat and the thermal expansion of the lightning channel [2], as assumed during most of the twenti-

eth century, but that the shock wave in air was driven by non-thermal forces of which electrodynamic forces were then considered to be the most likely. In view of our most recent findings, there exists the possibility that cold fog explosions also contribute to thunder.

During the Second World War, Frungel in Germany measured the unusual strength of water arc explosions and published his results in 1948 [3]. He concluded that the explosions were not caused by heat and steam and admitted freely that he was unable to explain the phenomenon.

Soon after Frungel's publication, water arc explosions found applications in electrohydraulic metal forming [4] and underwater pulse echo-sounding [5]. In 1969 the US Bureau of Mines issued a long report on their investigation of using water arc explosions for rock fragmentation [6]. In one experiment the investigators at the Twin City Mining Research Center noticed that the energy output was apparently 156 percent of the input. This result was dismissed as an experimental error. Not until the mid-1980s was the scientific basis of the puzzling explosions more extensively researched at MIT [7]. It was then shown that the discharge of 3.6 kJ of stored capacitor energy would create pressures in excess of 20,000 atm in 7 ml of saltwater. 3.6 g of water was ejected from the accelerator barrel at a velocity of the order of 1000 m/s and then punched a half-inch hole through a 1/4-inch thick aluminum plate [8].

At the time it was thought that the water was flying through the air as a coherent liquid slug. No evidence of boiling and steam formation could be detected and all the water found after the explosion was cool. Accepting the general view that plasmas are quasineutral and do not explode as a result of Coulomb forces, the available evidence seemed to leave little doubt that the explosions had been driven by electrodynamic forces. This observation did moti-



vate a ten-year investigation of the electro-dynamics of water arcs. The Lorentz force could not account for more than a small fraction of the measured force. Ampere's force law [9] fared better but still fell short of measured values by at least a factor of ten. The search for a new electrodynamic force was finally abandoned in 1994.

Another report of electrically induced explosions in water came from Kansas State University. Johnson [10] claimed that the loudness was distinctly greater than that obtained with an equivalent amount of gunpowder. He found that the remaining water was cool to the touch and apparently no steam had been produced. Johnson suggested the explosions may have been due to longitudinal Ampere forces and were tapping a new source of energy.

In 1994 the first video and high speed photographs were taken in three laboratories in the US, Canada, and England. They showed that the leading component of the water leaving the accelerator was actually very dense fog traveling at high speed and eventually rolling in air under the laboratory ceiling. By trapping the fog in a balsa wood absorber and measuring its temperature it was found to be quite cold, at most a few degrees above ambient temperature. The discovery of cold fog explosions changed the scientific outlook on the remarkable behavior of water arcs.

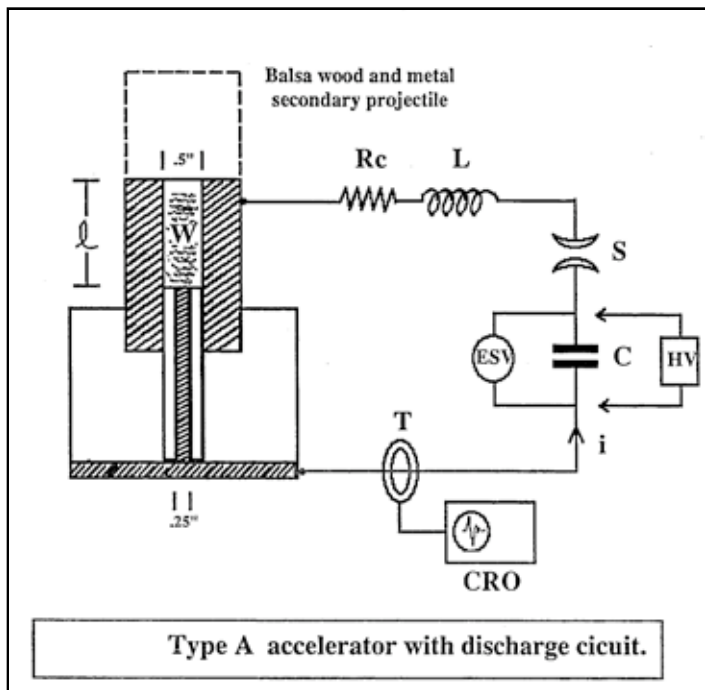
Discovery of Cold Fog Explosions

Our experiments and research on water arcs and cold fog explosions has been reviewed [9], up to October 1995, in our

book *Newtonian Electrodynamics* (See review in *IE#11—EFM*) This review enables interested scientists and engineers to repeat our experiments and build on them. The present paper is confined to the scientific basis of the process of extracting H_2O-H_2O bond energy from water.

