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SOLUTE ION COULOMB FORCE MONOPOLE MOTOR AND SOLUTE ION LINEAR ALIGNMENT PROPULSION

Authors

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Abstract

Electric Field Monopole Motor: Capacitive deionization relies on carbon aerogel or nanofoam having a surface area of 400 square meters/ gram to attract sodium and chlorine ions to the cathode and anode respectively by applying a voltage of about 1.5 VDC across the anode and cathode. By first physically isolating at least two anodes and two cathodes during charge accumulation, at least two positive monopoles and two negative monopoles are created. Positive/negative monopoles are formed by the enclosure of the cathodes/anodes by an electrically conductive material surrounding the sodium/chlorine ions. At least five or six like charged monopoles are created. At least four of the like charged monopoles (all negative or all positive) can be arranged on a disc. At least one stationary monopole of the same charge is placed adjacent to the disc and positioned so that a repulsive electric field is formed between the stationary monopole and at least one of the monopoles positioned on the disc so that the disc is then forced to rotate a shaft at the center of the disc. The Coulomb force between the monopoles is given by Coulomb's Law, i.e.,

$F = (k/e)[(q1)(q2)/(r2)]$

where k = 9E+09 Newtons-meter2/coul2 and e = dielectric constant for water of about 75-81, q1 & q2 are the charge in coulombs and r is the distance between the charges in meters. Only a very small amount of charge in each monopole is required, i.e., 10 millicoulombs, (less than a milligram) to provide a force of about 44,000 Newtons (almost 10,000 lbs) if monopoles are separated by 0.5 meters (assuming this equation for Coulomb's Law for this application is directly applicable without modification-this may not be the case). In a related approach, solute ions are accelerated by electrostatic field from solute ions collected on electrodes+,- . Using orthogonal electric field, close partition electrodes to capture like charged ions and reverse polarity using transverse (longitudinal) electric field. Linear alignment of ions results in vector alignment of Coulomb forces to create ion jet for propulsion or particle acceleration. Result is ionic marine propulsion and possible ionic jet engine that obtains propulsion energy from Coulomb repulsion forces of homopolar separated charge. No combustion or jet fuel is required. Details are available in WIPO Publication WO 2008/024927A2 "SOLUTE ION COULOMB FORCE ACCELERATION AND ELECTRIC FIELD MONOPOLE PASSIVE VOLTAGE SOURCE".

Presentation Author Biography

Anthony N. Fresco: I graduated from City College of New York (CCNY) in 1970 with a B.M.E. (five year program). I was nominated to Pi Tau Sigma, the national honorary mechanical engineering fraternity. From 1970 to 1974, I started out as an assistant engineer with Con Edison (New York City) in their gas engineering department. In 1974 I received an M.S.M.E. from then Polytechnic Institute of New York, now The Polytechnic Institute of New York University. From 1974 to 1979, I had several different engineering positions at Ebasco Services involved with the design of both fossil and nuclear power plants. From 1979 to 2000, I was at Brookhaven National Laboratory (Upton, New York) where from 1979 to 1981, I was involved with the design and procurement of a very large helium compressor installation for the superconducting magnets of the then ISABELLE Project (proton accelerator), now the Relativistic Heavy Ion Collider (RHIC). From 1981 to 2000, in what is now the Department of Energy Sciences and Technology, I was involved in various projects and tasks related to primarily regulatory safety issues for nuclear power plants, mostly for the US Nuclear Regulatory Commission (USNRC) but also for some U.S. Department of Energy (DOE) facilities. Since 2000, I have been working as a patent agent registered to practice before the US Patent and Trademark Office. I am currently at Carter, De Luca, Farrell and Schmidt, LLP, 445 Broad Hollow Road, Suite 420, Melville, New York 11747. I am a member of the American Society of Mechanical Engineers. I have been on the ASME Long Island Section executive committee since about 1985 and have served as a past chairman. I have organized many programs for presentation to the Long Island membership.

Reviewer Comments

Reviewer 1:

Reviewer 2:
Innovative concept proposed by other for propulsion

Draft Recommendations/Comments

Comments

Please consider the reviewers' comments and make any changes that you think will help improve the paper based on these comments.

Final Recommendations/Comments

Additional Recommendation

Comments

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Reviewer No.1

The topic of this paper is a very interesting look at converting Coulomb forces into mechanical motion and linear propulsion. Harnessing these forces to perform work would indeed be exciting. The paper's underlying assumption is based on Coulomb's Law and its validity in these applications. The paper discusses making use of a recent advanced carbon nanofoam material which has applications in the desalination process for salt water known as capacitive deionization. This is a clever use of a technology that was developed for a different application. The paper is divided into two sections; a monopole motor section and a linear alignment propulsion section and then followed by a closing "considerations" section.

The treatment of the physics for the motor section seem to be sound, except it was not made clear why the author assumed a dielectric constant for water (81)for the motor operation. The text did not describe the working environment of the motor once it was assembled. The monopoles are filled with ion solute which within can be assumed to be water, but for the majority of the distance, r, I would assume air with a dielectric constant of 1 and much higher resulting forces based on Coulomb's Law. The other difficulty with using water as the operating medium for the system is water's relatively high dielectric constant, especially relative to common insulators. The author suggests that the angular velocity would be controlled by opening and closing a movable layer of insulation to vary the force between the stator monopole and the rotor monopole. Dielectric constants for most insulating materials are well below that of water (~15). Based on the dielectric constants of materials, and assuming the system to be operating in air, the thickness of the layer of insulation would likely need to be quite thick (to drop force to 1/3 would require 80mm thickness out of the 500mm separation assuming a dielectric constant of 15 for the insulation layer). However, if instead of an insulating layer, a layer with a high dielectric constant were used, such as water, the thickness could be greatly reduced.

The treatment of the physics for the linear alignment propulsion section again seemed to be sound with some very significant forces and velocities attained. I find these values to be bordering on the absurd, but I have not found any fault in the reasoning. It would be amazing if this could be achieved!

The final section focuses on considerations, or essentially a reality check. I agree with the challenges in the three areas that the author identifies. The ability to contain a large number of like charges in a small confined container at first glance appears to be a major challenge, since the internal Coulomb forces should be quite large (based on the same assumptions that are providing the very large forces to perform motion). The author identifies this by suggesting that the number of ions should be minimized, and then suggests that maybe a different material other than the carbon nanofoam would be appropriate (which seems to contradict the introduction section of the paper). The author identifies monopole life concerns and suggests that leakage losses (all capacitors have some leakage), structural integrity, and corrosion tendencies will likely limit life span (the author does not identify expected life).

