INFINITE ENERGY™

The Magazine of New Energy Technology

Cold Fusion • New Energy Renewable Energy

Volume 6 • Issue 33 • 2000

WATER:

Its "Miracles" and Infinite Possibilities

Will the Fresh Water Crisis Evaporate?

Do We Need Hydro Power?

When and How Will the Water-Fuel Age Arrive?

Will the "Memory of Water" Revolutionize Medicine?

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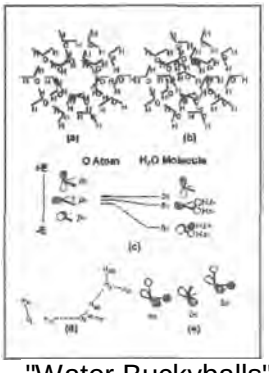
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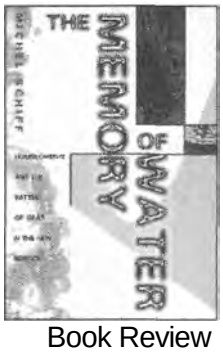

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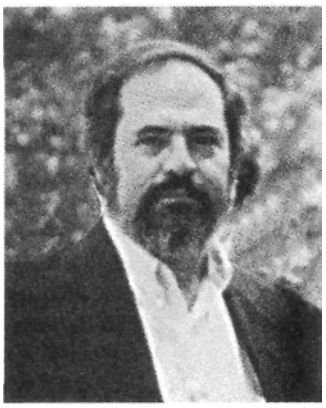


by Eugene F. Mallove, Sc.D.

Water, water, everywhere,
Nor any drop to drink.

Samuel Taylor Coleridge,
The Rime of the Ancient Mariner, 1798

Water is all around us and in us, yet we may be very far from understanding—or even recognizing—all its mysteries. It is an omnipresent enigma. We are water beings living on a water world, but we do not understand this substance, once considered by ancient Greek thinkers and those who followed to be one of four basic "elements"—air, earth, fire, and water. In chemist Paul Caro's paean to water,[1] he writes, "As a source of life and a means of purification, water is undoubtedly the prototype for spiritualized matter; the irrepressible attraction of water for human thinking was first expressed in religious or poetic form."

In the Judeo-Christian heritage, the Book of Genesis tells that before the "first day" of creation, all was water: the world was "without form and void; and darkness was upon the face of the deep. And the spirit of God moved upon the face of the waters." In many eastern religious traditions water was also the origin of all things. Whatever one's faith or non-faith, water stirs the soul. Who cannot find joy in contemplation at water's edge near an ocean, lake, pond, or babbling brook?

Our particular interest in water began with cold fusion and other claims of energy extraction from water—and these certainly are candidates for the most astonishing of water's "miracles." We could not help but notice other important claims and controversies surrounding water. We decided to gather them together and write about some of them in this issue of Infinite Energy—our special "water issue." Apparently we have just scratched the surface. It would be easy to dedicate a bimonthly magazine to nothing else but the many faces of water.

Water is omnipresent, as the "ancient mariner" of Coleridge's poem well knew, though he dared not drink the salty concoction that surrounded his boat and which covers 70% of his little planet. National Geographic's special edition on North America's water (November 1993) noted that 97% of Earth's water supply is salt water and only 3% is fresh, two-thirds of that being ice. The New York Times (December 8, 1998, p. E1) put these figures at 97.5 and 2.5% respectively. Its focus on water noted that only 0.008 of all terrestrial water is the renewable fraction that supports land-based life. We protoplasmic beings are about 60% (by weight) water. Since most other molecules in the human body are of greater mass than water molecules, one infers that water molecules must be by far the most abundant molecule, number-wise, in any organism.

As many readers may know, but it must be mentioned in tabulating water's "miracles," water is an extremely peculiar substance: its maximum density occurs at 4°C, above its freezing point 0°C, the inverse of the normal situation of maximum density at or below the freezing point. Thus, ice floats, and the world's life-giving oceans and bodies of fresh water have not frozen solid—as most certainly would have happened had the more dense ice been able to sink to depths. It is amazing that the "universal solvent" has this life-critical flotation property, while at the same time its tiny Mickey Mouse head-shaped molecule can cluster around large molecules in living organisms to transport and position them in the intricate dance of biochemistry.

Unlike comparable molecules, such as H_2S, H_2Se, and H_2Te, water remains liquid up to a very high temperature, 100°C.[2] The Earth is thus able to be a clement world, protected as it is by the most dominating "greenhouse gas" of all, namely water vapor.

Earth is not the only planet of the solar system that has water—Mars may have had much more than it has today as part of its frozen polar caps or locked underground. Recent close-up images of Mars suggest that water may have produced some erosion features in the comparatively recent geologic past. Jupiter's moon Europa has gained notoriety for its presumed very deep water ocean below its cracked ice shroud. These certainly are not the only places harboring water in and around the solar system. Literally trillions of icy comets are said to extend in a gigantic halo cloud far bevond the realm of the well-known planets. Much further out, water has been detected in interstellar space in unusual "Buckvball" clusters, as MIT Professor Keith Johnson reports (see his article, p. 29).

Noted space scientist Dr. Louis Frank has made his mark claiming that "small comets" are constantly bombarding Earth and other planets, virtually unnoticed except for the still controversial evidence for them from satellite images of Earth. He overturns geochemical dogma in claiming that these are the source of most of Earth's water; water does not come primarily from upwellings from the planet's primordial stores.[3] Because of this heresy, he's in as much hot water with mainstream geology as cold fusion people are with mainstream physics and chemistry.

Another water heresy that has caught our attention is the possibility that deep underground water not part of the hydrologic cycle, may be abundant worldwide. If only geologists who are expert in the hydrologic cycle could shift their paradigm a bit, they might see that water might be almost everywhere for the taking. From springs atop the driest mounts in the Middle East to mysterious inflows discovered and rejected by tunnelers below New York City, fresh, possibly virgin, Earth-generated, or "primary" water seems to be available in lots of strange places. Read the account of Morad Eghbal of the Riess Institute (p. 10), and you will understand how little we really know about water—we can't even agree on its sourcing! Virtually no articles written about the crisis in fresh water scarcity mention this stream of thought.[4,5] Just as pundits debating energy today never refer to cold fusion and other water energies, those who promote the fresh water crisis say nothing about Riess et al. and their findings.

When we are able to command the essentially infinite energies within water to generate clean power without pollution, the freshwater crisis will be handled by cheap ocean water desalination and transport. The Sahara Desert and other barren areas will be no more. Clean, fresh water will be anywhere and everywhere

we want it to be—with or without Earth-generated water a la Riess. Furthermore, better technologies for desalination already exist, but are little-known—see Don Bullock's article, p. 62. Cold fusion and the BlackLight catalytic process are in the vanguard of candidates to provide energies for desalination and transport, but we must also note the emergence of parallel technologies that extract energies from water that may be unfamiliar to many cold fusion and BlackLight Power advocates. A good example: the water-arc process described by Drs. Graneau, p. 33. Our colleague Ken Rauen's review of a major hydroelectric power project in Quebec, Canada, with which he has had direct experience (see p. 19), illustrates the intimate relationship of water, energy, and the environment. There will be no need for energy-producing, land- and culture-destroying dams anywhere when "small is beautiful" water-fueled power sources are in common use.

Jules Verne predicted the advent of the water-fuel age in his 1870 novel, The Mysterious Island. But in today's paradigm-paralyzed world, energy from water is still seen by the scientific establishment as science fiction. Even more "miraculous" are allegations of potential medicinal properties of ordinary water, which is treated in special ways. We first encountered this issue in the so-called electrochemical activation of water (IE, No. 18, p. 35 and IE, No. 21, p. 7). Robert Yukes provides an update and extension to this very, very heretical topic of health properties of specially treated waters (p. 26). When military authorities in the U.S. take seriously the potential of this water technology to assist in defense against biological warfare, and when Russian and some Japanese hospitals are routinely using this water as sterilants and curatives, scientists of good will need to take note. They need to suspend disbelief and conduct hands-on investigation; they must read the technical literature.

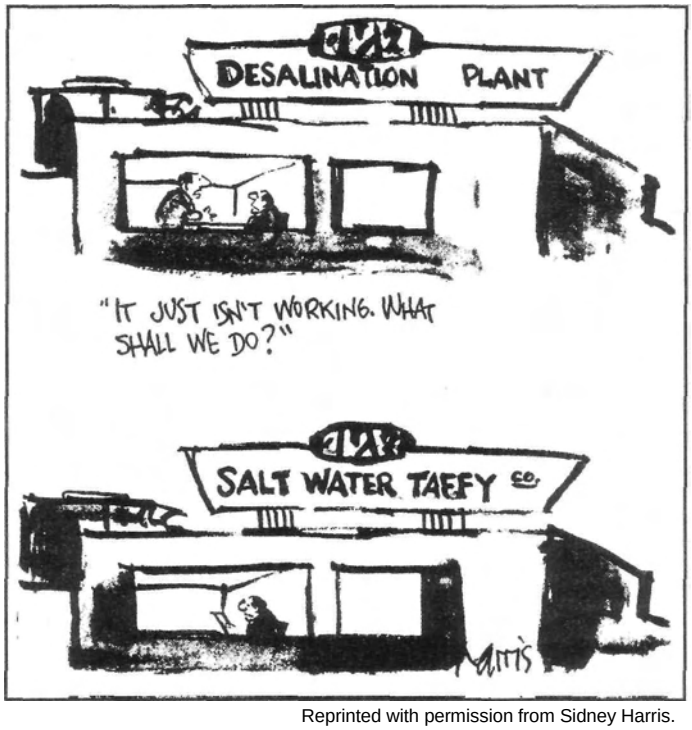
The alleged medicinal properties of electrochemically treated water pale in comparison to the claims being made in the "memory of water" controversy, which began in France in the mid-1980s with the work of Dr. Jacques Benveniste. Please read my review of Michel Schiff's remarkable book on this controversy, The Memory of Water, p. 55. In work

that has been reproduced and widely attacked as discredited science, Benveniste and his colleagues conclude that extreme dilutions of chemical agents in water—to the level that not even a single molecule of agent remains in the water—can have a significant effect on cells. This was nearly the first time, and certainly the most publicized, that a

foundation of the alternative medical practice, homeopathy, was brought literally under the laboratory microscope. If Benveniste is correct, a major revolution in the life sciences is on the horizon, once the establishment calms down and studies the data that it rejected so hurriedly.

As ancient peoples, we first knew water as just a major part of the environment. Our awareness of its practical properties evolved while its spiritual qualities also emerged in ancient and modern minds. Some ancients began to think of it as an "element" long before we had any idea of what an element was in the nuclear sense of twentieth century physics and chemistry. Remarkably, the several thousand year-old debate about whether the tangible world consisted of atoms or a continuum did not end until the nineteenth century became the twentieth.

And what about water? Water, it transpires, was not even discovered until the late eighteenth century![2] As Davis and Day relate in their excellent little 1960s work, Water: The Mirror of Science (well worth hunting for in used book stores), it was not until 1783 that Henry Cavendish in England could conclude that water was composed of the gases hydrogen and oxygen in certain definite proportions. Hydrogen he knew only as "inflammable air" and oxygen as "dephlogisticated air." Despite this primitive eighteenth century knowledge, it was a key turning point. Water was no longer an element. From then on, the path was open to reveal



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even greater mysteries within enigmatic water.

As did the ancient mariner of Coleridge's poem, we thirst for "miracles" from water—some of these, such as several laboratory-established energy sources, we now know to be real, though they still lag in acceptance and development. Others, such as Riess's theory of omnipresent Earth-generated water, and Benveniste's "memory of water," may turn out to be be mirages. But I would not bet that these claims will turn out to be ephemeral. Work is still going on; data is in hand, even building. A water "miracle" may be no miracle once you have seen it and measured it enough times and have checked your vision. What we most need now is that rarest of elements: open minds to study and develop these possibilities, plus the resources to make that happen.

Much of this Infinite Energy water issue owes its life to Barbara DelloRusso, our creative Managing Editor. Barbara was instrumental in pulling together all the diverse articles, materials, and fragments that, we hope, make this issue impressive to the beholder. Especially appreciated is Barbara's written contribution—an overview of the history of the Quoddy tidal power project. We can't thank her enough for her tireless efforts on behalf of this very special magazine, and for this very special issue.—EFM

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LETTERS TO THE EDITOR

IE "Dwells in Realm Where Few Scientists Tread"

I am writing to express thanks for your review of my book, The Monkey and the Tetrahedron (IE, No. 30). I was pleased to see the coverage and greatly appreciate your willingness to make note of it in your excellent, one-of-a-kind periodical. You have certainly surpassed any expectations I had when I originally sent the copy of the book to Dr. Mallove.

What I am most pleased with is the fact that, although Infinite Energy is often targeted toward a technical crowd, you are willing to consider a book touching on many of the "softer" aspects of science. I am the first to admit that my book may contain 99% junk and only 1 % truth. Yet, as you'll no doubt agree, it is within that hard earned 1% where truly meaningful scientific discoveries are made!

Your magazine dwells in that realm where few scientists tread, for fear of falling out of favor with the political machine du jour. It shows great open-mindedness and character behind your organization. I heartily recommend your periodical to anyone who expresses interest in "alternative" technologies and will continue to do so in the future.

Thanks again to everyone at Infinite Energy and especially to Lighthouse Press reviewer Jeremy Jones, who wrote an honest (I hope) but very positive (I think) review of my book.

David Jinks
Lacey, Washington

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Praise for Kooistra Work

I enjoyed Jeff Kooistra's Marinov pieces in Infinite Energy. The Warlock effect appears to imply much simpler equipment: magnet and ring fixed together, brushes replaced by fixed connections, even battery mounted on the fixture. The torque should still be there to spin the whole thing on a single tether from what you reported. With an electromagnet instead of permanent, it would all be just an oddly wound inductor.

Your coverage of Parry Moon (IE, No. 29) finally clarifies the obscure criticisms of electrical physics Jeff Kooistra wrote about in Analog. Quite a revelation. Makes me want my tax money back. not to mention tuition.

George Lyons
Jersey City, New Jersey

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Questions Abound

While the experimentalists and theorists are busy addressing the mysteries of cold fusion, those of us looking over our shoulders can't avoid forming our own questions:

1) Why does palladium and deuterium, but not protium, and nickel and protium (but not deuterium) form active parts? Surely nature is sending a message here.

2) If neutrons and di-neutrons are formed from hydrogen through electron capture, then the hydrogen atoms must transit the hydrino gauntlet to get there, releasing the energy associated with hydrino formation in addition to the energy of the subsequent nuclear reactions. Thus Randell Mills' Classical Quantum Mechanics, and not traditional quantum mechanics, may provide the more useful theoretical insight. (Confer IE, No. 29, "Electronuclear Catalysts and Initiators: The Di-neutron Model for Cold Fusion," by Robert Schultz and John Kenny.)

3) Since Dr. Randell Mills' hydrogen energy reactor (IE, No. 17) works on hydrogen atoms and not hydrogen molecules, might not other hydrogen energy reactors function better if the hydrogen molecules were decomposed into atoms with a hot filament? Dr. Les Case's deuterium gas reactor comes to mind (IE, No. 19). While the busy cold fusion researchers are not necessarily looking for more puzzles, still the history of scientific progress is dependent on asking the right questions.

Charles Stuart
Titusville, Florida

Aether Theory

It was interesting to read Jeff Kooistra's article on aether in Infinite Energy (No. 31) and hear that Infinite Energy is an aether friendly place. I am definitely aether friendly and see no way to explain action at a distance without an aether, except to believe in magic. I make no claim to expertise in this field, but it had been my good fortune by serendipity to come into possession of a book by Joseph Brown, A Unified Theory of All Science.

I will very briefly summarize Brown's theory: The universe is made up entirely of only one type particle. The aether is an extremely dense gas of extremely small particles, moving on average at several times the speed of light with enormous energy. He has calculated size, mass, density, and speed. The universe extends to infinity in our usual concept of three-dimensional space. It has existed forever and will continue to exist forever. It is in a steady state and not expanding. An extremely small percentage of aether particles are organized as dynamic vortices into the basic particles of matter, such as electrons and protons. There is a constant flow of particles through these vortices.

Dr. Brown arrived at his theory by trying to model the neutrino. The neutrino is moving at the speed of light. At the front, particles are moving in at the mean speed of the particles. By coming in on a curved path, the high speed particles separate from the low speed particles and become concentrated in density at the center of the vortex. They move out at the rear of the neutrino at the root mean square speed of the particles. This difference in speed from the mean square speed to the root mean square speed is the speed of light at which the neutrino travels. An electron or proton are neutrinos that have been knocked by collision into a circular path. It is the pulsing of the particle in the circular path that creates waves in the aether, which produces electric charge.

Dr. Brown uses basic Newtonian physics to do his calculations, but his figures agree with all known constants, such as the speed of light and the Planck length.

It is consistent with any proven figures from relativity or quantum mechanics. To me it is intuitively friendly and something that I can readily visualize.

This is a very crude, brief, and incomplete description of Dr. Brown's theory, but I hope it is enough to whet your readers' appetites for more. This book should be of interest to anyone looking for new approaches to understanding physics. I think his theories are worthy of further study and experimentation. They should suggest new approaches to many problems.

Walter Westerhold
Starkville, Mississippi

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Dissenters the Hope for Science Reform

"Strategies for Dissenting Scientists" by Brian Martin {IE, No. 31) is an impressive article that definitively expresses the tragic situation existing in science today. It should be required reading

by every scientist and every politician with scientific endeavors.

During the past twenty-five years I have experienced the truth of every point made by Martin. No matter how factual, any new idea that poses a threat to prevailing beliefs will not be permitted journal publication or open discussion on the main program of a national science meeting or a press release or grant money. The most effective way of maintaining this status quo is via the peer review system, in which any opposing idea must first get by peer reviewers schooled in prevailing beliefs—an impossible task.

For example, careful research during the past twenty-seven years has proven, beyond any doubt, the origin and evolution of hydrocarbon fuels via processes that adhere strictly to natural laws of physics and chemistry (1973-1985). These fuels were not and are not created in the incredulous manner that gave them the erroneous name of "fossil" fuels. Yet textbooks still mistakenly teach students that coal was made from plants and oil from marine life! Additionally, my manuscript, The Spacing of Planets: The Proposed Fourth Law of Planetary Motion (1980-1995), detailing the spacing of planets around our Sun, has been in peer review at the Royal Astronomical Society for two and a half years. The Journal of the American Astronomical Society immediately rejected the manuscript without finding or stating a valid reason. These actions speak volumes about the current status and objectivity in the physical sciences.

Contrary-wise, any speculative idea, no matter how unsubstantiated or force-fitted, if offered in support of prevailing beliefs, finds an easy path of acceptance and assistance at every step along the way. For example, advocates of the Big Bang accept, promote, and believe that an accelerating Universe suggests the existence of a cosmological constant—a fudge factor that would explain why the expansion of the Universe is accelerating rather than slowing down in the manner predicted by the Big Bang. This cosmological constant was first suggested by Einstein in 1917 but later discarded by him because it seemed impossible. He added that the suggestion was his greatest blunder.

However, advocates of the Little Bangs (1979-1980) recognize the accelerating expansion of the Universe as a basic principle of this newer concept that both predicts and explains this acceleration without the necessity of a cosmological constant. Additionally, the recent admission by astronomers that a black hole is at the center of most galaxies strongly supports another basic principle of the Little Bangs concept that both predicts and explains the presence of a black hole at the center of every galaxy. Yet the antiquated Big Bang concept, initiated by Edgar Allen Poe (Eureka, 1848), with its speculative foundation, its fatal flaws, and its lack of common sense, strongly prevails.

Truly, as stated by Martin, "if there is any hope of reform, dissenters have a crucial role to play." While facts, time, and common sense are great advantages on our side, we must become better organized and more aggressive in pushing together for open-mindedness in science. Otherwise, many ideas crucial to the progress of science will remain stymied by the current system in which vested interests protect and promote the status quo at too great a cost to all.

Alexander A. Scarborough
LaGrange, Georgia

Destroying the Establishment

Thanks for all the materials you sent. We must organize to destroy the anti-innovation mandarin establishment.

> The Universe is vast. Nothing is more curious than the self-satisfied dogmatism with which mankind at each period of its history cherishes the delusion of the finality of its existing modes of knowledge. Sceptics and believers are all alike. At this moment scientists and sceptics are the leading dogmatists. Advance in detail is admitted: fundamental novelty is barred. This dogmatic common sense is the death of philosophical adventure. The Universe is vast. [Whitehead, A.N. 1948. Essays in Science and Philosophy, New York, NY: Philosophical Library, 227.]

Dr. Rustum Roy
Bulletin of Science, Technology & Society
University Park, Pennsylvania

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Triumph of Alchemy

I very much enjoyed reading "The Triumph of Alchemy: Professor John Bockris and the Transmutation Crisis at Texas A&M" (IE, No. 32). It reminded me of a rather odd encounter there between a physics professor and a student, many years ago. Back in 1977, I was an EE undergraduate taking the obligatory "modern phvsics" class. I recall vividly the day we got to the subject of "relativity." A stranger casually strolled into class

during the middle of the lecture and took a seat in the back. I guessed that he might be a graduate student, but he looked like he was right out of the sixties, complete with sandals, beads, and wild, frizzy hair. As the professor continued with his lecture, the hippie decided to eat from a brown paper bag. (How rude!) I recall the sounds of the bag being opened, a sandwich being unwrapped, and the hippie munching away. All the while, he peered at the professor scribbling on the chalkboard, as if at a drive-in. Toward the end of class, Mr. Hippie stood up and began to pepper Dr. Establishment with several questions and challenges, all in rapid-fire succession. Unfortunately, I was unable to follow the heated technical discussion between them that day, but it did seem to me as if Mr. Hippie had the upper hand—before storming out.

Relativity theory is always presented (for the first time anyway) in an apologetic manner. I have been led to believe that it has caused an increasing backlash within the physics community. Having read dissident books by several noted authorities, I understand why!

Bill Cantrell
Texas A&M University Class of 1979
Haslet, Texas

Campaign 2000 and Cold Fusion

The following letter was sent from Infinite Energy subscriber David Moon to Green Party presidential nominee Ralph Nader: Mr. Ralph Nader, Nader 2000 Primary Committee, P.O. Box 180002, Washington, DC 20036

Dear Mr. Nader:

As a resident of Minnesota, I know third party candidates can win elections. There are many important issues in government. One issue, being sorely neglected, will fit perfectly in the Green Party platform. It is the new energy research known as cold fusion.

For years, the DOE and the Patent Office have stood against cold fusion, hurting even private investment in research. Developments in this field could take us off the power grid, and could virtually eliminate all pollution from fossil fuels. In addition, cold fusion experiments have demonstrated the ability to remediate radioactive waste. These processes need to be scaled up to commercial levels.

Please consider openly supporting the idea of cold fusion research in your campaign. Correcting the wrongs at the DOE and the Patent Office, and encouraging business investment in this revolutionary science and technology, would truly make the Green Party live up to its name.

I request that you contact Dr. Eugene Mallove, editor of Infinite Energy magazine. He can provide a complete briefing on the cold fusion field for your presidential campaign.

David Moon
Minneapolis, Minnesota

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IE subscriber John Miranda has also been in contact with presidential candidates and we reprint here his August 5 letter to Vice President Al Gore:

Dear Vice President Gore:

Thank you, again, for your reply of July 25. It's encouraging to know that you are being responsive to this important issue of the most recent breakthroughs in science, since they will affect this Nation for all years to come as we move forward into the future.

At this time I wish to bring to your attention a most unusual situation occurring within the United States Patent and Trademark Office (USPTO). As you will read in the enclosed article from the current issue of Dr. Eugene Mallove's Infinite Energy magazine, USPTO has effectively blocked five patents specifically related to

Letters continued on page 68

Some Technical, Legal, and Political Impediments
to Developing Water Resources in the Middle East

EARTH-GENERATED WATER: A POTENTIAL SOLUTION

"Waters divided... "[1] or "well[s] of living waters" and "living fountains of waters"?[2]

Morad Eghbal

The Middle East is not the only place where water crises and disputes arise and continue, but it is the region in which the potential for conflict over water is perhaps most extreme. A long history of hostilities and border disputes, plus the presence of oil, make the need for binding international agreement most pressing, though history gives us little confidence that international law can avert wars there. Though the region is generally referred to as a whole—the Middle East—it is full of contradictory values, ranging from those of the desert, shaped predominantly by nomads, to the ideas of shepherds of the plains, and to the expectations of farmers and urban population of the few areas rich in water resources. These regional and local rules, no matter how contemporary they might seem, were founded on values that grew out of religious and social customs—often more rigid than the harshest of state-made laws.

We will embark on a journey in three parts. Part One, about our "water planet," sets the stage for water use, water rights, and regional security in the Middle East. Part Two briefly surveys the paradigm-breaking scientific work of Stephan Riess, with its relevance to providing much-needed additional supplies of potable fresh water, particularly in the Middle East. One hopes this new paradigm could guide present dialogue in a different and long-ignored direction. Perhaps this could further the evolution of more cooperative, less adversarial approaches. In Part Three we will address the interface between water resources and water rights in the Middle East, considering two river systems of particular interest: the Euphrates and Tigris river system and the Jordan Valley.

If so much of the Earth's surface is covered with water, why are so many areas of the world, especially the Middle East, experiencing shortages and competing for fresh water?

The Water Planet

Every living thing on this unique planet has a water connection. Our bodies are approximately 60% water, which lubricates our internal systems, keeps them free from waste, and maintains normal body temperature. Beyond these confines, trees, which are considered the "lungs" of the Earth, are 70% water and rely for the most part on a steady and reliable supply of fresh water. Every living cell is water-dependent and therefore vitally affected by the quality and quantity of fresh water available.

One of the circulatory systems which provides this vital resource is known as the hydrologic cycle, which is both simple to describe and complex in its application. Circulatory means recycling, a word that has increasingly permeated the consciousness of the public. In nature, recycling is a built-in part of the ecosvstem and is the way water in changing form and function is used and re-used. Water descends upon the face of the Earth as precipitation of one kind or another. It penetrates the surface and migrates along aquifers, a word whose Latin origin connotes the leading of water collected along a particular stratum, toward a point where it will resurface once again, to run off in creeks streams, and rivers—ultimately collecting in the lowest points, from where it again rises by evaporating and condensing into clouds, to descend again as precipitation.

This evapo-transpiration system is run by the energy of the Sun, which causes liquid water to turn into vapor, a change which is under way constantly over all bodies of water and on wet surfaces. We could say that we live in a state of constant net-deficit of this vital resource. Forests act as natural water reservoirs and are an important part of the Earth's hydrological system. The leaves and branches of trees catch a great amount of rainfall that would otherwise run off into streams. They shed this moisture on the surface of the ground, some of it to be held in the thick Layer of duff that forms the mulch covering forest floors. Trees and plants also absorb water through their root systems. The moisture that is not used up by trees or plants rises through osmotic pressure and evaporates to the atmosphere. Remarkably, water from the hydrologic cycle is not the only source of fresh water, as we shall see!

If so much of the Earth's surface is covered with water, why are so many areas of the world, especially the Middle East, experiencing shortages and competing for fresh water? It is simply that fresh water resources, at least obviouslv accessible ones, are not evenly distributed either within national boundaries or globally.

The planet's rapidly expanding human population also places a severe strain on the supply of this vital resource. This is not so much because supplies are low in an absolute sense, but because an ever-increasing population places ever larger demands on locally available reliable sources of fresh water.

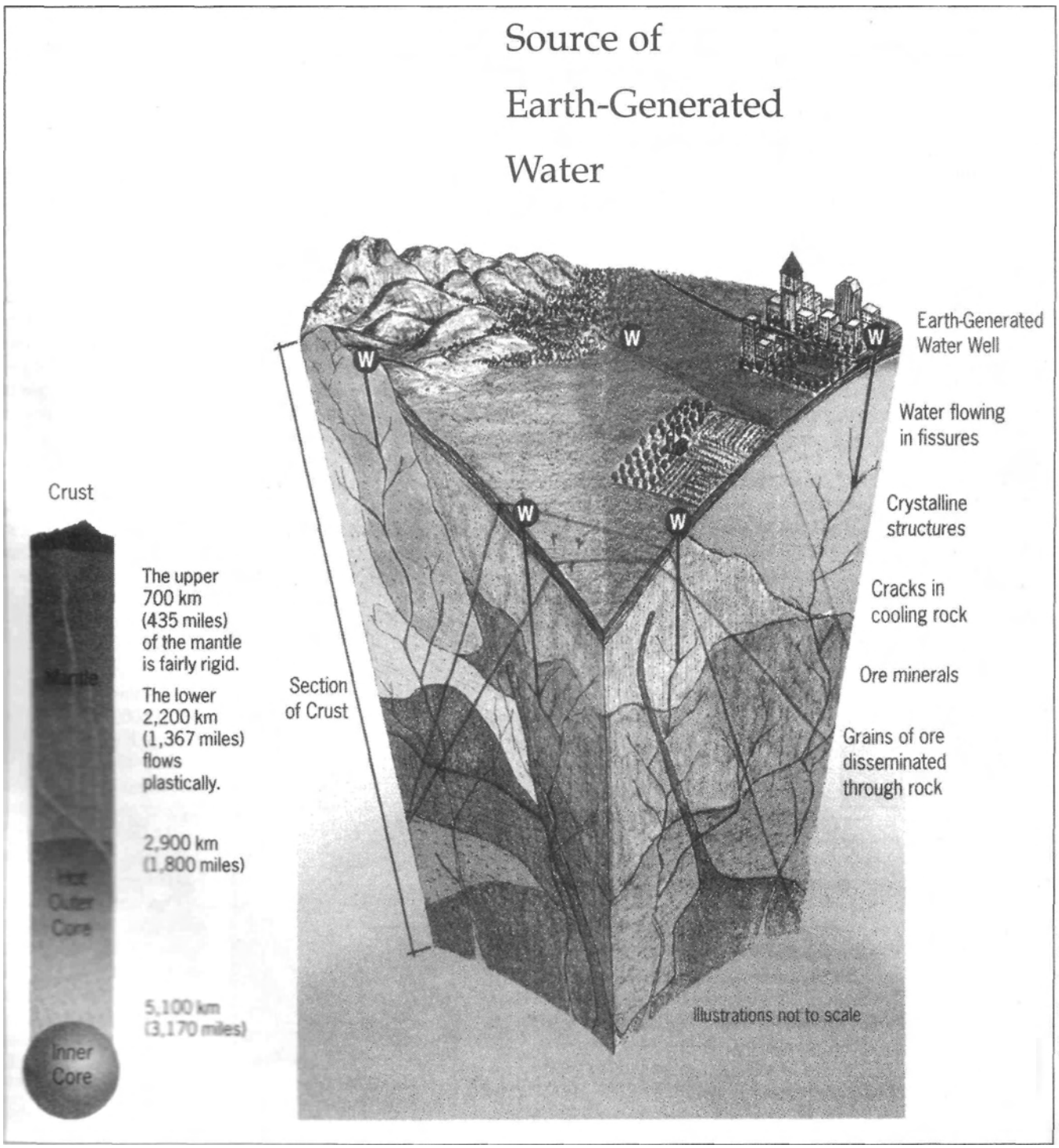
As a result of this population increase, every country today is not only confronted with a growing demand for water, it must also come to terms with accompanying legal problems. If we add the additional concern of increased levels of industrialization, one can readily see how complicated the equation becomes and why non-industrialized countries also have the highest demand for this resource. They lack technological advance, being dependent mainly on agriculture, perhaps the most water-intensive industry in the world.

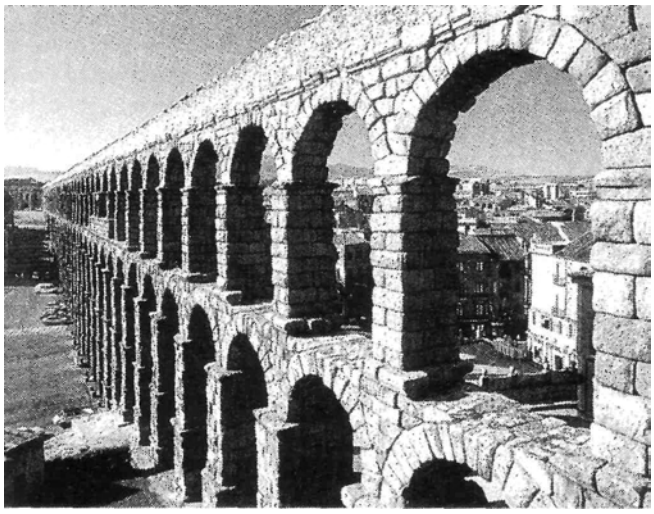
Earth-Generated Water

Turning now to the second part of our journey we discover possible alternatives to these persistent problems. For at least twenty-five years a global water shortage has been the focus of increasingly dire predictions in the national and world press.[3] First, there is over-pumping of groundwater from fairly shallow aquifers—for example, the Ogallalla that underlies the High Plains states in the United States from the Dakotas to the Texas Panhandle. Replenishment of this water by precipitation has not kept pace with an over-greedy use of this water. Should the tapping of such aquifers continue at present rates, the question arises whether that portion of the High Plains overlying the Ogallalla Aquifer will once again become the "Great American Desert." It was so labeled on maps in the middle of the past century, long before the water below it was used for irrigation.

Then there is the increasing pollution of groundwater sources in many areas due to the influx of chemicals and toxins. Typical is the nine million gallons of chemicals that have poured into Price's Pit, the municipal dump at Atlantic City, New Jersey, which caused water in ten of fourteen city wells to become unpotable in the early 1980s.[4]

The solutions to this problem advanced by policy-makers are basically of two kinds.[5] Solution one: Building very expensive "long-distance plumbing" in the form of pipelines, canals, and other conduits to channel water from rivers or from impoundments behind dams. This approach has been in favor since the days of the Babylonian King Hammurabi, who built an extensive system of irrigation canals in his Near Eastern domain. It





Roman Aqueduct, Segovia, Spain Photo by Barbara DelloRusso

also flourished in the vast network of aqueducts that were constructed throughout the Roman empire.

The second solution: Conserve existing supplies through voluntary limitation of use, i.e. rationing, or perhaps more effectively, through a steep rise in the price of water. Neither the "conservationists" nor the "long-distance plumbing advocates" seem to be aware of a third solution to water shortage problems. With the exception of a few stalwarts who have advocated its potential for more than a century, this solution has remained dormant, thanks to outworn dogma.

Dogma insists that all the water available to humankind derives exclusively from the hydrologic cycle, which we have described above. Even as recent a publication as "Water for the Future: The West Bank and Gaza Strip, Israel, and Jordan" by the National Science Foundation[6] overlooked this potentially highly promising alternative. Advocates take exception to the well-entrenched notion that the Earth's water can only be of "meteoric" origin. (Editor's Note: The author means weather-borne water, not extraterrestrial water—as in the controversy over the influx of "small comets."—EFM) They have affirmed that the Earth itself generates massive amounts of water from deep within, which has no connection with the water of the hydrologic cycle. They maintain that if this water were to be tapped by drilling, it would constitute a copious—for all intents and purposes an inexhaustible—supply of pure, unpolluted water.

Leonardo da Vinci, in his famous Treatise on Water, championed the idea that water comes both from precipitation and from internally generated sources. In his History of Hydrology, Asit K. Biswas notes that the Renaissance genius

> characteristically reported an occasional doubt about certain aspects of both theories, but nothing has been found which would indicate that he at any time had discarded the basic concepts of either of them. In fact, the chances seem good, that he believed both systems to operate concurrently.[7]

Adolf Erik Nordenskjold

In 1896, Adolf Erik Nordenskjold, a Stockholm professor of mineralogy and Arctic explorer, published an essay, "About Drilling for Water in Primary Rocks,"[8] which was to win him a nomination for the Nobel Prize in physics, though he died before the prize was actually awarded. Nordenskjold had spent years on rocky promontories on and islands off the Swedish coast, organizing the drilling of wells for pilotage stations that were forced to import water or capture rain. The impetus for his effort came from his father, Nils, who was Chief of Mining in Finland. He had told his son, with some awe, that while salt water never penetrated iron mines on the Finnish coast, even when they were below sea level, fresh water was always present on the rocky floors of the same mines!

From his work, Nordenskjold concluded that a new type of water, independent of the hydrologic cycle, and generated by the Earth itself, was available. He called this water "primary," due to its association with so-called "primary rocks," which geologists term magmatic, or those, such as granites, basalts, and rhyolites, which derive from the molten magma deep within the Earth and later cool to crystallize into igneous rocks. He also affirmed that one could sink wells capable of producing such "primary water" year-round along the northern and southern coast of the Mediterranean Sea and in the whole of Asia Minor—precisely the best known part of the world afflicted with aridity.

Shortly after the appearance of Nordenskjold's essay, his speculations about water newly formed in the Earth were echoed by a German geologist, Edward Suess, who coined the term "juvenile" or youthful, to characterize this water. Speaking with special reference to the thermal springs at Carlsbad (now Karolvy Vary in the former Czechoslovakia), he advanced persuasive arguments to show that waters of this class "see the light of day for the first time." That is, they issue from deep within the Earth, from the fundamental magma itself, to bring up veritable additions to the hydrosphere.[9]

Suess' contribution was noted by Frank Wigglesworth Clarke, a geologist with the United States Geological Survey, who, in a long memoir published in 1924, wrote that one of the most important questions for geology was whether it is possible to discriminate between waters of superficial origin and magmatic, or deep-seated, waters,[10] for which I have coined the more descriptive term "Earth-generated" waters.

Clarke cites the work of Armand Gautier, who pointed out several criteria for discriminating between Vadose (water located in the zone of aeration in the Earth's crust) and magmatic waters and who stated that one cubic kilometer of granite, subjected to requisite heat and pressure within the Earth, could yield from twenty-five to thirty million metric tons of water—or something in excess of eight billion gallons—which at 1,100°C would form 160 billion cubic meters of steam. A family of four uses an average of 600 gallons of water per day for their daily sustenance and personal use. Calculated accordingly, such copious supplies of water would be sufficient for the daily need of about 1.25 million households of four.

Courtesy of University of Pennsylvania are Book & Manuscript Library

Geologist
Frank Wigglesworth Clarke
1847-1931

The eminent mining geologist, Josiah Edward Spurr, in his two-volume treatise published in 1923, called attention to the fact that the existence of water as an essential component of igneous magmas had long been recognized. The existence was clearly shown

by the vast clouds of water droplets that condense from the emitted vapor during volcanic eruptions.

The fundamental idea that there is a thermodynamic cycle within the Earth that both produces and is fueled by water was still of concern at least up to 1942, when Oscar Meinzer, formerly head of the Groundwater Division of the U.S. Geological Survey in his book Hydrology (published in 1942), espoused the view that waters of internal origin are tangible additions to the Earth's water supply.

Fifteen years before the publication of his book, Meinzer in a long essay referred to huge springs in the United States that yield 5,000 gallons or more per minute. This phenomenon is not confined to the United States. One incredibly productive water source flowing out of limestone is the Ain Figeh spring that alone supplies water for the over one million residents of Damascus, Syria, and is also the principal source for the Barada River. A report on this spring by the World Bank reads:

> The principal emergence for the spring which has been enclosed in a structure since Roman Times resembles an underground river several meters across which flows up and out of the limestone formation of the mountain. The total flow has averaged about 132,000 gallons per minute. The quality is very good, its temperature and pH are relatively constant (14 degrees centigrade and 7.9, respectively), its taste and color are excellent, and bacterial contamination at the source is practically non-existent.[11]

(The same report is equivocal about the origin of the massive amount of water that has been flowing from this spring for millennia.)

Engineers digging tunnels have also frequently been faced with an outrush of water from what had to be considered an anomalous or mysterious source, given the depth at which it was contacted. Typical was the Tecolote tunnel in the United States, which runs 6.4 miles through the Santa Ynez Mountains to transport water from the Cachuma Reservoir to Santa Barbara, California. In the drilling process, the work was impeded by subterranean water flows of 9,000 gallons per minute, some of which was cool and fresh, some hot and mineralized. What the city of Santa Barbara could have saved by now in water supply expenses by drilling to tap such water (at a cost orders of magnitude less expensive than the 1957 completion price of the tunnel, $40 million) is a matter for conjecture. This issue is at the core of financial considerations in development schemes generally.[12]

Stephan Riess (ca. 1980) at one of his wells drilled at California City, California, in the middle of the Mojave Desert.
Photo by Peter Britton of The Riess Institute

Another episode, one of the strangest to occur in the annals of construction engineering, took place in Manhattan in 1955. An engineering firm had begun excavating for the addition to the Harlem Hospital at the intersection of 5th Avenue and 136th Street. On St. Valentine's Day, while removing a layer of hard rock only twelve feet below ground, workers were suddenly confronted with an enormous out-pouring of water, which rapidly began to fill the vast excavation. Pumps hurried to the site labored day and night at a rate of 2,000 gallons per minute to keep the working area free of water.

Stephan Riess with 1,900 gallon-a-minute well he drilled above bone-dry Simi Valley, California. Courtesy of The Riess Institute

Particularly puzzling to engineers was that during the cold winter months the water maintained a constant temperature of 68°F and was so pure that hospital chemists who analyzed it certified it could be drunk without chlorination or other chemical treatment! A billion and a quarter gallons were pumped out of the hole until twelve stories of structural steel had been erected and several lower floors were decked with concrete slabs, which provided enough weight to hold down the foundation of the new building against hydrostatic pressure from this mysterious water.

