POSSIBILITY OF LIBERATING SOLAR ENERGY VIA WATER ARC EXPLOSIONS

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ABSTRACT

This paper reports progress in an experimental investigation, started in the Hathaway laboratory in 1994, which deals with the liberation of intermolecular bonding energy from ordinary water by means of an arc discharge. A new fog accelerator is described and a table of results of the kinetic energies of fog jets is included. The energy of liquid cohesion is stored in water during condensation when the vapor molecules transform their kinetic energy to potential energy. Since the kinetic energy of the vapor was acquired by solar heating of the atmosphere, it is solar energy in concentrated form that is being liberated by water arc explosions.

INTRODUCTION

Frungel (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 electro-hydraulic metal forming (Gilchrist and Crossland, 1967). It was clearly recognized from the start that water arcs were relatively cold and no steam was raised. Measurements of arc explosion forces were started at MIT (Graneau and Graneau, 1985) and continued at Northeastern University (Azevedo et al, 1986). Not until 1993 was it realized that the water arc liberated energy from another source than the capacitor input energy. It caused Hathaway Consulting Services to resume experimentation with water arcs. The present paper presents a series of experiments which forms part of a continuing research program.

The principal discovery made in the past two years was that it is a collection of fog droplets in the water which explodes and not the liquid water itself. The term 'fog' is meant to include not only the tiny droplets which float in air but also larger droplets which fall in the atmosphere and would be more correctly described as 'mist'. The sole explanation of the explosions so far put forward contends that the intermolecular bonding energy in fog is less than 540 cal/g, the latent heat of bulk water. The bonding energy difference is then liberated in a quantum jump when the fog is formed in micro-seconds. It is difficult to determine the latent heat of fog, and no published measurements have been found.

The intermolecular bonding energy, that is the energy of liquid cohesion, is stored in water during the process of condensation. Vapor molecules give up their kinetic energy and exchange it for bonding energy. But the kinetic energy of the vapor in the clouds is the result of solar heating. Liberating the bonding energy is therefore a means of

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regaining concentrated solar energy.

Progress made in this research up to October 1, 1995, has been reviewed in a recently published book by Graneau and Graneau (1996). Further information is contained in a paper which was presented at the 1996 World Renewable Energy Congress (Graneau, 1996).

In the reviewed experiments, the energy delivered to small quantities of water, up to 1.5 cm^3, was typically less than 50 J. This could not have increased the water temperature by more than 10°K. Steam explosions were out of the question because no liquid breakdown mechanism is known which can channel a significant fraction of the current into a thin water filament. A photocell measurement established that ionization was completed in 0.8 μs and no current flowed around the circuit until after this time. It has to be remembered that the ionization process absorbs energy and does not generate heat.

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

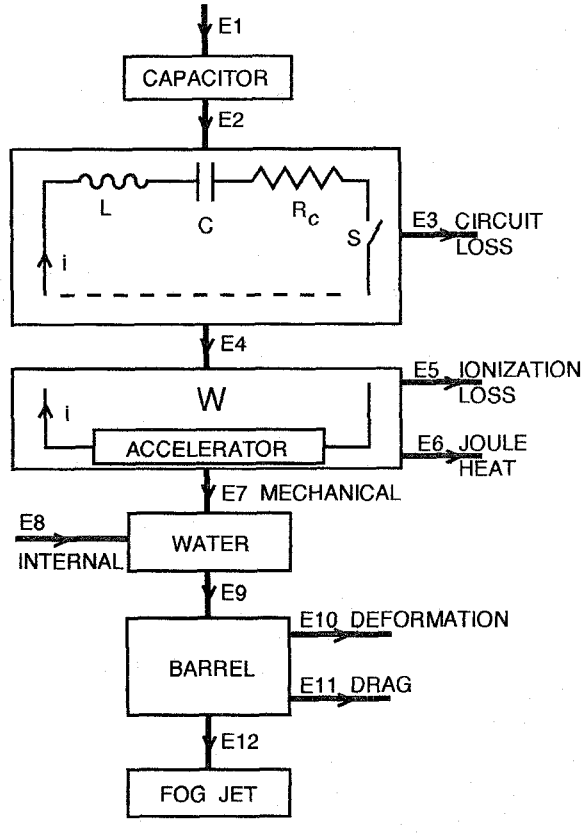

Fig. 1 Energy Flow Diagram

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

where I_o is the intercept of the exponential envelope on the current axis, T is the damping time constant, $\omega=2\pi f$ 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