The clarity of the figures was poor, and several readings were necessary to understand the topics as presented in the paper. Clearer figures would be a great improvement to this paper.

Overall, I found this paper very interesting and would like to see some experimental results from these theories.

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SOLUTE ION COULOMB FORCE MONOPOLE MOTOR AND SOLUTE ION LINEAR ALIGNMENT PROPULSION

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ABSTRACT

Capacitive deionization relies on carbon aerogel or nanofoam having a surface area of 400 square meters/ gram to attract sodium and chlorine ions to the cathode and anode respectively by applying a voltage of about 1.5 VDC across the anode and cathode. By first physically isolating at least two anodes and two cathodes during charge accumulation, at least two positive monopoles and two negative monopoles are created. Positive/negative monopoles are formed by the enclosure of the cathodes/anodes by an electrically conductive material surrounding the sodium/chlorine ions. At least five or six like charged monopoles are created. At least four of the like charged monopoles (all negative or all positive) can be arranged on a disc. At least one stationary monopole of the same charge is placed adjacent to the disc and positioned so that a repulsive electric field is formed between the stationary monopole and at least one of the monopoles positioned on the disc so that the disc is then forced to rotate a shaft at the center of the disc. The Coulomb force between the monopoles is given by Coulomb's Law, i.e.,

$$F = (k/\varepsilon)[(q1)(q2)/(r^2)] \qquad (1)$$

where k = 9E+09 Newtons-meter^2/coul^2, q1 and q2 are the charge in coulombs, r is the distance between the charges in meters and ε = 75-81 dielectric constant assuming water between the charges (more likely air having ε = 1). Only a very small amount of charge in each monopole is required, i.e., 10 millicoulombs, (less than a milligram) to provide a force of about 44,000 Newtons (almost 10,000 lbs) if monopoles are separated by 0.5 meters (assuming this equation for Coulomb's Law for this application is directly applicable without modification-this may not be the case). (For air, the force would be multiplied by 75-81). In a related approach, solute ions are accelerated by an electrostatic field from solute ions collected on electrodes +,-. Using an orthogonal electric field, partition electrodes are closed to capture like charged ions. Polarity is reversed via a transverse (longitudinal) electric field. Linear alignment of ions results in vector alignment of Coulomb forces to create an ion jet for propulsion or particle acceleration. The result is ionic marine propulsion and a possible ionic jet engine that obtains propulsion energy from Coulomb repulsion forces of homopolar separated charge. No combustion or jet fuel is required. Details are available in WO 2008/024927 A2 Ref. [1].

INTRODUCTION

Fossil fuels are considered as being from ancient sources while nuclear fission and fusion are considered to be modern developments. In fact, with respect to the earth's history, nuclear fission and fusion occurred with the big bang and the formation of the sun and the planets themselves, whereas fossil fuels could only occur billions of years after the formation of life forms. The purpose of this paper is to show that there is an overlooked and extremely powerful alternative energy source that is renewable and that has been available since at least the formation of salt water oceans: the electrostatic fields of like-charged solute ions.

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The best illustration of the enormous power of electrostatic fields is illustrated in FIG. 1, "ELECTRIC FORCE EXAMPLE" [2].

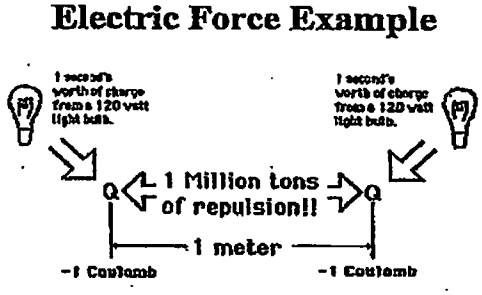


FIG. 1-Coulomb or electric force example

Two 120 watt lightbulbs are illustrated which are assumed to operate at 120 volts. Therefore a current of 1 amp or 1 coulomb/sec flows through each bulb. In one second, one Coulomb of charge flows through the conductor of each lightbulb. If the charge from each lightbulb of one Coulomb could be concentrated at points one meter apart, from Coulomb's Law, Eq. (1), then:

$$F = (9 \times 10^9 \text{ N-m}^2/\text{C}^2)\,(1\text{ C})(1\text{ C})/\,1\text{m}^2 =$$

$$9 \times 10^9 \text{ N} \qquad (1)$$

In this case, since it is assumed air or a vacuum is separating the concentration of charge, then $\varepsilon = 1$. **In SI units, since there are 9.8 N/kg and 1000 kg/metric ton, then F = 0.918367 x 10^6 metric tons or 918,367 metric tons of repulsion!!!** As indicated in the Hyperphysics website [2], the charges would move away from each other under the influence of this enormous force even if they had to rip themselves out of solid steel to do so! The reason given why there are no dramatic displays of electrical force is that, in general, at a given point in a wire, there is never much departure from electrical neutrality. Nature never collects a Coulomb of charge at one point.

However, it is a well known fact that salts such as sodium chloride, NaCl, readily dissolve in water with very little energy input, i.e., about 6.5 kJ/mole . This is attributed to the high dielectric constant for water of 75-81. The structure of the water molecule as a polar molecule enables the water molecules to easily penetrate between the sodium Na+ and chlorine Cl- ions in the NaCl crystal. This penetration of the polar water molecules between the Na+ and Cl- ions shields the Coulomb potential between the Na+ and Cl- by a factor of about 75 so that the NaCl crystals readily dissolve in water. In contrast, the enthalpy of formation of NaCl is about -410.9 kJ/mol. Although the Na+ and Cl- ions in seawater are considered to have originated separately almost entirely from different sources and virtually none have originated from solid sodium chloride which has dissolved, the fact remains that the oceans are a vast source of Na+ and Cl- ions which are segregated by transport to the surfaces of electrodes either in electrolysis or electrodialysis of salt water.

FIG. 2 is a figure originally published by Lawrence Livermore National Laboratory that illustrates a more recently developed process for desalination called capacitive deionization (CDI). CDI relies on carbon aerogel or nanofoam having a surface area of about 400 square meters/ gram to attract sodium and chlorine ions to the cathode and anode respectively by applying a voltage of about 1.5 VDC across the anode and cathode [3]. Thus, CDI is another process in which Na+ and Cl- ions are segregated by transport to the surfaces of electrodes, with the objective being to form a more dilute solution of salt water in the region between the electrodes. CDI is actually the initial stage of electrolysis or electrodialysis since electrolysis of water can only occur at higher voltages, i.e., above the barrier voltage, when an electron is transferred from or to the electrode surface to form complete atoms, e.g., sodium or chlorine atoms, which then react with water to form hydrogen and oxygen.