Despite the fact that New York City has repeatedly been faced with serious water shortages over the past decades, no effort has been made to utilize the more than three million gallons a day that came out of the granite of Gotham's body near the Harlem Hospital, or to drill for more such sources. Trying to explain this over thirty years ago, Michael Salzman, then a professor at the University of California's School of Commerce, who had served as an engineer with the U.S. Navy's Hydrographic Office, pointedly wrote: "There can be but one reason why this water, despite its purity and constant flow, is not used, and that lies in the many fears associated with it, since its existence cannot be explained by conventional hydrologic practice."

Salzman dedicated his book to Stephan Riess with an inscription, which said:

> To Stephan Riess, for demonstrating his firm belief in democracy, individual initiative, free enterprise, and the need for open minds to the end that all men [humans]

may truly be free to think and solve the great problems of their times.

Riess (1898-1985) was a Bavarian-born mining engineer and geologist who emigrated to the United States in 1923. While working in a deep mine at high elevation in the 1930s, after a load of dynamite had been set off in the bottom of it, Riess was amazed to see water come gushing out in such quantities that pumps installed to remove it at the rate of 25,000 gallons per minute could not make a dent in the flow. Staring forth into the valley below, Riess asked himself how water that supposedly had trickled into the Earth as rain could rise through hard rock into the shafts and tunnels of a mine nearly at the top of a mountain range.

The temperature and purity of the water suggested to Riess it must have a completely different origin than ordinary groundwater. Since none of the textbooks he had studied had referred to what seemed to confront him as an entirely anomalous phenomenon, he decided to look into it further.

In 1957, after Riess had been working on the problem nearly two decades, Encyclopedia Britannica's Book of the Year ran the following statement:

> Stephan Riess of California formulated a theory that "new water" which never existed before, is constantly being formed within the earth by the combination of elemental hydrogen and oxygen and that this water finds its way to the surface, and can be located and tapped, to constitute a steady and unfailing new supply.

This is not the place to document the incredible success Riess had over fifty years of practice drilling water wells at sites where professional hydrologists and geologists flatly predicted that not a drop of water could be found.[13] But the central questions that arise are: How far have scientists actually gone to determine the nature and amount of deep-seated, Earth-generated water, and in what way is society capable of accommodating the developments which would inevitably accompany the acceptance of this discovery and paradigm shift?

Earth-generated water pours from a rock face near the Dead Sea in Jerusalem.

Courtesy of The Riess Institute

In his foreword to Salzman's book, the English philosopher and writer Aldous Huxley comments poignantly: "It remains to be seen whether those who are now regarded as experts in the field of hydrology and the politicians whom they advise will also agree that a good case has been made and that large-scale experimentation is in order." Since Huxley penned that sentence more than a quarter century ago, there has been no such experimentation, large or small, funded by hydrologic officials, state or federal, in the United States, or elsewhere in the world. Only private investors and entrepreneurs with foresightful initiative have dared to carry the research forward.

By 1958, Riess' exploits came to the attention of the Israeli government, which invited the mining engineer and geologist for an official visit to find water for the then-new city of Eilat on the Red Sea's Gulf of Aqaba. After a flight to Tel Aviv, he met with Prime Minister David Ben-Gurion and his advisors, who urged him to go ahead with his search as soon as possible. Less enthusiastic were a group of leading Israeli geologists, who, like their American counterparts, vigorously opposed Riess' theory and methodology of water development. "Only after a protracted session during which I explained it," Riess would later relate, "did they agree that my proposal had merit." This was confirmed by Israel's chief water geologist at the time, Arie Issarof, who in a letter, wrote: "As a geologist who is occupied with water research in arid zones, I am fully aware of the limitations of our orthodox methods, in geohydrological possibilities which may be opening up before us while applying these methods. I decided, encouraged by my superiors, to cooperate with Mr. Riess' research for primary waters in our arid zones." High in the mountainous country along the Israel-Jordan border, Riess located the first of several wells about a mile and a half from Eilat itself. As Meir Ben-Dov wrote in the Jerusalem Post:

> The site chosen is where a five-meter-wide cleft, running vertically through the mountain, is crossed at right angles by a similar cleft, hardly twenty centimeters across. The bowels of the earth in erupting have filled these clefts with an igneous intrusion of a sort, soapy-feeling, mottled brown rock called gabbro. The drill slowly worked its way downward, alternately in igneous intrusion and again in granite as the cleft in the rock snaked its way downward.

During the work, problems linked to cave-ins and the jamming of drill pieces beyond the Israeli drilling team's experience were finally solved when Riess' associate, Jim Scott, who had worked with him on many wells over the vears, was sent to Israel to supervise operations.

On May 29, 1959, the Jerusalem Post published an estimate that the amount of water struck in the Riess-located wells was enough to supply a city of more than 100,000 persons including industry, air-conditioning, parks, gardens, and a dozen outlying villages. Analysis of the water, stated the newspaper, revealed that the Eilatis, used to drinking water with 3,000 parts per million of dissolved mineral salts (TDS), now had a supply with only 1/6 that amount of TDS. For his work in Israel, Ben-Gurion presented Riess with a medal and his wife with a sterling silver-bound copy of the Talmud in English.

The astounding find was not lost on Arab leaders, neighbors of Israel. Invited to Cairo by Egypt's Gamal Abdel Nasser, Riess became the only exception to a rigid years-long stricture prohibiting Americans who had visited Israel from setting foot in Arab lands. Along the Nile, Riess located several water wells on rocky promontories for well-known Egyptians before flying on to the Sudan at the invitation of the Mahdi, where a revolution disrupted his planned geological exploration for water. This prompted his return home.

In fact, Riess' exploits in drilling for fresh water were not quite as unusual as it might have seemed then, because his was perhaps the most recent of a number of accomplishments in this area by others, such as Leo Picard, a contemporary and fellow German who had been born into a Jewish family in 1900 in the city of Wangen near Konstanz, Germany. From 1924 to the present, Picard devoted his life to geology and groundwater exploration in what was then Palestine and is now Israel, following completion of his academic training in geology at the University of Freiburg, Germany. His accomplishments are in addition to and related to those of Riess, ones that we will not have an opportunity to revisit in this short space. Nor is it possible now to delve into the life and work of Fritz Josef Heidecker, another contemporary of Stephan Riess, who was born in 1912 in Georgensgmuend in Mittelfranken, Germany as the third son of an old, established Jewish family, whose documented lineage goes back to 1650. Fritz Josef Heidecker was another builder in the Middle East who devoted much time and energy to building wells during the infancy of the State of Israel.

By analogy, the concept of plate tectonics developed first by the eminent German geologist, Karl Wegener, nearly a century ago, was probably as difficult for geologists to tolerate then as the concept of "Earth-generated water" is for hydrologists now. Few of them are aware that the profession as a whole lags behind the times. In 1960, one of hydrological science's critics, William C. Ackerman (then-vice-president of the American Geophysical Union, AGU, and chief of the Illinois Water Survey Division) tried to shake up his colleagues at a regional meeting at Moscow, Idaho. He expressed his disappointment that for years many revolutionary papers on hydrology submitted to the AGU's Transactions had been refused publication. Ackerman concluded that the heart of the problem was that hydrology had been resting for too long on the laurels of its greatest figures, whose work had been performed prior to World War n. He said that nothing of consequence had been contributed to the subject since then.[14]

Water Rights and Water Use in the Middle East

In the ancient Middle East, water was perhaps the single most important factor that influenced the settlement patterns, life, and culture of its inhabitants. Since vast areas of the ancient Middle East were comprised of deserts, settlements and cultures developed for the most part in a region (often referred to as the Fertile Crescent) where fertile soil and a major source of water were located. Thus, we find in the history of antiquity the evolution of villages and towns along the Nile River in Egypt and the Tigris and Euphrates Rivers in ancient Mesopotamia. In Palestine and Syria some communities evolved near rivers, while others originated near springs, such as Jericho—perhaps the oldest known city in that region of the world.

Notwithstanding the location of such water resources throughout the Middle East, the accessibility of water was often a problem. In some areas water resources were present year-round, but the transport of water for irrigation and domestic needs was still difficult. So a variety of water systems developed throughout the ancient Middle East—irrigation systems, storage, and methods to transport water from one locale to another. You may recognize the following scene: A lone figure dressed all in black, tall and of proud bearing, materializes out of the mirage caused by the blistering heat, where the glare of the dry sky meets the hostile floor of the desert. As he slowly moves forward, his attitude becomes tense, and his eyes blaze with disdain as he reaches the well, where a stranger plunges his head into the water to slake his thirst. He looks up in sudden terror. With a single stroke of his sword, the man in black slashes off the wet head of a man taking more than his due. "He was sullying my well," explains the executioner.

The scene is from the film "Lawrence of Arabia," based on a passing reference in The Seven Pillars of Wisdom. Though it is a mythic event, it is a good image for the harsh reality of the desert—a clear warning that water in the arid environment of the Middle East is a matter of life and death. The tableau shows too the uncompromising rigidity of the laws and rules surrounding water that grew out of the customs of the desert. A thirsty man may drink from another man's well, but only in the manner prescribed. He may lower a container, and the water in the container will become his property, without any compensation due; but he must not dive into the water or immerse himself, which would pollute the well.

For centuries, the history of the desert lands of the Middle East centered on the wells and water courses as tribes followed the vegetation with their herds and traders traveled from well to well as they opened up the great caravan routes. In this century, Turks and Arabs—with the occasional involvement (some might call it interference) of British, German, French, and American forces—fought for control of the wells along desert routes to determine the outcome of the First World War in the dry and hostile wastes of the Arabian peninsula.

Eighty years later these old adversaries are still fighting over scarce and rapidly diminishing water resources. But now they have more destructive weapons, thanks to the willingness of external powers to provide them. Everyone wants to secure the riches provided by oil, a resource for which water is key, both in the exploration for oil and in its refining. The cinematic scene at the well demonstrates yet another truth in the Middle East: water cannot be owned. All that can be controlled is the means by which it is transported or distributed. Only in case of disputes does water itself become a strategic commodity, to be

Sinai Peninsula as seen from Space Shuttle Columbia mission STS-4, June 27 - July 4, 1982.

denied to an enemy or even contaminated in a way no desert-dweller would normally consider. At times, a whole civilization can be wiped out by the destruction of an irrigation system, as the Moguls did to the Persians, or the Iraqi government has attempted to do with Marsh Arabs in the lower parts of the Mesopotamian delta in more recent times. In times of peace (or "non-war," for that is the reality in the Middle East today), there are other rules. There is a slowly evolving set of basic criteria to complement the customs that for decades generally succeeded in organizing the sharing of water resources. The map of the Middle East has changed. Tribes acquired flags and national boundaries; customs and rules that were once effective in governing water-sharing between cousins and tribes related by blood no longer work when the cousins have become sovereign nations.

In the West Bank, Israeli military occupation forces are selective in applying Ottoman or Jordanian law, or the new military order, which tends to add to the burden of occupation and deepens the sense of alienation of the local population. Elsewhere, without water-sharing agreements, one state might limit water flow to others, as Turkey did to Syria and Iraq in January 1990. Turkey stopped the flow of the Euphrates to fill the Ataturk Dam, a part of Eastern Anatolia Development Project. At the same time, Cairo received reports that Israel was helping Ethiopia to erect dams on the Blue Nile, threatening to lower Egypt's already low water levels. In both cases, international law and diplomacy took over and the situation was resolved peacefully, but the potential for conflict was there and has not disappeared.

Apart from minimizing the danger of conflict and the potential for the outbreak of war, there is another compelling reason now for trying to codify the use of water resources in the Middle East. Environmental issues, expected to become even more urgent as the area works its way toward a level of peaceful co-existence, demonstrate an urgent need to balance optimum use of water resources with a well-founded understanding and concern for the quality of the environment.

> They have affirmed that the Earth itself generates massive amounts of water from deep within ... it has no connection with the water of the hydrologic cycle.

The most elaborate (even by modern day standards) irrigation systems in the ancient world were developed in Mesopotamia and Egypt. Evidence of more limited and less-elaborate systems have been found in ancient Palestine and elsewhere. The systems of Mesopotamia consisted of a series of canals, cut from rivers like the Tigris and Euphrates, into the fertile regions between the rivers. The feeder canals were then tapped by individuals who used smaller channels to bring water to private plots. The important societal role these systems played in the cultures of ancient Mesopotamia is demonstrated by references to them and information about their construction and maintenance in ancient records, e.g. the Mari tablets, as well as inscriptions from Assyrian kings such as Sennacherib and others.

While irrigation systems of Mesopotamia were designed primarily to transport vast amounts of water, the Egyptian systems were constructed to distribute "mud-water" (water with rich deposits of silt) from collecting pools or basins to agricultural plots in the Nile River valley. Irrigation systems were also applied in ancient Palestine, where evidence of sluice gates, channels, and catchment basins designed to capture run-off water from the Jordan River or streams in the Transjordan provide lasting testimony of those practices.

One of the most important sources of water, however, was the natural spring, such as the Gihon spring at Jerusalem and the spring at Jericho. The location of many of Palestine's earliest settlements was determined by springs of this type. Irrigation systems associated with springs have been found at Jericho, where water was diverted to fields or plots, and in Jerusalem where water was channeled from the Gihon spring along the east side of the Ophel ridge to provide water distribution for the Kidron valley.

Wells were constructed in semiarid regions used by pastoral nomads and village herdsmen, as well as in some ancient towns. Since southern Palestine was semiarid, wells such as those located at Beersheba[15] and Gerar[16] constituted the major water supply for herds and flocks. Even in ancient times, the wells were frequently a source of contention between the local herdsmen and the more nomadic pastoral nomads.[17] Large storage units, including reservoirs and pools hewn out of solid bedrock formations below the surface of the ground, were designed to capture the water that came during the rainy season. Excavations at Ai, Raddana, Qumran, and other locales have uncovered a series of such reservoirs or collecting vats that provided water for the ancient community. Though the water supply depended on rainwater, i.e. the hydrologic cycle, it was being channeled through a network of canals or watercourses from the surrounding hills to the collecting pools in the community. Generally, the systems were designed for one of two reasons: 1) to provide safe passage to the water supply; and 2) to bring the water to a more convenient location.

Warren's Shaft, named after Charles Warren who discovered it in Jerusalem in 1867, was designed and engineered by the pre-Israelite inhabitants of Jerusalem, the Jebusites. It was a water system located beneath the surface on the east side of the old city of Jerusalem, also known as the Ophel ridge, just above Gihon spring. It was designed to provide safe access to the spring during times of warfare, and consisted of an entrance on the side of the hill, a tunnel of approximately 130 feet length, a shaft about forty-two feet deep at the lower end of the tunnel, and a horizontal channel which brought water from the Gihon spring back under the ridge to the base of the shaft. This shaft was the means by which David captured the city and made it his capital.[18]

In another instance, two major water systems have been discovered at Gibeon, home of the Gibeonites who served the Israelites as "hewers of wood and drawers of water."[19] The earliest of the systems, perhaps built about the twelfth century B.C., consisted of a large cylindrical pool, approximately 37 feet in diameter and 35 feet deep, carved into solid bedrock. The pool had a spiral staircase which led to a tunnel that descended to a kidney-shaped water room.

Ancient Megiddo had a water system that was constructed in three different stages, with each replacing or improving the earlier. The earliest phase, from prior to the time of Solomon, consisted of a short stepped passage through the city wall that was connected to a covered stairway leading to the spring chamber near the base of the mound. The Solomonic system was replaced by an extremely large system constructed in the ninth century B.C., with steps and a tunnel that led from the base of the shaft of the spring near the base of the mound. At a

later time, the tunnel was deepened in order to allow the water to flow to the base of the vertical shaft. The ancient city of Hazor had a shaft and tunnel system similar to the one at Megiddo; however, the Hazor shaft was approximately twice as large as the Megiddo shaft with steps wide enough that pack animals could be used to carry the water up and out. The shaft-and-tunnel method was also used for the design of the water system at Gezer, which consisted of a rectangular shaft, and a tunnel that led to a large cave filled with spring water.

It is noteworthy that historical sources from antiquity, though filled with examples of different regimes governing the extraction and use of water, are generally silent about instances in which the rules actually denied the ruled access and use of this vital resource. Limited though it may have been, ancient rulers from pre-Solomonic times to the Middle Ages appear to have recognized that a persistent denial of access to and use of water would only invite a state of permanent conflict with the population—anathema to the rule of law and order. Even though water may have been used strategically in times of war to achieve victory, once the conflict was over, the victors typically would return in practice and policy to the sharing of water.

In present times, the apparent lack of clear interpretation of an international or regional legal regime in the water flashpoints of the Middle East will only help to aggravate the already tense situation and perpetuate existing imbalances in the exploitation of water—often based on certain states being militarily and politically dominant powers. Strong downstream countries use their military might to take more than their fair share of available waters, and regularly imply that they might take action that would threaten the stability of upstream countries if they attempted to develop hydrological projects on the shared watercourse. Thus we have Israel against Jordan, Lebanon, Syria, and West Bank Palestinians; Egypt against Ethiopia and Sudan.

Countries not in a position to force a powerful neighbor to reach a fair settlement on the use of water might start a war that would put Western interests at risk, thus requiring intervention. Since they could not win a war single-handedly against the neighbor who threatens their water supplies, they would create an unstable situation leading to a general regional conflict. Weaker states would hope to achieve two aims: 1) to secure allies against a powerful neighbor and 2) to precipitate a war invoking the international community, which would lead to water issues being put on the agenda of general settlement. Neither scenario is acceptable, of course, both being fraught with serious danger.

Mark Twain's witty comment, "Whiskey is for drinkin', water is for fightin'," describes the situation in the Middle East, where fresh-water resources are replacing oil as the probable cause for the next international armed conflict.

Mark Twain's witty comment, "Whiskey is for drinkin', water is for fightin'," describes the situation in the Middle East, where fresh-water resources are replacing oil as the probable cause for the next international armed conflict. While Egypt, Ethiopia, Sudan, and Uganda are staking out claims in the Nile River basin, and Iraq, Syria, and Turkey eye one another over the Tigris-Euphrates river system, Lebanon, Jordan, and Syria are competing with Israel over water rights in the Jordan Valley. The Ottoman Empire used the sharia as the basis for its water law in the civil code known as Al majalla othomaniyah, in which eighty-two articles deal with water. Those articles became an important source for the codification of Islamic law in the Levant, and they remain the residual legislation for Iraq, Syria, Lebanon, Jordan, and Palestine-Israel.

In the late seventeenth and early eighteenth centuries, there was a transformation of the Levant under Ottoman rule, with the rules of the sharia and the body of precedents being codified into legislation that was also affected by the influence of the French colonists. This helped establish a more comprehensive approach to water sharing in the Levant and other countries under both Ottoman and French influence.

The Ottoman majalla redrafted the original laws after incorporating the French legislation, and these were still the rules governing water use in places such as Mauritania (1921), Lebanon (1926), and Tunisia and Algeria (as late as the 1970s). Countries that came under the British influence—Turkey, Saudi Arabia, and most Gulf countries, Jordan, Libya, Sudan, and Yemen—had a different approach based on customary usage, sharia, and other rules. Egypt, however, was an interesting case: it had been in the heart of the Ottoman Empire, came under strong French influence, and was occupied by the British in 1882. From that time, it was the British who influenced the irrigation, educational systems, and army, right up to 1956. Yet Egypt never implemented the sharia, any of the Ottoman laws, or the French Code, but kept the ancient traditional ways related to the Nile. This showed, once again, how the state and the river together make the national identity of that which is Egypt. As in other parts of the world, population growth is of concern in the Middle East, too, where Israel's population has increased dramatically, and its national average use of water per person per day is at least five times as much as in neighboring countries. Israel is at present using 95% of its available water resources. In 2000 or soon thereafter, it may be short by one-third of its needs, as one million immigrants are awaiting re-settlement from abroad in that troubled country's borders. Since 1948, Israel has multiplied sixfold the acres dependent on irrigation for cultivation. Although Israeli farmers are admittedly among the most water-efficient in the world, the government may soon have to choose between water-intensive crops, such as cotton, and critical domestic and industrial needs.

The questions of a reliable source of water, whether potable or not, are closely connected to the far deeper, implicit questions of what development is, might be, and how it can be implemented. Is it not conceivable and appropriate now to anchor a lasting peace in the troubled Middle East in a Regional Water Authority with cross-boundary jurisdiction? It could be created collaboratively, staffed, financed, and operated cooperatively by all the nations in that region, friend and foe alike, who depend on this life-giving resource?

The legal, technical, and political issues surrounding water and its many-faceted uses transcend a human lifetime. They are certainly not confined neatly to national boundaries, and are perhaps among the great problems of our times. Perhaps the paradigm of "Earth-generated water," given increased attention and application, will lead to enduring solutions.

For now, let us bring our journey to a close with a quote from Aharon David Gordon (1856-1922), a pioneer in Galilee, whom Arthur Koestler quotes in his book Diebe in der Nacht (Thieves in the Night; 1983). Gordon:

We shall shake off the old life, which has become rancid

for us and shall begin anew. We do not want any changes or modifications and we do not want any improvements. We simply want to begin anew.

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About the Author

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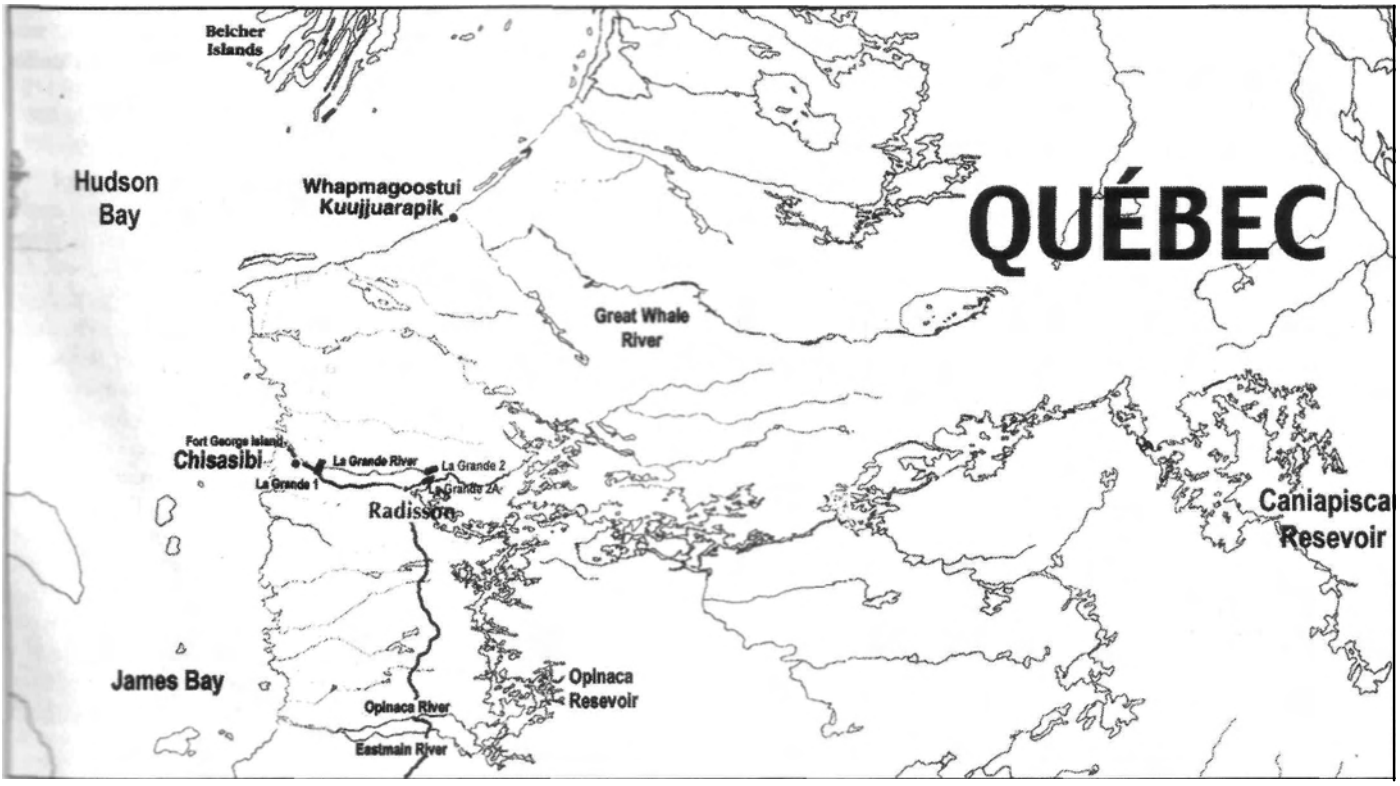
The Hydro Quebec Controversy: A Firsthand Report

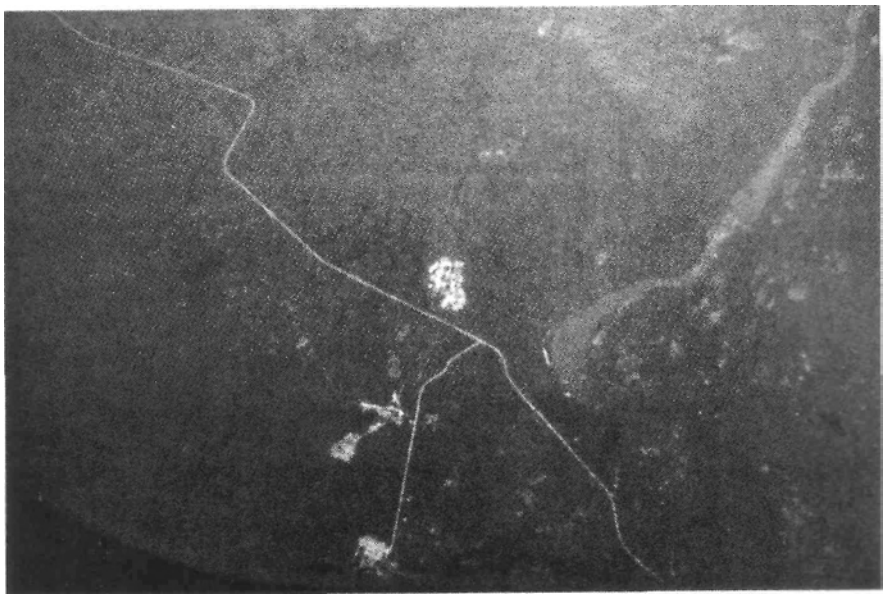
by Ken Rauen*

The dam and spillway at La Grande 2. The old riverbed has some standing water. Photos by Ken Rauen

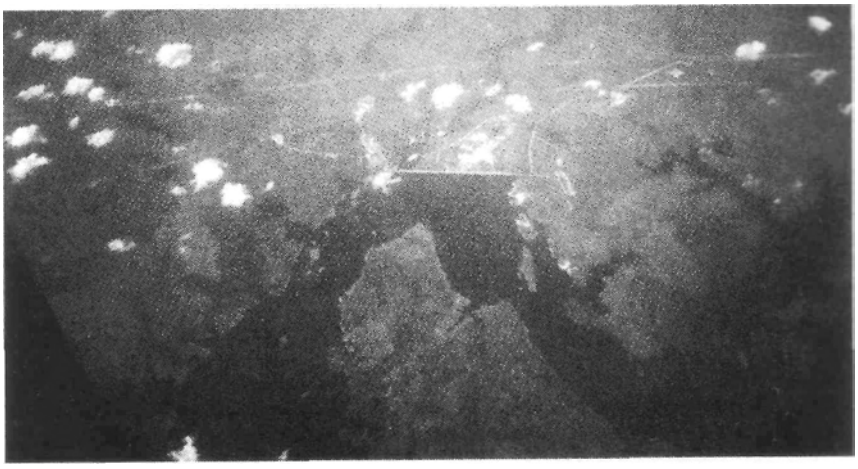
In the summer of 1993 I went on an expedition to Quebec, Canada to study firsthand the hydroelectric developments and their effects on the land and peoples of northern Quebec. I was living in Vermont at the time, and the New England states were interested in the politics of this issue. New Englanders were exposed to news media stories which ran the gamut of provincial pride in a clean and renewable energy development, to cultural genocide and environmental destruction. What was the truth of this controversy? A fact-finding expedition was organized. A group of people from Vermont and Montreal planned visitations with Hydro Quebec (HQ), the publicly owned electric utility for the Province of Quebec, and with the people who live in northern Quebec where the developments are, the Cree and the Inuit.

In 1973, HQ showed up on the shores of the La Grande River, which flows westward into James Bay, with bulldozers and started moving the earth. The Cree who live in the area asked, "What are you doing?" "We are building some hydroelectric dams; we





Aerial view of the Opinaca River below the diversion dam and the access highway. Three borrow pits are seen.



The diversion dam on the Eastmain River. The highway and the transmission line right-of-way are seen as white lines. A borrow pit is still seen just below the dam.

The view from the top of the huge spillway. The outlets of the generators from La Grande 2 and 2a are where the river is visible in the upper right. The height of the stone face sidewalls is about 60 feet.

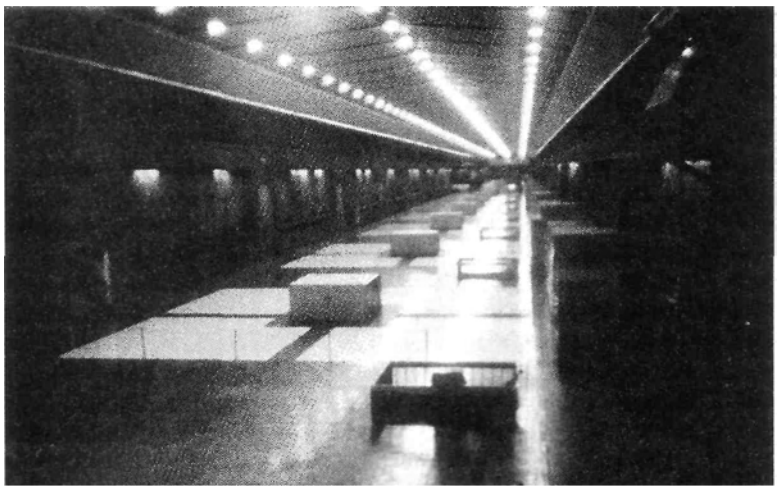
need more electricity for the 6.7 million people who live in the St. Lawrence River valley," said the Quebecois, the French-speaking people of southern Quebec. The Cree said, "This is our land; we did not give you permission to build these dams." The Quebecois said, "No, this is our land. King so-and-so deeded it to us." The Cree responded, "Who? We have been on this land for at least three thousand years and know of no such king."

One of our expedition members taught Canadian history in a high school in northern Vermont. I asked him what the slogan on the Quebec automobile license plate, "Je me souviens," means. He said, "It means, 'I remember.'" "You remember what?" I puzzled. "The Plains of Bebe, 1760, when the English defeated the French, which was the end of New France and the beginning of English domination," he responded. My, my. That sounds like an enormous "chip on the shoulder." This is central to the ongoing tensions in Canada about the larger Quebec problem, that of potential secession of Quebec from Canada. The Quebecois want to be self-directing and self-defining, and this desire has been unrealized for a long time. I can easily sense how the 6.7 million people of southern Quebec would overlook the desire of self-determination of the 20,000 or so Cree and the Inuit who live to the north on five times more land than they have. The Quebecois are fed up with being dominated and are overlooking the issues of domination of the northern peoples for the sake of a so-called democratic majority. Somehow this does not sit well with manv people, especially with many New Englanders. The Province of Quebec said they wen? treating the Indians and Eskimo more than fairly, exceptionally, in fact. The Cree and Inuit did not agree. Yet in 1975, the James Bay and Northern Quebec Agreement, a treaty, was signed. The Cree claimed it was signed under duress. Who is right?

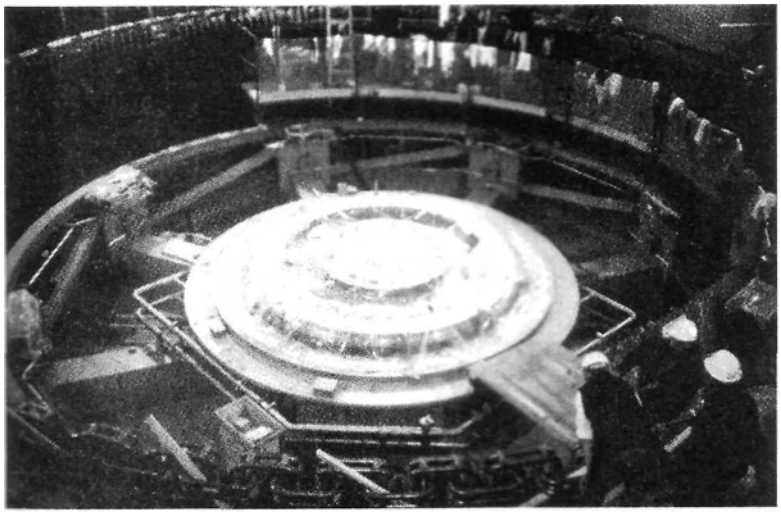
Visiting Hydro Quebec

Our trip started at the headquarters of HQ in Montreal. There, many people presented the design technology of the developments, the statistics of energy usage in Quebec and the world in comparison, HQ's energy conservation programs, and the geology and biology of northern Quebec. They spoke of the social and governmental issues involved, and elaborated on how the Treaty provides for the peoples and land of northern Quebec.

The Cree have another opinion of the Treaty and their newfound "wealth." The Inuit are not as vocal and not as unanimous as the Cree, and contribute less to this debate. We flew 800 miles north of Montreal to the construction town of Radisson, near the largest dam on the La Grande River, known as LG2. Here, we could visit two of the six dams on the river, and could find out from the Cree and Inuit what their experience has been.

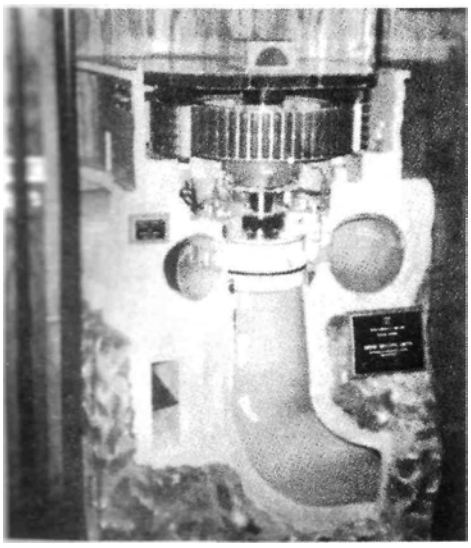


The LG2 generator hall. The tops of 16 generators are visible.



A generator under construction at La Grande 1.

Our little expedition turned up a lot of information. National Geographic, which has published several articles on the HQ controversy, would be jealous. (Editor's note: National Geographic published a special water issue, in November 1993, which included an article about HQ and the Cree, entitled "James Bay: Where Two Worlds Collide.") My expedition saw things which the National Geographic reporters probably never saw, or would be politically incorrect to publish if they did. I will give Infinite Energy's readership an honest straightforward perspective. It is not a black-and-white issue.



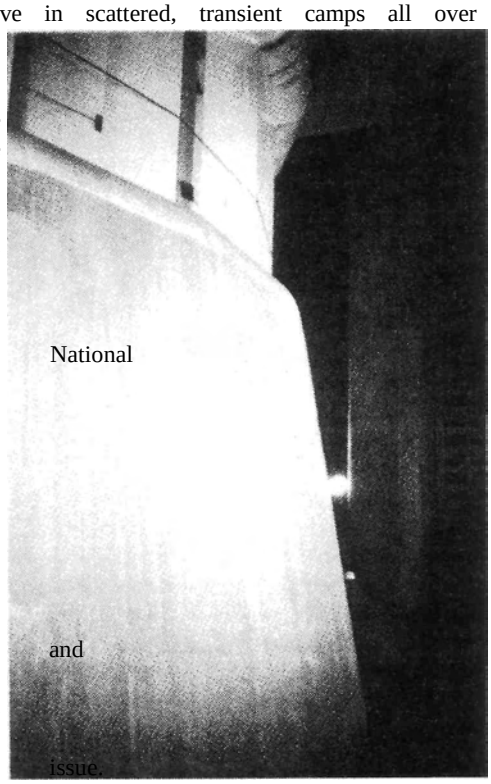
A four-foot high model of an LG2 generator

There is no clear "good guy" and "bad guy" here. There is far more to this story than can be told here. I could easily fill up this entire issue with what I experienced.

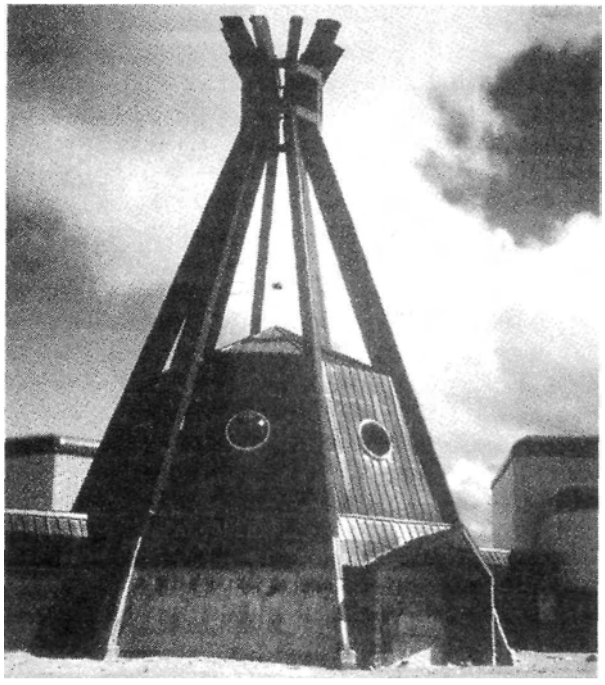
Some things that certainly were not shown to the National Geographic reporters by HQ caught my eye from the air while flying to the north. I saw the diverted Opinaca River, impounded to flow northward into the La Grande basin. The downstream riverbed of the Opinaca looked like a stagnant, open cesspool. It was ugly, and definitely unnatural and environmentally unhealthy. I also saw construction sites and borrow pits from construction which ended in 1978, fifteen years earlier. There was no restoration at these numerous sites way back in the woods. Yes, HQ is paying attention to restoration, but not everywhere they have been. Even the construction sites, to which they proudly took us, were sad to see. By my experience in the waterworks construction industry in New England, these sites were well above normal construction standards for neatness and minimal environmental disturbance. Despite exceptional care, their manipulation of Nature pales in comparison to the natural beauty and balance that once was there. At LG1, the first dam upstream on the La Grande, HQ has created gravel islands inside the upstream impoundment for ducks and geese to nest. This is hardly an equal substitute for their natural habitat, which was destroyed along this part of the river.

Background of the Cree

The Cree are a hunter-gatherer society: central to their lives is hunting and trapping of moose, caribou, fox, and beaver in the wintertime, hunting geese and ducks during spring and fall migrations, and fishing and berry picking during the summer while gathered together in nine summer villages. The Cree tribe, or nation, is divided into nine bands which identify themselves by their summer villages. Except for summer, the Cree live in scattered, transient camps all over northern Quebec. Both the Cree and the Inuit are part of a coalition of aboriginal people in Canada, called First Nations. In Canada, aboriginal people do not have Canadian citizenship. It is interesting to note that the Treaty trans-



Inside the penstock of one generator at LG1. Two people with hard hats are visible for perspective. The inlet gates to the turbine are at the upper left.



The main entrance of the Chisasibi community center, built by the French Canadians, but despised and never used by the Cree.

ferred ancestral land to the Province of Quebec for about $1 per acre, which is the great wealth which HQ brags that the Cree and Inuit now have. That Treaty money provides a single family an income of about $10,000 per year, what any Canadian citizen would receive under its welfare system, without giving up any land. The Quebecois are not the only people in this controversy who may be oppressed.

In 1973, legal counsel suggested to the Cree that they settle for a treaty with the Province of Quebec. If they did not, the legal proceedings could go all the way to the Canadian Supreme Court, which could take ten years. In that time, the dams would be built anyway. The Cree were like an eighteen year old dealing with his first legal contract, and signed it after making noble efforts at negotiation with the Province, another new and foreign experience to the Cree. The Cree are a primitive people, in the sense that they have not developed the sophistication of argument, contention, manipulation, conquest, and domination, which most other peoples of the world have acquired. I find traits of true civilization amongst the simplicity of the Cree. What they lack in sophistication, they have in a sense of community and humanity, which extends beyond their own cultural bounds. The Cree are one of the last aboriginal peoples of the world to lose their innocence of the rest of the world. They know it and accept inevitable changes, but they softly request the dignity to determine how much of the change will occur and how fast.

They already have changed greatly since Hudson Bay Company broke their isolation. They learned English from the fur traders, and English has become a second native language to them (much to the consternation of the Quebecois). The Cree accepted steel pots, knives, axes, and traps. They accepted guns, tea, flour, sugar, fabrics, and some western clothing. In recent times, they accepted snowmobiles and outboard motors for their large canoes, which they call "freighters." These additions to their culture are welcome; it helps to take the harsh edge off of their traditional way of living so close to the land.