The book reveals that a typical low-energy experiment involved a $0.5 \mu F$ capacitor charged to 12kV and, therefore, containing 36 J of stored energy. This energy was discharged through water volumes ranging from 1 - 5 ml. To appreciate just how little energy was fed into an explosion event it helps to know that striking a match liberates between 100 and 200 J of heat.

The arc explosions expelled most of the



water—but not all—from the accelerator barrel in the form of a vertical jet which pierced the laboratory atmosphere. The kinetic energy of the ejected water was measured with a balsa wood secondary projectile standing on the accelerator muzzle and absorbing the high-speed component of the water. The momentum acquired by the secondary projectile determined the fog kinetic energy.

Two arcs were in fact involved. A switching arc had to be struck in order to apply the capacitor voltage across the water cavity. The ionization of the switch and water arcs consumed more than half the input energy. This energy loss is easily measured by observing the almost instantaneous volt-drop on the capacitor terminals. The ionization energy is stored as electrostatic energy in the arc plasma. When the ions recombine, long after the explosion, the stored plasma energy is converted to heat. Ionization accounts for

the major energy loss of each experiment.

Another loss component is the Joule heat generated in the arcs, the capacitor, and the conductor connections. Its magnitude can be determined by observing the damping of discharge current oscillations. So it was found that more than 90 percent of the input energy was lost and converted to low-grade heat, a few degrees above ambient, which could not contribute to the explosion. The small remainder of the input energy was sufficient to supply the surface tension energy required for the transformation of bulk water to very small droplets. Electrodynamical Ampere forces in the arc, although far too feeble to explain the explosion, were nevertheless capable of tearing the liquid apart into small drops.

In general no more than three joules of electrodynamic energy were capable of generating 10 - 60 J of kinetic energy in the escaping water jet. The difference had to be made up by internal energy stored in liquid water.

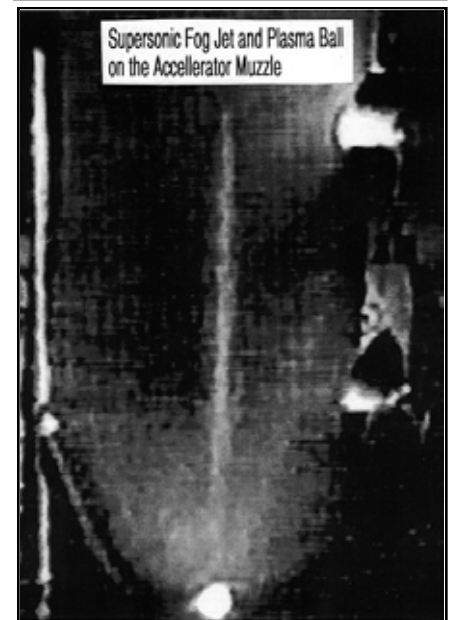
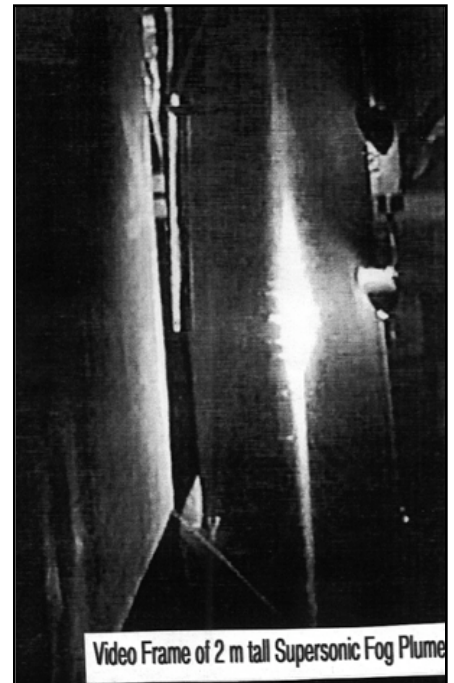
Not until 1944 were video and high-speed photographic cameras turned on water arc explosions to determine what was driving them. Since the ejected water was so powerful that it could penetrate metal plates, it was taken for granted that the water traveled as a liquid slug in order to concentrate