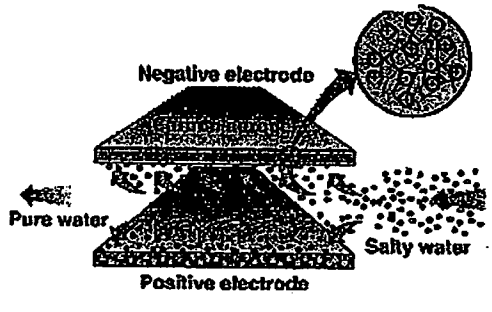


FIG. 2 – Illustration of CDI Process

ELECTRIC FIELD MONOPOLES FROM SOLUTE IONS

The purpose of this paper is to illustrate how the CDI process can be extended to create electric

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field monopoles which can be arranged to form a motor that is driven by the electrostatic fields, or Coulomb forces, of solute ions, e.g., Na+ or Cl-. In particular, FIG. 3 (see page 8) illustrates one method of making monopoles which is described and illustrated as (FIG. 93) in the author's Patent Cooperation Treaty (PCT) patent application [1]. A housing (130) made from an insulating material contains interfacing electrodes (145a and 155a) which may be made from carbon aerogel. With the application of a voltage of approximately 1.5 VDC across the electrodes, the aforementioned CDI process is executed to attract negative ions (101) and positive ions (102) from a salt water solution (10) to the respective electrode surfaces. The CDI process is extended with the continued application of the DC voltage across the electrodes such that cylindrically-shaped movable electrically conductive partitions (P145a, P145b, P155a, P155b) are moved to surround and confine the respective solute ions (101 and 102). To ensure the necessary confinement of the solute ions, the interface between the movable partitions (P145a and P145b and P155a and P155b) may be welded under water while the DC voltage is maintained. This is to ensure that solute ions are confined within the region between the electrodes (145a and 155a) and the movable electrically conductive partitions (P145a and P145b and P155a and P155b). Following the welding process, movable layers of insulating material (P145e, P145f and P155e, P155f) are moved into position around the electrically conductive partitions to electrically isolate the electric field forces of attraction between the negative and positive solute ions (Cl- ions 101 and Na+ ions 102) confined within their respective monopole. Once the monopoles (945, 955 or 1050) are so created, then the monopoles may be removed from the housing (130) by sliding out from the plane of the paper.

Since each single monopole (945 and 955) now contains an excess of like charged solute ions (e.g., Cl- ions 101 and Na+ ions 102), by interfacing monopoles which contain like-charged ions, e.g., two or more monopoles which each contains Cl- solute ions or two or more monopoles which each contains Na+ solute ions, and by opening the insulating layers (P145e, P145f and P155e, P155f), the Coulomb forces of repulsion due to the electric fields will be manifested through the electrically conductive partitions (P145a and P145b and P155a and P155b).

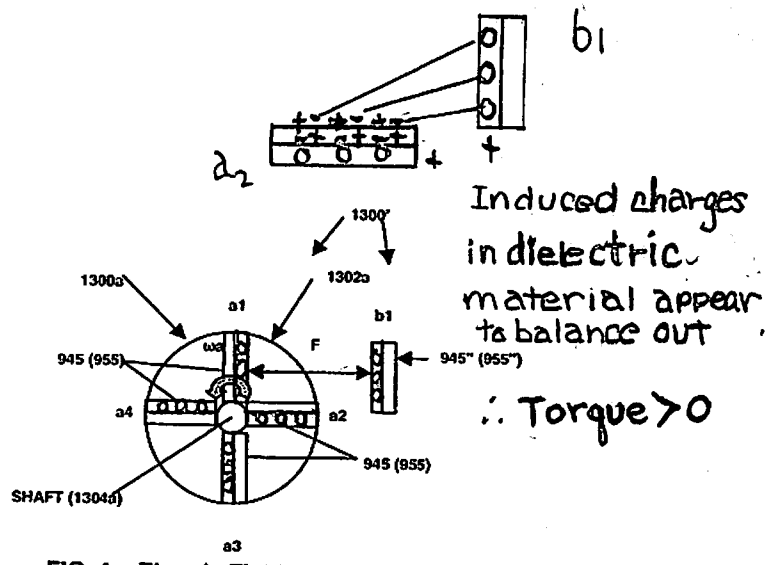


FIG. 4 – Electric Field Monopole Motor

ELECTRIC FIELD MONOPOLE MOTOR

Turning now to FIG. 4 (FIG. 98 of WO 2008/024927 A2), at least four of the like charged monopoles (all negative or all positive 945 or 955) can be arranged on a disc (1302a). At least one stationary or stator monopole (945'' or 955'') of the same charge is placed adjacent to the disc (1302a) and positioned so that a repulsive electric field is formed between the stationary monopole and at least one of the rotor monopoles positioned on the disc (1302a), causing a repulsion force **F**, so that the disc (1302a) is then forced to rotate a shaft (1304a) at the center of the disc. The monopole at position **a1** rotates to position **a4** while the monopole at position **a2** rotates to position **a1**, the monopole at position **a3** rotates to position **a2** and the monopole at position **a4** rotates to position **a3** in a repetitive manner.

The Coulomb force **F** between the monopoles (945 and 955) is given by Coulomb's Law, i.e.,

$$F = (k/\varepsilon)[(q1)(q2)/(r^2)] \quad (1)$$

where $k = 9E+09$ Newtons-meter^2/coul^2 and ε = dielectric constant for water of about 75-81, q1 & q2 are the charge in coulombs and r is the distance between the charges in meters. Only a very small amount of charge in each monopole is required, i.e., 10 millicoulombs, (less than a milligram) to provide a force of about 44,000 Newtons (almost 4490 kg or 10,000 lbf) if monopoles are separated by 0.5 meters (assuming this equation for Coulomb's Law for this application is directly applicable without modification. This may not be the case but is beyond the scope of this discussion). In actuality, mostly air, having $\varepsilon = 1$, would be present in the space between the monopoles and the force would be multiplied accordingly, **i.e., 3,564,000 Newtons (about 364 metric tons)!**

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The electric field, and thus the force F, torque and angular velocity ωa of the disc (1302a), can be controlled by the stationary or stator monopole (945'' or 955'') by opening and closing the layer of insulation (P145e, P145f and P155e, P155f) that was placed around each monopole to vary the force between the stator monopole (945'' or 955'') and the rotor monopoles (945 or 955). Note that ceramic materials have an ε ranging from about 2000 to 15000, and in most cases would be the preferred insulating material.