Television is here now, but many Cree regret this introduction to their lives; little good has come from TV. It has exposed their culture to the rest of the world, mostly from the fast-paced and flashy point of view. It has introduced war and profanity which were not part of their culture. Young Cree want the bright lights and the action, but are simultaneously swept into the crime, filth, and corruption that goes with it, especially when a highway now physically joins the Cree in one of their villages to the rest of the world.

Chisasibi Village

Fast food and litter seem to be an inseparable part of the new life. The Cree attitude about litter is not completely wholesome, as I was told by one: "It's the white man's trash." Cree litter their own village of Chisasibi, the summer village which is most greatly impacted by the La Grande project. Chisasibi residents fill themselves with carbonated beverages, potato chips, and other junk food.

Idle Chisasibi youths in a "park" bulldozed out of the forest.

Idleness is prevalent there. Cree elders say it is culture shock, that the young do not know what their identity is. The hydroelectric developments have changed so

An abandoned church on Fort George Island, the former village of Chisasibi.

William and Margaret Cromarty treating their "southern" guests to some Cree Indian lore around the hearth in their teepee, where the guests stayed.

Three Cree children in the village of Whapmagoostui.

much of the Cree lifestyle. Some Cree say the hunting is not as good as it was before HQ, and exposure to "southern culture" has also added to the Cree's problems. The young see the new opportunities that traditionally did not exist in the north, yet they are shocked by the hazards of that new lifestyle which make their traditional dependence upon the land look safe and secure by comparison. The Treaty money has allowed some to stay in the summer camps all year around, when in the past, the summer camps were the winter homes of only the infirm and the very elderly. Obesity is rampant in Chisasibi, presumably due to junk food and idleness. Alcohol and drugs are an even bigger problem there.

On top of all of this, Chisasibi's village used to be located on Fort George Island in the La Grande River. The increased water flow through the La Grande concerned HQ because of the island's geological instability. It is mostly sand. The river's average flow rate has increased due to diversion of several other rivers into the La Grande, now about 3500 cubic meters per second. LG1 is just upstream a few kilometers, but it is a run-of-the-river facility. It does not store any significant amount of water behind its impoundment. A bigger concern for Fort George Island is the emergency peak flow which could occur if the level of the LG2 reservoir gets too high and some water needs to be spilled. LG2's impoundment is a very large lake, about twice the size of Rhode Island! The LG2 spillway can handle 16,000 cubic meters per second, twice the flow of the St. Lawrence River at Montreal! HQ paid for the move of the village to the mainland and built houses for the Cree, and even a community center. The Cree prefer their cabins and teepees, and they hate the concrete and steel community center that looks like a teepee; it has never been occupied. The Quebecois are indignant that their efforts are not appreciated. It stands as a monument to misunderstanding.

Fortunately for Chisasibi, the Island has not washed away, and many Cree have returned there in search of the traditional, peaceful life. My group spent three days there as guests of a Cree family and we stayed in a teepee.

Great Whale

Not all of the Cree are in dire straits like the village of Chisasibi. The Cree Nation is divided into several bands, identified by their summer villages. I visited two of them, Chisasibi being one of them. The other was Whapmagoostui (pronounced "wap MAAG stwee"). It is a cosmopolitan outpost of human civilization. Four cultures call this little place on Hudson Bay their home: the English Canadians call it Great Whale, the French Canadians call it Grande Baleine, the Cree call it Whapmagoostui, and the Inuit call it Kuujjuarapik. It is located at the mouth of the Great Whale River, named so for the mysterious, occasional appearance of beluga whales from the Bay which roll around on the sandy beaches for awhile and then disappear into the Bay. Biologists think they come there to scrape parasites off of their skin. There are a string of islands just off shore which create a protected bay or sound which is unique to Hudson Bay. The ecosystem of this area could be significantly altered if HQ were to implement their plans to divert the Great Whale River. It would no longer flow to the sandy beaches. It would flow over a mountainside many kilometers to the north, where the islands come close to the shore; the Great Whale Sound might become a brackish water environment, presently as salty as the open water of Hudson Bay. Whapmagoostui has not been impacted by HQ yet. Its impact has been fifty years of Canadian government presence as a military outpost, part of the Dew Line defense system for detection of Russian invasion. Access is by water by traditional Inuit methods, walking overland by Cree tradition, and by air by "southern" standards. Even the air strip is still gravel, and pilots land visually, without the aid of air traffic control of any kind. There are no roads out of Great Whale. Few cars are present; where can you go? Four-wheeler ATVs will get you to and from the Great Northern all-in-one store with your groceries to your house. This is luxury by Cree standards, and a questionable and a not always appreciated one at that. Convenient, but not better. Indoor plumbing is truly appreciated; I sensed this as something the Cree and Inuit really did prefer. Their toilets are one liter flushers! Due to severe frost penetration in the ground, they have a pumper truck which empties holding tanks inside the houses daily and takes the soup to a treatment plant on the outskirts of town.

Great Whale is healthy. The Cree and Inuit (this is the southernmost Inuit village and the northernmost Cree village) have the benefits of the Treaty and, so far, none of the local disturbances except the land use restrictions,p which allow Quebec to rule most of their ancestral territory. They can trap anywhere, but cannot prevent others from doing whatever they please

within Provincial laws. Great Whale has their culture intact; intact as much as it can be considering the damage done by the influences of Hudson Bay Company and their missionaries, which were forced upon them. The Cree are docile people and, finding Christian theology compatible with their traditional spirituality, accepted the Anglican Church. Unfortunately, the early missionaries insisted that the drum was evil and must go. The ceremonial drum is coming back, based upon oral tradition just barely remembered by the eldest of the Elders. The Cree of Great Whale have a vibrant community. Drugs and alcohol have not invaded. The hunting grounds are still undisturbed. The air field restricts the influx of "southerners" to an insignificant minimum, unlike Chisasibi, with no limitation to access to anyone with a car. Great Whale is isolated and will stay this way for a while. The Great Whale River roars with raging Whitewater and is clean; I drank from the river. What a night-and-day difference between Whapmagoostui and Chisasibi.

Mercury Contamination

One of the biggest political issues of the northern Quebec hydro projects is mercury contamination. Environmentalists and alarmists were saying the dams are polluting the waterways and the fish with mercury. Naturally occurring mercury in the soil is being introduced into the water because of the flooding by the dams. HQ's health survey of the Cree showed the Whapmagoostui band had the highest levels of mercury out of all the villages. How could this be? A biologist told me the reason: flooding is flooding, regardless if it is caused by a hydroelectric dam or a beaver dam. The Whapmagoostui were exposed to mercury from natural sources. The soil changes its biota from terrestrial to aquatic organisms when submerged in water, and these organisms metabolize mercury differently. Mercury in the terrestrial soil was largely immobile. Soil that became bottom mud of a lake or pond produced biologically mobile mercury. A Dartmouth Medical School professor of toxicology told me before the trip that government allowable levels of mercury are established at concentrations in fish which are ten times lower than the concentrations known to cause even the faintest and temporary symptoms of mercury poisoning. That first threshold is parasthesia, or tingling in the fingers. Ocean-caught tuna and salmon contain mercury levels higher than the fish from the LG2 reservoir. None of the Cree have dangerous levels of mercury in their bodies. The scare has created just that among the Cree. There is no word or phrase for mercury poisoning in the Cree language; it translates as "fish disease." Imagine living in a culture which has fish as a food staple. It is comparable to the Swedes being afraid of the fallout from Chernobyl; it would unavoidably affect their food supply.

Other Issues

Flooding is central to the disagreement between the Cree and HQ. HQ points out that they have only flooded 4% of the vast land of northern Quebec. There is so much more land left for the Cree to roam upon. The Cree shake their heads and say HQ flooded the best 4% of a largely inhospitable land. The animals on which their lives depend live (or lived) primarily in the wooded river valleys, not on the rocky, barren hill tops. Likewise, the fish and aquatic life they knew is altered forever from those areas now under the dams, which are enormous, despite being only 4% of the territory. Only two manmade objects are visible from high orbit from the space shuttle: the Great Wall of China and the La Grande complex of HQ. Not even New York City is visible. I did not get anywhere near high orbit in my plane ride, but I did fly over some of the impoundments. It is impressive to look out the window at 20,000 feet and see reservoirs of water to the horizon 150 miles away.

Another flooding issue is more true to the word. In the early years of development, the highest impoundment, the Caniapiscau Reservoir near the Labrador border, was complete. HQ had diverted the upper stretches of the Caniapiscau River into the La Grande basin. Above average rainfall for almost two years resulted in the reservoir approaching dangerously high water levels, which filled the reservoir before it was expected. Higher water levels could breach any of a number of dams or dikes on the reservoir and cause damage. The generating stations on the La Grande were under construction and could not take an emergency release into the river. The water was let out of the spillway into the Caniapiscau River for a brief period in 1978 at a rate which HQ thought was a normal flood level. Ten thousand caribou drowned in the river when they tried to cross it. They crossed just upstream from a waterfall and many were swept over the waterfall. HQ said it was a fluke of nature. The Cree were certain that the deaths were caused by HQ's action because, and only because, their tradition relates no such disaster of this proportion. It turns out that HQ did not have hydrological data for the river before it was diverted; their guess as to how much water to release was just that, a guess.

The Dams and the Generating Stations

The two generating facilities that I visited were impressive from an engineering point of view. As mentioned, the damage to the land was minimal compared to what a construction project of this size could do. At least LG1 and LG2 were neat and tidy. LG2 was completed years before I arrived. It was a production facility. LG1 was half built, and already had water up to its intake doors and water poured over the dam's spillway, so seeing this site in a neat and clean state while it was being built was a welcome change of pace. The surrounding natural environment was apparently disturbed as little as could be expected with the flow of trucks and big machines around the site. It also was a deliberate showpiece.

At LG2, I was the most impressed. This is one of the largest electricity generating stations in the world. Together with its extension, LG2A next door, thev have a peak generating capacity of 6,700 megawatts. They could light New York City by themselves. LG2 and LG2A are Quebec's pride and joy. Generally just referred to as LG2, it is an engineering marvel. Its rock dam is about 500 feet high, dwarfing the volume of the Pyramids of Giza. The generators are located in two underground chambers carved out of solid granite 400 feet below the surface. There are twenty-two generators, 40 feet in diameter and rated at over 400,000 horsepower, each. The roar inside the generator halls sound like Niagara Falls in the tunnels under the falls. The transmission lines above ground send the power to the south at 735 kilovolts, one of the highest transmission voltages in the world. Round structures are added at points of connection to avoid corona discharge.

Despite the energy conservation presentation given by HQ in Montreal, I noticed that in the 1980s and early 1990s every sector of North America was able to avoid new generating station construction by implementing conservation measures, except for Quebec. What is unique about Quebec? To get a hint of what it may be, I asked a question at the end of the energy conservation program presentation: "When did you implement the nighttime household thermostat program?" The presenter looked shocked and was silent. She deferred to the corporate public relations director in the back of the conference room. He answered me, and I quote verbatim, "We have had

energy conservation programs since the '60s." Some answer, and a deceptive one I suspect. Who did he think he was fooling by not answering my question? They may have been too embarrassed to state that such a simple and profound conservation measure was just recently implemented. It is amusing to note that a couple of years ago the government of Quebec announced that its other hydroelectric projects in the north are indefinitely postponed. I wonder why. The Quebecois are intensely proud of their hydroelectric achievements. After feeling like second class citizens for so long, they have something that is world class, and they know it. The Chinese are now courting Hydro Quebec to help them with the Three Gorges project on the Yangtze River. The hydro dams went ahead, whether they were truly needed or not, at least for a few decades. The realities have caught up with the social momentum, and provincial debt (the worst bond rating for any government in North America) and the adequate supply of electricity have brought political agendas to the point that the remaining planned hydro developments for the Great Whale, Nottaway, Broadback, Rupert, and several other rivers have been indefinitely postponed.

The La Grande developments have changed the land and its people forever. HQ has blasted away the roaring first rapids on the La Grande. LG1 resides where the first rapids used to be. This has sent shock waves through the Cree, even more deeply than the rest of the world can imagine. Hydroelectric power is cleaner than coal or oil, but we must ask if it is worth the other disturbances which it creates. Can we find energy solutions in our future which are not questionable, and undeniably benefit the Earth and its inhabitants?

Bird Rock, on the Great Whale River.

There is an island in the Great Whale River named Bird Rock. It looks like the breast of a giant turkey that drowned belly side up in the river, in a stretch of river with a waterfall followed by enormous rapids with waves ten feet high. Cree mythology relates that a long time ago, a giant bird challenged the river, "I can shout louder and longer than you can!" The river replied, "Oh yeah? fust try it." So the bird sang and sang, trying to outshout the river's roar. After two years without food or rest, the bird collapsed into the river, dead. The moral of the story is to know your place in nature and respect the natural order.

*Laboratory Manager at New Energy Research Laboratory (NERL)

The measure of a master is his success in bringing all men around to his opinion twenty years later.

—Ralph Waldo Emerson

Submitted by Stephen Kaplan

Water and Health

Robert Yukes*

The intent of this article is to offer information on the importance of water to well-being, to report on the damaging effects of chronic dehydration and the benefits of drinking "wetter" water, and to preview new technologies that transform water into sterilizing solutions to fight disease. [Editor note: The author is not medically trained, does not dispense medical advice, and disclaims all liability in connection with the use of the information presented herein as does Infinite Energy.] This article is not intended as a replacement for sound medical advice from a physician.

This article will summarize information about water and human health including:

- The importance of water to improve health and overcome disease.
- Methods for increasing cell hydration through "wetter" water.
- The use of electrolyzed water as a sterilant to treat "incurable" diseases.

Each of the above subjects is worthy of much research and discussion, so this article is limited to only a brief overview of these subjects.

Water and Human Health

Water is the universal solvent. In the human body, water (the solvent) transports nutrients, hormones, and chemical messengers (the solute or dissolved solids) to various body organs. The amount of water in the body regulates all functions of the body, including the activity of the solids dissolved in the water. When the body is sufficiently hydrated, then it is healthier. Sufficient hydration is important[1] because:

1. Cells require water to live, function, and grow; that is, body metabolism is water- or hydrolysis-dependent.
2. Protein and the enzymes of the body function more efficiently in solutions of lower viscosity.
3. The osmotic flow of water through the cell membranes generates hydroelectric energy, which is stored in the form of ATP and GTP.

Dr. Batmanghelidj is a medical doctor has written a book entitled Your Body's Many Cries For Water to inform people about the importance of water to good health. He writes: ". . . the greatest tragedy in medical history is the fact that medical professionals have not understood the human body's variety of calls for water. They have traditionally resorted to using chemicals and procedures to deal with the chronic dehydration."[2] He further states: ". . . chronic water shortage in the body causes most of the diseases of the human body."[3]

With a chronic water shortage or dehydration, the body experiences dehydration stress. Chronic dehydration may manifest itself in the body in the form of symptoms which medical professionals diagnose and treat as disease. According to Dr. Batmanghelidj, the following diseases may originate or be caused by chronic dehydration: heartburn (dyspepsia), rheumatoid arthritis pain, anginal pain, low back pain, migraine headaches, hangover headaches, hiatal hernia, colitis pain, constipation, Alzheimer's disease, morning sickness, bulimia, depression, multiple sclerosis, chronic fatigue syndrome, fear, anxiety, insecurity, high blood pressure, high blood cholesterol, excess body weight, asthma, allergies, insulin-independent diabetes, and impotence.

> Most people simply do not drink enough water... the average person needs six to eight eight-ounce glasses of water daily.

Why is chronic dehydration associated with so many diseases? The answer is simple. Chronic dehydration causes dehydration stress in the body, which often leads to further dehydration. Medical professionals have documented the detrimental consequences of stress. According to Dr. Batmanhelidj, they have failed to realize that chronic dehydration over time is the cause of many of the same diseases that stress will cause.

Most of the people living in the United States are dehydrated. Why? Most people simply do not drink enough water! Although many people may drink adequate amounts of beverages, many beverages are dehydrating agents and cause the body to eliminate more water than is consumed. Specifically, tea, coffee, alcohol, and manufactured beverages (such as soda and diet soda) contain dehydrating agents and contribute to personal dehydration and are not "substitutes for the purely natural water needs of the body."[4]

According to Dr. Batmanhelidj, "The solution for prevention and treatment of dehydration-produced diseases is water intake on a regular basis."[5] Dr. Batmanhelidj believes that the average person needs six to eight eight-ounce glasses of water daily. He believes that it is best to drink water one-half hour before meals and two and one-half hours after meals. With the increase in water consumption, it may be important to increase salt intake at the rate of 3 g of salt (one-half of a teaspoon) for everv two quarts of water consumed. In addition, it may be necessary to add vitamins and minerals to your diet as well.

After treating many patients suffering from dehydration-induced diseases with drinking water, Dr. Batmanhelidj concludes that "common tap water has medicinal values hitherto unrecognized. Water is a readily available natural medicine for some of the prevalent and very serious medical conditions that are known to kill many thousands of people each year . . . dehydration ... is the biggest killer, more than any other condition that you could imagine."[6]

Of course, it is understood that many diseases are not caused by dehydration. However, the point of Dr. Batmanhelidj's observation is that we as a society do not understand that dehydration causes stress in the body, which in turn either causes disease or assists in premature aging and premature death of the body. And, that the best treatment for dehydration-stress diseases is the medicine called water.

Better, Wetter Water

In chemical terms, water is a molecule containing two atoms of hydrogen and one atom of oxygen and as a molecule is electrically neutral, but the electrical charges are polarized in the hydrogen(+) and in the oxygen(-). This polarity causes a water molecule to attract other water molecules to form water clusters. Typically, drinking water exists in clusters of eight to twelve molecules of water—electrically attracted to each other and usually surrounding a mineral molecule in the water.

When consuming water, the body does not easily absorb the large clusters and must "work" to break the large clusters into smaller clusters before absorbing them in the digestive tract. Likewise, in the body itself, large water clusters do not pass through the cell membranes as easily as smaller clusters. Researchers have concluded that small-cluster water or "wetter" water is better for the hydration of the body and contributes to greater health and longevity.

Researchers, who have studied populations and longevity, have concluded that the properties of the drinking water are a major factor in determining longevity in a population group. Specifically, five regions of the world were studied where people had healthy lives past the age of 100 years. Although the diets differed among the five groups, the only common factor that could explain their longevity was their drinking water. Their drinking water originated from melted glaciers and had different properties from tap water in the United States. The most famous region or group that was studied was the Hunzas, located in a remote mountain region in the former Soviet Union. Although the longevity of the Hunzas was exploited to produce advertisements for yogurt for U.S. television, the real secret of their longevity is their water.

Researchers have concluded that water that promotes good health has three important properties: lower surface tension, slightly alkaline pH, and a negative ORP (oxidation-reduction potential). Water which is "wetter" (smaller clusters) and has lower surface tension can more easily pass through the cell membranes, to deliver nutrients to the cells and to remove toxins from the cells. In addition, researchers have concluded that water which is slightly alkaline is also better for the body. Almost all disease is acidic, and alkaline drinking water is thought to assist the body in fighting (neutralizing acidic) disease. In addition, water that has a negative ORP has more electron availability and acts as an anti-oxidant in the body, negating harmful free-radicals, which tend to cause disease and aging.

In order to provide consumers with the health benefits of "Hunza" or "wetter" water, i.e., water with a lower surface tension, slightly alkaline pH, and a negative ORP, new businesses are emerging to bring "wetter" water to the market place.

First, some are bottling water at the source and selling it for its health properties to the public.

Second, several companies are processing water electrically to break the clusters and to remove unnecessary chemicals from the water such as chlorine. The resulting water is sometimes called "reduced" or "electrolyzed" water and is being sold in supermarkets and health food stores. (See IE, No. 18 pp. 35-38)

Third, some companies are selling consumer water processing units to produce "wetter" water (sometimes called "microwater")[7] from tap water. In Japan in the early 1990s, several companies manufactured and sold water processing units to make "wetter" water and had combined sales of over a billion dollars annually. Initially, the electrodes in the units corroded with usage and eventually did not function well, but the newer units reportedly do not have this problem.

Fourth, one company has discovered a way to treat water with minerals so that it is "wetter" water.[8] The product releases negatively charged hydrogen ions to transform tap water to "wetter," negative ORP water.

Many health claims have been made about the above four water products. It is logical to assume that if a sick person is suffering from dehydration-related stress or dehydration-related disease, that hydration will gradually reverse the problem and help the body to heal itself. The importance of "wetter" water is that it accelerates the hydration of the body and its cells and, in so doing, may cause a dramatic reversal of the symptoms of dehydration stress diseases.

Electrolyzed Water as a Vehicle for Ozone Therapy and as a Sterilant

Research indicates that bacterial and viral diseases grow more easily in a human body when it is oxygen deprived. So, to treat those diseases, the logical treatment would be to increase the amount of oxygen in diseased tissue to help the body to heal itself. Medical doctors and researchers have invented some clever ways of accomplishing this, including hyperbaric oxygen therapy, hydrogen peroxide therapy, and oxygen/ozone therapy.[9] Hydrogen peroxide and ozone are poisonous and should not be taken internally.

Two companies, Medizone International, Inc.[10] (MZEI-OTC) and Medical Discoveries, Inc.[11] (MLSC-OTC) have both independently invented a process to electrolyze water to produce a solution that is 99+% water but contains a small amount of oxygen and ozone. In the past, it has been difficult to deliver consistently reliable doses of ozone because of the instability of ozone, the impact of air temperature and pressure, and other variable factors that affect the production of ozone. The promise for these medical technologies is that each has discovered a method to produce reliably consistent doses of ozone and oxygen in water which will be able to treat many incurable bacterial and viral diseases, including hepatitis, HIV, AIDS, multiple sclerosis, and some forms of cancer. Although neither technology has been approved by the FDA, limited test results are very encouraging for both companies.

In the mid-1970s, Russian scientists invented a technology involving the electrolysis of salt water to produce a solution that contains small amounts of anti-oxidants containing "wetter" water, ozone, hydrogen peroxide, hydrochlorous acid, and hypochlorite. Together, at very dilute/weak concentrations of 50 ppm to 300 ppm chlorine, these chemicals disinfect more effectively than 5% bleach (sodium hypochlorite) solutions containing 50,000 ppm of chlorine. So, the dilute solutions made from salt water are 1000 times more effective than

bleach and therefore have very low toxicity, yet are effective against all bacteria, viruses, fungi, and spores.

After the end of the Cold War, the technology was applied to produce disinfectant solutions from tap water for medical applications. Shocking as this may seem, all hospitals in Moscow now use the electrolyzed water solutions to sanitize hospital walls, floors and surfaces, to sterilize hospital equipment (even used syringes), and to sterilize surgical incisions, wounds, and burnt tissue. The sterilizing solution is so effective that Moscow hospitals have been documented to be more sanitary than hospitals in the U.S., which use harsh chemical disinfectants! Each year, over 80,000 people die from infections and diseases which they receive while in U.S. hospitals because the sanitizing procedures in the U.S. are not able to eliminate many bacteria and viruses from the hospital environment.

It is theorized that the sterilizing solution works well because the solution has lower surface tension, which causes an osmotic pressure differential between the water inside the cell and the sterilizing water outside the cell. This enables the "wetter" water to penetrate the cell membranes of micro-organisms and to transport small amounts of oxygen, ozone, and chlorine into the cells, which quickly kill these micro-organisms. This technology has been successfully commercialized in the Soviet Union, Japan, and South Africa. A company called RSCECAT USA, Inc.[12] is attempting to commercialize this same technology in the United States. The company is working with the Department of Defense to produce disinfecting solutions that will clean up the residue of germ warfare weapons with only minimal environmental impact. In addition, it is working with the meat industry to develop methods and solutions to sanitize meat for the safety of consumers.

In summary, water is the universal solvent that brings nutrients to cells and removes wastes from cells. Most people do not have proper hydration and are subject to dehydration stress and the resulting symptoms and diseases. Water can be electrolyzed and transformed into "wetter" water for drinking or into an amazing medicine to fight virus and bacteria diseases in the body. When saline water is electrolyzed, the resulting solution contains many oxidants, which are an effective sterilizing solution with low toxicity. Water has always been important for the health of people, but with the new technologies, water will soon be important in sterilization and in the treatment of "incurable" diseases.

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This text reminds pupils through their study that they must face all problems

with open minds. —Franklin B. Carroll, 1935

I was going through my father's ancient book collection a few weeks ago and found a textbook from his junior high science class entitled, Understanding Our Universe, written in 1935. Always intrigued by such things, I cracked the pages to see what was inside...Wow! What a difference sixty-plus years makes in the world of scientific thought. —Jeremy Jones

The following is the exact text of paragraphs two and three of the foreword as written by the author, Franklin B. Carroll: The graveyard of once-credited scientific theories and axioms and the mistakes of pupils serve to educate no less than do brilliant explorations. Pupils are led to see that the generalizations that seem adequate at one stage of investigation are often inadequate in the light of new-found facts. Revision or abandonment of old for new is necessary as science advances. Science is shown as always tentative. The science of one age will often not do for the next. The achievements of scientists in the past are shown in relation to those of later date. It is hoped that pupils wi decide for themselves that science can advance only a short distance on the road toward eternal truth.

Not accumulation of memorized facts and principles but habituation to the scientific attitude toward common experience, as well as toward the strange and new, is the better goal of general science. Respect for facts and their interpretation, an attitude of open-mindedness, a willingness to accept the tentative explanation when facts warrant and to suspend judgement when explanation cannot be reached—these are habits to be established by the study of science. Difficult to test, the establishment of such attitude has too often been left to faith and hope. This text reminds pupils through their study that they must face all problems with open minds.

[Editor's Note: Jeremy Jones, one of the fellows who works at Lighthouse Press in Manchester, New Hampshire, where Infinite Energy is printed, was kind enough to send us this sage opinion from a 1935 high school textbook. - EFM]

"Water Buckyballs"
Chemical, Catalytic, and Cosmic Implications

Keith Johnson*

Abstract

Potential chemical, catalytic, and cosmic roles of pentagonal dodecahedral, "buckyball-like" water clusters are described, based on calculated electronic structures and "submillimeter" wavelength cluster vibrational modes. The cluster LUMOs are huge "s," "p," and "d" - like orbitals that readily accept an extra electron. Dynamic Jahn-Teller cluster molecular-orbital coupling to the submillimeter vibrational modes promotes water buckyballs as electron reservoirs and oxygenates in fuel combustion and as active agents in biology. The electronic and submillimeter vibrational spectra may explain certain diffuse interstellar bands, cosmic background radiation, "missing cosmic baryonic matter" and cosmic "gray dust." The role of water-cluster oxygen-oxygen interactions in the hydrogen bonding of liquid and supercritical water is also discussed.

Recent scientific interest in small water clusters has been motivated by their possible roles in atmospheric and environmental phenomena, as well as by their relevance to the structure and properties of liquid water and ice.[1] Experiment and theory agree that not only can such clusters be produced, but they also exist optimally in certain numbers (so-called "magic numbers") and configurations of water molecules.[2] Thus, they deserve a significant place in the expanding field of cluster science.[3]

Prominent among the magic-number water clusters that have been identified are ones having a "buckyball-like" pentagonal dodecahedral structure. These clusters have a closed, ideally icosahedral symmetry formed by 20 hydrogen-bonded water molecules, with their oxygen atoms at the vertices of 12 concatenated pentagons and with 10 free exterior hydrogen atoms (Figure 1(a)). Figure 1(b) shows an $(H_2O)_{20}H_3O^+$ cluster, which occurs as a dominant molecular species in a variety of experiments.[1-3] Its clathrate structure—a neutral water molecule trapped in the dodecahedral cage plus a relatively mobile proton—is an ideal subject for theoretical investigation.

This paper is directed to aspects of the electronic structure and the low-frequency vibrational modes of water "buckyballs" not reported in earlier work, as well as to the implications of adding electrons to the clusters on their chemical, catalytic, and astrophysical properties. Although the oxygen atoms of neighboring water molecules are second-nearest neighbors, modest oxygen-oxygen p-pi-orbital interactions are shown to play a key role, along with hydrogen bonding, in the electronic structures of these dodecahedral water clusters. They are shown to be largely responsible for the lowest frequency, submillimeter-wavelength H_g "squashing" and H_u "twisting" vibrational modes of the dodecahedral cluster, indeed the lowest of any known cluster or molecule its size.

Experimental evidence for submillimeter water cluster vibrational modes is discussed below. These symmetry-breaking cluster vibrations can be activated by the pseudo or dynamic Jahn-Teller (JT) effect,[4] coupling with the water cluster electronic states to influence chemical and spectroscopic properties. There is a strong similarity between the JT properties of electron-doped dodecahedral water clusters and the JT-induced intramolecular vibronic coupling believed by some scientists to underlie the superconductivity of doped solid buckminsterfullerene.[5] The fact that the squashing and twisting vibrational frequencies (5-100 cm^4) of water buckyballs are much lower than the corresponding vibrational modes (250-1500 cm^{-1}) of C_{60} is key to recognizing the submillimeter spectroscopic signatures of water buckyballs versus the infrared spectra of carbon buckyballs in interstellar space.

Figure 1(c) shows the occupied molecular orbitals for an isolated water molecule. Although the H_20 "in-plane" b_2 molecular orbital has the largest bond overlap between an O atomic p_x-orbital and H atomic s-orbitals, notice should be taken of the practically nonbonding $0(p_z)$-H(s) "in-plane" a_2 orbital and the nonbonding $O(p_v)$ "out-of-plane" b_1 orbital. The b_1 and b_2 orbitals are the basis for modest $O(p_x)$-$O(p_v)$-$O(p_x)$ "π-bond" overlap between neighboring water molecules in clustered water, as illustrated schematically for a water trimer in Figure 1(d) and (e). $O(p\pi)$-$O(p\pi)$ bond overlaps of this order of magnitude have been argued to trigger JT-induced anharmonic local electron-phonon coupling believed by this author to trigger high-T_c superconductivity in doped copper oxides.[6,7] O - O nearest-neighbor interatomic distances (2.7-2.8A) in such materials are remarkably close to those of water.

Semiempirical and ab initio density-functional molecular-orbital computations for the dodecahedral water clusters of Figures 1(a) and (b) holding an "extra" electron yield similar energy levels. Results for $(H_20)_{20}^{-1}$ are shown in Figure 2. The highest occupied molecular orbital (HOMO) of the "hydrated" electron is the gigantic cluster "s-orbital" mapped in Figure

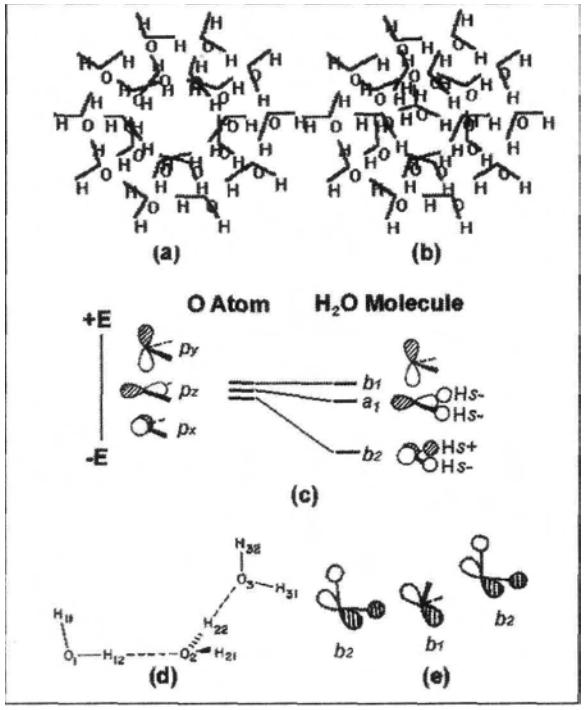

Figure 1. (a) Pentagonal dodecahedral $(H_2O)_{20}$ cluster; (b) pentagonal dodecahedral $(H_2O)_{20}H_3O^+$ cluster; (c) molecular orbitals of isolated H_2O molecule; (d) $(H_2O)_3$ trimer; (e) interacting H_2O molecular orbitals in $(H_2O)_3$.

Editor's Note: For a less technical look at the energy implications of Dr. Keith Johnson's work, see Bennett Daviss's article, "Just Add Water," p. 41—EFM

3(a). This is a spherical shell arising from O(pπ)-O(pπ)-O(pπ) atomic orbital overlap around the cluster "surface." The lowest unoccupied molecular orbitals (LUMOs) correspond to huge, nearly degenerate "p_x, p_y, and p_z" orbitals, one of which is mapped in Figure 3(b). These "Rydberg-like" LUMOs also arise from O(pπ)-O(pπ)-O(pπ) atomic orbital overlap around the water cluster surface. They are bound states with a HOMO —> LUMO (Cluster "s"—>"p_x,p_y,p_z") excitation energy of 1.8 eV, consistent with spectroscopic studies of somewhat larger negatively charged water clusters.[8] Spin polarization of the excess electron increases the HOMO --> LUMO energy to 5.9 eV. Excitations from the s-like HOMO to the higher lying unoccupied cluster "d" levels shown in Figure 2 and mapped in Figure 3(c) are forbidden by the selection rules. The "s"-HOMO --> "p"-LUMO excitations, as well as higher-energy (ultraviolet and X-ray) transitions from and to the O(2p), H-O bonding and deep-lying cluster "s"- and "p"- bonding levels in Figure 2 may have astrophysical spectroscopic significance. Because of the "extra" electron, $(H_2O)_{20}^{-1}$ and $(H_2O)_{20}H_3O$ clusters are paramagnetic.

Quantum-chemical computations of the vibrational modes for the hydrated-electron pentagonal dodecahedral clusters in Figures 1(a) and (b) have also been carried out. Figure 3(d) shows one of the lowest-frequency vibrational modes for cluster 1(b). This is a symmetry-breaking H_g "squashing mode" of the otherwise ideal icosahedrally-symmetric pentagonal dodecahedral cluster, with a large-amplitude vibration of the clathrated hydronium oxygen atom coupled to breathing vibrations of the cluster surface oxygen atoms. For both clusters 1(a) and (b), these modes are calculated to occur in the very low frequency (submillimeter-wavelength) range between 5 cm^{-1} and 50 cm^{-1}. Figure 3(e) shows another H_g cluster squashing mode around 50 cm^{-1}. Figure 3(f) shows an H_u cluster "twisting mode" near 90 cm^{-1}. These extremely low frequency vibrational modes owe their existence to the flexing of the dodecahedral water cluster

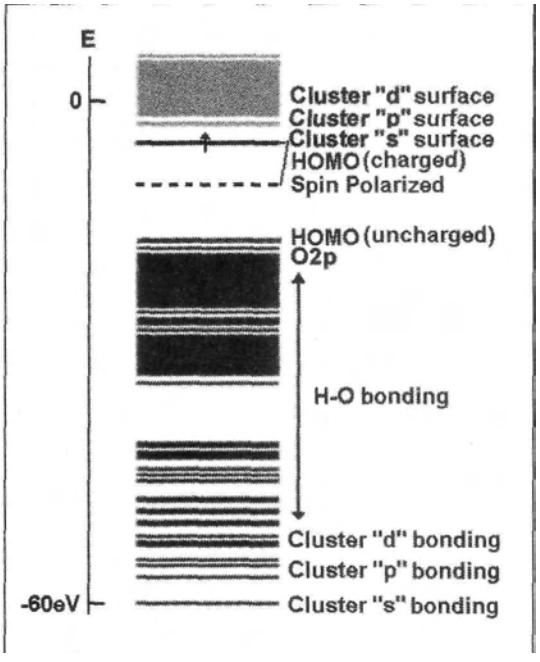

Figure 2. Molecular-orbital energies of an $(H_2O)_{20}^{-1}$ cluster. The highest occupied "s" orbital (HOMO) and lowest unoccupied "p" and "d" orbitals (LUMOs) are spread around and radially extended away from the cluster "surface" oxygen atoms (see Figure 3). Spin polarization of the excess electron increases the HOMO -> LUMO energy. Deep "s"-, "p"-, and "d"-bonding orbitals are localized within the cluster "cage." In uncharged $(H_2O)_{20}$, the cluster "s" surface orbital is the LUMO, separated from the 0(2p) HOMO by a large energy gap. Similar results are obtained for $(H_2O)_{20}H_3O$ and $(H_2O)_{20}H_3O^+$ clusters.

"surface" O - O - O bonds associated with adjacent 3-coordinated water molecules. This is consistent with recent He atom scattering studies of the surface vibrations of large water clusters, which show O - O - O "bending" modes at 5 meV (40 cm^{-1}) associated with adjacent 3-coordinated water molecules on the cluster surface.[9] The hydrogen bond flexing and stretching vibrational modes are calculated to occur, as expected, at much higher frequencies.

While ordinary bulk liquid water is not usually thought of as an "active" substance, water clusters, especially small symmetrical hydrated-electron clusters like the ones shown in Figures 1(a) and (b), are another matter due to the effectively large reactive cross sections of the cluster surface delocalized oxygen orbitals mapped in Figure 3. Indeed, experimental studies of the thermal energy chemical reactions of size-selected hydrated-electron clusters $(H_2O)_n^{-1}$ attribute their strong reactivity to the spatial derealization of the excess electron at the cluster surface.[10] Thus, charged water clusters can function as electron reservoirs for chemical reactions involving electron transfer to or from the reacting species. In the oxidation of carbon compounds, such as occurs in hydrocarbon fuel combustion or biological cell metabolism, water-cluster hydrated-electron delocalized orbitals, originating on the cluster surface oxygen atoms, can readily overlap with the reactive fuel carbon (e.g. pπ) orbitals, promoting oxidation. The proximity of the highest occupied dodecahedral water cluster excess-electron "s" orbital to the lowest unoccupied, nearly degenerate cluster "p_x,p_y,p_z" orbitals (Figure 2) suggests the strong possibility of coupling between the hydrated electron and the above-described low-frequency cluster H_g vibrational modes via the pseudo or dynamic JT effect.[4] The H_g cluster squashing modes associated with the icosahedral symmetry are known to be JT-active in the case of electron-doped C_{60}.[5,11] JT coupling in the water clusters 1(a) and (b) leads to a prescribed symmetry breaking of the pentagonal dodecahedron along the low-frequency H_g vibrational squashing mode coordinates Q_S, lowering the cluster potential energy from A to the equivalent minima A' shown in Figure 4. Because of the large JT-induced vibronic displacements (large Q_s) of water-cluster surface oxygen atoms in the H_g modes, the energy barrier for expulsion of water oxygen or OH radicals and their oxidative addition to reactive carbon atoms is lowered from $E_{barrier}$ to $E'_{barrier}$, , as shown in Figure 4. A more detailed discussion of the JT effect as an activation mechanism in chemical reactions and catalysis is found in Reference 4. The practical use of water clusters to break down and more completely burn particulate matter (smoke/soot) precursor molecules, as well as serving as a combustion oxygenate in fossil fuels, has recently been demonstrated.[12]

It has been pointed out by other workers[1,13-14] that polyhedral water clusters, especially concatenated pentagonal clusters, have been experimentally identified as being key to the hydration of biomolecules. It has even been suggested that water clusters may play a fundamental role in biological cell architecture.[15] In such scenarios, the cluster surface oxygen-based molecular orbitals and JT-induced low-frequency vibrational modes described above most likely underlie the active roles of water in biology.

On a cosmic scale, the electronic and submillimeter vibrational spectra of pentagonal dodecahedral water buckyballs may help to solve the long-standing mystery of "diffuse interstellar bands" (DIBs).[16,17] DIBs are optical absorption features in stellar spectra observed through dense interstellar material. Of the many encountered DIBs thus far, only a few have been tentatively identified molecularly. A key feature of the notorious DIBs near wavelength 6800A is an intriguing regularity in

the frequencies of the stronger spectral lines, namely a spacing of about 35 cm^{-1}, suggesting a molecular vibrational component at that frequency.[16] Speculations that C_{60} buckyballs, polycyclic aromatic hydrocarbons (PAHs), or other polycarbon chains may be responsible for the DIBs[17,18] are hampered by the fact that the lowest C-C and C-H vibrational frequencies of these species are much higher than 35 cm^{-1}.

As mentioned above, "excess-electron" water buckyballs have lowest-energy HOMO --> LUMO optical absorption around 1.8 eV, i.e. in the region of the 6800A DIBs, and lowest H_g squashing vibrational modes in the vicinity of the 35 cm^{-1} DIB line spacing ascribed to molecular vibrations.[16] Experimental evidence cited above for vibrations near this frequency in $(H_2O)_n$ clusters between n = 20-100 has recently been reported.[9] Considering the laboratory stability of water buckyballs at the magic numbers 20 and 21 and their anticipated stability in the cold of interstellar space, they are likely candidates for sources of unexplained DIB spectra. The 5.9 eV HOMO —> LUMO energy of a "spin-polarized" excess electron on a water buckyball (Figure 2) corresponds approximately (and perhaps coincidentally) to the notorious and thus far unidentified 2175A interstellar absorption feature.[19] Evidence for significant quantities of water "vapor" in nebulae, stellar atmospheres, and planetary objects has grown in recent years. Much of this evidence is based on the signature of the infrared O-H "stretching" and "bending" vibrational modes common to individual water molecules. Vibrational modes arising from H-O bonding also occur in water clusters, so at least some of the observed water vapor may actually be present in the form of water buckyballs.