the impact inertia force. Much to our surprise it was discovered that a jet of high-speed fog shot out of the accelerator which was followed by slow water of little kinetic energy.

Tip velocities as high as 600 m/s (Mach 2) were observed which pierced the atmosphere by a conical shock wave. At lower input energies the tip velocity was subsonic and formed a mushroom head. In the Workshop **[Ed.Note: This is Graneau's workshop at the 4th International Symposium on New Energy, a video tape of this lecture is available from Cold Fusion Technology, Inc.—EFM]** I will show a video film, shot by the British Broadcasting Corporation (BBC-TV) in the TCBOR laboratory of Richard Hull [11] in Richmond, VA. Hull has been collaborating with the author and George Hathaway of Hathaway Consulting Services in Toronto, and also with Neal Graneau in the Department of Engineering

Science of Oxford University.

The video film documents the whole process of the water arc explosion and clearly shows the fast fog jets. The fog ultimately collects under the laboratory ceiling



as a cloud which rolls around while it evaporates in a matter of seconds. To dramatize the events, the BBC asked for a 1/4-inch thick plywood sheet to be placed on the accelerator muzzle and an increased input energy of 324 J. The fog jet punched a 1/2-inch hole through the plate. The conical tip of the fog jet above the plate indicated that it was still traveling at supersonic speed.

Ball lightning enthusiasts will see a plasma ball sitting on the accelerator muzzle for at least 100 ms, long after the fast fog had left the barrel. This is of no practical

importance as far as the cold fog explosions are concerned. The plasma ball probably contained a fraction of the ionization energy.

High speed photography at 10,000 frames per second carried out at Oxford [9] showed in detail how the fog jet struggled with the laboratory air and quickly lost speed and kinetic energy due to atmospheric ablation. A long tail of slow water leaving the barrel consisted of large drops and films which were transparent. They suggest that the fog had to penetrate at least part of the liquid water in the accelerator and imparted velocity to it by drag forces.

Fog formation seems to be an essential phase of the water arc explosion. No fog-free explosions have been noted. It seems quite certain that what takes place is an explosion in which the tiny fog droplets repel and accelerate each other inside the arc cavity. As soon as the fog leaves the accelerator the droplets stop to repel each other, as proved by the absence of lateral expansion of the fog column just outside the accelerator. Higher up in the atmosphere the fog jet spreads laterally on account of air ablation and not droplet repulsion. The absence of this repulsion outside the accelerator, when much of the fog must still be ionized, appears to rule out repulsion by Coulomb forces.

There is much to be learned about the fog dynamics in the water arc. At the present stage of the research we have credible evidence that the fog droplet repulsion disappears and the fog explosion is over before the current ceases to flow. This is not to say that the current is responsible for droplet repulsion. A more likely explanation is that the electrodynamic forces, which are proportional to the square of the current, cause fog formation and this process fades out with the current.

H₂O-H₂O Bond Energy in Fog Droplets

There is reason to believe that the intermolecular bond energy in tiny fog droplets, of 1 - 100 μm diameter, is smaller per gram than what it is in bulk water. If this is correct, then the bond energy difference has to be liberated when water is converted to fog. Quantum mechanics is the theory of particle bonding. Bond energy appears and disappears instantly when bonds are made or broken. When the conversion from liquid water to a lot of fog occurs very quickly, that is in microseconds, the only way in which the quantum mechanical bond energy difference can be dissipated is by an explosion or strong particle repulsion. The conversion of bond energy to heat is too slow to achieve the same end, because it involves the time-consuming process of particle acceleration.