$$R = 2\ L/T. \qquad (2)$$

R has two components

$$R = R_o + e_b/i_{rms}. \qquad (3)$$

R_o is the ohmic resistance of the discharge circuit and e_b is the induced back-e.m.f. in the water which accounts for any mechanical work (E_7) which has to be done on the water to generate cold fog. We know of no way in which the components of equ.(3) can be obtained separately.

E_7 must supply the surface tension energy increase required by fog formation and it may accelerate the droplets a little. This has to be done by 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

$$F_7 = (\mu_o/4\pi)\ k\ i^2. \qquad (4)$$

The value calculated by Northrup for the dimensionless k-factor was k=0.5, whatever the diameter of the current cross-section.

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

$$P_{12} = \int F_{12}dt = m\ u_{av}, \qquad (5)$$

where m is the mass of the fog and u_{av} its average velocity. This should be compared to the mechanical impulse received by the fog droplets from the electrodynamic impulse P_7. We may write

$$P_7 = \int F_7 dt = (\mu_o/4\pi)\ k \int i^2 dt. \qquad (6)$$

The action integral $\int i^2dt$ is available from the current oscillogram. To compare P_{12} with P_7 we express P_{12} by

$$P_{12} = (\mu_o/4\pi)\ k' \int i^2 dt, \qquad (7)$$

where

$$k' = 10^7\ m\ u_{av}/\int i^2 dt. \qquad (8)$$

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

As soon as water arc explosion forces were measured ten years ago (Azevedo et al, 1986) it was found that k'>>k. This fact was confirmed in all subsequent experiments. It left little doubt that the water arc explosions contained additional energy (E_8) over and above E_7.

When Ampere's force law was used in equ.(6), the k-values increased from 0.5 to ~200 (Graneau and Graneau, 1996). This was still far too small to deny the existence of E_8 and gave an impulse ratio P_{12}/P_7 of the order of 50 - 100. Newtonian mechanics then requires that, provided the impulses act on the same mass (fog),

$$E_{12}/E_7 = (P_{12}/P_7)^2. \qquad (9)$$

This can be proved as follows. If a mass m is accelerated to the velocity v_1 it requires an impulse of

$$P_1 = \int F_1 dt = m\ v_1. \qquad (10)$$

Let the same mass acquire additional energy in flight (E_8) to reach the velocity v_2, then the impulse becomes

$$P_2 = m\ v_2. \qquad (11)$$

Therefore the impulse ratio is

$$P_2/P_1 = v_2/v_1. \qquad (12)$$

This makes the ratio of final to initial kinetic energy

$$E_2/E_1 = \tfrac{1}{2}\ m\ v_2^2\ /\ \tfrac{1}{2}\ m\ v_1^2 = (P_2/P_1)^2, \qquad (13)$$

which proves equ.(9).

For the impulse ratios of 50 - 100 of the water arc experiments this implies 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.

TYPE B ACCELERATOR RESULTS

The various accelerator designs used since 1983 were described by Graneau and Graneau (1996). A new design, which has been called the type B accelerator, is shown in fig.2.