Given that oxygen is the third most abundant cosmic element, following hydrogen and helium and preceding carbon, it is tempting to speculate on the more general cosmic significance of water buckyballs. Recent infrared observations of a water-generating gas cloud in the Orion Nebula[20] confirm theories of how shock waves emanating from star formation heat the gas and speed up chemical reactions, causing free hydrogen and oxygen to combine into water. Considering evidence that the shocks are creating water at an enormous rate, it is likely that water buckyballs are a plentiful interstellar product. Since star formation occurs in galaxies throughout the universe, the cosmic abundance of water buckyballs is a compelling possibility. Mass spectra of the carbonaceous residue in impact craters on the Long Duration Exposure Facility (LDEF) spacecraft have provided evidence for the occurrence of C_{60} and C_{70} buckyballs in space.[21] Collisions between chemically reactive charged water and carbon buckyballs in space and under the influence of cosmic radiation could produce some of the many organic species observed in nebulae.

Capture of cosmic-ray electrons by neutral $(H_2O)_{20}$ and/or $(H_2O)_{20}H_3O^+$ clusters may occur naturally in space due to the large capture cross sections of the cluster LUMOs. If cosmic electrons are traveling close to the speed of light, their interaction with the above-described low-frequency cluster vibrational modes could result in the conversion of the associated water-cluster far-infrared radiation to X-ray or gamma radiation via the inverse Compton effect (ICE).[22] A recent report of statistical observational evidence for a "gamma-ray halo" surrounding our Milky Way galaxy[23] attributes the halo either to the ICE or to "dark matter." If water buckyballs are responsible for certain DIB spectra, then they are also candidates for ICE-induced ealactic gamma radiation.

Selection-rule-allowed electronic transitions between the ionized water cluster deep-lying "s"-, "p"-, and "d"-bonding levels and HOMO/LUMO "s", "p", and "d" levels in Figure 2 are consisent with increasing evidence for low-energy X-ray emissions from some unknown vast filamentary network of "high-temperature baryonic gas/plasma" linking galaxies and galaxy clusters.[24] Cosmic water buckyballs and their paramagnetic ions could therefore be viewed as one possible species of "missing baryonic matter."

There has been much excitement over recent observational studies of the "dimming" in brightness of distant supernovae, leading to the bizarre conclusions that: 1) our Universe is currently accelerating in its expansion from "The Big Bang" and 2) there must be a positive "cosmological constant" of the same order of magnitude as the mass energy density of the Universe to produce effectively an "antigravitational" force causing the accelerated expansion.[25] The only astronomical phenomenon that would rule out these conclusions is the presence throughout the vast intervening space separating us and distant supernovae of some form of "gray dust" whose electromagnetic absorption properties would account for the supernovae dimming.[26] Among the various suggested forms of "cosmic dust"[17] having such a property is one based on micro- or nanoscopic spherical shells.[27] Water buckyballs indeed have this structural

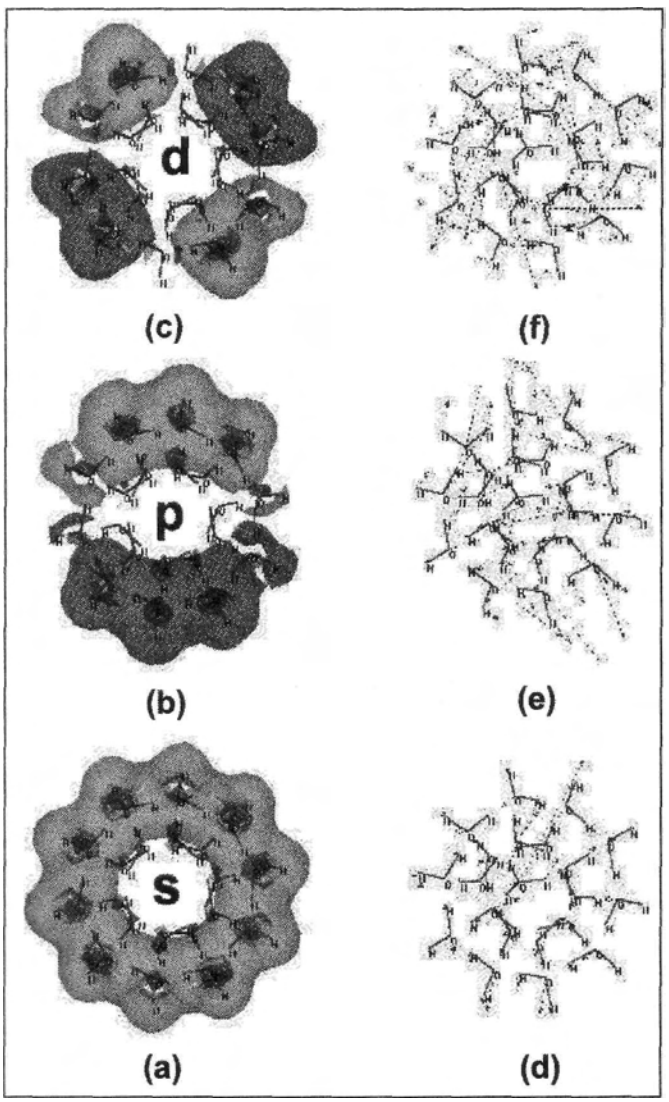

Figure 3. (a) "s"-like HOMO wavefunction of a $(H_2O)_{20}^{-1}$ pentagonal dodecahedral cluster; (b) "p"-like LUMO wavefunction of a $(H_2O)_{20}^{-1}$ cluster; (c) higher-energy unoccupied "d"-like $(H_2O)_{20}^{-1}$ cluster wavefunction; (d) "H_g squashing" vibrational mode of a $(H_2O)_{20}H_3O$ buckyball in the frequency range 5-50 cm^{-1}; (e) "H_g squashing" vibrational mode of $(H_2O)_{20}H_3O$ buckyball near 50 cm^{-1} (f) "H_u twisting" vibrational mode of $(H_2O)_{20}H_3O$ buckyball near 90 cm^{-1}. Vibrational vectors are indicated by the arrows.

and electronic absorption property.

Recent spectroscopic data from the Hubble Space Telescope have revealed vast amounts of ionized oxygen in intergalactic space.[2] Where there is ionized oxygen (the third most abundant element in the Universe), there should be copious amounts of hydrogen, albeit ionized and therefore difficult to detect spectroscopically. It follows logically that the presence of large amounts of hydrogen and oxygen in various states of ionization throughout vast intergalactic space should lead to the formation of water molecules and clusters, most likely also in various states of ionization. Perhaps data from the Submillimeter Common User Bolometric Array (SCUBA), which has recently detected striking far-infrared emission from distant star-forming galaxies in the very-low-frequency range of the above-described water buckyball vibrations, could be utilized to help confirm these conjectures.

In view of the emphasis placed here on the consequences of oxygen-oxygen interactions in pentagonal dodecahedral water clusters, it is natural to consider their possible relevance to the properties of and traditional hydrogen-bonding models for liquid water. Pauling[29] originally pointed out that "pentagonal dodecahedra may be arranged relative to one another in a large number of ways, so that highly random structures for liquid water might be based upon aggregates of water molecules bonded to one another in this way." Because of the tetrahedral coordination of hydrogen-bonded pentamers in such a model, it may be viewed as an extension of the conventional tetrahedral structural scenario for liquid water to include O - O - O interactions. Low-frequency Raman scattering studies of liquid water reveal a broad band between 5 and 100 cm^{-1} with a maximum at 50 cm^{-1} for a temperature of 20°C.[30] This band has been attributed to "flexing" vibrations of O - O - O units in water clusters having an effective Raman scattering cross section of 11A at 20°C.[30] If one adds the large amplitudes of the above-described H_g vibrational modes of a water dodecahedron to its equilibrium diameter, the Raman-implied 11A size is in accord with a dynamical dodecahedral model for liquid water. Raman measurements for both O^{16} and O^{18} isotopes of liquid water reveal a significant isotope shift of this low-frequency peak,[31] consistent with the oxygen-derived vibrational modes of the dodecahedron. Delocalized O-O-O pπ-bond overlap occurs not only around the surface of an individual dodecahedral water cluster but can also take place between connected dodecahedra in Pauling's[29] model of liquid water. The observation

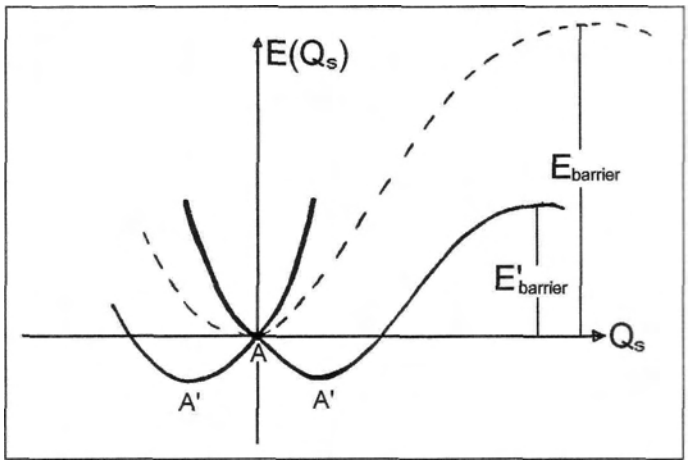

Figure 4. Schematic potential energy curves showing how pseudo/dynamic Jahn-Teller coupling of water buckyball molecular orbitals in Figure 3(a)-(c) with the cluster low-frequency vibrational modes in Figure 3(d)-(e) can, in principle, lower the energy barrier for a chemical reaction along reaction coordinates Q_S corresponding to the symmetry-determined vibrational modes.

that neighboring water molecule H s-orbitals are in a bonding phase relationship with the O pπ orbitals (Figure 1(e)) suggests that dynamical O - O - O pπ-bond overlap effectively "propagates" hydrogen bonding over long distances in liquid water. Thus, hydrogen bonding between water molecules may not be a purely local "electrostatic" sharing of a proton, as conventionally viewed, but is effectively delocalized via the second-neighbor O - O - O pπ bond overlap. This "many-body" electronic effect, JT-coupled with the calculated and measured low-frequency O - O - O vibrations, may explain the unique and still poorly understood properties of liquid water, such as its large heat capacity and anomalous freezing properties. The large heat of vaporization of liquid water may also be related to delocalization of hydrogen bonding via the O - O - O interactions.

If interacting water-cluster O-O-O pπ-electrons and low-frequency vibrations are relevant to the properties of liquid water at ordinary atmospheric pressure and temperature, it is likely that they also play key roles at the high pressures and temperatures of supercritical water. In fact, it has been deduced from X-ray and neutron diffraction studies of supercritical water that its extraordinary physical and chemical properties are associated with increased O - O bonding at the expense of significantly decreased hydrogen bonding due to water molecule clustering.[32]

In conclusion, it is suggested from quantum chemistry and available experimental information that pentagonal dodecahedral water "buckyballs" may play active roles in a wide range of chemical, catalytic, biological, and astrophysical scenarios. Furthermore, the technological use of such water clusters to enhance combustion and significantly reduce pollutants in fossil fuels has recently been demonstrated.[12] The author is grateful to Dr. Bin Zhang for assistance in the water cluster computations.

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Solar-Energy Liberation from Water by Electric Arcs

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Abstract

This paper reports progress in an experimental investigation, started in the Hathaway laboratory in 1994, dealing with the liberation of intermolecular bond energy from ordinary water by means of an arc discharge. Photographic evidence of fog generation and explosion during the arcing period is included. A new fog accelerator is described and a table of results of the kinetic energies of fog jets is provided. A renewable water energy cycle is outlined. The fog kinetic energy has been found to be greater than the difference between the capacitor input energy and the heat losses. Given energy conservation, the only external energy input that can account for the fog kinetic energy is solar heat from the atmosphere.

Introduction

Friingel (1948) discovered the working principle of water arc launchers. The arc was established in a small cavity between a vertical rod electrode and a coaxial ring electrode by the discharge of a capacitor. The unusual strength of the explosions led to the development of a new technology known as electrohydraulic metal forming (Wilson 1964). It was clearly recognized from the start that water arcs were relatively cold and no steam was created. Measurements of arc explosion forces were started at MIT (Graneau and Graneau 1985) in 1985 and continued at Northeastern University (Azavedo et al. 1986). On one occasion (Graneau and Graneau 1996), a 3.6 g water mass, travelling at approximately 1000 ms^{-1} punched a half-inch diameter hole through a quarter-inch thick aluminum plate. Not until 1993 was it realized that the water arc liberated energy from a source other than the capacitor input energy. This led Hathaway Consulting Services to resume experimentation with water arcs. The present paper describes a series of experiments that forms part of this continuing research program.

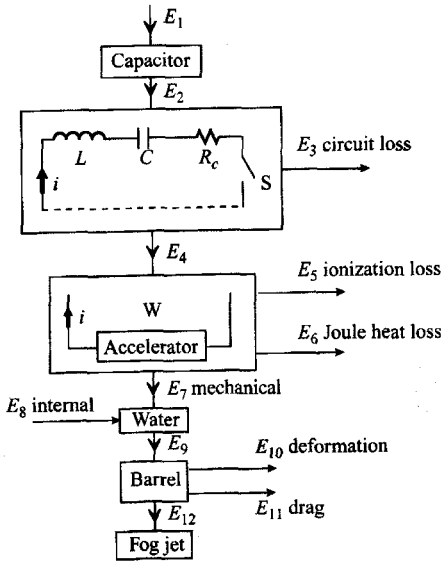

Figure 1. Energy flow diagram.

The principal discovery made in the past three years was that it is a collection of fog droplets in the water that explodes, and not the liquid water itself. The term "fog" stands for a multitude of tiny water droplets floating in air. Progress made in this research up to 1 October 1995 has been extensively reviewed in a recently published book (Graneau and Graneau 1996). Further information is contained in a paper presented at the 1996 World Renewable Energy Congress (Graneau 1996).

In the reviewed experiments (Graneau and Graneau 1996), the energy delivered to small quantities of water (up to 1.5 ml) was typically less than 50 J (E_2 in Figure 1). This could not have increased the water temperature by more than 10°C, which is in agreement with measurements. Steam explosions were out of the question, because no liquid breakdown mechanism is known that can channel a significant fraction of the current into a thin water filament. It has to be remembered that the ionization process absorbs energy and does not generate heat.

As shown in the energy flow diagram of Figure 1, the energy E_2 is discharged from the capacitor C into a simple series circuit comprising a switch S, the inductance L, the short-circuit resistance R_C, and the water-filled cavity or accelerator W. The discharge current i is of the form

$$i = I_0 e^{-t/T} \sin \omega t, \quad (1)$$

where I_0 is the intercept of the exponential envelope with the current axis. T is the damping time constant, $\omega = 2\pi f$, where f is the ringing frequency, and t stands for time. From the current oscillogram, we can determine T and the damping factor R given by standard circuit theory as

$$R = \frac{2L}{T}. \quad (2)$$

R has two components:

$$R = R_0 + \frac{e_b}{i_{rms}}. \quad (3)$$

R_0 is the Ohmic resistance of the discharge circuit and the water, and thus accounts for the total heat loss. The induced back-e.m.f. e_b in the water accounts for any mechanical work E_7 that has to be done on the water to generate cold fog. Unfortunately, we know of no way in which the components of (3) can be measured separately. Hence it is not possible to be precise about E_7.

E_7 must supply the surface-tension energy increase required by fog formation and, in addition, it may accelerate the droplets a small amount. This has to be achieved by either electrodynamic Lorentz or Ampere forces. The Lorentz pinch force can produce thrust in the direction of current flow. Northrup (1907) proved that the pinch thrust will be of the general electrodynamic form

$$F_z = \frac{\mu_0}{4\pi} \frac{1}{2} i^2. \quad (4)$$

This holds for all conductor diameters.

E_{12} is the kinetic energy of the fog jet as it leaves the accelerator. The impulse that this jet exerts on an absorbing balsa-wood secondary projective has been measured (Graneau and Graneau 1996), and is given by

$$P_{12} = \int F_{12}\,dt = mu_{av}, \quad (5)$$

where F_{12} is the force, m is the mass of the fog, and u_{av} is its average velocity. This should be compared with the mechanical impulse received by the fog droplets from the electrodynamic impulse P_7.

We may write

$$P_7 = \int F_7\,dt = \frac{\mu_0}{4\pi} k \int i^2\,dt, \quad (6)$$

where A: is a numerical constant. The value of the action integral $\int i^2 dt$ is available from the current oscillogram. To compare P_{12} with P_7, we express P_{12} as

$$P_{12} = \frac{\mu_0}{4\pi} k' \int i^2\,dt, \quad (7)$$

and, using (5),

$$k' = 10^7 \frac{mu_{av}}{\int i^2\,dt}. \quad (8)$$

The dimensionless factor k' is now an experimentally determined quantity.

When water arc explosion forces were measured over ten years ago (Azavedo et al. 1986), it was found that 1000 < k' < 7000. This fact has been confirmed in all subsequent experiments. It left little doubt that the water arc explosions contained additional energy Eg over and above E_7, which was likely to be energy stored in water.

When Ampere's force law is used in (6), the predicted k values increased from 0.5 (see (4)) to about 200 (Graneau and Graneau 1996). This is still far too small to deny the existence of internally stored water energy E_8, and gives an impulse ratio $P_{12}/P_7 = k'/k$ of the order of 50-100.

Provided that the impulses act on the same mass (fog), Newtonian mechanics then requires that

$$\frac{E_{12}}{E_7} = \left(\frac{P_{12}}{P_7}\right)^2. \quad (9)$$

This can be proved as follows. If a mass m is accelerated to the velocity v_a, it requires an impulse of

$$P_a = \int F_a\,dt = mv_a \quad (10)$$

Let the same mass acquire additional energy in flight to reach the velocity v_b; then the full impulse becomes

$$P_b = mv_b. \quad (11)$$

Therefore the impulse ratio is

$$\frac{P_b}{P_a} = \frac{v_b}{v_a}. \quad (12)$$

This makes the ratio of final to initial kinetic energy

$$\frac{E_b}{E_a} = \frac{\frac{1}{2}mv_b^2}{\frac{1}{2}mv_a^2} = \left(\frac{P_b}{P_a}\right)^2, \quad (13)$$

which proves (9).

For the impulse ratios of 50-100 of the water arc experiments (Graneau and Graneau 1996), this implies that E_{12} is at least 1000 times larger than E_7. We therefore claim that virtually all the kinetic energy of the fog jet leaving the water plasma accelerator is derived from the internal water energy contribution E_8.

Ionization of Water

A normal plasma consists of an ionized gas. Liquids break down under high electric stress without first forming a gas phase, because electron avalanches can propagate in liquids and readily ionize the molecules to form an arc plasma. Arcs in water have been investigated quite extensively. They form the basis of a technology known as electro-hydraulic metal forming (Wilson 1964).

Pure water is a good dielectric, and breakdown is difficult to achieve. Saltwater and tapwater are more easily ionized (Azavedo et al. 1986) because of an electrolytic conduction phase that wastes much of the energy supplied to the water without producing any ions. The experiments described in this paper were therefore performed with distilled water.

Ionization losses occur in the arc of the switch S of Figure 1 and in the water. A certain degree of ionization has to be established in both arcs before the discharge current can begin to flow. This causes a voltage drop on the capacitor terminals. The determination of this loss is discussed in Graneau and Graneau (1996). As a rule, it amounts to no more than approximately 10% of the input energy E_2 Further ionization losses will accumulate during current flow. In electrical circuit measurements they are indistinguishable from Joule and other current-damping losses. However, it is important to remember that ionization stores electrostatic energy and does not contribute to plasma heating. The stored energy is later regained as heat when the ions recombine. Figure 2 is an oscillogram of the discharge current and the voltage across the accelerator terminals. In this case the capacitor was charged to 11 kV. Before breakdown, but after the closure of the switch S, the full capacitor voltage is applied across the water insulation. When this breaks down, the voltage falls sharply because of the voltage drop across the external circuit portion. Part of this drop is likelv to be due to the initial ionization.

Fog Evidence

Figure 3 is a series of photographs showing the emergence of fog from a water arc accelerator barrel (Graneau and Graneau 1996). In this shot the energy in the capacitor was 40 J. For comparison, a match liberates about 200 J of heat. The camera was operated at 10,000 frames/s. Hence the time interval between exposures was 100 us, of which the shutter was open for the first 20 us. The high-

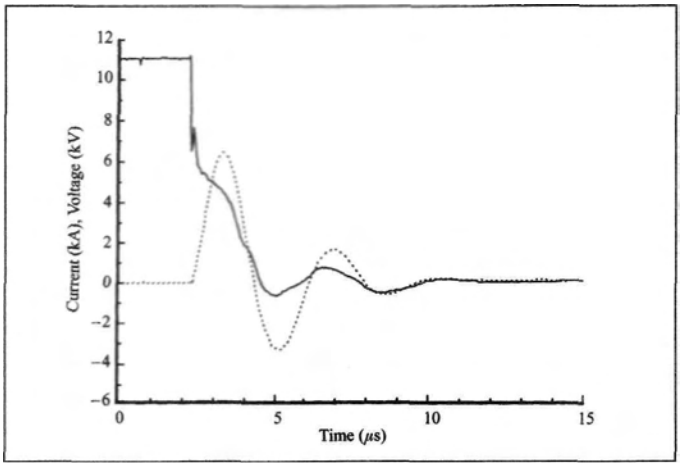

Figure 2. Current (……) and voltage (-----) oscillograms of a water arc.

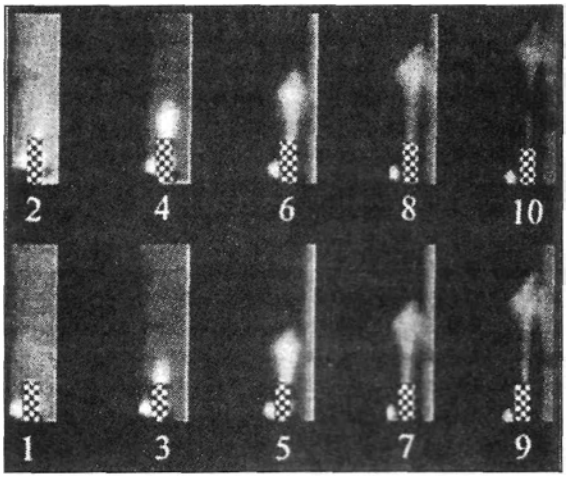

Figure 3. High-speed photographs of the development of the fog plume (10,000 frames/s).

speed photography was performed at Oxford University.

Water vapor and steam are invisible in air. Relatively large drops of water and films are transparent. They show up on photographs only as thin lines of light, which represent reflections from the water surfaces. The uniform whitish-grav appearance of fog and clouds is due to light scattering by a high density of very small droplets. Hence the photograph in Figure 3 provides conclusive proof that fog emerged from the accelerator barrel. As the heat evolved in these experiments is insignificant and the electrodynamic forces are too weak, the only way in which the fog explosion can be explained is by the sudden mutual repulsion of fog droplets.

A more dramatic fog explosion is shown by the two video frames of Figure 4. They relate to a capacitor discharge of 324 J of energy with a 1/4-inch thick plywood square initially resting on the accelerator muzzle. The fast fog is seen to penetrate the plywood and still pierce the atmosphere at supersonic speed, as indicated by the conical tip of the jet more than one meter above the muzzle. The second frame of Figure 4 shows the hole punched through the plywood board as the latter lifts off the accelerator.

The mechanism of condensation of water vapor in air is the most prolific fog producer on Earth. It is a slow process, and cannot generate an equivalent quantity of fog to that in the few microseconds of a water arc explosion. In the early formative stage of the arc, the fog density must approach that of liquid water, and is therefore up to 300,000 times as great as the fog density of clouds in the atmosphere, which is 3 g m~^{3}.

It is difficult to think of any other way of creating the dense fog than by mechanically tearing the liquid apart into tiny fragments. These fragments are the fog droplets, probably ranging in size from 1 to 100 um in diameter, as deduced from the fact that they float in air. For want of any other force known to be present in the explosion, the tearing force has to be of electrodynamic origin. The directions of the Lorentz forces are not such that they could split water into fog droplets. However, Ampere tension (Graneau and Graneau 1996) is well-qualified to accomplish this task.

The best-known consequence of Ampere tension in metallic conductors is the phenomenon of wire fragmentation. In liquids and plasmas it leads to plasma bead formation, which has been observed in plasma focus fusion and other filament fusion processes. All these facets of the action of Ampere tension are fully described in Graneau and Graneau (1996).

In any case, the existence of the surface tension of water actually requires the presence of tearing forces. The surface tension gamma of water at 20°C is 72.75 dyn cm^{-1}. It turns out that surface tension energy per unit area has the same dimension as surface tension per unit edge, and is numerically equal to it, so that

$$\gamma = 72.75 \text{ dyn cm}^{-1} = 72.75 \text{ erg cm}^{-2} = 72.75 \times 10^{-7} \text{ J cm}^{-2}. \quad (14)$$

It is known that the surface energy changes with the age of the surface. As a result, for the first 10 ms after fog formation, the surfaces are likely to store more energy than indicated by (14). The fog mass generated in our experiments was typically 0.2-0.5 g. Let us thus calculate the additional surface energy required to convert 1 g (1 cm^{3}) of water into fog. If the droplets are all of the same diameter A, measured in cm, then the number n of droplets generated will be

$$n = \frac{6}{\pi d^3}. \quad (15)$$

Fog droplets are said to be between 10^{-4} and 10^{-3} cm in diameter. Hence the number of droplets lies in the range from 1.9 x 10^{6} to 1.9 x 10^{12} per gram of bulk water. The total new surface energy for drops of the same size is

$$E_s = \gamma n \pi d^2. \quad (16)$$

For the two extreme droplet diameters of 10^{-2} cm and 10^{-4} cm, this comes to 4.37 mJ and 437 mJ respectively. Hence the part of E_7 in the energy flow diagram of Figure 1 that must supply surface-tension energy is only a fraction of one joule. Ampere tension forces can comfortably meet this energy demand according to (6) with k = 200 (see the discussion in Section 1).

Type B Accelerator Results

Some of the various water accelerator designs that have been used since 1983 are described in Graneau and Graneau (1996). A design that has been called the type B accelerator is shown in Figure 5. To determine the fog-jet momentum, a secondary projectile consisting of balsa wood stands on the accelerator barrel. The balsa wood is given mechanical strength by steel washers at the top and bottom, held tightly by screws outside the wood. The dry mass of the projectile is denoted by M, and was usually around 64 g, while the mass of the fog absorbed in the wood

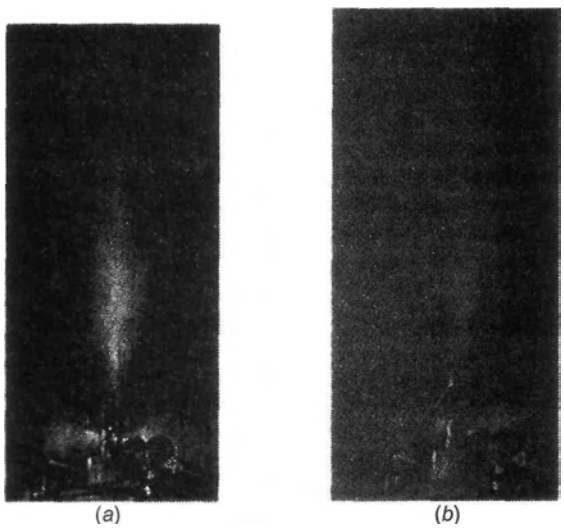

Figure 4. Two video frames from a BBC TV program in which Richard Hull of the TCBOR laboratory, (Richmond, Virginia) demonstrated water arc explosions: (a) supersonic fog jet penetrates plywood sheet; (b) hole punched through sheet by fog jet. (Editor's Note: We apologize for the poor photo quality; we were unable to get original photos to use.)

is denoted by m. A capacitor, C = 9.565 uF, is charged to the voltage V_0 and then discharged through the accelerator by closing the switch S. An oscilloscope records the discharge current i(t) as in Figure 2.

The throw height h of the secondary projectile is measured with a freeze-frame video camera. This defines the initial velocity of the projectile as

$$v_0 = (2gh)^{1/2}, \quad (17)$$

where g is the acceleration due to gravity. Because of momentum conservation, the average velocity u_{av} of the fog mass that penetrated deep into the balsa wood is given by

$$u_{av} = \frac{(M+m)\,v_0}{m}. \quad (18)$$

In some shots, not all of the capacitor energy is discharged, leaving a residual voltage V_r on the capacitor terminals. Hence the net energy actually discharged into the circuit is

$$E_2 = \tfrac{1}{2}C(V_0^2 - V_r^2). \quad (19)$$

The kinetic energy of the fog jet is

$$E_{12} = \tfrac{1}{2}mu_{rms}^2. \quad (20)$$

Neither the mass distribution of the fog droplets nor their velocity distribution are known. However, as on previous occasions, the simplifying assumption is made that the droplets are of equal size and their velocity distribution is half a cycle of a sine wave. This results in

$$u_{rms} = 1.11\,u_{av}. \quad (21)$$

Table 1 lists the results of 14 shots. In all cases the initial water charge was 1.5 ml of distilled water at room temperature.

Discussion of Results

The kinetic energies of the fog jets, E_{12} , have been derived from the dry and wet weights of the balsa wood secondary projectile, M and M + m, the throw height h and (17)-(21). Table 1 shows these energies to vary between 13.0 and 29.2 J. Take shot SP24 with the largest kinetic-energy output. For this shot, the fog mass m = 0.504 g and its average velocity came to u_{av} = 306.4 ms^{-1}. This resulted in an impulse exerted on the secondary projectile of $P_{12} = mu_{av}$ = 0.154 Ns. The action integral of this shot was $\int i^2 dt$ = 157 A^2 s. With the Ampere force factor, k < 200, (6) gives $P_7 < 3.14 \times 10^{-3}$ N s. The impulse and energy ratios are therefore $P_{12}/P_7 >= 49.0$ and $E_{12}/E_7 >= 2401$. Hence E_7 <= 12.1 mJ, which is negligible compared with E_{12} = 29.2 J and demonstrates that virtually all of the kinetic energy developed, by the explosion must be internal water energy. Note that the calculated value of E_7 is in line with the estimated surface-energy increase required for the formation of a large number of fog droplets, as discussed at the end of Section 3.

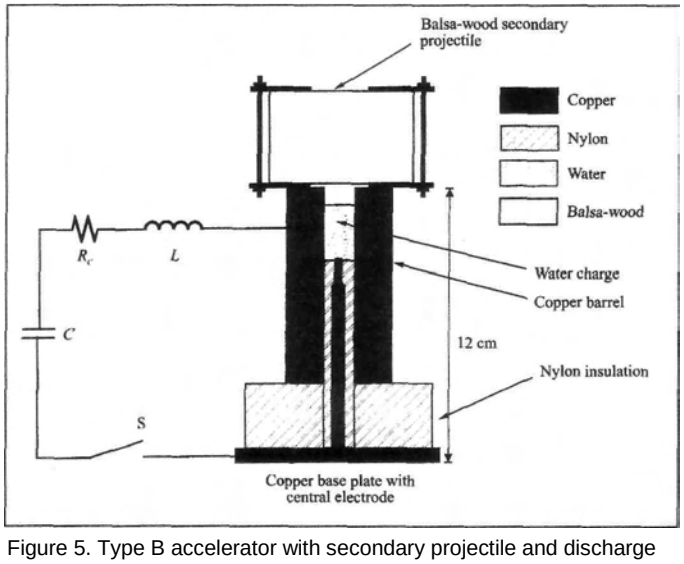

Figure 5. Type B accelerator with secondary projectile and discharge circuit.

In spite of the gain in internal water energy, the overall ratio E_{12}/E_2 is less than unity because of the five loss components indicated on Figure 1. A circuit loss $E_3 + E_5 + E_6$ estimate was made with the current oscillogram of shot SP24. This indicated a ringing frequency of 384 kHz, which, together with the capacitance C = 0.565 uF, gave a self-inductance L = 0.3 uH. The decay time constant T = 3.5 us and the action integral came to $\int i^2 dt$ = 157 A^2 s. From (2), the damping resistance was found to be R = 173 mΩ. This resulted in a total damping loss of R $\int i^2 dt$= 27.2 J. To this should be added at least 10% of E_2 = 39.8 J to account for the initial ionization loss, to arrive at the circuit-loss figure of around 31 J for the 12 kV shots in Table 1. By adding the approximate circuit loss to the fog kinetic energy E_{12}, it is found that the sum is greater than the input energy. This can be expressed as

$$E_{12} + (E_3 + E_5 + E_6) > E_2, \quad (22)$$

proving once more the involvement of internal water energy. This argument ignores further significant energy losses such as E_{10} and E_{11} of Figure 1. It is not out of the question that E_{11} is as large as E_{12}.

In order to utilize the internal water energy for electricity generation, large reductions in circuit loss and barrel losses have to be achieved. Our objective has been to prove the liberation of internal water energy. We have made no effort to optimize the process.

Renewable Water Energy Cycle

Figure 6 is a block diagram showing the circulation of water molecules through the fog accelerator, whence they dispersed into the atmosphere and condensed to raindrops in clouds. The high-voltage capacitor energy E_C is known accurately. The low-grade heat losses E_h, and the fog kinetic energy E_k. have been measured with adequate precision. From the measurements, we know that

$$E_k \gg E_C - E_h. \quad (23)$$

Hence internal water energy must be contributing to the fog explosions. Other than the capacitor energy, the only external energy supplied to the experiment is solar heating of the fog and atmospheric water vapor. Accepting that energy has to be conserved, this proves that the fog explosions are, indirectly,

Table 1. Results of reported water arc experiments.

Shot no.	V_0 (kV)	E_2 (J)	$E_3+E_5+E_6$ (J)	u_{av} (m s^{-1})	E_{12} (J)
SP12	10	28.3	20.5	258	21.0
SP13	9	22.9	17.5	273	21.5
SP14	12	40.7	31.2	235	221.5
SP15	12	40.7	31.2	244	17.8
SP16	12	40.7	32.2	229	20.9
SP17	10	28.3	22.2	172	13.0
SP18	10	28.3	22.2	258	21.8
SP19	10	28.3	22.2	274	23.1
SP20	10	28.3	22.2	218	17.8
SP21	10	28.3	22.2	191	16.1
SP22	10	28.3	22.2	251	19.7
SP23	12	39.8	31.2	243	22.3
SP24	12	39.8	31.2	306	29.2
SP25	12	39.8	31.2	275	28.5

driven by solar energy. The process is renewable, and does not pollute the atmosphere or contribute to global warming.

Owing to thermal agitation, the molecular structure of the water is continuously fluctuating. This structure, that is the mutual arrangement of the H_2O dipoles, is the subject of intense research elsewhere. All we can do with respect to the H_2O-H_2O bonding is to speculate what the relevant energy processes may be.

In our present state of knowledge, the most likely explanation of the fog explosions is that they are caused by the liberation of intermolecular bonding energy when the bulk water is transformed into tiny fog droplets. This bonding is caused both by hydrogen bonds and the weaker van der Waals forces, and the energy stored by the bonds (which means the energy that must be supplied to break them) is roughly equal to the latent heat of water, and is found to be 2.3 kJ g^{-1} at 20°C.

The creation of a large number of droplets is thought to be caused by the mechanical effects of the elecrrodynamic forces in the arc discharge. A lack of significant temperature change rules out a thermal mechanism for droplet creation. A certain amount of mechanical energy is thus used to create the droplets, and is consequently stored as surface tension energy. However, the molecules in the small droplets now have significantly fewer neighbors than in the bulk water, and can orientate themselves more easily into lower-energy states. These lower energies imply that the bonds become stronger, thus requiring more energy to break them. This bond-redistribution behavior is normally observed in thin films of water, and is called vicinal water (Adamson 1990). Recent results of inelastic incoherent neutron scattering (IINS) experiments in water and ice (Li and Ross 1993; Li 1996) have revealed that in ice there are two molecular optic peaks in the IINS spectrum at 28 and 37 meV (24 and 32 meV for liquid water). The two peaks can be explained by a model involving two types of hydrogen bond (Li and Ross 1993), and they are referred to as the weak and strong bonds respectively. If in the newly formed droplets some of the weak bonds drop to the strong bond energy in a quantum shift, there will be a consequent release of kinetic energy causing the explosion of the vicinal water droplets. The same is true if either a weak or strong bond is formed between two molecules that were previously only held together by van der Waals forces. If enough of these bonds change energy level then more kinetic energy could be released than the mechanical energy used to create the droplets in the first place, thus liberating a net amount of energy from the original bulk water. In order to restore the droplets to their normal water state, some energy input is required; in our case this must come from atmospheric heat, and this process can occur away from the explosion region and over a much longer time. Therefore the explosion is conjectured to be a sudden release of energy from the water that was originally stored by atmospheric heat and is later restored to the water after the explosion also by atmospheric heat, while in the meantime the net gain in kinetic energy can be harnessed for useful means.

The following argument should clarify how atmospheric heat is stored in the bulk water. When molecules condense into a droplet, the system is heated by the kinetic energy produced by the decrease in potential energy from (a) the molecule and droplet infinitely far apart and (b) in the bonded position, and represents the quantity of energy normally referred to as latent heat. This process represents the creation of atmospheric heat as a result of collisions of the incoming molecule (attracted by the droplet) with other vapor molecules. If the molecule arrives at the droplet with a non-zero kinetic energy, this will heat the droplet additionally. Similarly, when two molecules inside the droplet form a hydrogen bond or change from a weak to a strong bond, the drop in potential energy must also create an increase in kinetic energy. These shifts represent the liberation of energy stored in the water that must have been there to allow weak bonds and unbonded molecules to exist. It is thus conjectured that the original source of this stored energy is heat supplied from the atmosphere, and this makes it possible to effectively tap the solar energy that is stored in normal bulk water.

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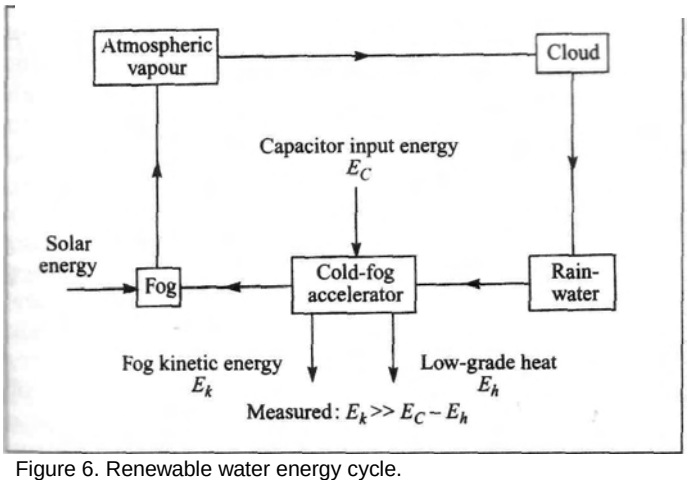

Figure 6. Renewable water energy cycle.

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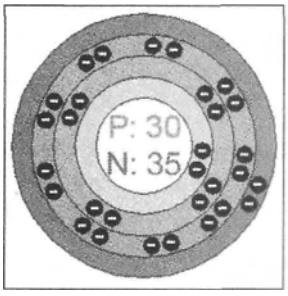
The Journal of Plasma Physics published another paper by Peter Graneau, Neal Graneau, George Hathaway, and Richard Hull, titled "Arc-Liberated Chemical Energy Exceeds Electrical Input Energy," in Volume 63, 2000. We have permission to reprint it in 2001.

ZINC: PRECIOUS METAL?

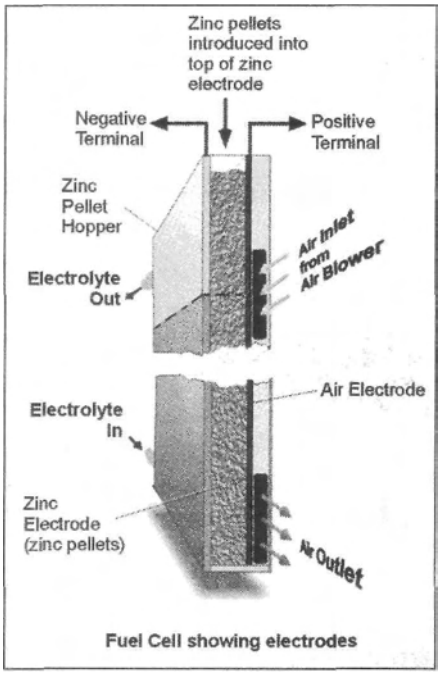
Bennett Daviss

Some tout zinc as the energy reserve of the future. It is one of the planet's most abundant elements; an estimated 224 quadrillion tons lie buried, much of it ready for cheap extraction. It yields energy without producing noxious wastes. Better yet, after it surrenders its considerable energy it can be recharged to deliver the same amounts of power all over again, virtually without end.



Suddenly, zinc seems like something more than just a base metal. Two U.S. companies have thought so for years. By 2003, EVonyx, in the New York town of Elmsford, and Metallic Power, Inc., in Carlsbad, California, will introduce self-contained, clean-firing fuel cells that harness electrons loosed from zinc as electric current.