Bond energy is potential energy which particles possess by virtue of their mutual forces of attraction and repulsion. Repulsion is said to be associated with positive potential energy and attraction with negative potential energy. There is no doubt that liquid water molecules attract each other. This is the essence of liquid cohesion and it must involve a certain amount of negative potential energy.

The two hydrogen atoms of the water molecule are not attached symmetrically about the larger oxygen atom. This lack of symmetry makes the water molecule an electrostatic dipole. The strength of the attraction between two electric dipoles depends on their distance of separation and their mutual angular orientation. The H₂O molecules in the liquid are in continuous motion and rotation relative to each other. Because of this chaos it should be impossible to make any prediction about the bond energy of liquid cohesion.

There are, however, grounds to argue that the dipole orientation in water is not entirely random because water has a definite dielectric constant which requires a certain degree of dipole alignment. The study of water structure is a very active but complex field. The consensus of opinion seems to be that locally the dipole structure changes perpetually, but globally there exists a certain average order which can be equated to a definite amount of bond energy per unit mass. This is numerically equal to the latent heat of evaporation which amounts to 540 cal or 2260 J per gram. The latent heat is in fact the energy required to break all intermolecular bonds.

When considering droplets of varying diameter it would not be surprising to find that the bond energy per unit mass varies with droplet size. This is expected from the fact that the droplet surface must have some effect on dipole structure

because of the forces which bring about surface tension. Surface energy and tension are aspects of liquid cohesion.

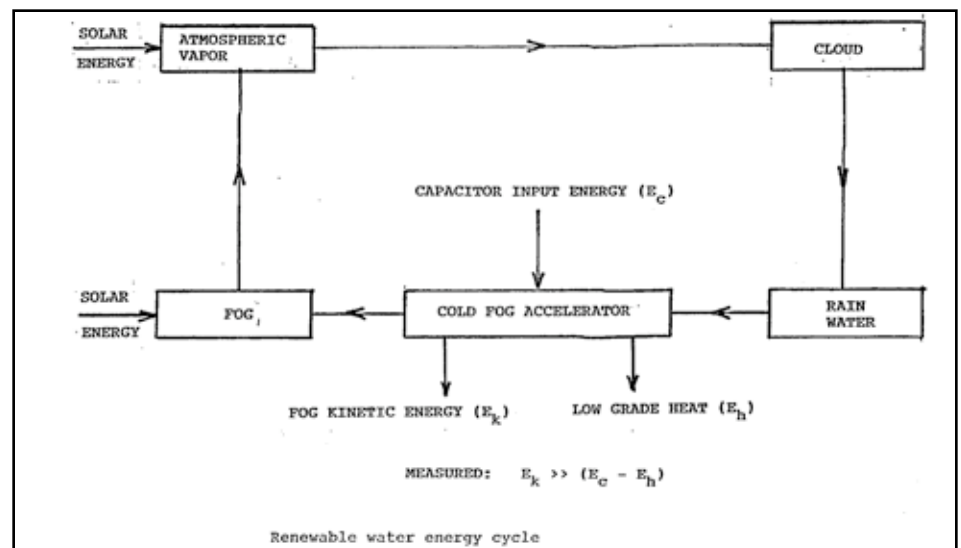
Water scientists argue that the vapor pressure above the droplet surface increases as the droplet diameter decreases. A high vapor pressure implies that it is easy for a water molecule to escape from the liquid. It is another way of saying the bond energy per unit mass decreases with decreasing droplet diameter. This argues in favor of the starting hypothesis of the bond energy in fog being smaller than in bulk water. It provides an explanation for the cold fog explosions.

The Water Energy Cycle

The fog ejected by the water arc into the laboratory air later takes up its latent heat of evaporation from the environment. Thereby it is converted to vapor and drifts away. On its wanderings through the atmosphere, the vapor somewhere meets the correct conditions for condensation into raindrops which fall to the ground and collect in pools. The rain water can again be fed into an arc accelerator and there be converted to fog. This completes the water cycle.