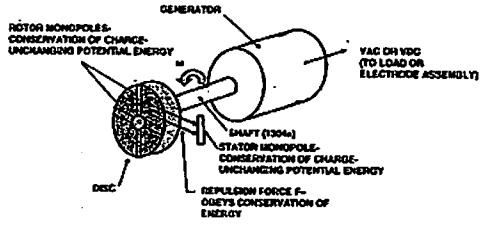


FIG. 5 – Monopole Motor Driving an Electrical Generator (AC or DC)

As further illustrated in FIG. 5, the shaft (1304a) can either drive an electrical generator to supply AC or DC power for power generation or to supply power to electric motors at the wheels of a vehicle or it can simply drive a transmission shaft as is currently done by internal combustion engines, or drive any other rotary equipment (pumps, compressors, etc.). The opening and closing of the insulating partition layer (P145e, P145f or P155e, P155f) on the stator monopole (945'' or 955'') allows control in a linear manner so shaft rotation can be controlled similar to a conventional DC motor. The law of conservation of charge dictates that constant, unchanging potential energy in the form of an electric field is continuously emitted from the like charged solute ions (Cl- or Na+), regardless of any prior repulsive or attractive interaction with other charged ions. That is, for a singly charged ion, the charge q always remains at 1.6×10^{-19} Coulombs. Conservation of energy is manifested by the forces of repulsion F between the one or more stator monopoles (945'' or 955') and the rotor monopoles (945 or 955). Without conservation of energy, rotation and power output from the motor would not be possible.

Carbon aerogel costs about $2000/kg but charge accumulation is in the range of 15-30 Farads/gram (15-30 Coulombs/Volt/gram) so very small amounts of aerogel should be needed [4]. In one Coulomb of charge for a singly charged ion such as sodium Na+ or chlorine Cl-, there are 1 ion/(1.6×10^{-19} Coulombs) or about 6×10^{18} ions/Coulomb. According to Avogadro's number, there are 6.02×10^{23} ions/mole and one mole of sodium ions has an atomic weight of 23 grams while one mole of chlorine ions has an atomic weight of 35.5 grams. Thus, one Coulomb of sodium ions has an atomic weight of approximately 23×10^{-5} grams or only 0.023 milligrams while one Coulomb of chlorine ions has an atomic weight of approximately 35.5×10^{-5} grams or only 0.0355 milligrams. It should be noted that the solute ions are hydrated, i.e., there are about six to eight water molecules which, since water is a polar molecule having a positive end and a negative end, attract to the sodium and chlorine ions. Thus, the weight of each hydrated ion should be considered in the calculations (H_2O has a molecular weight of 18 grams per mole). Nevertheless, it can be appreciated that the weight of the ions in a Coulomb's worth of charge is in the range of milligrams. Additional stator monopoles can be added at 90° intervals and more than the four rotary monopoles can be placed on more than one disk to increase the amount of power available. Since separated charges provide an electric field 24 hours per day, seven days per week independently of temperature, no "fuel" costs occur or greenhouse gases are created. Electric fields are far more powerful than any known fuel sources, even greater than nuclear reactions in terms of energy density (Joules/kg). Such a motor is extremely versatile, being capable of driving small scale loads, home heating, industrial pumps and compressors, through desalination, automotive, marine and aviation loads, and decentralized power generation as well as large scale central station grid-based power generation.

Closed monopoles can also be used as a means for "magnetic" levitation, i.e., "electric levitation" for railroad applications and aircraft launching. There are numerous potential applications such as for construction equipment and particle accelerators with medical applications such as proton therapy.

PROPULSION BY LINEAR ALIGNMENT OF SOLUTE IONS

In a related approach, illustrated in FIGS. 6 and 7 (FIGS. 29 and 30 of Ref. [1]), as already discussed with respect to FIG. 3, the process of CDI is applied to an electrode assembly (100E). CDI is the charge accumulation mode of the present process. The work W1 is known from

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past experimentation with CDI as a desalination process. Thus, as shown in FIG. 6, an orthogonal electric field (**E113a-113b**) is applied across the electrodes so that solute ions (101 – and 102 +) are first collected on the surface of the anode (113e) and of the cathode (113f). As shown in FIG. 7, in a similar manner as before, electrically conductive partitions (P127a, P127b and P127c, P127d) are then temporarily closed to surround the anode and cathode.

Once the desired amount of solute ions has been accumulated, as shown in FIGS. 8 and 9 (FIGS. 37 and 38 of Ref. [1]), a transverse longitudinal electric field is applied from the anode and cathode (113e and 113f) and from the partition electrodes (P127a, P127b and P127c, P127d) of like polarity so as to repel the solute ions which were accumulated during the charge accumulation mode.

As illustrated in FIG. 10, if a hypothetical single layer plane of like charged hydrated solute ions, e.g., Na+ or Cl- (102 or 101) 1 meter long by 1 cm wide is formed, assuming each pair of ions is separated by 10^{-9} meters and the Coulomb force of repulsion between each pair of solute ions is about 10^{-12} Newtons, then the force **F1** at the open end acting on the solute ions near the open end is given by:

$$\mathbf{F1} = (10^{+9} \text{ ions/meter}) \times (10^{-12} \text{ Newtons/pair of ions}) \times (1 \text{ meter}) = 10^{-3} \text{ Newtons} \quad (2)$$

Note that this assumes only a single line of solute ions. The force F1 could even be far greater if the "cross-forces" are applied based on the forces from adjacent rows of ions acting cross-ways on the ions at the end (and at intermediate positions as well).

Assuming Stoke's Law is applicable, as the best available current method known to the author, the terminal velocity of the solute ions near the open end of the electrode assembly can be calculated as follows:

$$R = 6\pi\mu r i v = \mathbf{F1} = 10^{-3} \text{ N} \quad (3)$$

where R = the applied force acting on the individual ion; μ = the dynamic viscosity in N-sec/m^2 which for water at 20.2°C is 10^{-3}; ri is the radius of the solute ion which is assumed to be $10^{-9}/2 = 5 \times 10^{-10}$ meters; and v is the terminal velocity in m/sec.

Therefore, solving for the terminal velocity v in water:

$$v = \mathbf{F1}/6\pi\mu r i = 10^{-3} \text{ N}/(6\pi\ [10^{-3} \text{ N-sec/m}^2]\ [5 \times 10^{-10} \text{ meters}]) \approx \underline{\mathbf{10^{+8} \text{ m/s}}} \quad (4)$$

Note that the speed of light $c \approx 3 \times 10^{+8}$ m/s.
Note also that the viscosity of water varies significantly with temperature. At 100 °C, the dynamic viscosity of water is only 0.282×10^{-3} N-sec/m^2, or less than 1/3 the viscosity at 20.2°C.