It is possible for two reasons. First, zinc is among the metals that will surrender its electrons with relative ease in an aqueous solution. Second, its reaction to water is poised between enthusiasm and restraint. Some metals, such as sodium, shed electrons so readily that they seem to erupt in a glass of tap water. Others, like tin, hold their electrons much tighter even under considerably more chemical or physical force. In contrast, metals such as zinc and aluminum need just the right amount of coaxing: the water must be mixed with an electrolyte—a substance that supplies ions to foster chemical reactions and spark an electric current—to prod zinc to react. By controlling the concentration of the electrolyte in the water, it is possible to control the reaction and, therefore, the amount and rate of energy produced.



Fuel Cell showing electrodes

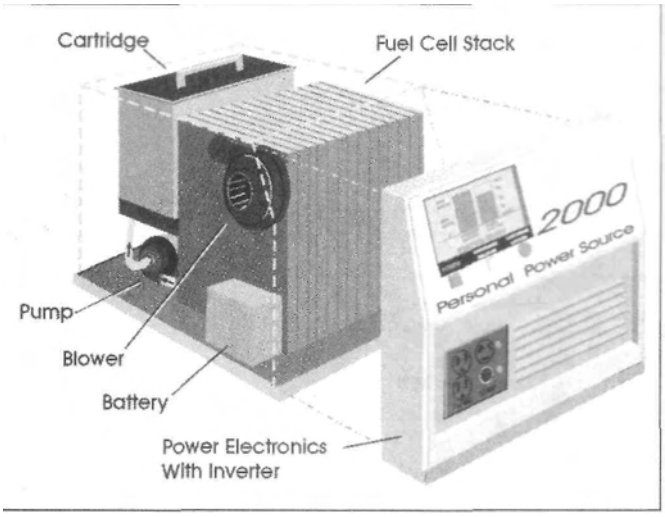
The resulting chemical reaction is a simple one. In Metallic Power's device, a bed of zinc granules, each a few millimeters across, is washed with an electrolyte of half potassium hydroxide and half water. As the zinc combines with oxygen, each zinc atom gives up two electrons which are drawn off as electric current.

The electrolyte is pumped continuously throughout the cell and washes the spent zinc from the reaction chamber. As the slurry moves out of the chamber, pure zinc oxide precipitates out. The leftovers—consisting of water, hydroxyl ions, and potassium—are reabsorbed into the electrolyte for re-use.

Reconstituting zinc from zinc oxide is even simpler. In a separate chamber, the Metallic Power system runs an electric current through the zinc oxide. By putting electrons back into the mix, the process reverses the reaction: the zinc oxide gives up its oxygen, leaving pure zinc behind.

The company was formed in 1995 by Jeffrey Colburn, who holds a doctorate in electrical engineering from MIT, and New Zealander Stuart Smedley a world-regarded expert in the electrochemistry of metals. The privately-owned firm raised $8.5 million in venture capital and expects to debut its first commercial fuel cell in 2002. The box, about the size of a microwave oven weighing around 100 lbs., will deliver as much as 4kW of electricity. The amount of energy can be increased by adding individual cells to a stack, like adding individual cells to make a more powerful lead-acid battery.

Figures courtesy of: www.reveo.com



"We're targeting users of 1 kW or more at first," says Margaret Deardorf, Power's marketing director. "Our unit will be useful for campsites, to run tools at construc-

tion job sites, and as emergency back-up power for homes and offices." The company also senses keen interest in the trucking business. Drivers now have to leave trucks' engines running to supply lights and heat or air conditioning for hours each day as they relax or sleep in their cab quarters. "Given the price of diesel fuel, we expect to find some ready acceptance there," Deardorf says.

That will be only the company's debut on the open road. "The vehicle market is potentially the strongest for us but also the toughest," Deardorf explains. "The combustion engine has been around for more than 100 years. Its cost is about as low as it can get and an entire economic and physical infrastructure has been built to support it."

EVonyx is deploying a broader portfolio of technologies as well as a bolder vision. "The twentieth century's economy was based on fossil fuels," says company founder Sadig Faris. "Our mission is a twenty-first century economy based on energy from solid metals." To pursue the mission, Faris—a former electrical engineer with IBM—founded EVonyx as a subsidiary of Reveo, Inc., his contract research firm, to commercialize his inventions.

Faris and his technical team also liberate electrons from zinc using potassium hydroxide as an electrolyte. But, rather than using loose zinc particles as raw fuel, they apply the metal as a powder to credit-card-like wafers and to rolls of plastic sheeting that look like the spools in audio cassettes or camera film. Each of these zinc delivery mechanisms then is enclosed in a tiny chamber and immersed in electrolyte.

Faris' most startling achievement has been to devise a solid-state electrolyte. The breakthrough eliminates liquid from the metal-powered cells, sharply reducing complexity, the number of parts and processes involved, and cost.

In devices using the solid-state catalyst, the zinc-coated "PowerCard" is slipped into a slot the way a floppy disk is inserted into a computer. A spring-loaded mechanism then presses the solid electrolyte into contact with the card.

Faris compares the mechanism to a sandwich. The filling is the zinc-covered card. The surfaces of the bread next to the filling are coated with the solid-state electrolyte. The "bread" is a porous material that lets air through to contact the electrolyte and initiate the flow of electrons. In the spooled version, the zinc-covered tape rolls past a fixed surface covered with the solid electrolyte just as an audiocassette rolls past a read head. Both the card and tape can be recharged in about two hours in simple devices similar to battery rechargers.

Although he won't disclose its chemical components, Faris notes that the solid-state electrolyte "contains no precious metals and so will be very low in cost."

Regardless of the type of electrolyte, he notes, zinc-powered fuel cells can be scaled "from milliwatts to megawatts. This technology can power flashlights, lawnmowers, cars, trains, planes, power plants, paper mills. We will see an automobile running on [the energy from] solid metal well before the year 2010." To hasten that day, EVonyx is in discussions with partners in the U.S. and Asia, including electric utilities and consumer electronics companies. In March a subsidiary of Niagara Mohawk Holdings, parent company of Niagara Mohawk Power Corporation in New York state, paid $42.75 million to buy 16% of EVonyx.

Says Faris: "This technology has the capacity to be to our age what the steam engine was in its day."

Bennett Daviss contributes to several national and international magazines including Discover, New Scientist, and Air & Space.

Energy Focus Should Fall on Russia

Money spent improving energy efficiency in the U.S., Europe, and Japan might save more energy if it were redirected toward Russia and the Third World instead, because they waste so much energy. This would cut pollution and lower the price of energy for everyone.

An AP report in the Boston Globe on April 26 says Greenpeace estimates the oil and gas that Russia loses each year in leaks and spills could provide enough energy to allow the country to close its nuclear power plants. Between 70 million and 140 million barrels of oil are spilled annually in Russia, out of the approximately 2.1 billion barrels the nation produces, the group says. Russian Nuclear Power Ministry spokesman Vladislav Petrov was skeptical about the Greenpeace proposal. "It's a bit like saying, 'Let's take the whole humankind and transport it to a new, wonderful planet,'" he said. "The idea is nice, but can it be realized?" He does not understand capitalism. It can be realized simply, at no cost to anyone, by hiring U.S. corporations which specialize in pipeline refurbishing and oil well maintenance. Russia is broke and cannot pay in cash, but it can pay with a share of the oil and gas the companies conserve by repairing equipment. These companies would be well-positioned to arrange shipment of the oil to nearby European and Asian markets if they could not sell it in Russia at a profit. Everyone would come out ahead.

American observers in Russia saw this sort of thing during World War II and throughout the Communist era. Tons of coal used to spill out of holes in the coal train cars, scattered along thousands of miles of track in the uninhabited Siberian wilderness. No one would take responsibility for fixing the holes. Potatoes and other crops would lie in the fields to rot, even in places where there was plenty of manpower to gather them. —Jed Rothwell

View from the Green Isle

Several interesting sites are revealed by a simple search for "renewable energy" on the www.

The Greening Earth Society, who believe that CO_2 is beneficial to humankind and all of nature attempt to show on their site [www.greeningearthsociety.org] that there is a huge conspiracy to convince us that the greenhouse effect is a reality when, in fact, it is "the federal establishment distorting the science of climate change in an effort to validate the vision of apocalyptic global warming set forth in Vice President Al Gore's released Earth in the Balance."

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Renewableenergy.com is a very comprehensive site for checking out the latest developments in wind, wave, and solar energy.

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The Daily Telegraph reports that fifty nuclear power stations will be needed by 2050 to provide the UK with the same energy it uses today without adding to global warming. It also declares that the UK is the world's worst at recycling and utilizing sustainable energy resources.

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The German government has agreed to phase out nuclear power in twenty years.

Johnson-Matthey has formed an alliance with Texas Utilities to build a new fuel cell energy system to power homes and offices.

For up to the minute information on who's merging with whom in the energy business, and the technologies involved, a UK site [ukbusinesspark.co.uk] just about covers the lot. —Soo Seddon

Volkswagen in Midst of Record-Setting Drive Around the World

WASHINGTON, VW Press Release, June 30—A Volkswagen Lupo 3 Liter TDI passenger car—the best mileage production car in the world—and its professional endurance driver have reached Washington, D.C. on their way to establishing a new record for the most fuel-efficient trip around the world.

Representing one of the most unique endurance tests ever, the Volkswagen Lupo's "Around the World in 80 Days" tour began on May 16, 2000 in Berlin, Germany. From there, the Lupo has been driven through parts of South Africa, Asia, and Australia.

Its trek is scheduled to end after eighty days on August 3 back in Germany at Volkswagen's headquarters in Wolfsburg.
As of this morning, the car is averaging a phenomenal 97.1 mpg. It has traveled 12,153 miles, more than half-way around the globe. The North America stage of the Lupo's journey began earlier this month in San Francisco and continued via Los Angeles and Mexico City, Laredo, Dallas, Tulsa, Memphis, Atlanta, Gainesville, Miami, and Jacksonville. After a stop in Washington, the Lupo visits New York and will then be air-lifted back to Europe to restart its road trip in London, setting its sights on North Africa, Spain, France, North Europe, and finally Germany. All told, the Lupo's planned expedition will traverse the globe over 20,712 road miles in eighty days—an idea based on the celebrated book by Jules Verne (1828-1905), Around the World in 80 Days. Remarkably, the planned fuel consumption for this extreme test is just 264 gallons, or an average of 78.7 miles per gallon.

If successful, it will set a record for the least fuel used for a car traveling around the globe.

Relatively unknown to the U.S., the Lupo 3L TDI made history last year in Europe when it was introduced, becoming the first production car to meet the longstanding environmental challenge of being able to travel 100 kilometers (62 miles) on just 3 liters (0.79 gallons) of fuel.

A practical four-seater, the Lupo 3L TDI uses a revolutionary high-tech Turbo Direct Injection diesel engine that is the world's most efficient combustion engine in production today. As the name implies, this technically advanced 3-cylinder engine uses direct fuel injection, whereby a precise mist of fuel is injected into the engine's cylinders via electronically controlled pump-injector units. From its displacement of just 1.2 liters, this ultra efficient powerplant is able to produce 61 horsepower and just as importantly 103.25 lb./ft. of torque at just 1,800 revolutions per minute. The Lupo 3 Liter TDI's engine also uses a turbocharger with variable blade geometry, a charge-air intercooler, and various friction-reducing designs that have increased the efficiency of this engine to more than 40%—an unsurpassed value worldwide for a passenger car.

Adding to this remarkable fuel performance is the Lupo's automated direct-shift gearbox with a stop-and-start function. This transmission offers the convenience of automatic shifting or clutch-free manual gear changes. In the Economy mode, the engine automatically switches off when the car comes to a standstill with the brakes applied and then instantly restarts when the accelerator is depressed. Additionally, the clutch is disengaged when the accelerator pedal is lifted, so that the Lupo coasts at engine idle speeds, thus saving even more fuel.

Yet another factor that enables such amazing performance is the weight savings of the vehicle. The doors, flaps, and wheel-arch panels of this Lupo are made of aluminum and components of the suspension and axle assemblies are also composed of lightweight materials.

Advanced aerodynamics that result in a drag coefficient of just 0.29 and low-friction tires with silica in the rubber mix cut rolling friction and make an additional fuel-saving contribution.

Renewables in the News

BP Amoco Buys Into Clean Energy

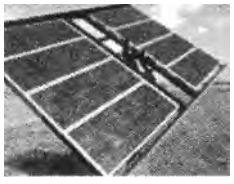
In May, BP Amoco purchased 18.5% of the shares in GreenMountain.com, the leading supplier of clean energy in the United States. GreenMountain formed in 1997 and serves over 100,000 households in three states; rapid expansion into the energy market is expected as full energy deregulation continues. (See IE, No. 32, p. 42 for full story about GreenMountain.) BP Amoco also plans to market and promote GreenMountain's solar energy offerings under the auspices of its division, BP Solarex.

DOE to Fund Wind Power Initiative

At the American Wind Energy Association's annual conference, held from April 30 to May 4 in Palm Springs, California, the Department of Energy (DOE) announced that it will provide $2.7 million in grants to help expand the use of wind power in the United States. The DOE just last year began a "Wind Powering America" program; their goal is to have 5000 MW of wind power capacity in place by the year 2005. This is the first grant issued under this program, and it is intended mainly for helping to provide technical information to lawmakers.

Solar Energy Powers South African Schools

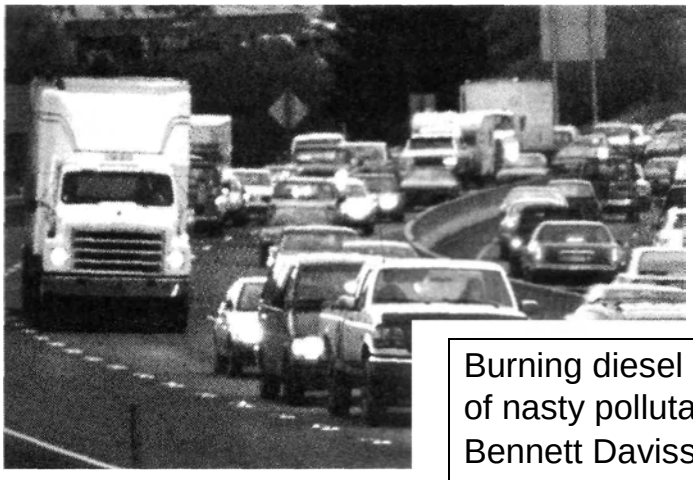
Photovoltaic systems provided by Isofoton, of Spain, and funded by the European Union, have been installed in 1000 rural schools throughout South Africa. These schools have never been served by grid electricity, so this new power source will enable the schools to hold evening classes which will allow for an expanded educational system and for use of modern educational media tools, including much audio-visual equipment also installed as part of the program. Each school's power potential will be 880 Wp.

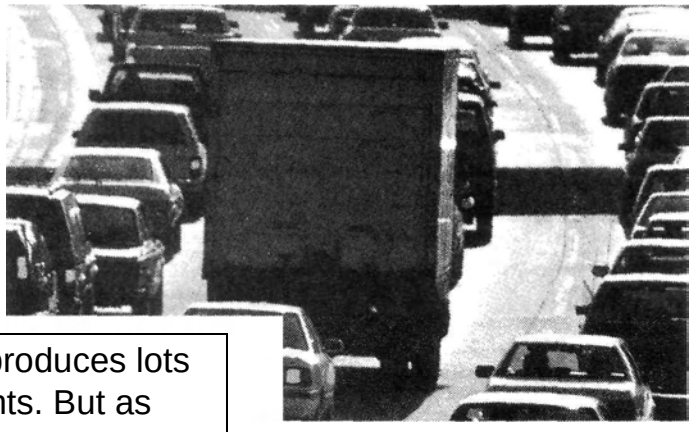


Wood Residue Electricity

Boralex, an independent power producer in the Abitibi region of Quebec, Canada, will invest over $50 million to build a 75,000 m^2 facility which will generate 32 MW of renewable energy power from wood residue. The station will burn tree bark and branches supplied by local saw mills, with an anticipated annual consumption of 400,000 tons of wood residue. Currently, wood residue is incinerated under strict combustion standards or buried at a high cost. The electricity generated by Boralex will be sold to Hydro-Quebec. Construction is expected to be completed by November 2000 and the plant operational by June 2001.

—Christy Frazier





Burning diesel produces lots of nasty pollutants. But as Bennett Daviss reveals, there's a surprisingly simple way to turn it into a clean, green fuel.

Just add water

Reprinted with permission of New Scientist (www.newscientist.com), from the March 13,1999 edition.

If you believe that oil and water don't mix, it's time to meet Keith Johnson. Recently retired as a professor of materials physics at MIT, Johnson has succeeded where many have failed—by combining diesel fuel with tap water to form a mixture that cuts pollution, maintains engine efficiency and works in existing engines.

His fuel is as simple to make as instant coffee, yet it is stable for years. If he can make it cheaply enough, it could improve the lives of millions of people who live in cities packed with old, diesel-powered buses and cars. Their clapped-out engines belch soot and nitrogen oxides (NO_x) that damage the environment and cause lung disease. Clean up vehicle exhausts, and these cities should become cleaner and healthier places to live.

The reason that his fuel is so stable and green, says Johnson, is that he has found a family of detergent-like surfactants that chemically bond molecules of water to molecules of the diesel, nudging the water molecules into stable 20-molecule clusters resembling "buckyballs." Johnson calculates that these clusters pulsate with vibrations, an effect that endows them with remarkable chemical properties. He has licensed his discovery to Quantum Energy Technologies (QET), based in Cambridge, Massachusetts, which plans to make and market his watery fuel worldwide.

Johnson's find is the culmination of research that started early this century when car drivers noticed that adding a splash of water to their fuel often boosted engine power. During the Second World War, researchers worked without success to improve fuel performance and stretch supplies by doping petrol with water. And in 1994, American physicist Rudolph Gunnerman made headlines by claiming that his cream-colored blend of water, naphtha, and petrol cut pollution and boosted fuel efficiency by more than 40 percent. But Gunnerman's fuel has yet to reach the market.

That honor has gone to the French oil company Elf Aquitaine, which has begun to market "Aquazole," a milky-looking blend of diesel fuel, surfactants and about 13 percent water. After two years of tests, Elf claims that Aquazole halves the amount of exhaust particulates and cuts NO_x emissions by about 15 percent.

Both Gunnerman's fuel and Aquazole are emulsions in which the water is dispersed in the fuel as small droplets. Water molecules are polar, possessing a tiny electrical charge that leaves them ready to bond with other charged molecules but unwilling to link to electrically neutral ones like those in petrol or diesel fuel. To overcome this repulsion, chemists use surfactants with polar groups at one end and non-polar groups at the other. These behave like molecular peacekeepers, stabilizing the mixture by locking the water inside small surfactant bags called micelles.

The micelles in these fuels are micrometres across, so large that they scatter light and the two fuels appear white. The size of the micelles also makes them unstable. With time, the non-polar and polar components separate into distinct layers and the mixture becomes useless. This, says Johnson, is a huge problem for anyone attempting to manufacture fuels in this way: "Emulsions of water and fuel have a history of separating over time."

According to Frederic Barnaud, who leads the Aquazole project team, Elf's fuel is stable for at least three months, "but it should last for over six months," he says. However, diesel fuel is sometimes stored for long periods before use and a short shelf-life could be a big problem. The more stable the fuel, the better chance it has of becoming a commercial success. And this is where Johnson's mixture scores.

He has succeeded in creating a "microemulsion" in which the water is dispersed in droplets just nanometres across. These are too small to scatter light so the mixture is clear. Unlike the larger droplets in Aquazole, the surface tension in Johnson's tiny water clusters makes them stable for long periods. "A microemulsion is a thermodynamically stable system," agrees Philip Schulz, a chemist involved in the development of Aquazole at Elf. The water molecules in Johnson's clusters are also attached directly to molecules in the diesel fuel via covalent bonds formed with the surfactant. These bonds further stabilize the mix. Johnson's tests seem to confirm this: samples of his fuel have remained stable for up to three years, he says.

Tom Kearns, professor of diesel technology at Massasoit Community College in Massachusetts, backs Johnson's claim. Kearns began testing Johnson's fuel more than a year ago. "When I first heard about it, I thought it was ridiculous. I laughed," Kearns admits. "But we have some of the fuel that's been sitting on a shelf for a year and it hasn't separated."

Best of all, producing this microemulsion doesn't require any fancy processing—just mix the ingredients and stir, says Johnson. He refuses to reveal exactly which surfactants he uses, but claims that part of the secret to making nanometresized drops lies in the way the water molecules arrange themselves.

Tiny clusters

Researchers such as Richard Saykally at the University of California, Berkeley, and David Clary at University College London have shown that water gathers spontaneously into various structures, such as a ring of five molecules held together

with hydrogen bonds ("Wacky water," New Scientist, 21 June 1997, p. 40). These rings join in a variety of shapes and Johnson says that one of the most common is a 12-sided structure using just 20 water molecules—a pentagonal dodecahedron.

In nature, these clusters exist only for a split second before they grow larger or are destroyed by the jostling molecules around them. But Johnson has hit upon a family of surfactants that gather round the 12-sided clusters and stabilize them. "In essence," he says, "we're nanostructuring water."

In Johnson's estimation, these 12-sided water clusters have some remarkable properties. First, electrons in the oxygen atom of each water molecule interact with the electrons on nearby oxygen atoms. Together, they form what chemists call "delocalised pi orbitals," which stick out from the surface of the cluster like bristles from a brush. This arrangement increases the reactivity of the cluster since the electrons can bond with nearby molecules. Here again, Johnson's secret surfactants have an important role to play. They are rich in oxygen and donate electrons to the water clusters, making them more reactive. 'The electron is not very strongly bound into the system, so if s easier to share it to form a bond," says Ken Jordan, a chemist at the University of Pittsburgh.

The cluster's architecture also means the oxygen atoms are just 2-7 angstroms apart—so close that the electrons on one oxygen atom can feel the charge of the electrons on its neighbors. The charges repel, but as the oxygens are gripped by strong bonds, they can't move apart. Johnson suggests that the bonds continually deform to minimize repulsion, twisting and stretching in an effort to stabilize the cluster. This is known as the dynamic Jahn-Teller effect ("The heat is on," New Scientist, 3 May 1997, p. 26). These vibrations make the water clusters more reactive, says Johnson, by lowering the energy barrier for chemical reaction.

This, Johnson argues, is part of the reason why his fuel is so clean. He has calculated that electrons on the clusters' oxygen atoms react with molecules such as anthracene in the diesel fuel that would normally turn into soot particles as they burn. Instead, the electrons break these soot precursors apart and the fragments turn into water, carbon monoxide, and carbon dioxide. Simultaneously, the water in the fuel cools the combustion process and slows the formation of NO_x. The result: in lab tests, QET has found that the fuel reduces sooty particles in diesel exhaust by as much as 80 percent and NO_x by more than 30 percent. There's also a slight improvement in engine power, says Johnson.

Despite the evidence, Johnson's theories don't convince everyone. "There's no way to tell if his fuel is using 20-molecule water clusters," argues Saykally, a pioneer in the study of water clusters. "Chemical models aren't reliable enough to address this. Calculating the properties of something as big as a 20-molecule cluster greatly exceeds quantum chemistry's current state of the art." Chemist Dudley Herschbach from Harvard University agrees: "Keith's theory is plausible but speculative."

Johnson is confident about his ideas because of computer models that he has developed based on his earlier studies of metal clusters. He has simulated the electrical behavior of molecules in all sizes and shapes of water cluster, substituting different oxygen isotopes into the model and charting the changes in the vibrational frequencies of the cluster's bonds. "It's only with clusters of around 20 molecules in size that you begin to see vibrations in the range matching those where the Jahn-Teller effect is active," he contends.

Wobbly molecules

He also points to a team at the University of Lyon that used Raman techniques to measure the vibrational properties of water. He claims their findings are consistent with his theory. "Nature is never kind enough to give you just one size of cluster," he says, "but in our fuel, evidence tells us that the 20-molecule cluster is the predominant form."

Jefferson Tester, director of MIT's Energy Laboratory, agrees that Johnson is onto something. "Keith's claims are logical," he says. "His ideas are also compatible with what we see in our lab when we test mixtures of water and fuel. And the increased reactivity is an indication that the Jahn-Teller effect could be at work here."

Jordan may not be convinced, but he is intrigued. "It certainly doesn't sound impossible," he says, citing cage-like structures of water molecules called hydrates that exist in nature: "One couldn't have predicted those shapes in advance."

Whatever the truth, the ultimate test for Johnson's fuel lies out on the street. And so far, things look promising: in June last year, a team from West Virginia University tested the fuel in a bus under simulated urban driving conditions. The results were encouraging, with reductions in pollution levels approaching those seen in the lab. And Johnson's water fuel has certainly pleased Douglas Wheaton, responsible for alternative fuels at the Massachusetts Port Authority. For about a year, a Massport bus has used QET's diesel blend as it shuttles passengers around Boston's airport. "We're a large airport crammed into a corner of East Boston," Wheaton says. "Using Johnson's fuel to reduce pollution is one way to mitigate our impact on the community." Although Massport hasn't measured the amount of pollution produced by Johnson's fuel, Wheaton is convinced: "It is obviously significantly cleaner than regular diesel exhaust," he says. Others are interested too. Three private bus companies in Costa Rica are conducting long-term tests of Johnson's water fuel and QET is in talks with several companies worldwide.

When the fuel is ready for sale—within six months, Johnson says—Massport will be a customer as long as the cost is comparable to regular diesel fuel. And that means no more than a 5 percent price difference. Right now, Johnson's fuel can't meet that target, but QET expects its price to fall as production is scaled up.

Reducing the cost of the fuel while maintaining its environmentally friendly performance is a trade-off. The surfactant is the most expensive component of the fuel but Johnson can reduce pollution levels even more by adding as much as 21 per-

Just Add Water continues on page 47

Tidal Power

Jeane Manning*

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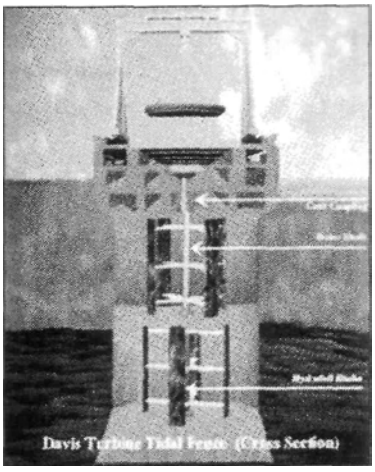
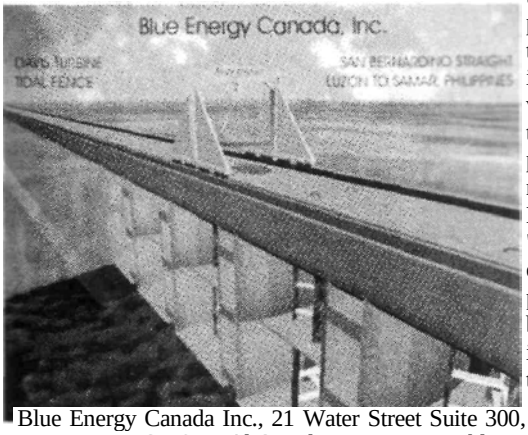
(www.shared-vision.com), November 1998.

The massive tides that ebb and flow through BC's Georgia Strait every day may be part of the answer to one of humankind's greatest challenges. Global climate change has forced governments to look for clean energy. One of those sources is the untapped tidal power that literally rolls in under our nose twice a day. A local company is preparing to harness this power around the planet, and it is getting a boost from the Kyoto, Japan agreement. [The Kyoto Protocol was established at a climate-change conference in Kyoto, Japan in December 1997, to define greenhouse gas emissions for all countries.]

For years, Vancouver's Blue Energy Canada Inc. (formerly Nova Energy Ltd.) has advocated the use of ocean tides for clean energy. Boaters and swimmers respect these forces, and the rest of us can appreciate the power shouldered by roaring waves which toss massive logs onto beaches. Martin Burger, president of Blue Energy, estimates that 25-30% of the world's energy needs could be met by using the tides. In his book Energy (Time Inc.), American textbook writer Mitchell Wilson is even more optimistic: "The tides' surge, if put to use, could provide half our energy."



The unique technology of Blue Energy has caught the eye of planners in the UK, India, and other countries, as well as the New Brunswick government. New Brunswick, for example, burns enough coal to create an expensive problem for itself when emissions penalties must be paid. "Our technology is looking very attractive to these people now," says Burger. "The Kyoto event is proving to be the turning point toward sustainab1e energy." The Philippine National Power Corporation is first in line to sign up with Blue Energy. The company is negotiating a 74-megawatt deal to design and help build a demonstration tidal-power project in the southern Philippines. This novel "tidal fence" of separate concrete structures will house large turbines. A highway will run along the top of the tidal fence between two islands.



Blue Energy Canada Inc., 21 Water Street Suite 300, Vancouver, BC V6B 1 Al Canada, Internet: www.bluenergy.com, Phone: 604-682-2583, Fax: 604-682-8683

This small Canadian company is able to earn this new business because of proprietary turbine and other technologies designed by chairman Barry Davis. With a slight Australian accent and quiet voice, this modest inventor was formerly the chief hydrodynamic designer for the DeHavilland Aircraft company, where he worked on the Bras d'Or hydrofoil ship. He also analyzed aerodynamic loads for the famous Avro Arrow supersonic aircraft.

Davis noticed that the energy in ocean currents was ignored, apart from a few early tidal power installations, such as the one located off the coast of France. "Tides are an overlooked viable, reliable, economic, ecologically benign and sustainable source of energy," he says. He came up with a new design, inspired by an old concept patented, but never built, by French hydro engineer G.J.M. Darrieus more than 50 years ago. Darrieus proposed a type of vertical axis wind turbine. Davis built his own versions and installed them in fast-moving water. With funding from the National Research Council in the 1980s, he tested his insights, from the St. Lawrence Seaway to the Florida Gulf Stream, and evolved a new type of low-head water turbine. With this form of turbine, there is no need to create a significant height-of-water difference such as with the damming which devastated Bay of Fundy marine life in a quite different approach to tidal power. The result is Blue Energy's tidal fence concept.

Blue Energy's vision encompasses not only megaprojects on the ocean, but also river units that could power a village and fit in a small pick-up truck. Burger, a native of the Northwest Territories, wants to see the invention bring power to aboriginal people in the North. A private foundation in Toronto indicated that it would fund the building of a small turbine for a demonstration project—a necessary step before the Department of Indian Affairs would support more ambitious projects.

The Davis Turbine generates power from both surging and ebbing tides. Thanks to Davis' knowledge of hydrofoils, the blades have been designed to rotate faster than the water that flows over them. However, even when anchored into a swift current, the blades turn at less than 25 revolutions per minute. At these speeds, fish can safely swim through the turbine, and larger sea creatures can veer around it.

Last year, the Institute of New Energy, in Salt Lake City, Utah, ranked the Davis Turbine as "number one for commercial development" among 114 energy systems. Tidal power turns out to have advantages over solar and wind systems. Though sun and wind are well-proven and developed sources, the proportion of sun and wind energy converted into electricity is not high enough to compete economically with heavily tax-subsidized nuclear and fossil-fuel industries.

Whereas wind, for example, is diffused, water is 832 times denser and, when moving at the same speed, will have hundreds of times more power to turn blades. If air were blowing past a windmill at a speed of a typical tidal flow, not much would happen. Tides flow into the Burrard Inlet at about five knots per hour, but because of the density of water, the blades are hit with as much force as that of hurricane winds. The turbine blades can then turn the shaft of a generator.

For eight years, Martin Burger tried to interest BC Hydro in the estimated 50,000 megawatts of tidal power resources along the west coast, especially a site in Massett Inlet in Haida Gwaii territory on the Queen Charlotte Islands. Rebuffed, he finally turned away and focused his efforts elsewhere. Burger notes that the government of the Philippines will soon be recognized as a world-class innovator in environmentally safe technology, and that British Columbia could have been that leader. Barry Davis, with characteristic understatement, says, "It is always difficult to change the status quo."

The switch to clean sources of power is imminent, however. Tidal power may play such a large role that the phrase "sea change" can be revised to describe this technological transformation of energy generation.

Jeane Manning is author of The Coming Energy Revolution.

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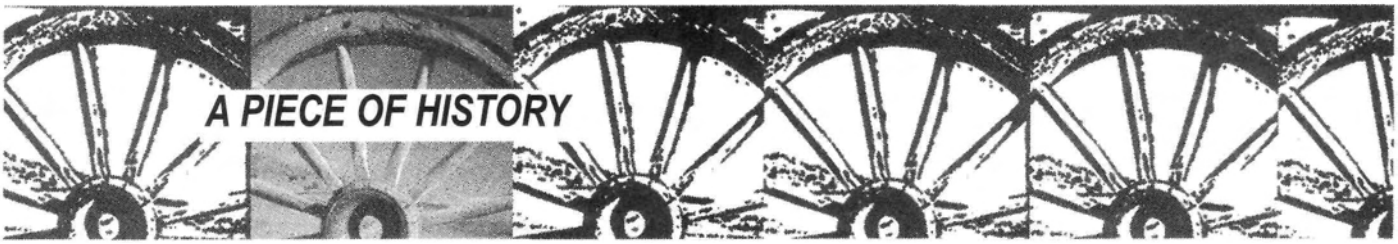


Waves of the Future?

Harnessing Tidal Power

Barbara A.F. DelloRusso

A Historical Review of the Passamaquoddy Bay Tidal Project and the La Rance River Project

Think but the movement of the waves, the ebb and flow, the to-and-fro motion of the tides, the ocean has a vast amount of lost power. —Victor Hugo

In 1919, Eastport, Maine (U.S.) was the site of Dexter Cooper's dream for a tidal power plant. This easternmost city of the United States was the gateway for Passamaquoddy Bay, which is part American and part Canadian, and its immense tidal flow in and out of the Bay of Fundy. Cooper's dream also envisioned attracting chemical and metallurgical plants and establishing a vast industrial complex, which would increase the size and economic status of the population considerably.

Eastport's economy was heavily dependent on fishing in the nineteenth century and was one of the busiest ports on the East coast. Estimates of Eastport's population at the turn of the century were generally over 6,000. During the early twentieth century, there was little employment for the area and a dwindling population due to the declining canning industries. Today, the population hovers around 2,000.

Dexter Cooper was a hydroelectric engineer, a graduate of the Royal Technical University at Karlsruhe, Germany in the early 1900s and previously an engineer on projects such as Niagara Falls and the Panama Canal; he was the builder of the Keokuk Dam on the Mississippi River. He worked and invested his own money for five years, surveying 400 miles of shore and building and testing a scale model of harnessing the tides in the Passamaquoddy Bay with water rushing in from the Bay of Fundy with its up to 53 foot tides. Tides that rise and fall 18 to 26 feet every twelve hours would, he believed, furnish a never ending source of power.[1,2,3] Cooper's original international plan was to create two great tidal basins by the construction of dams from Lubec to Eastport to Perry enclosing the waters of Cobscook Bay. The Atlantic Ocean swells Passamaquoddy and Cobscook Bay with over 70 billion cubic feet of water—more than flows down the Mississippi River in two weeks. About fifty square miles of water would have been enclosed by dams in which gates would open and close to conform to the rise and fall of tides.

Dexter Cooper
Courtesy of Eastport 200 Committee

When the tides ebbed, the impounded water would be released through turbine generators and then back to the ocean.[1] Estimates of cost at that time were around U.S. $40 million and it would have been financed by companies such as Boston Edison, General Electric, and Middle West Industries, prominent companies at that time.

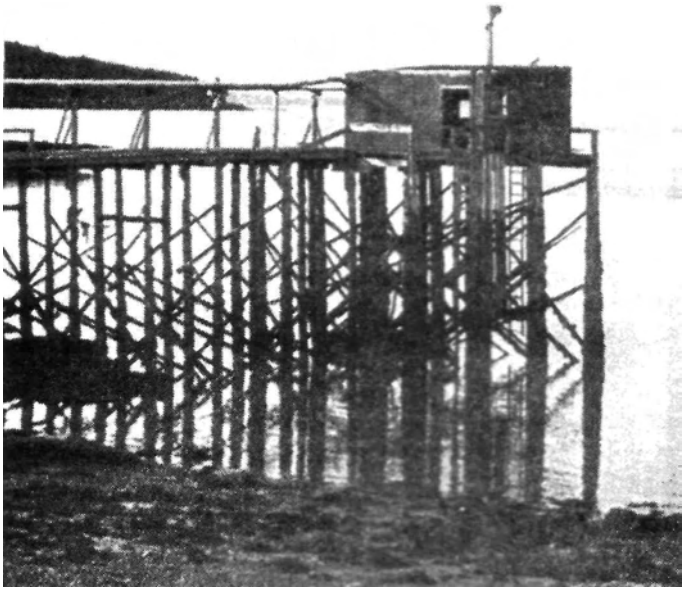
When the stock market crashed in 1929, so did the Quoddy project. Cooper left for a hydroelectric development project in Russia. The International (Canada and U.S.) Passamaquoddy project was lost when the report of the International Passamaquoddy Fisheries Commission, which was appointed in 1930, was submitted to Congress. The findings of the commission were that the construction of the proposed dams would practically extinguish herring fishing inside the dams, but that fishing most likely would not be affected in the Quoddy area or along the Maine coast. These findings eventually restricted the Quoddy project to the national Cobscook Bay two-pool plan, because Canada feared risking its fisheries (see map).

Franklin D. Roosevelt, who had a summer home on nearby Compobello Island, was a friend of Cooper and had supported his plan since its beginning. When he became President, he resurrected Cooper's plan and started a commission to study it. The headline "Passamaquoddy Became Mixed in Politics" sums up the key issue during the election year in Maine, which was then typically a Republican state. "Two days before the election, the Republicans levied a charge against Roosevelt that the Administration was trying to bribe voters of Maine into support of the New Deal by holding out hope of a $47,000,000 Public Works Administration (P.W.A.) project."[4] These charges did little to offset the Democratic sweep in Maine in 1933. The President's Commission final report summed up by saying that it would be economically feasible.[4]

This author spoke with Irene Shepherd, who grew up in that part of Maine during the 1930s. She told me about the tidal project when I alerted her to this special issue's focus on water. Irene

Courtesy of Eastport 200 Committee

President Franklin Roosevelt looking over model of the Passamaquoddy Tidal Power Project at Quoddy Village in Eastport. Left to right: Roscoe Emery (Mayor of Eastport), Oscar Brown, FDR, Governor Ralph Brewster, Dexter Cooper, and Lt. Col. Fleming.

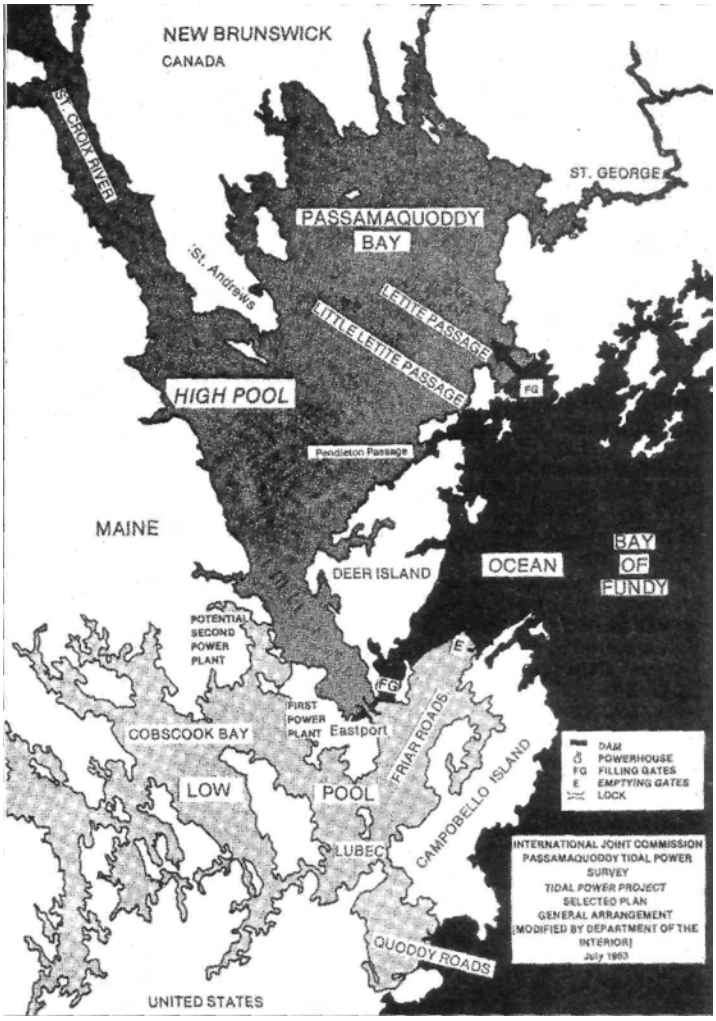


An example of the enormous tides on Passamaquoddy Bay. Pier with lobster shack at "half tide" shows ten feet of pilings. Photo by John Megas. The Ellsworth American

remembers Quoddy bringing much hope and eventually much prosperity to the area for a few years. The headlines in a 1935 newspaper article states: "Men Who Dreamed of Harnessing Quoddy Tides Now See End of Depression. Uncle Sam to Spend More Than a Million a Month for Two and a Half Years, Giving Employment to Over 1,500 Workers; Creating a Tremendous Business Impulse in Maine and Especially to a Section in Urgent Need of Aid."[5]

Other headlines spoke about the impending prosperity: "Bright Sunlight of Prosperity Shines DownEast. The City Will Be Rebuilt—New Buildings, Water System and Roads Needed for Army of Workers."[6] "125 Men From Relief Rolls to Start Work on Houses Monday."[7]

At that time $35 million was projected to be spent by the government. President Roosevelt began funding the project in 1935. The project was to be undertaken by the War Department, not because it had anything to do with defense, but because the Army Corps of Engineers were traditionally assigned to such federal projects. Dexter Cooper was retained as a consulting engineer on the project at $15,000 a year. Roosevelt gave $10 million from his discretionary reserve in the Public Works Administration.