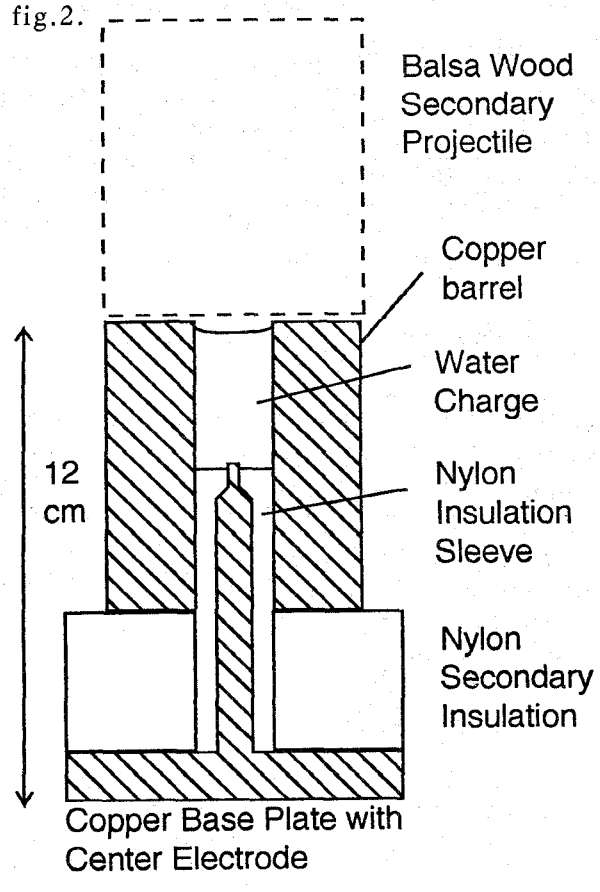

Fig. 2 Type B Accelerator with Secondary Projectile

To determine the fog jet momentum, a secondary projectile consisting of balsa wood stands on the accelerator barrel. The dry mass of the projectile is labeled M while the fog mass absorbed in the wood is denoted by m. C=0.565 μF capacitance is charged to the voltage V_o and then discharged through the accelerator by closing the switch S. An oscilloscope records the discharge current i(t).

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

$$v_o = \sqrt{(2\ g\ h)}, \qquad (14)$$

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

$$u_{av} = (M+m)\ v_o/m. \qquad (15)$$

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

$$E_2 = \tfrac{1}{2}\ C\ (V_o^2 - V_r^2). \qquad (16)$$

The kinetic energy of the fog jet is

$$E_{12} = \tfrac{1}{2}\ m\ u_{rms}^2. \qquad (17)$$

Neither the mass distribution of the fog droplets nor their velocity distribution are known. 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

$$u_{rms} = 1.11\ u_{av}. \qquad (18)$$

The table lists the results of 14 shots. In all cases the water charge was w=1.5 cm^3 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 equs.(10) to (14). The table 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 was m=0.504 g and its average velocity came to u_{av}=306.4 m/s. This resulted in an impulse exerted on the secondary projectile of $P_{12}=mu_{av}=0.154$ N s. The action integral of this shot was $\int i^2dt=120.5$ A^2s. Then with the

TABLE OF RESULTS

Shot #	V_o kV	E_2 J	Min Loss J	u_{av} m/s	E_{12} J
SP12	10	28.3	24.4	258	21.0
SP13	9	22.9	22.4	273	21.5
SP14	12	40.7	27.2	235	21.5
SP15	12	40.7	27.2	244	17.8
SP16	12	40.7	27.2	229	20.9
SP17	10	28.3	24.4	172	13.0
SP18	10	28.3	24.4	258	21.8
SP19	10	28.3	24.4	274	23.1
SP20	10	28.3	24.4	218	17.8
SP21	10	28.3	24.4	191	16.1
SP22	10	28.3	24.4	251	19.7
SP23	12	39.8	27.2	243	22.3
SP24	12	39.8	27.2	306	29.2
SP25	12	39.8	27.2	275	28.5

Ampere force factor k=200, equ.(6) gives $P_7=2.41\times10^{-3}$ N s. The impulse and energy ratios, therefore, are $P_{12}/P_7=63.9$ and $E_{12}/E_7=4083$. Hence E_7=7.15 mJ, which is negligible compared to E_{12}=29.2 J and demonstrates that virtually all the kinetic energy developed by the explosion must be internal water energy.

In spite of the gain in internal water energy, the overall energy ratio, E_{12}/E_2 is less than unity because of the five loss components indicated in fig.1. Additional losses occur because of electrolytic action in the water and the emission of light and sound from the arc. We have made a rough estimate of the circuit losses. E_3 is derived from the short circuit resistance R_c and the action integrals of the water shots. E_6 is obtained from the water temperature rise of a few degrees measured with a thermocouple projecting through the barrel into the water cavity. The ionization energy is estimated by

a method described by Graneau and Graneau (1996). The sum of the three loss components is listed in the table under minimum circuit loss. It varies between 67 and 94 percent of the input energy E_2, providing further confirmation that $E_{12}/E_7>1$.

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.

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