Referring again to FIGS. 8 and 9, assume that the resulting propulsion force **Fp** is given by:

$$Fp = \rho A V^2 \quad (5)$$

where ρ is the density of the Na+ and Cl- solute ions, assumed for simplicity equal to the density of water or 10^3 kg/m^3,

A = the area of the end of the hypothetical single layer plane of like charged solute ions 1 cm wide x 10^{-9} high, then

$$A = 10^{-2} \times 10^{-9} = 10^{-11} \text{ m}^2 \quad (6)$$

and

$$V^2 = (10^8 \text{ m/s})^2 = 10^{16} \text{ m}^2/\text{s}^2 \quad (7)$$

So

$$\mathbf{Fp} = (10^3 \text{ kg/m}^3) \times (10^{-11} \text{ m}^2) \times (10^{16} \text{ m}^2/\text{s}^2) = \mathbf{10^8 \text{ Newtons (100 MEGANEWTONS!! or about 10,000 metric tons)}} \quad (8)$$

This is a result comparable to the force of 9×10^9 Newtons calculated for the Electric Force Example from Ref. [2]. Since there are actually two layers of solute ions, the positive ions and the negative ions, the result may be multiplied by two: **2×10^8 Newtons.**

The potential energy of the single layer of 10^{16} ions may be approximated as follows. Assume that the ions are distributed as $(10^9 \times 10^7) = 10^9$ LONG (z-direction) X 10^7 WIDE (x-direction), i.e., (1 METER LONG X 1 CM WIDE)

$$Fz = nz\ F(r) = nz\ [kq1q2/\varepsilon r^2] \quad (9)$$

$$Wp = nx \iint nz\ [kq1q2/\varepsilon r^2] dnz\ dr = nx\ [nz]^2/2 * [kq1q2/\varepsilon r] \quad (10)$$

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for nz = 1 to 10^9 , the number of ions in the z-direction, and r = 10^{-9} meter to ∞, the distance between each pair of solute ions, and nx = 10^7 , the number of ions in the x-direction. The terms q1 and q2 are the charge of each ion, in coulombs, k is a constant 9 x 10^9 N-m^2/$coul^2$.

$Wp = ½\ 10^7\ [10^9]^2 * [\{(9x10^9)(1.6x10^{-19})(1.6x10^{-19})\}/\{(81)(10^{-9})\}] = 1.4x10^4$ N-m

$= 1.4x10^4$ Joules = 14KJ (11)

If we factor out nx, then

Wp for a single line of ions is $1.4x10^4$ Joules/10^7 = $1.4x10^{-3}$ Joules –

Wp is the potential energy, in Joules, due to the expansion of the ions due to the Coulomb forces. Note that this calculation does not consider the "cross-force coefficient or factor, c" illustrated in FIG. 10. If the factor c is considered, the potential energy should increase even more dramatically.

It remains to be determined the amount of work necessary to be performed by the transverse longitudinal electric field to form a linear near planar alignment of solute ions using as an example the electrode assembly (100E) shown in FIGS. 6 through 9. However, it can be appreciated that, under the hypothetical conditions of accumulated charge at the theoretical distances assumed in the calculations, there is no known more powerful force than separated like charged ions. In concert with power provided from the monopole motor, even if the power requirements for the charge acceleration process are very large, these requirements would be offset by the power from the monopole motor.

There are numerous potential applications for the proposed linear alignment of solute ions, the most obvious being marine propulsion to replace current propellers and superconducting magneto-hydrodynamic concepts. In addition, the commercial aviation industry currently spends over $US 100 billion per year on aviation fuel. Such costs could be averted if the proposed propulsion system is shown to be feasible for aviation. Other applications include possible proton and other ion therapy, wastewater and nuclear waste treatment, and separation of rare metals from solutions, e.g., gold from seawater, by deflecting the high velocity beam of various solute ions in seawater via a magnetic field.

CONSIDERATIONS FOR MONOPOLE DESIGN

There are three minimum basic considerations for the design of closed electric field monopoles:

1. How much charge can be accumulated?
2. How long can the accumulated charge be confined?
3. What are the resulting electric fields and forces between monopoles, either attraction or repulsion, as a function of distance between the electrically conductive surfaces of the monopoles?

The first question of how much charge can be accumulated relates to the internal forces or pressure within the monopole. In one sense, creation of a monopole via confinement of solute ions is similar to magnetic confinement of a plasma in nuclear fusion. In nuclear fusion of say deuterium and tritium ions, the repulsion (Coulomb) forces due to the creation of an ionized gas must be confined by a magnetic field or by inertial confinement. Not only must confinement occur but the ions must overcome the Coulomb forces to travel from distances of 10^{-10} meters apart to distances of 10^{-15} meters where the strong nuclear force, which acts only over extremely small distances, causes the ions to fuse. In contrast, to create a monopole, only an equilibrium or relatively static condition of the solute ions is necessary. However, the forces of repulsion to maintain such a static condition must be overcome by brute strength of materials.

This leads to the second question of how long the ions can be confined. The separated homopolar ions will constantly seek to become neutralized by moving towards and seeking out oppositely charged ions to become neutralized. This process can occur not only by leakage and loss of structural integrity due to the brute force necessary to confine the homopolar ions but also by other factors such as corrosion. Thus, in practical terms, as with any other engineering product, there is an as yet undetermined finite life to a monopole. It should be noted that, in comparison to the requirements of desalination wherein the electrode material should be capable of absorbing comparatively large amounts of charged ions, for the most part, the current application for the closed end monopoles only requires (and can only accommodate) small amounts of charged ions. Therefore, many

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corrosion resistant, high strength materials can be substituted for carbon aerogel, e.g., copper alloys, gold, silver and platinum, among others. Attempting to reduce the amount of internal pressure and brute force necessary may also be directly a factor in answering the third question. As shown in FIG. 11, at the very least, a solution of excess homopolar ions will reach an equilibrium condition by pressing against the internal surfaces of the monopole. Any excess homopolar ions in the interior region of the monopole may not in fact contribute significantly to the intended purpose of the monopole of repelling (or attracting) another monopole because it may be that the electric field E emitted from the electrically conductive external surface of the monopole predominantly originates from the solute ions pressing against the internal surface of the electrically conductive partitions. The electric fields (and the resulting internal repulsion forces) from any homopolar ions suspended in the solute in the interior may only be increasing the brute force necessary to confine the ions, rather than assisting significantly in the repulsion of another monopole (the external repulsion force). Thus, at first glance, it appears that it is extremely important to limit the accumulation of solute ions to just enough to no more than coat the internal surfaces of the monopole.