This is a 1963 map showing how the Passamaquoddy power project would work. It illustrates the continuing story of the ambitious project to produce energy through the tides. Simply, the tides would be harnessed like this: the advancing tides would come from the Atlantic Ocean (dark screened area) through northern passages into Passamaquoddy Bay. At high tide, the locks there would be closed and the receding tide would be vented through the lower locks and the power stations near Eastport, from the high Pool to the Low Pool. Courtesy: The Ellsworth American

Pleasant Point Dam, part of the plan for the Passamaquoddy Tidal Power Project, under construction in 1936. Courtesy Eastport 200 Committee

Seven miles of locks and dams were estimated to take three years and $36 million to construct. These would produce 260 million kilowatt hours per annum.[1] The first phase of the project involved constructing housing quarters, later known as Quoddy Village, built at a cost of over $1 million. According to reports from 1935 to 1938, problems began when the bill to oversee the project and its debts was opposed by three power companies controlling 95% of Maine's electricity. Bangor Hydro Electric, Cumberland County Light, and Central Maine Power feared that the Quoddy Authority would drive these companies away by charging lower rates. The companies persuaded the two-thirds Republican legislature to block the bill.[1]

Roosevelt could not continue expenditures and withdrew $5 million from the project. All additional money would have to come from the U.S. Congress.

Many other problems ensued. Quoddy Village hurt Eastport because workers weren't housed in their town. Cooper's original plan was altered by the engineers and the cost went up considerably. In

the disastrous flood of 1936, Quoddy personnel were transferred to flood control projects and never returned.[6]

All in all, an expenditure of $7 million was used with only $2 million for the actual construction; one million dollars was for Quoddy Village and the rest for test borings and the building of certain smaller dams.

Dexter Cooper died in 1938 and never recovered the money he had invested ($85,000), and he was not paid the full $60,000 which the Army owed him for his services.

Over the years, Cooper's dream of a tidal plant in the Passamaquoddy Bay resurfaced. In 1948, President Truman directed the State Department to request an International Boundary Commission to conduct a survey to determine the feasibility of renewing the abandoned Quoddy Tidal Power project. Interest had developed because of power shortages in Maine and Canada.[8]

In 1950, the International Joint Commission (IJC) wanted to further investigate the economic feasibility of the project. In 1956, the U.S. government put up $3 million and Canadian government $300,000 for the IJC to do more studies. The IJC concluded in 1961 that it wasn't economically feasible under existing conditions, but that could change in the future. [7]

An article in the Maine Sunday Telegram in 1963 reported that the Secretary of the Interior had recommended to President John F. Kennedy a full review of the project. "The primary result will be 1 million kilowatts of dependable and needed peaking capacity for the region and, combined with hydroelectric development of the Upper St. John River, 250,000 kilowatts of dependable load factor firm energy for use primarily in Maine, both at a cost substantially below the cost of alternative source of power. . .unique engineering undertaking and will certainly become a tourist magnet, contributing further to the economy of the area."

The article lists many other positive aspects to the project. On October 20, 1963 Kennedy took a flight from Orono, Maine to Boston and detoured over the Passamaquoddy region.[9]

There was still much criticism in the media about the proposed Quoddy-Dickey power project. An article appearing in Electrical World blasted the sixteen-page Interior Report. It said that there were many mistakes in the Interior Department work and attacked basic assumptions on which some of the report was made. To no one's surprise, the Main Co. prepared its negative report for the Electric Council of New England, which is a private power company-backed organization.[10] The project died when Kennedy was assassinated a month later.[11]

In 1977, President Gerald Ford set aside $50,000 to study tidal power and at that time Quoddy supporters formed an advocate group to inform the public about the advantages of Quoddy. In the year 2000, nothing suggests that the Quoddy Project will ever be revived.

Tidal Power in the News

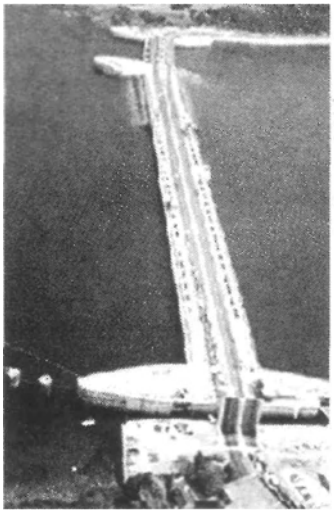
The September 2000 issue of Geographical magazine mentions that the University of Plymouth has invented a new device called a Wave Energy Device which "comprises a column or cylinder, five meters in diameter, which extends some 14 meters below the surface of the sea." According to researchers there, "the device is based on the principle of multiple water columns which oscillate owing to the movement of the waves. Air in the columns, under pressure from the water below, drives a turbine to generate power." The device can move with the tide as it's like a free-floating buoy. It can, according to the inventors withstand storm conditions. The device is patented by a British company. Embley Energy Ltd. According to the article, researchers hope to have initial tests completed by early 2001 —SDR

The La Rance River Project

By way of contrast with Quoddy, some tidal wave projects have been successful. The La Rance River Project in the Gulf of St. Malo, Brittany, France, took six years to complete, from 1961 to 1966. The 240 megawatt tidal generating station is at the mouth of the Rance River estuary on the northern coast of France (a large coal or nuclear power plant generates about 1,000 MW of electricity).[12]

With a French national energy crisis in full bloom, the La Rance River Tidal Project had successfully operated for more than six years. But French experts admitted at that time that they would not initiate another tidal project because it could not compete with recently developed nuclear power plants. In fact, the tidal project was considered unsuccessful in the beginning, but that was due to the drop in oil prices immediately following its completion.

Comparing Quoddy to Rance was one more way for the U.S. Interior Department to maintain that the Quoddy Project, standing on its own, couldn't meet the feasibility test. "The construction cost has escalated over 30 percent, according to U.S. engineers. There is considerable doubt that the Passamaquoddy Tidal Project can meet the feasibility test as being economically sound..."[13]


La Rance. World WideWeb

The article details some of the technical and economic achievements of this tidal project.

The estuary where La Rance River Project was built has tides that are stronger than at any other point on the coast of Continental Europe. The tide reaches as much as 44 feet. This fact plus the use of so called 'bulb groups' which use new turbine alternator generators have made the Rance project an engineering success.

The dam is built across the estuary at a point where the distance from shore to shore is 2,460 feet. Turbines and generators are located within the dam which is 150 feet in area. It took the engineers six years to overcome a problem of the tides running strictly on their own schedule. They devised bulb shaped power units, 45 feet long and 18 feet in diameter, each housing a turbine and a generator and sunk in the dam below the lowest tide.

Rushing waters spin the four 18-foot long propeller blades of the turbines which, in turn, activate the generator. The bulbs can be run by water flowing in either direction—and they can also be used as pumps.

The pumping is what really counts. This makes it possible to use surplus electricity to fill the reservoir behind the dam to a greater depth than the top level of the tidal flow. Later, this extra water can be released to turn the turbines at the moment when the power is needed, not just when the ocean has seen fit to recede.

If the bulb breaks down, or needs cleaning, it can be

sealed off by massive doors at either end. Overhead shafts allow access by technicians to a limited extent even when the bulb is in operation.

French engineers say the Rance project cost 25 per cent less in terms of concrete than conventional French hydro plants of matching capacity. The final cost of the project was in the area of $85 million.

There have been some economic and recreational side benefits from the French project. The motor road running across the dam had cut 25 miles off the tortuous upstream loop that had to be made to drive from St. Malo to Dinard. And, for boating enthusiasts who used to shun the Rance because of its ruthless tidal currents, a whole new playground has been opened. The reservoir, stretching 12 miles upstream from the new dam to a centuries old dam near Dinan, offers a large and placid surface, covering nine square miles...the dam top offers spectacular views.[13]

In 1997, a $78 million renovation project was underway at the La Rance Tidal Plant. The half mile long dam furnishes 90% of Brittany's electricity. This project appears to be a continuing success story.[14]

In the previously mentioned 1973 article[13] concerning the pros and cons of Quoddy, The Rance River Project was known as being very successful from a technical standpoint. The article stated: "No other tidal power operation of that scope had been started anywhere in the world. The Russians were believed to have a small facility for experimentation in the Bay of Kislaja on the White Sea where there are tidal advantages rather like those at Rance. South Korea did a feasibility study for a project and the British talked of applying the Rance concept at the Severn Estuary where the tidal range is 45 feet."

According to recent information on the web, the Soviet Union did complete construction in 1969 of about 1,000 kilowatts of tidal power on the White Sea. There is a 20 MW experimental facility at Annapolis Royal in Nova Scotia, in the Bay of Fundy, and a 0.4 MW tidal power plant near Murmansk in Russia. It was estimated that a barrage across the Severn River in western England could supply as much as 10% of the country's electricity needs (12 GW). Cook Inlet in Alaska also has the potential to generate large amounts of electricity.[12]

Michael Brower's book Cool Energy[15] states: "The potential of tidal power is limited... about 3 million megawatts are dissipated in tides worldwide, of which it is estimated that no more than 2% (60,000MW) could realistically be captured in tidal power plants. . . the "lack of experience with tidal power also means that its environmental impact are not wholly understood." Brower's comments reflect his opinion about damming tidal flow, not at turbines such as those mentioned in Jeane Manning's article Tidal Power (p. 43). The low-impact efficient Davis turbine system uses a type of slow-moving blade that even large fish can swim through and it doesn't require as high a difference in water depth. Jeane Manning feels that "unless a low-impact efficient turbine is used, conventional tidal power changes the location and nature of 'intertidal zones' in a bay which in turn interferes with fish migration" (personal communication).

Cleaner energy sources such as tidal power are being looked at increasingly by governments.[16] Tidal power has the potential to generate electricity and be an important renewable energy source. Construction costs and environmental impact seem to be the biggest barriers to developing this resource. Perhaps past studies of the Quoddy project should be reexamined given new technical expertise and advancing technologies[16] (inset, p. 45) of this field that might make such a huge project more cost-effective and environmentally feasible in the future. Inexhaustible and non-polluting tidal power may be one of the waves of the future.

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Just Add Water continued from page 42

cent water. But add more water and Johnson must mix in extra surfactant to keep the fuel stable—and the costs rise.

So he is looking for ways to eliminate surfactants altogether. One answer is to subject water to "supercritical" temperatures and pressures—about 374 °C and 220 atmospheres. Supercritical water is somewhere between a liquid and a vapor, and Johnson believes that its primary form is 20-molecule clusters. Under these conditions, the molecules of diesel fuel and the water molecules in the clusters bond directly, without the need for surfactants.

In lab tests, the supercritical fuel reduces pollutants even more effectively than the surfactant-aided blend—removing about 90 percent of particulates and halving NO_x emission, says Johnson. This makes it cleaner than natural gas. QET is negotiating with a U.S. electricity company to test the fuel in a power station. QET is also designing engine modifications to enable a vehicle to create the blend on board.

But this combustible cocktail is just the beginning. Johnson has set out on a scientific voyage of discovery to explore and exploit the other strange properties of these water clusters. He is already awash with other applications and is looking into the role his clusters might play in biomedical products. He can't reveal anything about these yet—commercial interests are at stake—but he has even bigger ideas on his mind. He points to data gathered recently by NASA's new submillimetre-wave astronomy satellite (SWAS) that suggest clouds of freezing matter in deep space throb with vibrations resembling those of 20-molecule water clusters. Johnson speculates the clusters might pack the voids between distant stars and galaxies: "These should be stable in the low temperatures and vacuum of space," he suggests.

His modest office is also stacked with papers implying that water clusters may even play a key role in protein folding and in determining the structure of living cells. Perhaps his watery fuel is just the tip of an iceberg? "The more we can learn about the molecular behavior of water," he says, "the more we'll learn about life itself."

Bennett Daviss is a science journalist based in New Hampshire.

BRIEFS

COMPILED BY EUGENE MALLOVE

Sheikh Yamani Predicts End of Age of Oil and an Oil Price Crash

The authoritative UK newspaper, The Sunday Telegraph (June 25,2000), featured an interview with Sheikh Yamani, the former oil minister of Saudi Arabia (1962-1986), who is now an energy consultant. Yamani told interviewer Gyles Brandreth, as reported in a summary by Mary Fagan that "he expects a cataclysmic crash in the price of oil in the next five years" and that "within a few decades, vast reserves of oil will lie unwanted and the 'oil age' will come to an end."

Further remarkable statements by Yamani directly from the interview: "Thirty years from now there will be a huge amount of oil—and no buyers. Oil will be left in the ground. The Stone Age came to an end, not because we had a lack of stones, and the oil age will come to an end not because we have a lack of oil."

Recent oil discoveries, new technologies, and increased investment in exploration and production collectively will create the collapse in the price of crude oil, he said. Yamani told the interviewer: "I have no illusion. I am positive there will be some time in the future a crash in the price of oil. I can tell you with a degree of confidence that after five years there will be a sharp drop in the price of oil." He predicts a cut in gasoline consumption of 100% "before the end of the decade"!

Sheikh Yamani, a man clearly ahead of his time, appears to know more about the rush of new technology than does the U.S. Department of Energy.

Clinton on New Energy

President Clinton may not have "phoned Bow" yet to comment on the memorandum on cold fusion we submitted to him in March (see note, IE No. 31, p. 37), but we do have some of his thoughts on revolutionary energy, even if not of the cold fusion kind. In cleaning up some files at our Bow, New Hampshire offices, we ran into an excerpt from a Clinton news conference on October 14. (Don't ask what year—our filing system isn't that good and it doesn't matter what year; he said it!)

"...the world is still largely in the grip of a big idea that isn't true anymore. And that big idea is that in order for any country that's not rich to get rich, they have to burn more fossil fuels and put more greenhouse gases in the atmosphere. . ."

"The whole economics of energy and the economy have changed. And we could have a revolution in the environment with more trade and investment in presently available environmental technologies, in alternative energy sources. . . But it won't necessarily happen automatically."

Water: To Blame for Earth's Wobble

The role of water in the universe never ceases to amaze. According to this NASA press release, water is responsible for the slight wobble of the Earth's axis of rotation:

A MYSTERY OF EARTH'S WOBBLE SOLVED: IT'S THE OCEAN

The century-old mystery of Earth's "Chandler wobble" has been solved by a scientist at NASA's Jet Propulsion Laboratory in Pasadena, California. The Chandler wobble, named for its 1891 discoverer, Seth Carlo Chandler, Jr., an American businessman turned astronomer, is one of several wobbling motions exhibited by Earth as it rotates on its axis, much as a top wobbles as it spins.

Scientists have been particularly intrigued by the Chandler wobble, since its cause has remained a mystery even though it has been under observation for over a century. Its period is only around 433 days, or just 1.2 years, meaning that it takes that amount of time to complete one wobble. The amplitude of the wobble amounts to about 20 feet at the North Pole. It has been calculated that the. Chandler wobble would be damped down, or reduced to zero, in just 68 years, unless some force were constantly acting to reinvigorate it.

But what is that force, or excitation mechanism? Over the years, various hypotheses have been put forward, such as atmospheric phenomena, continental water storage (changes in snow cover, river runoff, lake levels, or reservoir capacities), interaction at the boundary of Earth's core and its surrounding mantle, and earthquakes.

Writing in the August 1 issue of Geophysical Research Letters, Richard S. Gross, of NASA's Jet Propulsion Laboratory, reports that the principal cause of the Chandler wobble is fluctuating pressure on the bottom of the ocean, caused by temperature and salinity changes and wind-driven changes in the circulation of the oceans. He determined this by applying numerical models of the oceans, which have only recently become available through the work of other researchers, to data on the Chandler wobble obtained during the years 1985-1995. Gross calculated that two-thirds of the Chandler wobble is caused by ocean-bottom pressure changes and the remaining one-third by fluctuations in atmospheric pressure. He says that the effect of atmospheric winds and ocean currents on the wobble was minor.

Gross credits the wide distribution of the data that underlay his calculations to the creation in 1988 of the International Earth Rotation Service (IERS), which is based in Paris, France. Through its various bureaus, he writes, IERS enables the kind of interdisciplinary research that led to his solution of the Chandler wobble mystery. Gross's research was supported by NASA's Office of Earth Science.

Media Relations Office, Jet Propulsion Laboratory
California Institute of Technology
National Aeronautics and Space Administration
http: / /www.jpl.nasa.gov
Contact: Rosemary Sullivant (818) 354-0474

Dr. Randell Mills Responds to Attacks, Outlines BlackLight Progress

On the public electronic forum, The Hydrino Study Group, Dr. Randell Mills of BlackLight Power Corporation provided forum recipients with this stark message, reproduced in full here. It is a good

overview of where things stand with BlackLight Power and how far the company has come. Of course, the real acid test for the company will be the advent of an irrefutable electricity generating device based on water fuel, as they project they will have.

Hydrino Study Group (HSG): A serious look at the novel theory of Dr. Randell Mills. http://members.tripod.com/Hydrino/ Post Message hydrino@eGroups.com Subscribe hydrino-subscribe@eGroups.com Unsubscribe hydrino-unsubscribe@eGroups.com List Owner hydrino-owner@eGroups.com

[Editor's Note: Items in double brackets were added by Infinite Energy to annotate Dr. Mills' text.]

Comments on Park's
Misrepresentation of Myself and
BlackLight Power, Inc.

After ten years of dogging me without studying the sound theoretical basis of my work or the extensive experimental work and confirmations, Park can't even spell my name correctly. [[Park used Randall; his name is Randell.]] Criticism of my work appears in about two pages [of] his book [[Voodoo Science]] (pp. 133-135). His account of events is factually inaccurate, and it is a clear work of "spin" and slander.

I held a press conference in the city where I was working, Lancaster, Pennsylvania in the Spring of 1991. I announced my experimental results that were to be published in a peer reviewed journal. Other journalists did not fail to miss this point, as evidenced by front page articles by various Lancaster newspapers. For example, in a front page article of a leading Lancaster paper [Lancaster New Era, Thursday, April 25, 1991] appears: "Mills said his findings will be published in the August issue of Fusion Technology, a scholarly journal. He said he also will present them at the annual meeting of the American Chemical Society Meeting in New York this August."

Park implies that this was recent news. He further falsely represents that I had, and currently have, no data to support my claims.

The technology has advanced tremendously since 1991. Park failed to mention the results summarized in thirty-nine abstracts of our reports and publications found on our web page at http://www.blacklightpower.com.

Furthermore, I did not become bored of practicing medicine. I had a contract with Toray Japan to develop a revolutionary approach to cancer treatment when I graduated from Harvard Medical School. The work was published in Nature ["A Novel Cancer Therapy Using a Mossbauer-Isotope Compound," Randell L. Mills, Carl W. Walter, Lata Venkataraman, Kevin Pang, John Farrell, Nature," 336, 787, (1988); "On the Potentialities of Nuclear Gamma Resonance (Mossbauer Effect) Spectroscopy as a New, Low Dose Approach to Cancer Radiation Therapy," W.M. Reiff, R.L. Mills, J.J. Farrell, The Proceedings of the International Conference on the Applications of the Mossbauer Effect, ICAME 1989, Budapest, Hungary-Sept. (Hyperfine Interactions, 1990)].

It was my intent upon entering medical school to start a high technology company. I had filed patents on several breakthrough medical technologies while a medical student at Harvard and an electrical engineering student at Massachusetts Institute of Technology (MIT). Upon graduating, I formed Mills Technologies to develop these and other technologies.

Regarding Park's comments on my theory:

Quantum mechanics (QM) theory does not say why an atom radiates. The Schrodinger equation (SE) was POSTULATED in 1926. Schrodinger realized that his equation was limited. It is not Lorentzian invariant; thus, it violates special relativity. It also does not comply with Maxwell's equations and other first principle laws.

Schrodinger sought a resolution of the incompatibility with special relativity for the rest of his life. He was deeply troubled by the physical consequences of his equation and its solutions. His hope was that the resolution would make his equation fully compatible with classical physics and the quantization would arise from first principles.

Quantum mechanics failed to predict the results of the Stern-Gerlach experiment which indicated the need for an additional quantum number. Quantum electrodynamics was proposed by Dirac in 1926 to provide a generalization of quantum mechanics for high energies in conformity with the theory of special relativity and to provide a consistent treatment of the interaction of matter with radiation. From Weisskopf [Weisskopf, V. F, Reviews of Modern Physics, Vol. 21, No. 2, (1949), pp. 305-315], "Dirac's quantum electrodynamics gave a more consistent derivation of the results of the correspondence principle, but it also brought about a number of new and serious difficulties." Quantum electrodynamics:

1. DOES NOT EXPLAIN NONRADIATION OF BOUND ELECTRONS.

2. Contains an internal inconsistency with special relativity regarding the classical electron radius—the electron mass corresponding to its electric energy is infinite.

3. It admits solutions of negative rest mass and negative kinetic energy.

4. The interaction of the electron with the predicted zero-point field fluctuations leads to infinite kinetic energy and infinite electron mass.

5. Dirac used the unacceptable states of negative mass for the description of the vacuum; yet, infinities still arise.

Quantum states of QM refer to energy levels of probability waves. From these, emission and absorption of radiation is inferred. But QM doesn't explain why it is emitted or absorbed or why certain states are stable.

For example, the SE cannot be directly tested, and is nonphysical. Even QM aficionados do not believe that QM describes physical reality. I quote Fuchs and Peres, "Contrary to those desires, quantum theory does NOT describe physical reality." [C.A. Fuchs and A. Peres, "Quantum Theory Needs No Interpretation," Physics Today, March (2000), p. 70.]

Furthermore, it does not explain the stability of the hydrogen atom. To say that the atom obeys the SE is nonsensical. Consider the hydrogen atom without regard to the mathematical formula called the SE. Mathematics does not determine physics. It only models physics. The SE is not based on directly testable physical laws such as Maxwell's equations. It only gives correlations, and is in fact inconsistent with physical laws.

As a Historical Note:

> [My father] said, "I understand that they say that light is emitted from an atom when it goes from one state to another, from an excited state to a state of lower energy."
>
> I said, "That's right."
>
> "And light is kind of a particle, a photon, I think they call it."
>
> "Yes."
>
> "So if the photon comes out of the atom when it goes from the excited to the lower state, the photon must have been in the atom in the excited state."
>
> I said, "Well, no."
>
> He said, "Well, how do you look at it so you can think of a particle photon coming out without it having been there in the excited state?"
>
> I thought a few minutes, and I said, "I'm sorry; I don't know. I can't explain it to you."
>
> -Richard P. Feynman, The Physics Teacher (September 1969).

I started working on the theory on which BlackLight's energy technology is based in 1986, three years before cold fusion. In 1986, I was at MIT studying free electron lasers. My electricity and magnetism professor, Dr. Haus, gave me a copy of his article describing the solu-

tion of the physics of electromagnetic radiation from the free electrons in the laser based on Maxwell's equations.

I reasoned that his solution could also be used as a constraint for a nonradiating electron.

I had studied quantum mechanics as an undergraduate and was never comfortable with the inconsistencies with the physical world and the postulate that different physics applied on the atomic scale than on the macroscale. So, I reasoned that if Maxwell's equations predicted the radiation of a free electron, why shouldn't it predict the physics of nonradiation when the electron is bound in an atom?

I applied Haus's condition to one of the most significant enigmas of the early nineteenth century: why doesn't the electron in the hydrogen atom radiate and spiral into the nucleus with the release of thousands of times the energy that is observed. The textbook answer is that it doesn't obey physical laws. In other words, the hydrogen atom is stable and stops radiating at a much higher energy level than thought at the time to be reasonable.

When I solved the atom using Maxwell's equations, the answer was clear. According to this law of nature, the electron can not emit or lose energy as light directly. Historically, this state was misnamed the "ground state," but the hydrogen atom is extremely reactive, and only exists in isolation. Otherwise, it is always found in a lower energy state than the "ground state" in a molecule such as molecular hydrogen.

On further examination of the equation, I realized that it is possible to release further energy nonradiatively and form other stable states (hydrinos) wherein the principal energy levels are given as the reciprocal of an integer in place of an integer in the Rydberg formula, the famous equation discovered from spectroscopy data in the late 1800's that gives the hydrogen energy levels.

In fact, nonradiative energy transfer is the mechanism involved in the formation of molecular hydrogen. Nonradiative mechanisms are familiar to chemists. Phosphors in fluorescent lights transfer energy by a nonradiative mechanism. So, I predicted certain atoms and ions which would work the same way to release energy from atomic hydrogen.

The results of BlackLight's experiments and those of others demonstrate that the process works as predicted. The process also explains an enormous amount of astrophysical spectra and phenomena. For example, atomic hydrogen in fractional quantum energy levels below the traditional "ground" state, hydrinos, can be assigned to soft X-ray emissions from the interstellar medium (space between stars), the Sun, and stellar flares, and to certain far-infrared spectral lines obtained by a spectrometer which measured the cosmic background radiation. A new molecular species, the diatomic hydrino molecule, can be assigned to certain infrared line emissions from the Sun. New hydride species, hydrino hydride ions, may be assigned to certain soft X-ray, ultraviolet (UV), and visible emissions from the Sun.

My theory gives closed form solutions for the atom including the stability of the n=l state and the instability of the excited states, the equation of the photon and electron in excited states, the equation of the free electron, and photon which are derived from first principles and give the wave particle duality behavior of particles and light. Nonradiation based on Maxwell's equations is a necessary boundary constraint since nonradiation is observed experimentally. Spin, magnetic moment of a Bohr magneton, Stern Gerlach experiment, g factor, Lamb shift, resonant line width and shape, selection rules, correspondence principle, wave particle duality, excited states, rotational energies, and momenta, orbital and spin splitting, spin-orbital coupling, Knight shift, and spin-nuclear coupling are derived in closed form equations based 'axwell's equations.

In contradiction to Park's statement that hydrino lines have not been observed, Prof. Dr. Johannes P. F. Conrads, then the Director and Chairman of the Board of Institut Fur Niedertemperatur-Plasmaphysik e.V. and the Ernst-Moritz Arndt-Univeristat Greifswald (INP), a top plasma physics laboratory in Greifswald, Germany, and four of Prof. Conrads' top scientists recorded line emission from our cell which matches hydrogen transitions to lower energy states. A paper has been prepared which will be submitted to a leading journal by the recently retired Director and Chairman of the Board of INP. Furthermore, hydrogen transitions to electronic energy levels below the "ground" state corresponding to hydrinos match the spectral lines of the extreme ultraviolet background of interstellar space and from the Sun. I have recently received acceptance of a paper that points out major problems with the current theory of the hydrogen atom and analyzes spectroscopy of the interstellar medium that clearly shows hydrinos

BRIEFS continued on page 70

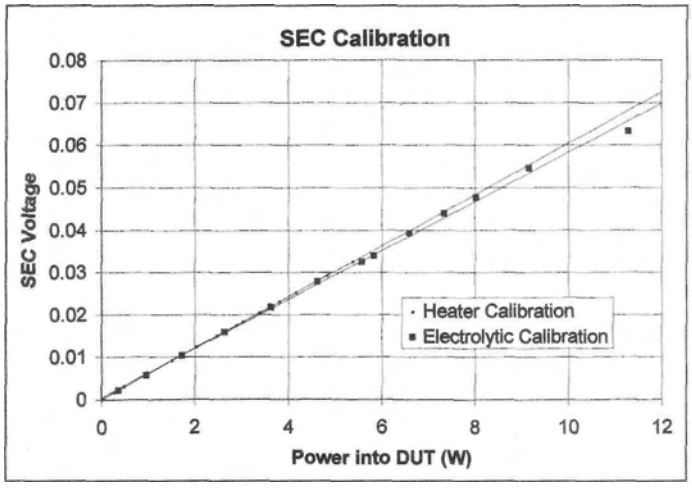
New Energy Research Laboratory *** Device and Process Testing Update

Ed Wall

Dash Cell Progress

Progress has been made on the Dash Cell work at NERL. Calibration of the Seebeck Envelope Calorimeter (SEC) was accomplished by two means: a simple electric heater and by using an electrolytic cell with ordinary water and two platinum electrodes. The latter is to provide a reference that most closely mimics the kind of heat generation that is found with the platinum anode and titanium cathode heavy water cell that has been reported by Professor John Dash and his colleagues to be a fairly reliable generator of small percentages of excess heat.

As can be seen in the SEC Calibration chart, which contains both the heater and electrolytic calibration, the latter is somewhat below the former. The calibration lines differ. The difference can be accounted for by fact that there is some loss of water in the electrolytic cells, on the order of 1 g/day. The loss is due to gas leakage. The leaking gas would have produced heat if it had been recombined into water in the cell. The cell design is good, because it is simple, but it is not yet completely gas tight. One can



see how the square data points, which are for electrolytic calibration, fall below the heater calibration at higher power.

Dr. Edmund Storms was kind enough to provide us with some valuable suggestions on improving the sealing of the cell. He also urged us to implement a secondary recombiner, which he uses. The recombiner is a catalyst that produces water and heat from the oxygen and hydrogen produced in the electrolysis process. This secondary recombiner is a small bit of catalyst to recombine the hydrogen and oxygen that might escape from the cell if the primary recombiner begins to fail. If the recombiner failed, and we did not know it by any indications, and the cell seal was very tight, the pressure build up in the cell could be dangerous; we would have no indication of recombiner failure. The secondary recombiner temperature is monitored. If the cell's recombiner fails, an indication is generated.

Storms reports that he has essentially no mass loss from his cells because of the excellent gas seals he employs. With his system the electrolytic calibration line would be virtually co-linear with the heater calibration line.

After electrolytic calibration, the platinum/titanium heavy water cell was run, and some small apparent excess heat appeared at low power (up to 5.2 watts input). This is only a preliminary result, for the following reasons. The cell power wiring became an issue. The wires that provide power to the electrolytic cell do more than provide power. They convey heat out from the SEC in a way that avoids detection by the thermcouples that make up the SEC. This was known to me previously, so I used small diameter wires to make such heat flow negligible. Small wires have high resistance, so they can generate non-negligible heat. This would not have been a problem if the voltage sensing wires to measure cell voltage for the data acquisition system were not directly on the leads at the top of the cell. The part of the power wires between the top of the cell and the SEC perimeter was dissipating heat into the SEC, and the electrical power that made that heat was not directly measured. I thought that this would not be a problem, because the SEC was to be calibrated with an electrolytic cell, which I thought would perform in a manner very similar to the test cell. However, when we detected the small apparent excess heat, it was a small enough excess that even such trifling sources of possible error as this had to be taken seriously. The calibration and the test cells had different resistance across their leads. This was an issue, because at the same power level, the heat dissipated in the power wires was different because of the different currents. This was a small calibration error.

We also became more concerned about how sensitive the SEC might be to where inside of the SEC the heat source was located. Ideally, such sensitivity would be nil. However, the heat conductivity of the SEC walls is not perfectly uniform, nor is the cooling of the temperature reference plate for the reference thermocouples. So, a test was designed with four 10-watt resistors, one at each corner of the SEC, configured so that the resistors could be activated separately or in combination without opening the SEC. The resistors were placed on a piece of sheet metal, which was raised off the floor of the SEC by a short plastic stand. This offered a fairly extreme test of the SEC by the standard of normal use, when a much less concentrated source of heat is located in the center of the unit on the short plastic stand. The resulting SEC output voltage for a given resistor input power was not expected to exceed the voltage seen when that power was applied to a large, centrally located calibration resistor. In fact, none of the corner resistor lines exceeded the calibration line, and the maximum deviation was an SEC reading 4.3% below the calibration line. From this test, we can fairly conclude that the location of the cell will have a negligible affect on the result and, if the slight change in heat source position does affect SEC output, it will probably only decrease the output. In other words, if we see excess heat exceeding the heater calibration line by more than three standard deviations, we can be pretty confident that the source of the excess is not a statistical fluke or due to a calorimeter problem.

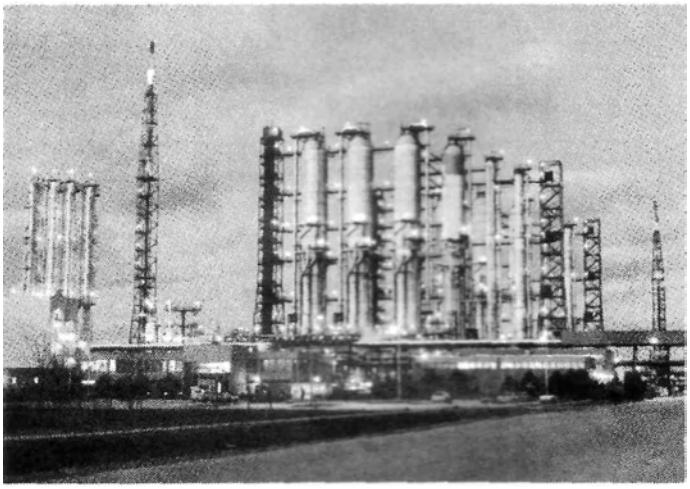
The power leads were replaced with a heavier gage wire from the perimeter of the SEC to the cell, and the voltage sensing now takes place at the SEC perimeter. This means that the voltage we measure is not exactly the cell voltage, but we are accounting for the very small amount of heat dissipated in the power wires.

A second titanium cathode was tested. The gas leakage now proved to be serious. It was decided to change the cell to incorporate gas seals, and that is being done as we go to press.

Experimentation is a series of careful steps to gain better results, results that mean more. Eliminating gas leakage will improve electrolytic calibration and should give us clearer

Device continued on page 67

Heavy Water



[Editor's Note: Ontario Hydro is no longer in operation and heavy water is no longer produced there. Ontario Power, the successor company to Ontario Hydro, inherited the heavy water inventory and currently sees no need for additional production: the plant is being dismantled. However, we thought that Infinite Energy readers would appreciate this information regarding heavy water production and use which was in literature published by Ontario Hydro. —EFM]

Unlike most of the world's nuclear reactors, the Canadian-developed CANada Deuterium Uranium (CANDU) nuclear reactor used heavy water to transfer heat and to help control the nuclear reaction. Ontario Hydro operated CANDU nuclear reactors for over twenty years, and produced its own heavy water since 1973. As a result of this experience, Hydro developed world-leading expertise in the production and handling of heavy water.

What is heavy water?

Heavy water is a clear, colorless liquid that looks and tastes like ordinary tap water. It occurs naturally in water in minute quantities, about one part heavy water to 7,000 parts of ordinary water.

The importance of heavy water to the Canadian reactor is suggested in the name itself—CANDU, or CANada Deuterium Uranium. Unlike normal water, which is composed of hydrogen and oxygen (the well-known H_2O formula), heavy water is made up of deuterium and oxygen (D_2O). The name heavy water sterns from the presence of deuterium, which is a form of hydrogen that has an extra neutron in its atomic nucleus and weighs slightly more than ordinary hydrogen. [Editor's note: It is twice as heavy.] As a result, headwater is about 10 percent heavier than normal water. It also has different freezing and boiling points.

Helping the chain reaction

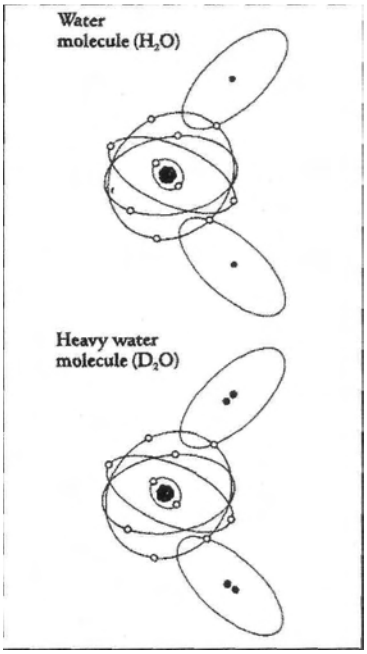
An explanation of the way nuclear power is generated will help in understanding heavy water's role in the process.

CANDU reactors are fueled with natural uranium, which consists mainly of uranium-238 with a very small percentage of uranium-235 (0.7%). It is this tiny percentage of uranium-235 that is important in the production of nuclear energy because the unstable properties of the uranium-235 atom make it easy to split when struck by a neutron.

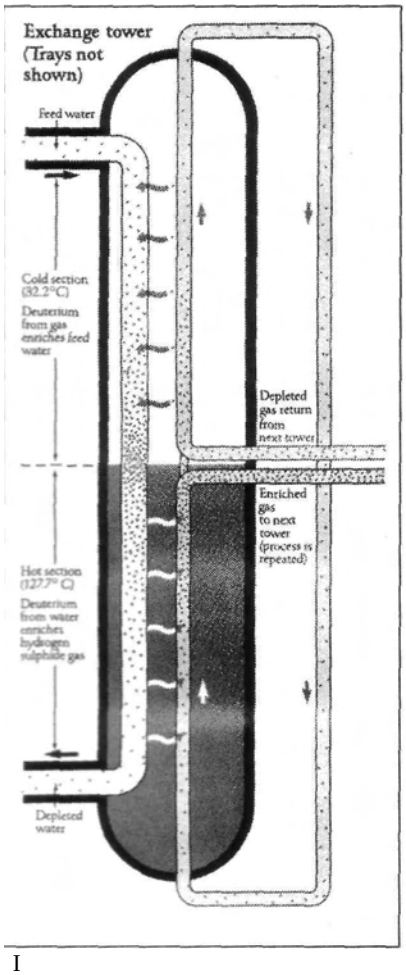
Once this happens, enormous heat is produced, and this heat can be used to generate power.

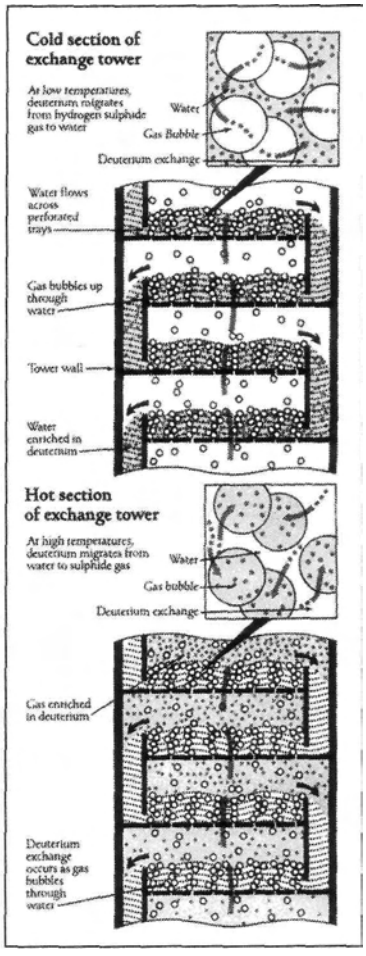
The initial splitting or "fissioning" of the uranium atom will produce two or three more neutrons. If these neutrons are able to split other uranium-235 atoms, which in turn give off more neutrons to split yet more uranium-235 atoms, then a chain reaction is created. It is this self-sustaining chain reaction or "fissioning" that enables nuclear reactors to produce the constant heat energy needed to generate electricity.

There is one important consideration in this process. The neutrons from the split atom travel at a speed of about 19,000 kilometres per second. At this velocity, the probability of the neutrons colliding with uranium-235 atoms is very small. For this reason, a material called a moderator must be used to slow down, or "moderate," the neutrons to about three kilometres per second so they are more likely to collide with the uranium-235 atoms and have a better chance of causing fission.

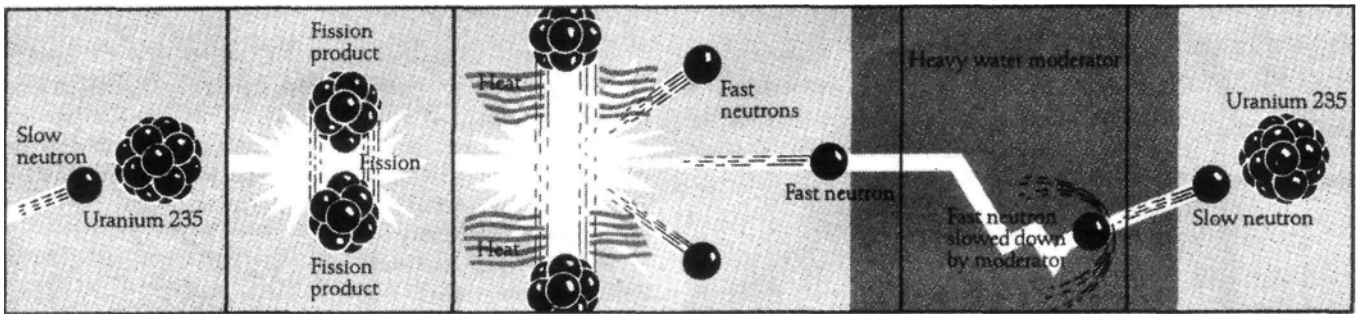


Heavy water is a particularly good moderator because the deuterium





How heavy water is used:



A slow neutron strikes nucleus of uranium-235 atom and splits—fissions—it into smaller atoms. Neutrons given off at the same time are slowed by the heavy water moderator so they can strike and split other nuclei and sustain a chain reaction.

atom already contains a neutron. This means that neutrons released when the atom is split have little chance of being absorbed by the heavy water and, once slowed, will continue to split other uranium atoms and sustain the chain reaction. Heavy water is about 30 times better than ordinary water in slowing down neutrons without absorbing them. In fact, because heavy water is such a good moderator, CANDU reactors can use natural uranium—unlike most other commercial reactors, which use ordinary water as their moderator and therefore must use fuel that has been "enriched" with extra atoms of uranium-235.