The accelerator extracts internal energy from the water. The only place where this energy can be restored to the water molecules is in the air. Almost all heat energy of the atmosphere derives from solar heating. In this way the water arc accelerator actually utilizes solar energy in concentrated form. The problematical aspect of this energy cycle is how the kinetic energy, or heat, of the water vapor ends up as bond energy in the raindrops. This clearly involves a phase change from vapor to liquid and the transfer of what is called the 'heat of condensation.'

It is a remarkable coincidence that the heat of condensation is equal to the latent heat of evaporation, which itself is equal to



the intermolecular bond energy. From this it would seem logical to conclude that the heat of condensation is directly converted to bond energy. After all, the bond energy springs into existence at the instant of condensation. If we believe in energy conservation, it must be possible to locate the bond energy before condensation and it is only natural that it should have been stored in the vapor.

This was the reasoning I put forward in two previous conference papers [12, 13]. Subsequently I was told that the teaching of physical chemistry claims that the condensation of water is an exothermic process. The heat of condensation must then become sensible heat which raises the temperature of the condensate and the environment. It would, therefore, not be available for the creation of bond energy. In addition, thermodynamics tells us that the heat flow away from the seat of condensation is such that it cannot be captured in a calorimeter. Therefore it is impossible to demonstrate by experiment that condensation is an exothermic event. This is the first surprise of physical chemistry as taught at the end of the twentieth century.

The second surprise is the lack of any indication of the origin of the H₂O-H₂O bond energy. There is no doubt of its existence as potential energy and the fact that energy must be expended to break the bonds. Energy conservation is not denied. At the same time the physical chemistry textbooks have no answer to the question: where was the bond energy before condensation? Not only is the answer missing, the question is never discussed.

Faced with these two surprises, my suggestion remains that the heat of condensation of water vapor is transformed into H₂O-H₂O bond energy right at the moment of condensation. If this is untrue, then we have no explanation of how internal water energy can be liberated by cold fog explosions.

A consequence of this reasoning is that the energy set free in fog explosions is actually renewable solar energy which involves no pollution of the environment. Furthermore, since the energy is first subtracted from the heat of the atmosphere before it is used technologically and converted back to heat, the whole water energy cycle does not contribute to global warming or the greenhouse effect.

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The Nucleo-Electric Effect by David Moon and Chuck Bennett

Disclosed herein is a proposed device to harvest electricity directly from a cold fusion type cell. Semiconductors of the N and P type are utilized in the construction of the main elements of the device. A thin metallic layer (of palladium, nickel, or titanium) is added to the N-type rod. The apparatus is sealed in a container that supplies H or D gas or an electrolyte with H or D.

The interface between the thin layer of metal and the surface of the N-type semiconductor is expected to be the focus of action to generate excess electrical voltage potential. The metal-Si (doped) interface is anticipated to satisfy the description of the theory originated by G. H. Miley and H. Hora, et al. [1,2] of the "swimming electron layer" (SEL) existing at the interface of semiconductors and metals having very different Fermi energy levels.

The expected result of the fusions in the metal-Si layer is the excitation of the valence electrons in the N-type semicon-

ductor, thereby promoting these valence electrons from the valence band into the conduction band. Thus a direct conversion of a cold fusion reaction to electricity is accomplished and the term "nucleo-electric" effect is coined to describe the process.

A massive flux of excess electrons creates an electro-potential voltage to drive a complete circuit and power a load. The accompanying figure shows the cell details including an initial ignition energizer circuit. Once the nucleo-electric effect has started, the ignition energizer can be completely turned off and the cell will operate entirely on its own power. A cold fusion type fuel cell emerges and is supplied by the fuel of H or D in gaseous form or from an electrolyte containing H or D. Although the device functions as a cold fusion "engine," once started, the label of "nucleo-electric battery" may be more applicable.

The invention disclosed herein is in line with our efforts to find ways to produce actual devices that will "speed to market" the development of cold fusion energy for practical use.[3] We believe that this should be the utmost concern of cold fusion activists and researchers. In a side note, we would like to mention a peculiar discovery relating to the history of cold fusion. In reference[2], Hora demonstrates a dedication to revealing the secrets of transmutation within metal lattices. Hora, et al.[4] produced a patent in 1969 that seems to anticipate nuclear reactions within metal lattices.

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