With respect to the open end monopoles for linear alignment, FIG. 12 illustrates a simplified example of linear alignment of solute ions during the charge acceleration mode. Electric fields **E1** (from the housing electrode) and **E1'** (from the partition electrode) are shown surrounding the positive (+) solute ions that have been accumulated on the positive (+) electrode. The upstream, downstream and side walls of the housing of the electrode assembly form a resistance barrier to the linear expansion of the solute ions. The electric fields **E1** and **E1'** act laterally on the linearly aligned solute ions, in a manner similar to that shown of a compressed spring which is moved laterally by a downward force F_L acting along the length of the spring, until the downstream wall is no longer present and the spring (or solute ions) suddenly expand. During the lateral motion, the coefficient of friction μ and the spring force F_s (=-kx) at both ends of the spring determine the magnitude of the lateral force F_L (= 2 μ F_s) that is required, where **k** is the spring constant and **x** is the longitudinal compression displacement along the spring centerline axis.

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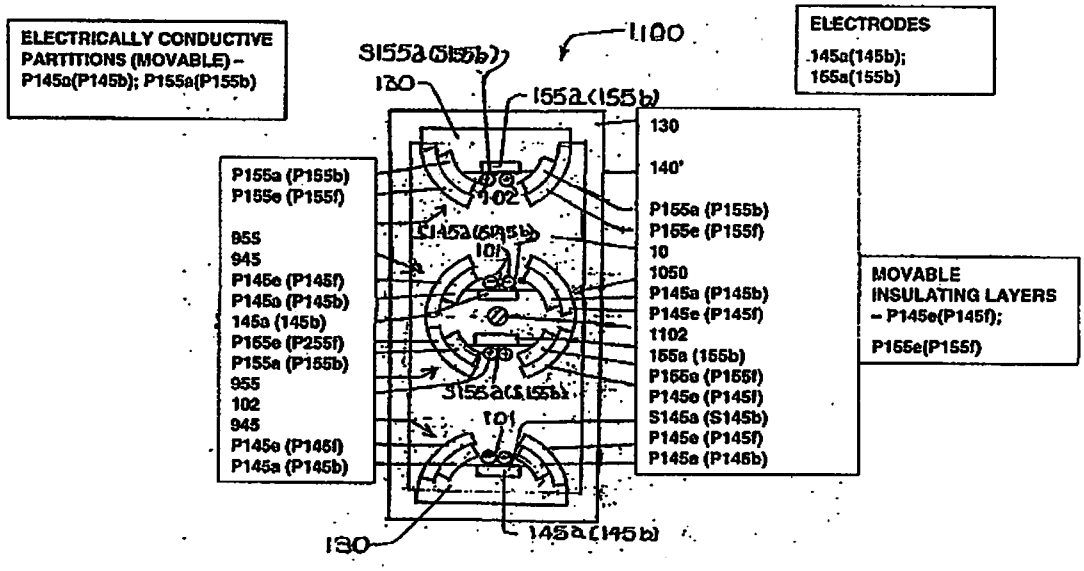


FIG. 3 – Method of making monopoles

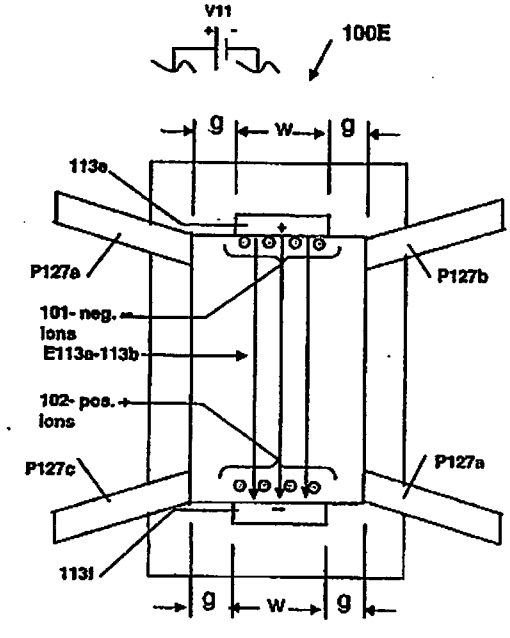


FIG. 6 – Charge accumulation mode – Work W1

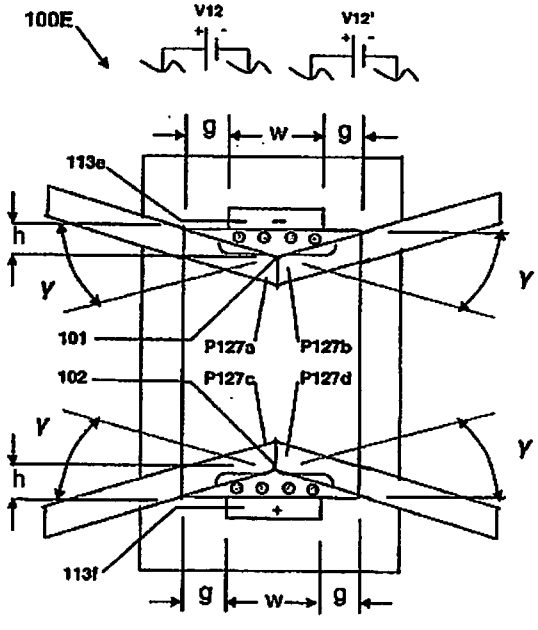


FIG. 7 – Charge acceleration mode – Work W2

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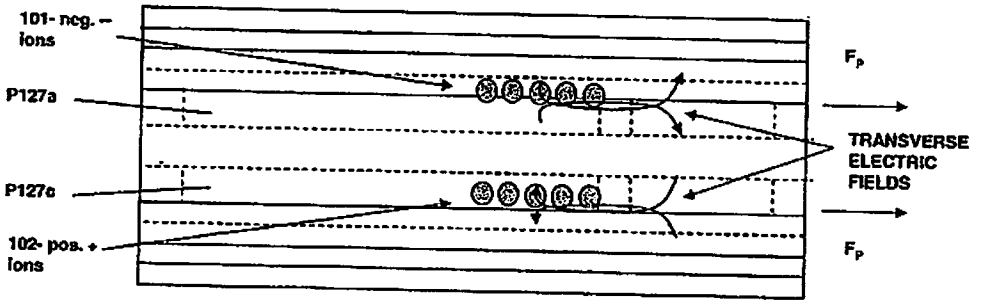