The process of enriching uranium is expensive, and reactors that use enriched uranium can require up to double the fuel to produce the same amount of electricity as a CANDU reactor.

A heat transport medium

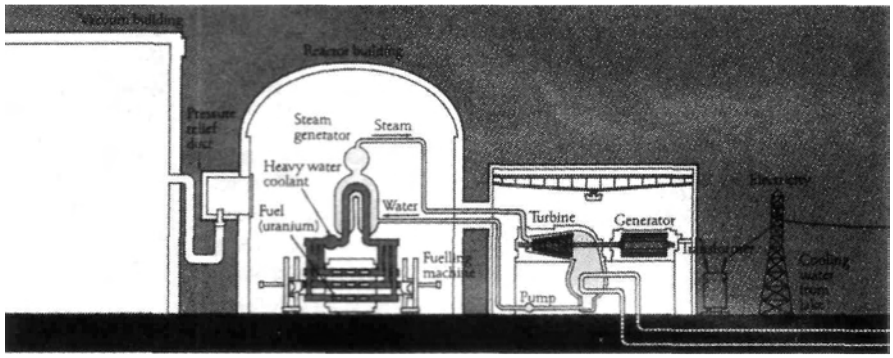
CANDU also uses pressurized heavy water to carry heat from the reactor to the huge boilers that produce steam to run the electric generators.

When the chain reaction starts, heavy water is heated by being circulated through the tubes containing the fuel. From there, it moves on to a boiler where it, in turn, heats ordinary water to steam. Heavy water is a good heat transport medium for the same reason that it is a good moderator: the extra neutron. Because of this extra neutron, heavy water is less likely to absorb neutrons crucial to the fissioning process while it collects the heat from the reactor.

How it's produced

Ontario Hydro produced its own heavy water at the Bruce Nuclear Power Development. These facilities provided heavy water for all of Ontario Hydro's CANDU reactors. The reactors at the Pickering Nuclear Generating Station initially require 600 tonnes of heavy water and the larger reactors at the Bruce

Heavy Water continued on page 64



A CANDU nuclear generating station

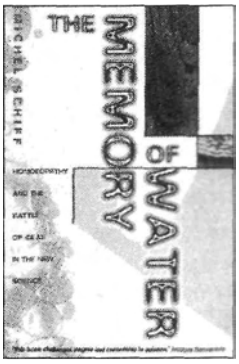
Reprinted with permission from Sidney Harris.

Book Reviews

The Memory of Water: Homeopathy and the Battle of Ideas in the New Science

by Michel Schiff

Review by Eugene Mallove



This exceptional book chronicles the "Benveniste Affair," as it came to be known, which erupted in June 1988 after Nature magazine grudgingly relented and published French immunologist Dr. Jacques Benveniste's research on the effects of extreme water dilutions of chemical agents on human cells in vitro.—"homeopathic dilutions" of antibodies producing visible, quantifiable responses in cells.[1] The conclusion of Benveniste and his colleagues in France, Israel, Canada, and Italy was that extreme dilutions of immunological agents in water—to the level that not even a single molecule of agent remained in the water—had a significant effect on cells. Moreover, they claimed, the effect was rigorously repeatable. (Another fantastic property: the measured activity of the agent on successive dilution typically follows a cyclic pattern of enhanced-effect and diminution, as a function of the logarithm of the dilution, or what is the same, the cycle number of the dilution, since dilution is to 1/10th strength each cycle.) This was nearly the first time that a foundation of the alternative medical practice, homeopathy, was brought under the laboratory microscope.

The intense scientific dispute, which surfaced only nine months before cold fusion was announced (March 23, 1989), continues to this day, a contest perhaps not quite as well known as cold fusion, the most prominent water heresy. I have long suspected that Nature's reaction against cold fusion was partly spurred by the scorn that Nature readers expressed after the Benveniste paper was published.

The battle over Benveniste's work, carried out at a premiere medical research institute, INSERM, at the University of Paris, South, became known as the "memory of water" controversy. To explain his group's results, the formerly mainstream medical researcher, some of whose scientific papers were among the most widely cited prior to the controversy, hypothesized that high dilutions could leave an electromagnetic trace of the nonexistent molecules in water, akin to a magnetic tape recording. Benveniste makes the broad claim that he has uncovered a heretofore unknown mechanism of electromagnetic communication among molecules. If real, this might be a primary facilitator of biochemical action within cells, a major discovery.


The ghostbusters report from Paris

How should the scientific establishment respond when confronted with inexplicable results? The journal *Nature* sent in its own fraud squad

Gail Vines

Nature's way: (left to right) Stewart, Randi and Maddox examine the evidence

Headline from New Scientist, August 4, 1988

Benveniste went beyond his initial reports to find astonishing evidence that this alleged electromagnetic signature of molecules could be transmitted over wires—or could be erased by intense electromagnetic fields (or by heating the dilution to 70°C). Starting from coils surrounding a closed glass ampule of material, the molecular memory trace could travel electronically in a circuit to a vial of pure water, which would then take up the potency of the original material! Corporate activities are underway to further this "internet pharmacopoeia" concept. (See Benveniste's website, http://www.digibio.com; an excerpt from the site is appended to this review.)

Author Dr. Michel Schiff is eminently suited to present the technical and sociological aspects of the controversy. A physicist by training, with a Ph.D. in high energy physics from the University of Chicago, he broadened his focus and spent years exploring the sociology of science. He is open to the remote possibility that Benveniste may be wrong, but he does not conceal his conclusion that Benveniste's work is probably correct. He participated in some replication experiments and was given free access to all the laboratory notebooks. He presents the breadth and quality of the experimental confirmations of Benveniste, which is impressive and includes double-blind experiments that Nature refused to publish. He presents compelling evidence that the prominent "failures to confirm" were in many cases sham investigations, which by design or subconscious intent were destined to fail. Schiff concludes, "... the memory of water is only one of the various signs that there is something fundamentally inadequate in our current understanding of water as a liquid, as a chemical solvent, and as a component of biological cells... In the next century, water will perhaps be considered more significant than DNA for an understanding of life." Schiff begins with a broad outline of the science and the controversy in Part I (Chapters 1-3). Readers who want more technical detail will find it in the appendices, which make up about a quarter of the book. Part II of the book, aptly titled "The Strange Behavior of Ordinary Scientists," delves deeply into the psycho-sociology of science and scientists in general. Schiff draws comparisons with other controversial science, albeit with scant reference to cold fusion. He does note a possible connection with cold fusion in the "coherent domains" theory of cold fusion scientists Prof. Giuliano Preparata and Dr. Emilio DelGuidice, which predict collective behavior of water molecules as well as phenomena in metal lattices. Martin Fleischmann alluded to these applications in his ICCF8 talks and in his obituary for Preparata. (See IE, No. 32, p. 8 and p. 25.)

Schiff's observations about scientists' behavior will ring true to those

familiar with other controversies, especially cold fusion. Schiff writes of a "selective amnesia" syndrome: "When confronted with unexplained facts, most scientists seem unable to remember previous historical examples in which such facts eventually turned out to be the starting point of important new theories; in their selective amnesia they remember only past examples of scientific affairs where proposed heresies were later shown to be unfounded." And, "Because of its religious connotation, the use of the word 'sect' in a discussion about scientists might appear inappropriate. The latter are vehemently opposed to the idea that their scientific world view might constitute a system of beliefs. But it is precisely this illusion of not having beliefs which characterizes the scientific Church. In this respect, the scientific believer is closer to the Marxist believer than to the religious one." And, "Scientists who refuse to take into account anything that might contradict their vision of law and order in natural phenomena follow a simple rule: that which cannot be understood is impossible. They are obsessed by the fear that something should escape them and one of their key words is 'control.' In politics, when the need for law and order is too strong it leads to the death of democracy. In science, it leads to the stifling of innovative research." This is but a small sample of the wisdom in this book.

The Benveniste controversy began with a publication in Nature magazine,[1] no friend of paradigm-breaking anomalies. An accompanying editorial headed, "When to believe the unbelievable," stated: "... there is no evidence of any other kind to suggest that such behavior may be within the bounds of possibility." Again the old establishment litany: No explanation, ergo the data must be flawed and the hypothesis not worthy of consideration. Yet the editorial admitted: "Indeed, during the long period since this article was first submitted to Nature, it has been plain that Benveniste has been as puzzled as many of those who have read his article by the data he reports. On many occasions, he has responded to referees' suggestions at great inconvenience to himself. When told, for example, that the experiments should be repeated at an independent laboratory, he arranged for this to be done." The results have now been repeated extensively at many laboratories—numbering now thousands of experiments—none of which interest Nature magazine today or the professional bigots of the medical scientific establishment. These positive results have all been ignored or dismissed in favor of the handful that have failed, but which were rapidly published by Nature to show that Benveniste was wrong. This is precisely the pattern of attack journalism masquerading as a scientific publication used against cold fusion in 1989-90. A crime is evident and it fits a pattern. The ever arrogant Maddox editorialized: "Certainly there can be no justification, at this stage, for an attempt to use Benveniste's conclusions for malign purposes. .," i.e. to actually use them to better human health. Maddox ridiculed the research in his editorial: "... it strikes at the roots of two centuries of observation and rationalization of physical phenomena," while by contrast praising physicists' preoccupation at that time with experimental evidence for a possible "fifth force" in nature.

The quid pro quo for the publication of Benveniste's work was Maddox's right to bring a team of investigator's to the Benveniste lab to witness how the experiments were carried out. The team included Maddox, magician James Randi, and NIH "fraudbuster" Walter Stewart. The group perpetrated a farcical rush to judgement based on their own errors and incompetence. This is documented in Schiff's book and in Benveniste's rebuttal to the Nature attack.[2] It was also revealed in an excellent half-hour BBC television documentary in 1994, one of a six-part "Heretics" series. After its sham on-site investigation in France, Nature concluded that Benveniste's work was a "delusion."[2]

Schiff's multifaceted book should be required reading for those interested in frontier medical research and in the dynamics of scientific controversy. If the Benveniste group's results and those who reproduced them were accepted as valid but unexplained, a top-to-bottom reformulation of molecular biology, medicine, and much else would be in order. It seems to this reviewer far more likely than not that Benveniste et al. have done careful research and are on to something very, very big. The scientific establishment appears—no surprise—once again to be holding back scientific progress on a fundamental issue of overarching importance, and in the process causing immense harm to human health.

Extract from Benveniste's DigiBio Homepage
http://www.digibio.com

OVERVIEW OF DIGIBIO

The principal mission of DigiBio is to bring a dear and irrefutable answer to the controversy over Dr. Jacques Benveniste's observations of what has come to be known as "the memory of water"phenomenon,that is: that water is capable of carrying molecular information (biological messages),and that it is possible to transmit and amplify this information, as can be done for sounds and music.

We consider the indicators and the stakes to be such, that it would be irresponsible not to bring forth the earliest possible explanation.

ORIGIN AND HISTORY OF THIS RESEARCH

Dr. Jacques Benveniste is at the origin of this work. Doctor of Medicine, former Resident of the Paris Hospital System, Research Director at the French National Institute for Medical Research, known worldwide as a specialist in the mechanisms of allergy and inflammation, he distinguished himself in 1971 by his discovery of Paf (Platelet Activating Factor), a mediator implicated in the mechanisms involved in these pathologies (for example, asthma).

In 1984, while working on hypersensitive (allergic) systems, by chance he brought to light so-called high dilution phenomena, which were picked up by the media and labeled "the memory of water."

The phenomenon referred to involves diluting a substance in water to a degree where the final solution contains only water molecules. With the hypersensitive systems he was using, however, he observed that this highly diluted solution initiated a reaction, as if the initial molecules were still present in the water: water kept a trace of the molecules present at the beginning of the dilution.

International scientific reaction was undoubtedly a match for the implications of this discovery: incredulity, even rumors of fraud, though an investigation made by experts came to the conclusion that it might be an artifact, but it was under no circumstances fraudulent.

From a scientific standpoint, we dismiss all of this, for the history of science has already shown us that the more a discovery runs counter to intuition and "good'common sense,the more its acceptance is long and difficult,

PRESENT SITUATION

From the first high dilution experiments in 1984 to the present, thousands of experiments have been made, enriching and considerably consolidating our initial knowledge.

Up to now, we must observe that not a single flaw has been discovered in these experiments and that no valid counter-experiments have ever been proposed. Furthermore, these experimental observations, far from opposing currently-accepted biological theories, can be integrated as an extension to them.

Finally, the probability that we are in the presence of an artifact and that our work has been erroneous for the past 15 years is diminishing day by day, and we are more and more convinced that we have brought to light a phenomenon essential to biology and to life.

On this basis, DigiBio's objective is to become the essential actor in the scientific and industrial developments which will emerge from this research.

STRATEGY

Supported by industrial and financial investors, in the last two years we have entered a phase of acceleration: setting up a company, finding capital and strengthening our team with new and complementary qualifications. The "team" is still very limited in size, but multidisciplinary, and energetically making rapid progress.

Results have been achieved: since the end of 1997, major technical progress has been made that has led to the filing of three new patents, as well as a relatively simple experimental protocol which allows validating some of the phenomena in question.

Our present strategy can be summarized as follows:

1) INDEPENDENT REPRODUCTION OF OUR EXPERIMENTS: designing experiments which can be totally reproduced outside of DigiBio's laboratories, defined by precise and rigorous protocols, clearly demonstrating the existence of up-to-now unknown phenomena by the way certain molecules interact; locating laboratories interested in voluntarily reproducing these experiments in order to demonstrate that no artifact is involved; certifying experimental results, leading to international scientific acknowledgment; formulating hypotheses about theories which could explain these phenomena.

2) INDUSTRIAL DEVELOPMENT: identifying potential industrial applications; filing patents to protect these innovations; finding industrial and financial partners in order to conduct research programs and develop industrial applications related to these phenomena.

CONCLUSION

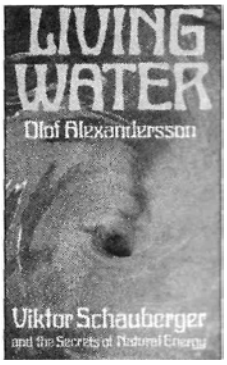
We hope we have enabled you to share our interest in the study of these phenomena; we invite you to experience with us what probably will be one of the great scientific and industrial adventures of the 21st century.

Memory of Water continued on page 67

Living Water: Vikrot Schauberger and the Secrets of Natural Energy

by Olof Alexandersson

Review by Soo Seddon



This bizarre little book introduces us to the life and work of Austrian naturalist and inventor, Viktor Schauberger, the "water magician from Linz" whose theories, his biographer friend Alexandersson tells us, have staggering implications for the future of our technological civilization.

Certainly Schauberger was ahead of his time in many respects. He knew that water was a fascinating, grossly undervalued compound and the majority of his inventions were centered around harnessing its natural powers to provide unlimited clean energy.

During his early years as a forester, he built highly efficient log flumes and went on to experiment with suction and spiral "trout" turbines designed to power futuristic vortex-driven flying machines.

As one of the earliest eco-warriors, way back in the 1930s, he founded the "green front" to campaign against deforestation and the burning of fossil fuels.

The book is vague, however, on many aspects of Schauberger's work. He appears to have led a chaotic existence with abduction, imprisonment, and constant threats from various agencies a regular occurrence. That he often spoke in riddles, made lengthy encrypted notes, and guarded his secrets in a highly paranoid fashion clearly didn't help his cause or credibility and many of his grand projects appear to have fizzled out—were declared inconclusive or, more frequently, to have been without any practical application at that time.

Yet he appeared to have received no end of encouragement. Hitler allegedly offered him a laboratory and the resources to refine his water energy theories into practical technologies and yet somehow, as Alexandersson notes, this simply "didn't happen." An un-named U.S. "expert" once declared Schauberger's work to herald the "biotechnical path of the future," but apart from an obscure reference to his expertise in the field of atomic power, no specific information about this project is given.

Whatever Schauberger's talents, I don't believe this book is sufficiently detailed and well ordered enough to promote them convincingly.

When I first read this biography several years ago, I decided to try out Schauberger's technique for energizing water in the vain hope that I could actually—for once—get a houseplant to survive and flourish. As the least green fingered person on the planet, I have to say that the only noticeable difference was the plant fed "energized" water wilted and died . . . but only did so several days later than the control specimen!

Note: The Phythagoras-Kepler School founded by the Schaubergers is currently running seminars on Energy and Eddy Research and Implosion Technology.

The PKS website is located at http://www.pks.or.at.

Polywater

by Felix Franks

Review by Jed Rothwell

"Physicists claim a much better understanding of esoteric substances like liquid helium or liquid nitrogen than they have of liquid water." (p. 6)

"Polywater as an episode in the history of science is by no means unique. Many other discoveries have failed the test of searching scrutiny, just as many have been rejected out of hand by local scientific establishments only to reappear later in other places to be hailed as major advances. There was, however, something about the enthusiasm with which this particular artifact was pursued, and denounced, that demands our attention." (p. 1)

Polywater was the name given to a substance that was thought to be polymerized water, that is, pure water molecules linked together in a solid at room temperature. It turned out to be water contaminated by silica. It was an artifact, an experimental error. If it had been real, it would have been a Nobel class discovery, and the substance might have been extremely useful or dangerous. Some people feared that a minute sample of polywater might escape from the laboratory and polymerize all the water on the planet in a chain reaction, extinguishing life.

In 1962, polywater was "discovered" in Russia by an obscure researcher who has not been heard of since. A famous Russian scientist, Boris Deryagin, expropriated the discovery as his own, and formed a research group of a dozen people who worked on it for a decade. In 1968 his work became known in the West, and research took off in the U.S. and Western Europe. A brouhaha erupted in the newspapers, which published sensationalized reports. Mainstream science journals discussed it dispassionately. Scientists rushed to try polywater experiments. Eight years later, Deryagin finally retracted his claims. Before the subject faded, 227 peer reviewed papers about polywater were published in the U.S. Seventy-five were published in the USSR, and 210 papers in other countries (Figure 9, p. 120, not shown here).

Polywater was one of the great scientific errors of the twentieth century. It was an illusion, caused by fevered imaginations, wishful thinking, and people trying to measure microgram samples with finicky, newly-invented, ultra-precise instruments. The samples were so tiny they could only be analyzed by heroic means. Results appeared to be "close to the noise" at best—and they turned out to be within the noise. It was clear from the start that the results might be due to contamination, yet this was not checked for carefully, and some of the leading scientists dismissed the concern.

This book is a gem. Written by a leading expert in water, it is a stark warning to cold fusion researchers and others who think "water memory" and other far-out unconventional ideas may be real. It is also a warning to skeptics who are quick to dismiss these ideas. The book is wonderfully well-written, and short. Only one chapter is technical; the rest is suitable for the general reader.

Franks, a chemist, shows how difficult it is to distinguish mistakes from real breakthroughs. While polywater is now acknowl-

edged by all to be wrong, it is closely related to many established areas which are right as far as anyone knows, especially relating to the structure (geometry) of water. The rough treatment meted out to polywater by the establishment hurt this legitimate, established research.

Here are some of the many unexpected aspects of the polywater story:

Water is complex and not well understood. More is known about exotic fluids such as liquid helium. Water is unique, having many strange properties, such as the fact that the density of solid water is lower than the liquid form. (In other words, ice floats.)

Liquid often does have loose structure, or geometry. A water molecule is usually oriented with four other molecules placed "more or less" at tetrahedral corners. Franks explains, "... in spite of the violent molecular motions that characterize a liquid, individual molecules are 'happiest' when surrounded by a fairly well-ordered arrangement of other molecules, the actual identities of which change constantly." This structure is affected by the interface to solid surfaces (illustration, p. 23, not shown here). When water moves away from the solid surface, the structure may continue to be affected by the surface for a fleeting instant. If this may be called water memory, no expert will dispute that it exists. The claim made by some that this kind of structure survives for days, or indefinitely, is not supported by conventional knowledge.

One researcher told Franks she had a wonderful time working on polywater, and she considers this work the high point of her career, even though her results were all negative.

What are the lessons for cold fusion and other claims?

This book will make any thoughtful supporter of cold fusion nervous, although it does describe many reassuring differences. The biggest difference is that while cold fusion is sometimes difficult to detect, in many cases it produces a huge signal. It does not require specially designed, expensive, or state of the art instruments.

The most important lesson is that independent replication at a high signal to noise ratio is essential. The experiment does not need to be "easy" to replicate. Experiments do not have to produce the same results. Some results may be marginal and extremely difficult to detect. But when all results are difficult to detect, you should have serious doubts about the reality of the claim.

Other lessons: Do not jump to conclusions.

Many of the prominent polywater researchers were well-known in their own fields but relatively ignorant about advanced research in water.

Even experts can make a mistake, and keep making it for years. Deryagin was "an eminent and highly respected surface chemist." When others could not replicate him, and a researcher from the U.S. Naval Research Lab (NRL) expressed doubts about the existence of polywater and wondered whether it might be caused by contamination, Deryagin dismissed the possibility and insisted the NRL replication was not up to his high standards. He also made a fatal mistake, investing too much of his own life and prestige in the project: "Deuryagin [said] that he had been investigating it over nine years and currently had twenty-five scientists working on it, and he would not put that much effort into an artifact."

Beware of results that are difficult to measure. A result may be difficult to obtain, but it should be easy to measure. Polywater was thought to be extremely difficult to detect: "With never more than a few micrograms available, ingenious analytical methods had to be devised if definitive and quantitative results were to be obtained ... The instrumentation required for much of this work was of the most advanced kind, only available at a few centers in the United States. In the end the analysts ... [demonstrated] that polywater really contained little water, and that its composition was quite variable." (p. 87) Unfortunately, many cold fusion experiments are also "close to the noise," and some of the latest ones in Italy are being conducted with small or even microscopic devices, which exacerbates the problem. But in several leading experiments, cold fusion effects are easily detected with ordinary instruments. As Mike McKubre of SRI International says, when the effect occurs it is "neither small nor fleeting."

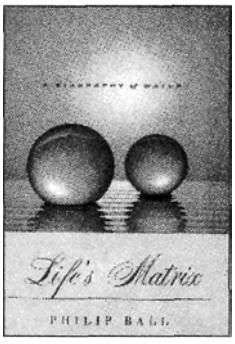
Cooperate! The polywater mistake was prolonged because scientists did not cooperate or share information enough. Samples were not sent from one lab to another. Results were kept secret. Deryagin did send samples to another lab in 1968, and the results were published in Russian, but never translated into English. The other lab concluded that the samples contained as much organic contamination as water, and no evidence of polymer chains was found (p. 111).

This book is occasionally still available at "overstock" sales by MIT Press in its store in Cambridge, Massachusetts. Wherever you are, it would be well worth the effort to track a copy down and read it for its lessons about science at the frontier.

Life's Matrix:
A Biography of Water
by Philip Ball

Review by Soo Seddon

That water is a mythical substance and far more than merely the sum of its components inspired Ball to write a comprehensive biography of this remarkable life-giving chemical compound which covers two-thirds of our planet's surface yet only one-tenth part in a thousand is naturally palatable to humans.



He sets out a detailed CV for water and examines every known feature of its creation and behavior, from the basic hydrological cycle through the formation of glaciers, icebergs, geothermal springs, and tsunamis right up to the techniques employed by biological organisms to utilize and preserve their personal water supplies. While it is water which makes the Earth unique, its abundance in solid form throughout the solar system and its detection in the spectra of the Sun is well-documented. Ball also provides a concise overview of the history of water research, touching upon alchemy, early atomic theory, and the discovery and naming of oxygen.

Water, as he states, is the most studied and least understood substance on Earth. One chapter is devoted to its many anomalous properties, and is illustrated with cute little drawings of the molecular structure featuring hands grasping ankles to explain the nature of the hydrogen bond.

All in all, a reasonable book and a good introduction to the subject but not, as one would possibly expect from a member of the editorial team of Nature, written entirely without prejudice. I referred the chapter outlining the discovery of cold fusion on to to my esteemed colleague, Jed Rothwell, who has corrected Ball's severely flawed interpretation of the 1989 Pons and

Fleischmann announcement in an addendum to this review.

Ball isn't quite totally intolerant of innovative theories; he does mention the work of James Lovelock and Gaia with some favor, but is summarily dismissive of Schauberger and Benveniste and tends to quote the Book of Job a lot.

He verges on realism, however, when he states that hot fusion "requires such extreme conditions it is impractical even to consider achieving it on Earth." A pity he and his scientific colleagues weren't more dismissive of the project before billions of dollars were squandered upon it.

As a peer reviewer himself he is, naturally, scathing of "the dawn of scientific disclosure by press release," a phrase he uses in his chapter on polywater, but which he also very closely applies to the work of Pons and Fleischmann. When once asked why many apparently "off the wall" ideas weren't followed up by the science fraternity he bemoans that it simply isn't worth it if "the last twenty times you did decide to follow up a claim it turned out to be moonshine." An intriguing insight into how the peer review selection process reallv works, perhaps?

Our magazine does get a dishonorable mention (fortunately, there's no such thing as bad publicity) in his sneering chapter on the work of Jacques Benveniste. On Maddox's "debunking" of Benveniste for "striking at the root of two centuries of observation and rationalization of physical phenomena," he declares that such dispassionate treatment was essential or we'd be "forever seeing unicorns telling us that there is infinite energy available for free," followed by a footnote stating: "Not for nothing is there still in circulation a magazine for cold fusion enthusiasts called Infinite Energy."

Naturally, I shall be forwarding him a copy at this issue just to reassure him that, unlike the unicorn, we're still alive and kicking.

Jed Rothwell on Technical Aspects of Life's Matrix

Soo Seddon mailed me a seven page section of Philip Ball's Life's Matrix: A Biography of Water, describing cold fusion. I have not seen the rest of the book. This section is riddled with errors, baseless rumors, confusion, scientific impossibilities, and unsupported opinions. I count seventeen major errors, such as:

"Pons and Fleischmann claimed that the deuterium released by electrolysis of heavy water must have become concentrated so densely within the palladium lattice that it had undergone fusion . . ." This is a ridiculous oversimplification. In a fully loaded palladium lattice, deuterons are held farther apart than they are in water. The theoretical models proposed by Fleischmann and others are far more complex than this.

"No one could duplicate the findings clearly and consistently." ... The National Cold Fusion Institute (NCFI), "was finally and sheepishly shut down in 1998." The Institute was run by F.G. Will, one of America's pre-eminent electrochemists. There is nothing "sheepish" about him. The NCFI results were revolutionary and incontestable. Researchers at NCFI established beyond any doubt that cold fusion produces tritium, a nuclear product. Twenty different experiments were performed at the Institute. Nine or ten of them produced elevated levels of neutrons or tritium. With the best method, developed in the later stages of the project, four out of four heavy water experiments produced significant tritium, while none of the light water controls did. Tritium enhancements up to a factor of 52 were observed. One hundred and fifty unused samples of palladium were tested extensively, by dissolving in acid and other methods. None of these samples yielded measurable levels of tritium. (See: F.G. Will, K. Cedzynska, C. Yang, J.R. Peterson, H.E. Bergeson, S.C. Barrowes, W.J. West and D.C. Linton, National Cold Fusion Inst., University of Utah, USA, "Studies of Electrolytic and Gas Phase Loading of Palladium and Deuterium," presented at Second Annual Conference on Cold Fusion, June 29-July 4,1991, Como, Italy.)

Despite these magnificent results, the NCFI was shut down because by the time the research was finished and ready to be published, cold fusion hysteria prevailed and journals summarily rejected cold fusion papers.

"The experiment was simple in principle ..." Richard Oriani, one of the top U.S. electrochemists, said this is the most difficult experiment he has performed in his fifty-year career. Every electrochemist who has knowledge of the experiment agrees. Several hundred electrochemists have successfully replicated the excess heat, and they have all said that it was a difficult experiment.

"The phenomenon were never more than barely detectable." At the leading laboratories in this field, the signal-to-noise ratio ranges from 10 to over 100 Sigma for excess heat and tritium. Recently, a post-experiment sample of gas was tested for tritium at McMasters University, one of the world's leading laboratories specializing in measuring light isotopes. The sample turned out to have a thousand times more tritium in it than any previous sample submitted to that mass spectrometer. There was so much tritium it swamped the instrument, which required two months of repairs before it could be used again.

"Pons and Fleischmann made much of their claimed meltdown in one experimental run, but only later confessed that no one had ever witnessed it." In every published description of this event, and on every occasion I have heard about it from Fleischmann in person, he has always said that the event occurred overnight when no one was at the lab. There was no "confession," and no facts about the event have been hidden.

"Ad hoc excuses were the norm, from vague 'recalibration' of spectra to the idea that some electrochemical cells were inherently 'dead' while others were 'alive.'" The cathodes, not the cells, are either "dead" or "alive," and there is nothing vague or controversial about the distinction, which predates cold fusion by many decades. Cold fusion with palladium requires "high loading" (a high ratio of hydrogen or deuterium to metal). So do many other well-established chemical and electrochemical phenomena, such as hydrogen filtration, metal embrittlement and corrosion research studies, and many catalytic processes. The reasons why some metal samples load well, while others do not, has been the focus of intense research since the 1930s. A great deal more about the subject has been established in the last ten years by the cold fusion scientists.

A few differences of opinion between Ball and myself: "When the first [Pons and Fleischmann] paper finally appeared, it was distressingly short on crucial details." You would not expect a short paper of this nature to have many technical details. Ball does not say that after 1989 thousands of pages of technical details have been published.

"Cold fusion... collapsed in a welter of calumny, bad blood and libel threats. Ultimately its fate was sealed for the same reason that all that bad science eventually meets its demise: irreproducibility." In my opinion, cold fusion never collapsed. As far as I know, there was only one brief libel threat, not "threats." A great deal of science both good and bad is irreproducible, or terribly difficult to reproduce. Well-known examples include the top quark and cloning sheep. Only a few labs are capable of cloning sheep,

and their success rate was initially 1 out of 227 attempts, which is much lower than the success rate for the excess heat cold fusion experiments. Ball dates the end of cold fusion with the closure of the NCFI, in Utah. As noted above, this project achieved 100% reproducibility, at a very high signal-to-noise ratio.

"It takes relatively little theory to show that fusion of deuterium absorbed in palladium should be utterly out of the question." This is common knowledge. Every cold fusion scientist will acknowledge this point. However, science is ultimately based on experiments, not theory, and when replicated, high Sigma experimental evidence conflicts with theory; the evidence always wins.

"The [Bockris] claims were to become particularly notorious, culminating in accusations that Bockris' experiments were being spiked with tritium by persons unknown." The name of the person who allegedly spiked the cells is Nigel Packham; this was known from the time the allegations were made. An official inquiry at the University cleared him of all charges. (See full story in IE, No. 32.) An experiment performed at Los Alamos proved that it would be impossible to spike the cells in the manner he was accused of. Gary Taubes, who made the accusation, is notorious; Bockris and Packham are blameless.

"One of the most extensive attempts to verify the Utah claims was made at Harwell by a team led by electrochemist David Williams." I would call this the least "extensive" of the published attempts, or the most extensive unplanned fiasco in 1989. It was performed in a few months, mainly by inexperienced graduate students working on their own. Ph.D. electrochemists who understood the Pons-Fleischmann claims, and who have experience in calorimetry, generally devote six months to one year preparing equipment and calibrating before performing the actual experiment. The method of calorimetry selected at Harwell is not recommended for this type of study, because it is very noisy.

Dr. Peter Graneau on Life's Matrix

This is a fascinating book, well-written by a senior editor of Nature. Sketches of the history of chemistry alone make it worth reading. It is not merely a historical account. Philip Ball's story dashes from here to there and back and forth through the centuries. The book holds the reader's attention like a detective story. As in all good mysteries, it leaves a number of questions unanswered and some answers are questionable.

As a byline, the book reveals a little of the maneuvering behind the doors of the premiere science journal, Nature. To please the professors, a way can always be found to suppress unwanted scientific results. Cold fusion receives a cold dousing. The liberation of H_2O-H_2O bond energy by fog explosions is ignored. The chief editor of Nature headed an inquiry, with a magician at hand, to debunk dilution experiments.

Water is probably the most remarkable, most studied, and least understood substance known to man. The author calls it the matrix of life. He implies much more than that life started in water. Ancient Greek philosophers made water one of only four elements which form our world. Two-thirds of our bodies are water. Why do we not slosh around like a wineskin, asks Ball. The wonderful subdivision into cells saves us this embarrassment. The fluid inside the cells is mostly water in which swim proteins, DNA, sugars, salts, acids, and hormones. In discussing the happenings in the cell bags, the author provides a glimpse at the incredible complexity of biochemistry.

Water is probably the most remarkable, most studied, and least understood substance known to man.

The biography of water has gaps. There is no mention of the mystifying way in which water defies gravity. Huge quantities of it rise to the top of the highest mountains whence they come crashing down over waterfalls and through hydroelectric turbines. This beautifully clean energy cycle owes its existence to the sun. So much we know.

Do you realize that a birch tree can perspire eighty gallons of water per day through its leaves? All this water flows vertically upward in the stem, driven by something Ball calls negative pressure. This is tension and water scientists refer to it as stretched water. It occurs because the H_2O molecules attract each other. The humidity of tropical forests is the result of water transpiration from leaves. Deforestation dries the atmosphere and has a detrimental effect on the fertility of the soil.

Even more surprising, but of less practical significance, Ball reveals that between -140 and -120°C water can be liquid with the viscosity of asphalt. Above -120°C it freezes once more. Ice comes in ten varieties (densities) depending on the pressure exerted on its surface. For example, ice-VI requires a pressure of at least 6,500 atmospheres and melts immediately after the pressure is removed. Ice-VII can be heated to 100°C without melting, provided the pressure is 22,000 atmospheres. In his amusing way, the author explains that 20,000 atmospheres are equivalent to the weight of 40,000 elephants piled on one square meter. More seriously, if all the ice of Greenland and Antarctica were to melt, the sea level would rise by 200 feet. Venice is already in deep trouble with gondolas plying St. Mark's square. At the other extreme, ice ages can drop the sea level by 360 feet. As Ball observed, one could have walked from Australia to New Guinea without getting one's feet wet.

The book discusses the well-known anomalies of water. Icebergs float in the sea, while in more normal liquids the solid form of the compound sinks to the bottom. Water has relatively high melting and boiling points, which just span the narrow temperature range in which life is possible. The great heat capacity of liquid water, its large dielectric constant, and appreciable surface tension have many engineering consequences. It is a fabulous solvent and a good electrolyte. In no small measure do these unusual properties of liquid water depend on the "hydrogen bond." This term was coined by the American chemist Gilbert Lewis in 1920. One of his graduate students suggested to him that while the hydrogen atoms of the H_2O molecule are strongly bonded to the much larger oxygen atom, there also exist weak O-H bonds between oxygen and hydrogen of neighboring molecules. The weak bonds became known as the "hydrogen bonds." In recent decades hydrogen bonding has assumed a central role in water science.

The book lucidly explains hydrogen bonding with the cartoon of Figure 6.5, depicting a group of ugly oxygen dancers. The two arms of each dancer are the firmly attached hydrogen atoms of the H_2O molecule. The two feet of each dancer are positions to which hydrogen atoms of adjacent molecules can weakly bond. Each dancer must twist the hips through 90 degrees, so producing a three-dimensional network which gives water its tetrahedral structure. The rules of the dance are that only hands can grip feet and all hips must be twisted. In this way each H_2O molecule can have up to four hydrogen bonds. For readers preferring a scientific diagram, Ball provides Figure 6.4b. The lone pairs of electrons are the feet. The diagram clearly depicts the tetrahedral geometry with four apexes surrounding the central oxygen atom.

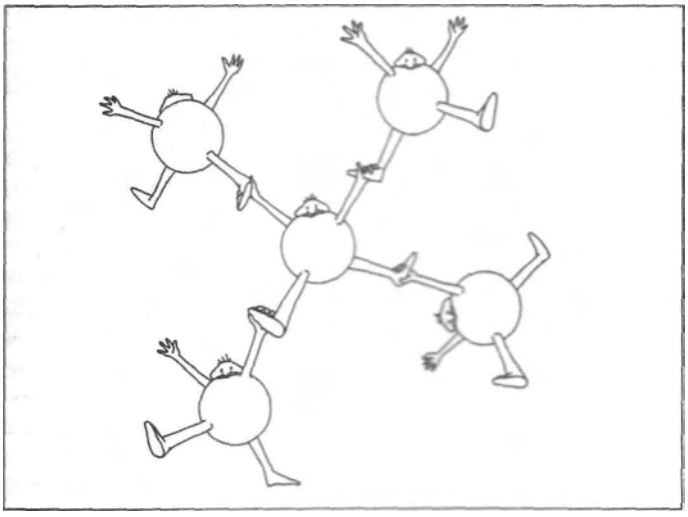


Figure 6.5. Water Molecules—with hands representing hydrogens and feet representing lone pairs of electrons—perform a dance that involves grabbing neighbors by the ankles. These clasps, due to hydrogen bonding, lead to a tetrahedral arrangement of neighbors around each molecule. This is the central motif of the structure of water, and the key to all its anomalous properties.

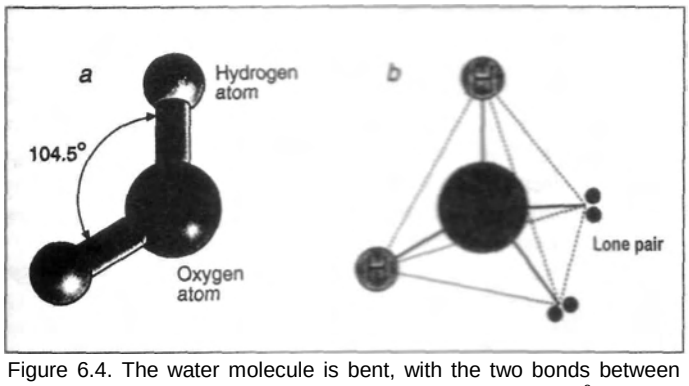


Figure 6.4. The water molecule is bent, with the two bonds between oxy gen and hydrogen splayed at an angle of 104.5° (a). To understand the structure of liquid water, we must also take into account the two "lone pairs" of electrons on the oxygen atom. The hydrogen atoms and the lone pairs sit more or less at the corners of a tetrahedron (b). At the molecular scale, the structure of water is imprinted with this tetrahedral geometry.

This has become the signature of liquid water and ice structure.

In the world of atoms and molecules the liquid state of water is not as well-understood as the solid state of metals. The mystery of the liquid is that all molecules appear to be in continuous thermal motion relative to each other, breaking intermolecular bonds all the time and yet, at any given instant, they maintain a high degree of tetrahedral order. Pressure does not foreshorten the arms and legs of dancers. Increased density is the result of overlapping tetrahedrons. The intermolecular bonds which keep the liquid together are of course the hydrogen bonds. To evaporate water, these bonds must be broken and it takes the latent heat to break them. Like all chemical bonds, hydrogen bonds are also associated with a certain amount of stored potential energy. Neither Ball's book nor textbooks on physical chemistry give as a due as to how much energy is stored in the bonds and could be liberated if the forces of hand-foot attraction were switched off by electric means.

This is exactly what we do in electric arc induced cold fog explosions. An early paper on our research in this field was submitted to Nature and returned, without peer review, as being of

Graneau, Life's Matrix continued on page 67

Free Energy, More Fish, and Weather Control

J. Gridelin

Ever since the price of diesel fuel passed the price of gasoline, I've been flashing back to the good old days of the original OPEC oil crisis of the early 1970s. (Just how many hundred years of coal and natural gas were there anyway, and why'd we just waste a quarter century without really doing anything?)

I think I'll just step to the fore and solve several problems at once. Just like it says in the title ... No, seriously.

There really was a rather mild-mannered method of generating electricity mentioned way back then, called ocean thermal conversion.

It uses the temperature difference between the top of the ocean and the abyss to generate a little electricity. It's not that big a temperature difference (typically 25°C, down south, in the tropics) but the ocean is big and the heat source is free. Generators are allegedly in the megawatt range and prone to rusting. It's apparently a big investment in equipment to get a mere megawatt, which is one of the reasons it hasn't caught on.

But it has a couple of side benefits which mean it might catch on big time, seeing as in the future we'll want a lot of, electricity to make the hydrogen we'll need for our fuel cell cars.

One: colder surface water leads to more dissolved oxygen, which makes the ocean more inhabitable for fish. Sushi, anyone?

Two: colder surface water won't evaporate as much, and that has an effect on the weather.

Warm air, as we all know, rises and moist air rises; warm, moist air, over the tropics in August through November, rises so fast air is pulled in from far enough north and south that hurricanes result. (Hurricanes are one of nature's ways of evening out energy differences. The same nature, of course, that evened out the dinosaurs with a meteorite.)

I forget the megawattage of a hurricane, but it's one megawatt less for each ocean thermal generator out there.

The same reasoning seems to apply to tornadoes, which seem to arise when moist air from the Gulf of Mexico intersects dry air from out west.

Cool off the Gulf of Mexico and maybe this won't happen. (Of course, it might not rain in the southern U.S.)

Well, there's a lot of ocean out there, and it'll take a lot of ocean thermal generators to have a big effect. But even a small effect would knock a hurricane back to being a more survivable tropical storm.

You've got to believe they're sick and tired of rebuilding Florida every few years.

This article first appeared in the May 10,2000 issue of Green Mantle magazine (www.greenmantle.com).

Deep Sea Reverse Osmosis: The Final Quantum Jump

Donald C. Bullock* and William T. Andrews

Abstract

This paper presents the rationale and plan for utilizing the ocean depths to produce potable water at the lowest economic and environmental costs. After more than fifteen years of land-based reverse osmosis (RO) development, commercial seawater RO plants can no longer be dramatically improved with regard to energy consumption, plant costs, and environmental impact.

The final quantum jump for the improvement of seawater RO will involve membranes submerged in the ocean depths to achieve:

1) Energy consumption levels at less than twice the theoretical energy of separation.

2) Plant cost reductions of over 50%.

3) The elimination of almost all current environmental impacts of desalting.

The authors detail the advantages of Deep Sea RO and describe the current project plan to achieve the commercialization of the concept in the Caribbean Basin. Additionally, for current seawater RO operators, the Deep RO is valuable in understanding energy consumption as it relates to energy recovery systems. As ecological models, Deep RO systems identify the end point of environmental impact goals: no intake, no outfall, no plant.

Introduction

The purpose of this presentation is to explore the final quantum jump in commercial seawater desalination as it relates to reverse osmosis, energy consumption, simplicity of plant design, and reduction of environmental impact. The key word here is "commercial," which mandates a prime objective to produce desalted water at the lowest cost per quantity of water produced. It is the authors' contention that this final quantum jump will be realized by the commercial implementation of Deep Seawater Reverse Osmosis. Deep Sea RO is the placement of reverse osmosis membranes at ocean depths to obtain the driving pressure for desalination. Desalted product water is then pumped to the surface for distribution.

A three-phase project plan for realization of this concept is presented to assist in the examination of the pros and cons associated with its commercial development. The examination of this project plan allows for the development of models for land-based plants with regard to energy recovery, simplicity, and environmental impact. Finally, the obstacles to Deep Sea RO are reviewed.

> .. . the almost pathological resistance to major technological change in the water industry will surely bring out the detractors with all their imagined fears and reasons for not pursuing the concept.

Brief Historical Overview of Desalination Improvements

What have been the quantum jumps of improvement in desalination over the last fifteen years?

Early Seawater Reverse Osmosis: The jump from thermal to RO desalination occurred in the 1970s with the experimental and small commercial RO plants based on the advent of hollow fiber membranes capable of surviving pressures in the 800 to 900 psi range and producing potable water with a single pass. Development engineers then began to learn the hard lessons of pre-treatment, high-pressure materials, and membrane life performance. Commercially, the market was small resorts, offshore drilling platforms, and construction sites. Energy consumption in the range of 40 kWh per 1,000 gallons (40 kWh/kgal) and ease of operation made RO plants highly competitive with the best of the thermal processes, particularly for small remote plants. However, membraned replacement costs could easily equal energy costs.

The 1980s: During the latter part of the 1970s and most of the 1980s, the quantum jumps were made up of a series of incremental improvements, such as higher operating pressures, higher recoveries, attention to pre-treatment requirements, and improved membranes. The demand for larger plants and the introduction of spiral membranes during this period set the stage for the current quantum jump. Because of the highly competitive nature of the spiral membrane industry their lower production costs, and their ability to handle difficult feed waters, plant operators have seen their membrane replacement costs dramatically reduced, while membrane performance has improved. For a variety of reasons spiral membranes lend themselves to large sized plants and the current quantum jump to energy recovery. Towards the end of the 1980s, operating pressures had risen to the 900 to 1,200 psi range, recovery rates had risen to the 35 to 55% range, and the total power consumption had dropped under 30 kWh/kgal. Most important, large plant membrane replacement costs had fallen below 25% of the energy operating costs.

Current Improvement Efforts: The current quantum jump in land-based RO systems is being driven by two major factors. First, some in the RO industry have discovered that there is more money to be made selling water than manufacturing plants. Second, with the lowering of membrane replacement costs, the major target available to reduce operating costs is energy consumption. Depending on the local cost of power, energy can represent well over 50% of the total operating costs. If you're selling water, this is your major concern. Thus, the current quantum jump is concerned with energy recovery (ER) systems. A goodly variety of these ER systems are currently being tried—everything from pelton wheels, to back-running pumps and work exchangers. The ER systems are expensive and troublesome to operate, but their potential economic returns are dramatic. The most efficient are the work exchangers.

A work exchanger attached to a RO plant can cut the energy consumption by half or even more if the RO's recovery rate is low. This fact gives rise to a very strange phenomenon that will eventually see spiral membranes replace hollow fiber mem-

branes. Hollow fiber membranes, such as DuPont, pursued the path of higher and higher operating pressures and recovery rates to obtain more product water from their relatively more expensive membranes. As energy recovery systems come into their own, DuPont will discover that their efforts were in the wrong direction. With the advent of efficient ER work exchangers, energy reduction will dictate lower operating pressures, lower recovery rates, and greater membrane surface areas. Since spiral membranes are generally less expensive, they are expected to be the membrane type of choice.

Today's RO plants with ER systems are operating near the 15 kWh/kgal level and can probably be improved down to the 12 kWh/kgal range, if operating pressures can be reduced towards the 800 psi level. Much below this total operating energy level will involve undesirable tradeoffs for land-based RO systems.

The Future: The final quantum jump will be into the ocean depths. Submerged Deep Sea RO plants will have initial energy requirements in the order of 8 kWh/kgal. Ultimately, Deep Sea RO holds the promise of energy requirements that are less than two times the theoretical energy of separation. At that point, the targets of cost reduction may change.

In this Deep Sea RO environment, recovery rates will approach zero and polarization concentrations will go to minimums, not just for the upstream membrane element, but for all membrane surfaces. Perhaps the future Deep Sea RO membranes will give us quality product water just below the osmotic pressure depth. For current day RO operators, Deep Sea RO holds the promise of newer having to pump seawater or struggle with ER systems.

The Current Deep Sea RO Development Project

What is "Deep Sea RO Desalination" and what is this project to prove, develop, and commercialize the concept?

In brief, it is the system utilizing RO technology to pump fresh water from the ocean's depths. It will also offer the desalination of seawater at the lowest costs and with the least environmental impact. The concept long known to desalination experts, is now being developed by The International Institute for Water Purification and others.

Desalination by RO is the process of choice for most of the world's desalination applications. Current seawater RO systems pressurize seawater to the 800 to 1,200 psi range, thus enabling RO membranes to produce potable water. By placing the membranes at ocean depths of 1,200 to 2000 feet these membranes can deliver fresh water to standard submersible pumps for transport to the surface.

Compared to the current state-of-the-art, Deep Sea RO uses half the energy and requires an estimated half the capital costs. Since Deep Sea RO uses no real estate, no chemicals, no pre-treatment, no intake wells, and no brine rejection outfalls, it is as environmentally friendly as rain, but more dependable. Maintenance-wise, Deep Sea RO has only one moving part the submersible pump.

Project: This development project by The Water Institute, a non-profit organization, consists of three phases: proof of concept, commercial feasibility, and commercial.

Phase I: The "proof of concept" phase will consist of lowering a vessel and membrane to a depth of 2,000 feet for a short period, then retrieving the rig to the surface aad demonstrating that the vessel contains fresh water. In this case, the 2,000 foot depth will provide the driving force to fill the vessel which maintains the atmospheric pressure. This phase is required to make non-RO experts appreciative of the potential value of the concept, to gain public support, and to help marshal support for Phases II and III.

Phase II: In the commercial feasibility phase, a larger vessel will contain a 10 horsepower pump connected to additional membranes. The vessel-pump configuration will be connected to the surface via a water line and electrical cables to operate continuously. This configuration will allow engineers to optimize the various parameters of temperature, depth, water quality electrical poser consumption, etc. It is anticipated that this unit will produce 12,000 to 24,000 gallons per day, depending on depth and membrane configuration.

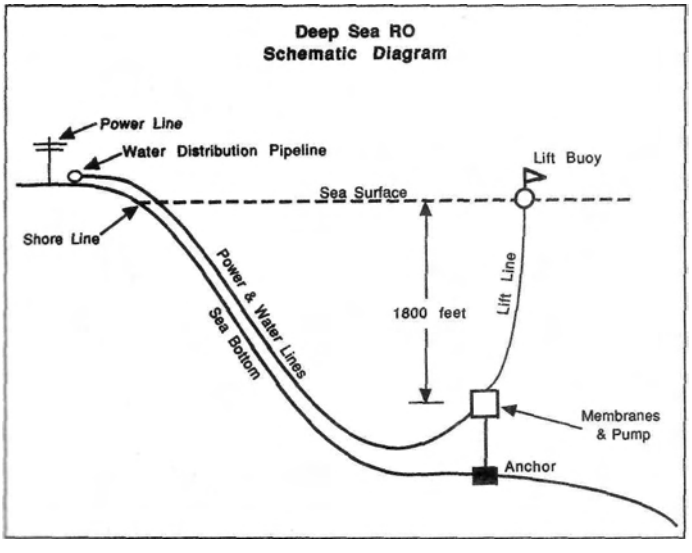
Phase III: The commercial phase will set a series of units in the 100 horsepower range to produce 250,000 gallons per day each. The number of units will be determined by local water demand. Because of the low capital costs of the units, it is anticipated that some of the units will only be operated during the night time to flatten the power demands on local electrical utilities. The Water Institute will turn these units over to commercial concerns for ongoing operation.

Some of the Advantages of Deep Sea RO

Initially, one of the authors thought to title this section "The Pros and Cons of Deep Sea RO," but after fifteen years of championing its cause, he believes his view of the concept is too biased. Additionally, the almost pathological resistance to major technological change in the water industry will surely bring out the detractors with all their imagined fears and reasons for not pursuing the concept. Some have already hinted at the monsters and microbes that will eat the membranes. Others claim that storms and currents will sweep the system away. Still others claim that it shouldn't be tried because it is applicable in only a few places. So, from an admittedly biased source, here is a short list of the real and imagined advantages of Deep Sea RO compared to land-based desalination systems.

No land-based facility is required: Land-based plants require real estate and industrial-type buildings with all of their attendant requirements of security, safety, environmental, and logistical considerations. The Deep Sea RO system is completely submerged, with only a power and water line coming ashore. These two lines and the offshore marker buoy can be easily protected from storms such that potable water supplies are not interrupted during violent weather.

Seawater feed and brine injection wells are eliminated: The elimination of these intake and rejection subsystems, together with pre- and post-treatment subsystems, makes Deep RO less expensive and environmentally gentle. Deep Sea RO also eliminates all requirements for chemical injections, and removes the



possibility of obnoxious off-gassing, such as hydrogen sulfide.

High pressure seawater pumping, piping, and pressure vessels are eliminated: With the exception of the product connections and the vessel containment for the fresh-water pump, no high pressure metal containments are required. Additionally, in these few minimal areas all metals can be isolated from direct contact with seawater.

Deep Sea RO requires no energy recovery systems: All land-based energy recovery systems attempt, unsuccessfully, to approach the efficiency of Deep Sea RO. While land-based ER hardware represents high capital and maintenance costs, Deep Sea RO represents the ultimate ER system without a single piece of hardware.

Complex control and monitoring systems are eliminated: Under steady-state operating conditions, Deep Sea RO requires only the monitoring of the power consumption, product flow, and product quality. The only controls available are power on/off; lowering and raising of the membrane array; and applying minor back pressure to the product flow.

Capital and operating costs are cut in half: The quantum jump to Deep Sea RO is represented by the reduction in hardware components and the reduction in power consumption, which in turn results in a 50% or more reduction in the total cost of desalination.

Deep sea RO is almost operator-proof: Not only are there no valves within the entire system, no known operators or other persons can get to the plant. Operations managers of complex process plants of any kind are keenly aware of the problems caused by the interactions of the plants and personnel. Repairs, manipulations, and improvements in one component in a complex system by engineers or operators often result in major failures of other components.

Maintenance intensive components are eliminated: Recent experience with large land-based RO's incorporating ER systems and sophisticated control systems indicate that the following are high maintenance items: ER's, control systems, instrumentation, seawater pumps, metal-to-seawater contact areas, and chemical adjustment subsystems. Additionally, valve and accumulator malfunctions cause many failures. Since none of these components exists in Deep Sea RO systems, it is reasonable to expect fewer maintenance problems. The single moving part in Deep Sea RO, the standard deep-set fresh-water submersible pump, has a long history of trouble-free performance. Experts in deep sea mooring systems do not foresee major problems in positioning the membrane arrays.

The Obstacles to Deep Sea RO

As with any change or quantum jump in technology, there are obstacles and resistance. So it is with Deep Sea RO. Most of the technological objections are just typical challenges and potential problems associated with any new development. Many objections are put forth by those who fear or don't want a change in the status quo for some undisclosed reason. There are, of course, some who will have honest reservations.

The major technological unknown: Will the seawater side of the membranes disperse salt concentrations quickly enough to avoid the use of fans? Given the 0.25 knot minimum current and the fact that a square foot of membrane area has over two hours to make one gallon of water, it is reasonable to expect this may not be a problem. It is a primary purpose of the feasibility test to answer this question. Should this be a problem, there are a number of possible solutions.

Other potential technical problems: The feasibility project will determine the extent of the following potential problem areas: anchoring of the system, dissolved gases, and membrane arrays.

Non-technical obstacles: The absence of public, political, governmental, and financial support will represent major obstacles to the realization of Deep Sea RO. A number of private companies may have highly vested interests in maintaining the current status quo in desalination. Also, the current difficulty in obtaining enforceable patent rights for the process will make private R&D financing difficult to obtain.

Conclusion

Why deep RO now?: There are several reasons that the present is the appropriate time to seriously pursue the commercialization of Deep Sea RO. Some of these reasons are technical, some economic, and some environmental.

Until recently, most desalination experts considered the membranes to be too delicate to be subjected to an open sea environment. Like the general public, experts associated the word "membranes" with something like "mucus membranes" of biological life forms. The experience with early membrane failures reinforced this perception that RO membranes are delicate species that must be protected like fragile life forms. The authors' recent experience with Filmtec seawater membranes convinced them that these RO membranes are relatively indestructible and can tolerate abusive conditions. In fact, compared to the abuse these membranes receive in many production plants, the deep sea environment will be far more gentle.

Because of the ruggedness of today's commercial membranes and the emphasis on reducing environmental stress, the development of this Deep Sea RO concept should be initiated at appropriate test sites. If the concept can be fully commercialized, the savings per year for an island economy will nearly equal the total capital cost of the system. Few investments offer this percentage and magnitude of return.

The Water Institute, 34 Logging Hill Road, Bow, NH 03304

Heavy Water continued from page 54

Nuclear Generating Station began with 800 tonnes, equal to a year's production at the Bruce Heavy Water Plant. After that, the reactors were "topped up" each year with about five tonnes—less than one percent of their total requirements. At the Bruce Plant, heavy water was extracted from water pumped from Lake Huron. Roughly 340,000 tonnes of lake water are needed to produce one tonne of heavy water. After passing through the system, water is returned to the lake, depleted of 19 percent of its heavy water molecules. This discharge has no effect on the quality of the water in the lake. Heavy water is produced using two processes. First, a series of chemical enrichment processes using hydrogen sulphide gas (H_2S) increases the concentration of heavy water in the water to about 35 percent. The second step is a distillation process which brings the water to 99.75 percent or more heavy water. Once the heavy water is in use, small amounts may leak from the reactors. Most of the heavy water that escapes from the reactors is collected in sumps or vapor dryers. Because each generating station has a small heavy water upgrading facility it is possible to repurify this heavy water and introduce it back into the system.

Safety is top priority

Because the production of heavy water involves the use of a toxic gas, hydrogen sulphide, safety is a top priority at any heavy water plant.

Although small leaks of hydrogen sulphide may occur from time to time, most of the escaped gas is collected by recovery systems, while the remainder is safely expelled by directing it to a special flare tower where it is burned off. The risk of dangerous concentrations of hydrogen sulphide gas reaching the community is very remote. However, should such an unlikely event occur, emergency plans are in place to ensure the safety of the public and employees.

Review of the Lafree Electric Bicycle

by Jed Rothwell

Lafree Electric Bicycle

These are exciting times for electric vehicles. New models of electric and hybrid cars are announced every month, and thousands are being sold. Yet I have never encountered one on the road. Although Honda and Toyota promote their hybrid vehicles with expensive television advertisements, their efforts seem more like a public relations stunt than serious marketing.[1] They are selling fewer than 10,000 vehicles in the United States, and the waiting lists are so long that some dealers will not accept new names. I was surprised to learn that another kind of electric vehicle is already available: the electric bicycle. Some models are inexpensive, well-engineered, and well-suited to a short commute.

After investigating several electric bicycles on the Internet, I recently purchased a Lafree model 602 XU, manufactured by the Giant Bicycle company of Taiwan.[2] Many of the other brands appear to be kludges, with electric motors added to regular bicycles as an afterthought. The motors are often coupled to the tire with a friction roller. This is inefficient, and it probably wears out the tires. The Lafree is engineered from the ground up to hold the battery and motor, with a heavy-duty frame and brakes. The motor is coupled to the pedal crankshaft. The local dealer said he tried a variety of electrical bicycles from different makers, and he recommended the Lafree. A German not-for-profit organization called Extra Energy V.i.G. rated it best out of thirty brands.[3]

I have been commuting a short distance (2.7 miles one way; 4 km). The trip takes 9 minutes by car and 15 minutes with the electric bicycle. I performed 20-mile test runs on a level track and in suburban neighborhoods. I conclude that the Lafree may be more practical than an ordinarv bicycle for many people, especially middle-aged or older people. It is slower than a motorcycle or a moped, but much faster than walking. It may be safer than a regular bicycle because it encourages you to stop at stop signs (because starting up again is effortless), and it accelerates rapidly and keeps up with automobile traffic up to 15 mph.

The Lafree looks and performs like a mountain bicycle. It has a 7-speed rear derailleur with a wide range of gears. Its main drawbacks are limited range and the fact that it weighs 80 lbs. (36 kg). The battery alone is 25 lbs. (11 kg), which is more than the entire weight of a good road-racing bicycle. The Lafree is designed for comfort, not speed. The position of saddle, pedals, and handlebars make it hard to lean over and put your full weight on the pedals. On a level track with the motor turned off, pedaling as hard as I could, I barelv reached 25 mph. The motor is most noticeable—and most welcome—at low speed when you start up, and going uphill. It does not make hills effortless, but it does not leave you out of breath or tempted to get off and walk. The motor can handle a 15% grade. A person in reasonable shape can pedal a bicycle three miles in 15 minutes, but in Atlanta, Georgia in the summer he will arrive at the office soaked in sweat, whereas the electric bicycle takes no more effort than a 15-minute walk. It is not as hot as walking either, thanks to the head wind, which makes bicycling the coolest form of exercise. (This is why professional bicycle racers are able to exert more effort per day than other athletes. The Tour de France is the equivalent of more than two marathon foot races every day for twenty-two days.[4])

The company says the battery range is 22 to 24 miles at full output, and it recharges in 4 hours. I found the range is only 20 miles (32 km), and it takes 4 to 6 hours to fully recharge. On a level track at maximum speed, I went 21.4 miles in 74 minutes, averaging 17.8 mph (28.6 kph). On residential suburban roads, early Sunday morning with no traffic, over gentle hills with few stop signs I went 20.4 miles, at 12.6 mph (20.3 kph). In other tests I reached 18.4 and 21.5 miles. The company says my battery may improve after several deep discharges.

When the battery is 90% drained, motor power falls off noticeably. When it runs out, an alarm sounds briefly and the motor turns off automatically. The bicycle can be pedaled without power, but it is a lot of work. The battery can be removed from the bicycle in a few seconds, and it includes a transformer and a grounded plug. If you ran out of power a few miles from home, you might pull into a coffee shop, plug in, recharge, and relax for a half-hour or so. A row of five LEDs indicate the battery charge. Each light indicates 20% of capacity; as you travel, every 4 miles a light goes out. The LEDs are remarkably accurate, but I recommend an inexpensive electronic speedometer with a trip odometer, which you reset after charging the battery.

The limited range makes the Lafree unsuitable for touring. A company spokesman says they are looking into NiMH batteries, which should reduce bulk and weight, and increase range 20 to 30%. Unfortunately, they cost about five times more than the lead-acid battery.[5] Another company has developed a fuel-cell electric bicycle prototype with a range of 60 miles (70 to 100 km).[6]

Despite its weight, the Lafree performs and feels like a bicycle rather than a moped or motorcycle. The electric motor cannot push the machine on its own; the rider must pedal, and exert some force. When the speed exceeds 20 mph, the motor-assist smoothly disengages, leaving you free to pedal faster, if you can! These performance restrictions were designed by Fiat, according to agreements worked out by manufacturers and Congress. Congress mandated that a "bicycle" is a vehicle which must be pedaled, and which goes no faster than 20 mph with motor assist, and that electric bicycles must be allowed on bicycle paths and lanes built with federal money. The performance limitations seem sensible to me. The Lafree is well suited for bicycle paths, and safe for children over 12 years of age.

The motor has two modes of operation:

1. Automatic, in which a fuzzy logic computer senses the gear, the speed of rotation, and the torque exerted by the rider, and it supplements the rider.

2. Manual override. The rider must still pedal but a throttle on the handlebar controls the motor input. This is handy for rapid acceleration after a stop sign, up a hill, or in traffic. Above 10 mph, full power manual override is indistinguishable from automatic mode.

The motor produces 400 watts maximum (about a half-horse-

power), which is not much. On a level track with little effort I maintained a steady 17 mph for 20 miles. On a steep hill at full motor power with moderate pedaling effort, I went about 5 mph. When riding over gentle hills, you get the odd sensation the landscape is flattening out in front of you. The motor makes an unobtrusive whine, which stops when you stop pedaling or freewheel downhill. A fuzzy logic computer measures the rider's effort with a built-in torque meter, and automatically integrates power from the rider and the motor. This works smoothly, but after awhile you may sense that the computer wants you to pedal at 60 rpm. Most experienced riders prefer a faster cadence, 70 to 90 rpm, with a lighter gear setting. At speeds well below 60 rpm, the sound and thrust of the motor oscillate slightly, fading in and out with each revolution, unless you turn up the throttle for manual override. The experience is a little like riding on a tandem (a bicycle built for two), with a partner on the back who is cooperative and indefatigable, but a little stupid.

This bicycle would be good for a middle-aged or older person in good health, who wants about as much exercise as you get from walking. Bicycling is low-impact exercise. It does not jolt or damage the joints; it is more like swimming than jogging.

Electricity Is an Improvement

Gary Starr, who developed another electric bicycle, made an interesting comment. He spent many years working on electric cars, but he grew frustrated because the market seems stalled. Electric vehicles still cannot compete in important ways. A pure electric automobile or truck does not have the range of gasoline models, and the hybrid vehicles are expensive and complex. But, when you put an electric motor and simple, inexpensive lead acid batteries on a bicycle, you actually improve performance.[7] The Lafree suffers from the limited range and heavy weight that plague electric automobiles, but range is not as important as it is with a car, because a bicycle is slow. It takes over an hour to reach the 20-mile range, and most commuters would be too saddle-sore or tired to ride for an hour. You would not use a bicycle to run a 30-mile errand, or pick up a 40-lb. carton of paper or a mattress.

The use of any bicycle, motorcycle, or moped in U.S. urban areas is severely limited by the appalling designs of the roads, traffic jams, and the homicidal behavior of some drivers, who make a sport of intimidating pedestrians and bicyclists. You are not supposed to ride a bicycle on the sidewalk, but in Atlanta it would be suicidal to ride on some of the main roads. Atlanta has the second worst pedestrian fatality rate in the U.S., mainly because it lacks sidewalks and crosswalks, and some drivers zip through red lights or exceed the speed limit by 10 or even 20 mph. The market for electric bicycles in Asia and Europe is more promising. In Japan the population is rapidly aging, and many people depend upon bicycle transportation, especially older women who often cannot afford automobiles and do not have licenses.

Like all bicycles or motorcycles, the Lafree is not suitable for inclement weather, ice or, snow. Commuters must have an alternative form of transportation available (a taxi, or a ride with a co-worker or spouse). The problem with this in places like Japan, where bicycles are heavily used, is that everyone counts on the same alternatives, so on a rainy day taxis cannot be found.

Overall, I am impressed by the performance and practicality of the Lafree. It is not meant for afficionados or small children. It does not have the responsive, feathery feel of a lightweight road racing bicycle. The extra mass, big tires, and shock absorbers make it ponderous and insensitive to road conditions and potholes. It seldom goes faster than 25 mph. You could not use it for a 100-mile open-road tour. Despite these limitations, the Lafree does one thing very well. A tired, middle-aged commuter, wearing business clothes, facing a long tough hill on a hot summer afternoon will feel a lot happier on a Lafree than a regular bicycle. The machine invites you to hop on. After a month of commuting, I find I use the Lafree more than I used a regular bicycle. No matter how tired you are, you go about the same speed, and you can always "cheat" and turn up throttle for maximum motor power on every hill and rise.

Some Puzzling Deficiencies and Accessories to Make up for Them

Although the overall design, power controls, indicator lights, self testing, and other engineering details are elegant, in some ways the design seems unfinished. The bicycle has a 25 lb. battery with loads of electricity to spare, so a headlight and taillight should have been designed to draw power from the battery, but that is not an option. The fuzzy logic computer is connected to an rpm counter in the back wheel, yet there is no built-in speedometer. (It would cost only a few dollars to add one.) A key locks the battery in place and turns the motor off, yet it does not also lock down the chain wheel to prevent a thief from pedaling off without power. This key fits an awkward U-lock on the front fork, which stops the front wheel from turning. To leave the bicycle outside, you remove the key from the back, undo and reposition the U-lock, and yet after all this fiddling, a determined thief can still pick up the whole 80 lb. machine and stagger off with it. A cable lock that secures the bicycle to a rack or small tree is safer. A spokesman for the company said they intend to add a speedometer, and they have been debating whether to offer lights.

To make up for these deficiencies, and to make the machine a little more practical and comfortable, I recommend: an electronic speedometer ($25), a cable lock ($30), a carrier for the back of the bicycle ($20), and pedals with toe clips ($30). An extra battery costs $115. You may need a heavy-duty automobile carrier ($230, for one bicycle). You should always wear a bicycle helmet when riding ($30 to $80).

Lafree Electric Bicycle Specifications and Features

- List price $1,000, about the same as a good mountain bike.
- Heavy-duty frame with shock absorber on front fork, designed to accommodate the extra weight of the motor. Low center of gravity. A "step through" (woman's) frame is available: 26" tires. Quick release front and rear wheels.
- 7-speed rear derailleur, with a wide range of gears. The shifter is on the left handlebar: Heavy-duty caliper brakes, with quick release.
- Padded saddle custom designed with a latch and hinge to allow quick removal of battery.
- Two-point motorcycle style kickstand
- 400-watt motor.
- 20-mile range. (The company says 22 - 24 miles, and the web site and Owners Manual version 1.0 say 28 miles, but the company reports this has been revised.)
- PAP: Power-Aided Pedal. A torque sensor monitors the rider's input. A fuzzy logic computer adds measured electric power in response.
- VPC Throttle: Variable Power Control - a twist throttle on the right handlebar overrules the PAP computer. Useful for quick

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results as we test a variety of cells at different power levels.

Hydrosonic Pump

In case you are new to this saga, the Hydrosonic Pump is a mechanical heater for a liquid stream that works by cavitation. It has been reported bv some to exhibit anomalous energy efficiency (see IE, No. 23, p. 28).

As reported in the last issue, HydroDynamics agreed to provide a replacement Hydrosonic Pump for the one originally purchased from them, because of a design error on their part. The pump was too large for the motor (or the motor was too small for the pump) and the motor was drawing too much current for its rated power. The new pump has finally arrived. The old one was removed and replaced. It was not an ideal fit to the existing steel frame, but very close. With some cutting, drilling, and professional alignment, the new pump is being installed.

The new pump mounting will be on three points, instead of the former four. One of the points will incorporate a load cell, which is an accurate force measuring transducer. With the load cell, we will be able to measure torque delivered to the pump. That quantity, along with RPM measurement, will allow accurate input power measurement.

Memory of Water continued from page 56

We can hope there will be a day of atonement for the killers of new knowledge such as "memory of water" and cold fusion. An only temporarily defeated Benventiste, whose funding and position had been obliterated by what he termed the "Ayatollahs of science," declared at the end of the 1994 BBC documentary: "When I think about the whole episode, I constantly ask myself: what did I do wrong? Maybe I should have thrown the data away—so, you have your peace of mind, you are not threatened. If I am right or if I am wrong, that is not the problem. The problem is to change the system. As strange as it may sound, science has become unfriendly to new ideas. If we can be, as scientists, stamped as 'heretics,' it is because there is a dogma. And the fact that all dogma has been crushed in the past by new ideas is not a lesson for these people. We have to destroy the system." Amen.

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Lafree continued from page 66

startups or times when you do not feel like doing much work.
• The owner's manual is well-written and illustrated.

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3. http://www.extraenergy.org
4. Morrison, P. 1997. "Air-Cooled," Scientific American, October
5. E-mail exchange with Fred Teeman, Giant Bicycles Co.
6. http://www.mhtx.com/media_center/pressrelease24.htm
7. "ZAPPED To The Future A Interview with Gary Starr," http://www.evworld.com.

Graneau, Life's Matrix continued from page 60

no interest to the readers of this journal. Ball has denied knowledge of our paper "Solar Energy Liberation from Water by Electric Arcs" which was subsequently published in the Journal of Plasma Physics of Cambridge University Press (Vol. 60, p. 775, 1998), and reprinted in this issue of Infinite Energy on page 33.

If someone comes along to Nature with an experiment that disproves Einstein's relativity, "you just know," says Ball, that he is wrong. It requires no further inquiry. After all, would you go to Peru, he asks, to check a claim that apples there are blue? This was the attitude of professors at Pisa when Galileo demonstrated that heavy objects fall no faster than light objects. "One just knew" that Aristotle was right and Galileo wrong. The Greek philosopher was the Einstein of the Renaissance, with one difference. At the age of seventy Einstein knew he was wrong and wrote to one of his oldest friends: "There is not a single concept of which I am convinced that it will stand firm, and I feel uncertain whether I am in general on the right track."[1] In 1993 my paper, "The Difference Between Newtonian and Relativistic Forces" (Foundation of Physics Letters, Vol. 6, p. 491), fell victim to Ball's "blue apple syndrome."

It was a joy to read the water biography. I learned a lot from it. On one issue, however, I find myself in stark conflict with the author. This is cold fusion. He trashes Pons and Meischmann as pathological scientists. It is grossly unfair because cold fusion was first discovered—and firmly established—in the 1950s by teams of physicists at the Berkeley and Harwell laboratories. They did not use the words "cold fusion," but proved with easily reproducible and simple experiments that streams of neutrons left deuterium pinches at plasma temperatures far below the thermonuclear reaction threshold. It is there for all to read in Physical Review[2] and in a book titled Project Sherwood: The U.S. Program in Controlled Fusion.[3] Like Ball, Pons and Fleischmann were also ignorant of the early cold fusion results. The hot fusion scientists, who since then have consumed billions of research dollars, were more effective in wiping out all memory of cold fusion then in making hot fusion work.

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the work of Dr. Randell Mills of BlackLight Power in New Jersey.

What makes this action most curious is that there was absolutely no reason officially given for their action, although there was a statement made to the effect that Dr. Robert Spar, Director of Special Programs, has blocked the BlackLight Power patents because they are "based upon cold fusion." As this article states, there is, in fact, no mention of cold fusion in any of the patents and USPTO is aware of that because USPTO and BlackLight Power attorneys at the onset of the application process reviewed it.

Therefore it appears that guilt by association with an area of scientific inquiry incorrectly defined by a handful of scientists as "voodoo science" was sufficient reason for his action. If true, his actions are unprofessional and he should be held accountable for them.

As you know by now from my previous correspondence, "new energy" includes more than cold fusion. More importantly, it is time for false allegations and innuendo to be replaced by observable facts. While the elective components of the United States government have been constructed to operate on politics, neither the science community or official government bureaucracies are chartered to do so, although it is plain to see they do.

The article further indicates that BlackLight Power already has a $375 million private capitalization with an expected $1 billion capitalization when it is publicly traded. The IPO was scheduled for March of this year. Of course, Mr. Spar's action has also prevented this exercise of free enterprise from happening.

Please read the enclosed article and take whatever action is appropriate before the November election.

Once again, I remind you that the technologies of "new energy" are those that will most effectively deliver the kinds of alternatives needed to address the pollution and electrical power issues that we face today and for the foreseeable future. To quote one final point from the article, "The new composition of matter can be used to provided better batteries the size of a briefcase that would drive an automobile 1,000 miles at highway speeds on a single charge, without the use of fossil fuels."

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About the Author

Dr. Keith Johnson, a condensed-matter theorist in the MIT Materials Science Department, retired early from teaching at the Institute to co-found the high-tech company, Quantum Energy Technologies Corporation (QET), and to produce and direct the feature science-fiction film, "Breaking Symmetry," which he also scripted. Guided by patents awarded to Dr. Johnson and associates, QET is devoted to the research and development of nanostructured water for fuel technologies, as well as R&D on nanostructured electroluminescent materials. His film, "Breaking Symmetry" (website: www.breaksym.com), shown theatrically at the 1999 Cannes Film Festival and premiered locally in Boston last spring, will be available on videotape soon through Infinite Energy Magazine. A DVD version of the film is also in the works, and a "sequel" to the original film (working title: "Polarity") is in preproduction at Dr. Johnson's film studio in Cambridge.

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[R. Mills, "The Hydrogen Atom Revisited," Int. J. of Hydrogen Energy, accepted].

The investments in BlackLight were extremely conservative. PacifiCorp spent more than $100,000 in due diligence that resulted in reports from two independent, respected consulting firms:

Technology Insights, 6540 Lusk Boulevard, Suite C-102, San Diego, CA 92121, "HydroCatalysis Technical Assessment Prepared for PacifiCorp," August 2, 1996. This report documents a technical assessment of a novel source of hydrogen energy advanced by HydroCatalysis Power Corporation now BlackLight Power, Inc. (BLP). The assessment was conducted as part of the due diligence performed for PacifiCorp. It was conducted by a literature search and review, site visits to BLP and collaborating organizations, and telephone interviews with others active in the general area. A description of concept is provided in Section 3. Section 4 presents an assessment of the concept background, supporting theory, laboratory prototypes, projected initial products, and economic and environmental aspects. Section 5 documents the results of telephone interviews and site visits. An overall summary and conclusions are presented in the following section.

Kline-Anderson, Inc., 8926 Kirby Drive, Houston, TX 77054, "Review of Schedule and Resource Requirements to Develop a HydroCatalysis Functional Prototype Unit Final Report for Technology Insights," October 23, 1996. This report documents a technical assessment of a novel source of hydrogen energy advanced by HydroCatalysis Power Corporation now BlackLight Power, Inc. (BLP). The report is based on fact finding trips to BLP and NovaTech and written documentation provided by BLP and Technology Insights. The assessment was conducted as part of the due diligence performed for PacifiCorp under guidance of Technology Insights. The work scope was to assess and formulate a plan to commercial the BLP technology by a new commercialization company COMCO with a considerable investment by PacifiCorp. Plans for development of a functional prototype unit and comments and recommendations regarding planned tasks, resource requirements, and project schedule are given.

Atlantic Electric had their MIT trained scientist test our cells in our laboratory for several months. His results were published as his Masters Thesis [P.M. Jansson, "HydroCatalysis: A New Energy Paradigm for the 21st Century," Thesis Submitted in partial fulfillment of the requirements of the Masters of Science in Engineering Degree in the Graduate Division of Rowan University, May 1997, Thesis Advisors: Dr. J.L. Schmalzel, Dr. T. R. Chandrupatla, and Dr. A. J. Marchese, External Advisors: Dr. J. Phillips, Pennsylvania State University, Dr. R.L. Mills, BlackLight Power, Inc., W.R. Good, BlackLight Power, Inc.].

NASA Lewis tested a cell [Niedra, J., Meyers, I., Fralick, G.C., and Baldwin, R., "Replication of the Apparent Excess Heat Effect in a Light Water-Potassium Carbonate-Nickel Electrolytic Cell, NASA Technical Memorandum 107167, February, (1996) pp. 1-20.; Niedra, J., Baldwin, R., Meyers, I., NASA Presentation of Light Water Electrolytic Tests, May 15,1994.] described by Mills et al. [Mills, R., Good, W, Shaubach, R., "Dihydrino Molecule Identification," Fusion Technology, Vol. 25,103 (1994).]. A cell identical to the test cell with heater power only (no electrolysis) was the calibration control and the blank cell with the heater power equal to zero. The test cell was also calibrated "on the fly" by measuring the temperature relative to the blank cell at several values of heater input power of the test cell. "Replication of experiments claiming to demonstrate excess heat production in light water-Ni-K_2CO_3 electrolytic cells was found to produce an apparent excess heat of 11 W maximum, for 60 W electrical power into the cell. Power gains ranged from 1.06 to 1.68." The production of excess energy with a power gain of 1.68 would require 0% Faraday efficiency to account for the observed excess power.

Dr. Niedra, the scientist who ran the test, confirms that the cell worked.

The work did not continue because the NASA Administrator, Ira Myers, died about the time the tests were completed. I was then focused on gas energy cells that were a significant advancement over electrolytic cells. We probably could have continued with NASA with another administrator. But, I only had one employee at the time, and we were overwhelmed with collaborations with Pennsylvania State University, Westinghouse Corporation, Thermacore, Inc., and MIT Lincoln Laboratories.

Park states that the experiment was a failure, and NASA walked away. This is not true.

We are publishing papers at the rate of about one per month. We have submitted eight so far this year, and five are accepted for publication. We are working with Prof. Conrads on two more. They are being posted on our web page.

We have presented at a number of recent scientific meetings. The Company conducted a four hour symposium of its technology at the October 6 American Chemical Society Meeting (1999 Pacific Conference on Chemistry and Spectroscopy and the 35th ACS Western Regional Meeting, Ontario Convention Center, California, (October 6-8, 1999)). At the conference, Prof. Dr. Johannes P. F. Conrads, the former Director and Chairman of the Board of MP, the Institute of Low Temperature Plasma Physics, announced that he had confirmed that the BlackLight process creates an energetic plasma of atomic hydrogen with no input power to the cell. Having forty years of experience with hydrogen plasmas, he stated that the company's process represents a new chemical source of power.

The ACS presentation was reported by Dow Jones and the Associated Press. We also presented at the National Hydrogen Association Meeting (National Hydrogen Association, 11th Annual U.S. Hydrogen Meeting, Vienna, VA, (February 29-March 2, 2000)), the National ACS Meeting (219th National ACS Meeting, San Francisco, California, (March 26-30, 2000), and the June ACS Meeting (29th Northeast Regional Meeting, University of Connecticut, Storrs, CT, (June 18-21,2000)). We will be presenting at the August National ACS Meeting (220th ACS National Meeting, Washington, DC, (August 20-24, 2000).

Significant Scientific Validation Points

1. The Company has produced about forty novel hydride compounds in bulk that contain hydrino hydride ions.

2. The Company has extremely convincing data confirming the new hydride compounds bv twenty-five types of tests at twenty-five independent laboratories.

3. The Company has produced a plasma of hydrogen under unprecedented conditions of heating it to 700°C in the presence of certain catalysts, and in the absence of catalvst, no plasma forms.

4. The Company has recorded spectral emissions of hydrogen in the plasma are ten times more energetic than burning hydrogen.

5. Prof. Dr. Johannes PR Conrads, then the Director and Chairman of the Board, of Institut Fur Niedertemperatur-Plasmaphysik e.V. and the Ernst-Moritz Arndt-Univeristat Greifswald (INP), a top plasma physics laboratory in Greifswald, Germany, and four of Prof. Conrads' top scientists recorded line emission from the Company's cell which matches hydrogen transitions to lower energy states, and some of these transitions are about 100 times more energetic than burning hydrogen.

6. INP and the Company have recorded a hydrogen plasma in the Company's cell with no electric energy input.

7. The Company has sustained an energetic plasma in hydrogen at 1% of the theoretical or prior known voltage requirement and with thousands of times less power input in a system wherein the plasma reaction is controlled with an weak electric field.

It is very surprising and disappointing that Oxford University Press would publish Park's puff piece that discredits and damages a private corporation backed by other reputable corporations without first checking the facts that Park deliberately ignores.