FIG. 8 – Left side view of FIG. 7 during charge acceleration

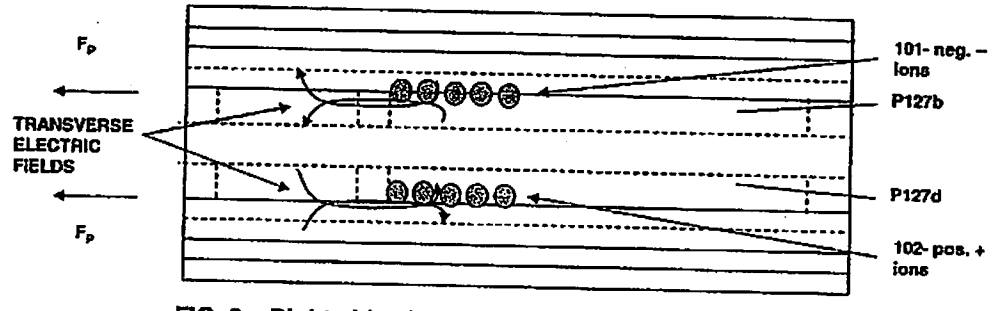


FIG. 9 – Right side view of FIG. 7 during charge acceleration

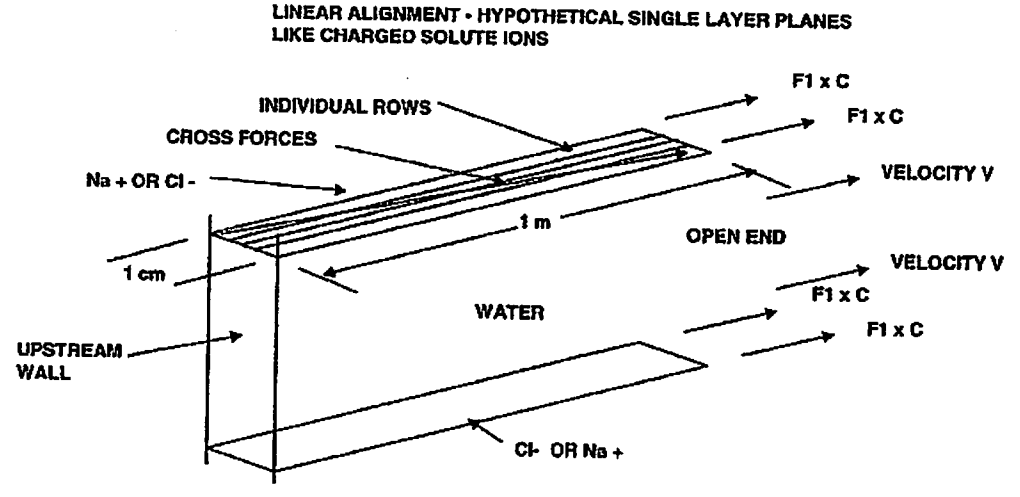


FIG. 10 – Hypothetical planes of solute ions in linear alignment

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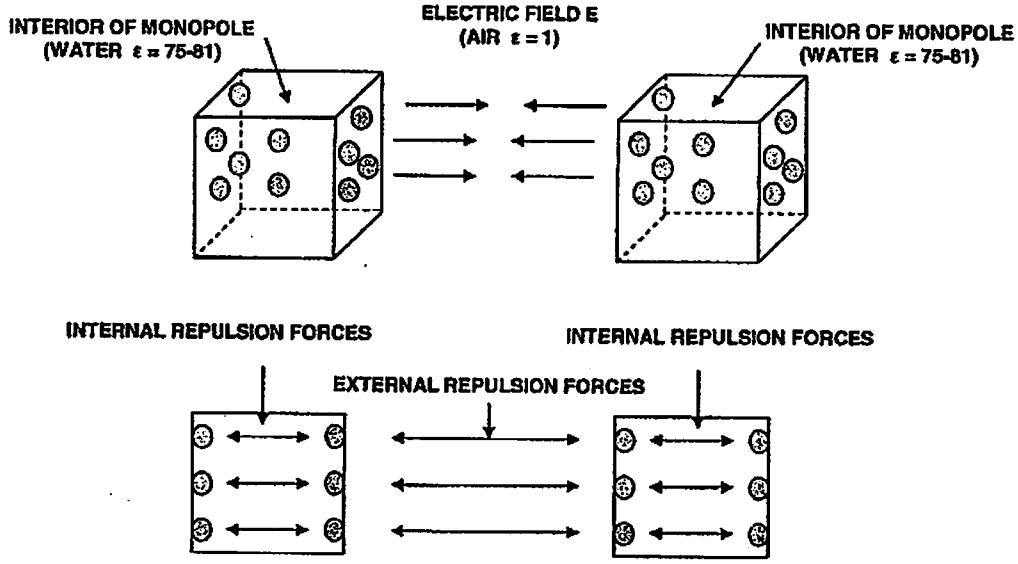


FIG. 11 – Internal and external forces and electric fields of closed monopoles

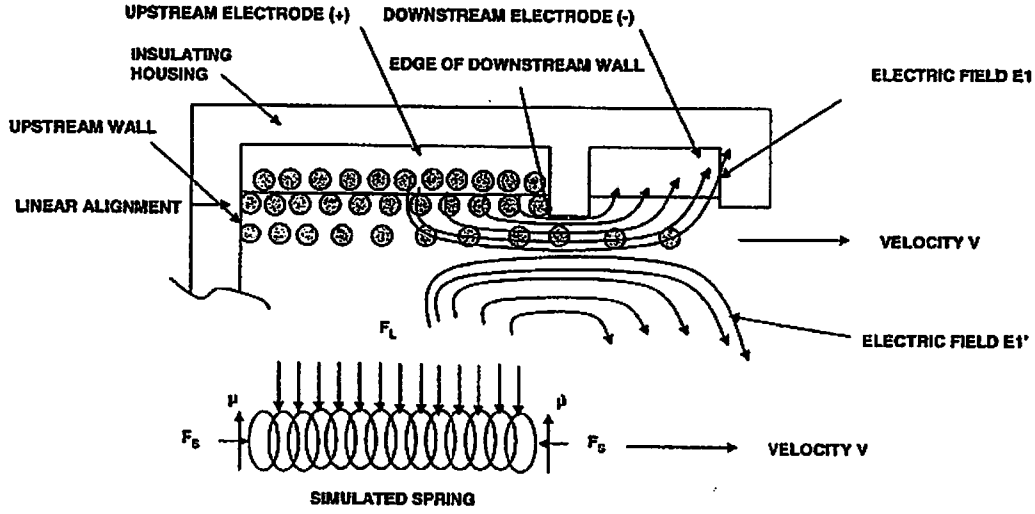
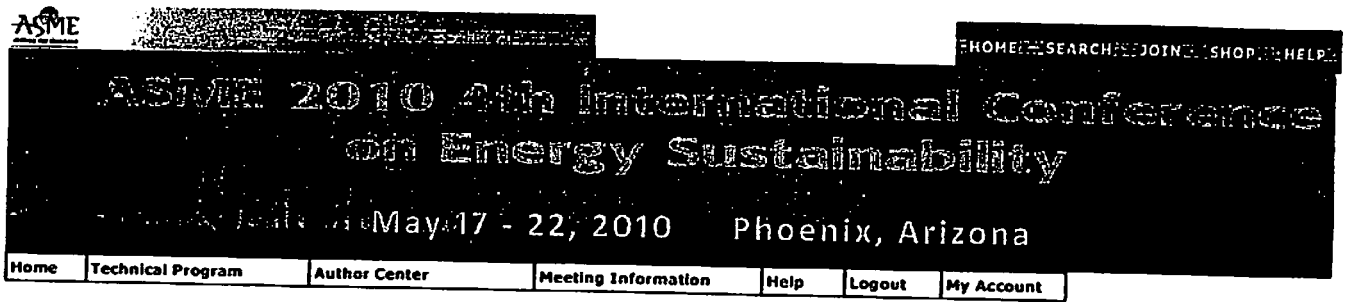


FIG. 12 – Linear alignment of solute ions for charge acceleration

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Track 1 Policy, Education, and Legal Aspects of Energy Expand All Sessions In Track

Track 2 Climate Control and the Environment Expand All Sessions In Track

Track 3 Fuel Cells and Hydrogen Energy Technologies Expand All Sessions In Track

Track 4 Energy Systems: Design, Integration, Implementation Expand All Sessions In Track

Track 5 Renewable and Alternative Energy Technologies Collapse All Sessions In Track

Track Co-Chair: J.Rhett Mayor, *Georgia Institute of Technology*

Track Co-Chair: James Menart, *Wright State University*

Papers Not Assigned To A Session

ES2010-90456 Economics of Using the Producer Gas from Biomass in Co-Firing Mode in a CCHP Unit to Meet the Building Load of a Commercial Building — Technical Publication

5-1 Energy from Waste Products *(Technical)*

Session Schedule: Wednesday, May 19, 2010 10:30 AM-12:00 PM

Session Sponsors:

Session Chair: Byard D. Wood, *Utah State University*

Session Co-Chair: Makame Mbarawa, *Tshwane University of Technology*

ES2010-90219 Design of Farm Waste-driven Supply Side Infrastructure for Data Centers — Technical Publication

ES2010-90479 Colorado Community Benefits from Installing Waste Heat Recovery System — Technical Publication

ES2010-90397 Economics of Wastewater Treatment Codigestion — Technical Publication

ES2010-90510 Experimental Studies on a DI Diesel Engine Using Tyre Pyrolysis Oil Diethyl Ether Blends — Technical Publication

5-2 Alternative Electric Power Technologies I *(Technical)*

Session Schedule: Wednesday, May 19, 2010 02:00 PM-03:30 PM

Session Sponsors:

Session Co-Chair: Jacek Kalina, *Silesian University of Technology*

ES2010-90089 Converting low-grate heat into power using a supercritical Rankine cycle with zeotropic mixture working fluid — Technical Publication

ES2010-90231 Designing, Integrating, and Implementing a Microgrid — Technical Presentation Only

ES2010-90195 Human Power Generation in Fitness Facilities — Technical Publication

ES2010-90303 A Roadmap for Rural electrification in Developing Countries using MiViPPs (Micro utility virtual power plants). — Technical Publication

ES2010-90396 SOLUTE ION COULOMB FORCE MONOPOLE MOTOR AND SOLUTE ION LINEAR ALIGNMENT PROPULSION — Technical Publication

5-3 Energy Storage *(Technical)*

Session Schedule: Wednesday, May 19, 2010 04:00 PM-05:30 PM

Session Sponsors:

Session Chair: Rathinam Selvam, *University of Arkansas*

Session Co-Chair: Debjyoti Banerjee, *Texas A&M University*

ES2010-90067 Leveling Intermittent Renewable Energy Production Through Biomass Gasification-Based Hybrid Systems — Technical Publication

ES2010-90227 Electric Utility Operational Cost and Emissions Management with Grid-scale Energy Storage — Technical Publication

ES2010-90377 PROJECTIONS OF LEVELIZED COST BENEFIT OF GRID-SCALE ENERGY STORAGE OPTIONS — Technical Publication

5-5 Renewable Energy Studies *(Technical)*

Session Schedule: Thursday, May 20, 2010 10:30 AM-12:00 PM

Session Sponsors:

Session Chair: Mohammad O. Hamdan, *United Arab Emirates University*

ES2010-90006 Reflections on the Motive Power of Fire II — Technical Publication

ES2010-90129 Low Capital Cost Renewable Energy Conversion with Liquid Piston Stirling Engines — Technical Publication

ES2010-90488 Lessons Learned from 30 Years of Experience with Renewable Energy Technologies at Fort Huachuca, Arizona — Technical Publication

ES2010-90374 Western Wind and Solar Integration Study Hydropower Analysis: Benefits of Hydropower from Large-Scale Integration of Renewables in the Western United States — Technical Publication

S-6 Turbines and Engines *(Technical)*

Session Schedule: Thursday, May 20, 2010 02:00 PM-03:30 PM

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ES2010-90350 Performance and testing of a unique low speed water turbine. — Technical Publication

ES2010-90351 Paper Title:The design of a low speed water turbine. — Technical Publication

S-9 Alternative Electric Power Technologies II *(Technical)*

Session Schedule: Thursday, May 20, 2010 04:00 PM-05:30 PM

Session Sponsors:

Session Chair: Daniel Zimmerle, *Colorado State University*

ES2010-90446 Pre-feasibility analysis of a wind-solar-diesel electricity generation system for a remote island community in the Gulf of Guayaquil in Ecuador — Technical Publication

ES2010-90382 Dynamic Simulation of an Integrated Solar Power Plant — Technical Publication

ES2010-90193 A Scalable, Economical, Uninterrupted Solar Thermal Power System — Technical Publication

ES2010-90015 Analytical Thermal Analysis of Solar Chimney Power Plant — Technical Publication

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