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# Dark Current in Liquid and Electric Energy

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***ABSTRACT :*** *The dark electric current arising from the contact of aluminum with water can be a source of electrical energy. The strength of the dark current is proportional to the ambient temperature. This does not contradict the second law of thermodynamics, although the dark current in a liquid in contact with two unequal aluminum electrodes flows for a very long time without noticeable attenuation. Chemical reactions of aluminum with water do not play role in creating this current.*

***KEYWORDS:*** *Aluminum, Water, Voltage, Dark current, Resistance, Temperature.*

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## I. INTRODUCTION

In physics and in electronic engineering, dark current is the relatively small electric current that flows through devices even when no photons are entering the device. It consists of the charges generated in the detector when no outside radiation is entering the detector. Physically, dark current is due to the random generation of electrons and holes within the depletion region of the device [1]. If voltage applied to two electrodes of such devices, value of the dark electric is typically $10^{-7}$ A. Another thing if a photosensitive device consists of two aluminum electrodes immersed in water. In this case the value of dark electric current can achieve 0.1 mA without external voltage [2].

The aluminum oxide layer is too thin that particles of the metal and the water can pass through a potential energy barrier of the layer that is higher than the energy of the particles. A tunneling current therefore can flow through the contact of aluminum with water. The second law of electrodynamics asserts that the current can occur at the temperature difference between electrodes. Since the tunneling is quantum process, the principle of nondecreasing entropy can be violated [3]. Such a simple hypothesis, arguing for the appearance of a dark current, requires confirmation. It's not about whether it's fair or not. To tell the truth, this hypothesis seems doubtful, but the dark current in a liquid in contact with two aluminum electrodes flows without noticeable attenuation for a very long time, weeks or even months [4].

Can an aluminum-water condenser located in a heated environment produce electrical energy, violating the classic version of the second law of thermodynamics [5]? This is the question that needs to be answered. Chemical reactions occurring in one cell with two dissimilar aluminum electrodes in the liquid have nothing to do with what happens in the other. Therefore, the voltages created by two approximately identical cells with aluminum electrodes immersed in a liquid should be measured simultaneously. If electrical energy is generated by the environment, this will be recorded. If these are two ordinary chemical sources, then there should be no correlation between voltages in principle. On the other hand, the intensity of chemical reactions depends on temperature. Therefore, the time independence of dark currents arising in two independent sources should be, if not confirmed, then studied.

## II. MEASUREMENTS

The setup shown in Fig. 1 enables to measure simultaneously voltages created each sources. The main part of the each source is a cell ($K$) filled with distilled water ($L$). Two cylindrical electrodes ($S$) and ($C$) with diameters 7 mm and 70 mm respectively are immersed in the water. The high of electrodes is 50 mm. The depth of immersion was 6 cm. Voltages $U_1$ and $U_2$ on the load resistances $R$=6 kΩ are registered simultaneously. The cells 1 and 2 are in light-proof vessels $V$. The voltage drop across the resistor is accompanied by energy losses in the liquid. As a result, the temperature of the liquid may differ from the ambient temperature. Therefore, the third vessel with opaque walls filled with water with the same volume is intended for measuring the ambient temperature $t$.

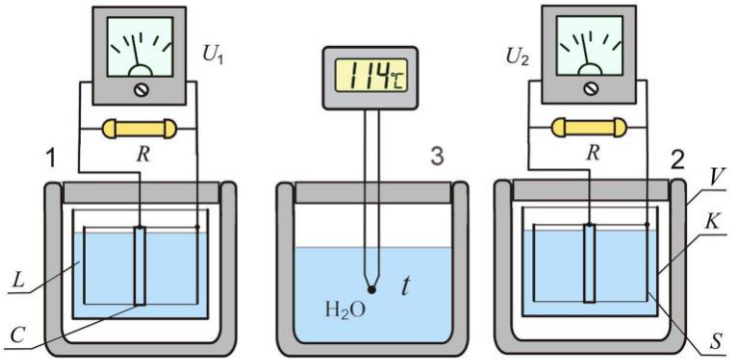


**Fig. 1. Experimental setup**

What is shown in Figure 2 means that the voltages are dependent on the external environment. An increase in the voltage created by one source is accompanied by an increase in the voltage in other source. In other words, a simple solution to the problem, assuming the dominant role of chemical reactions, did not take place.

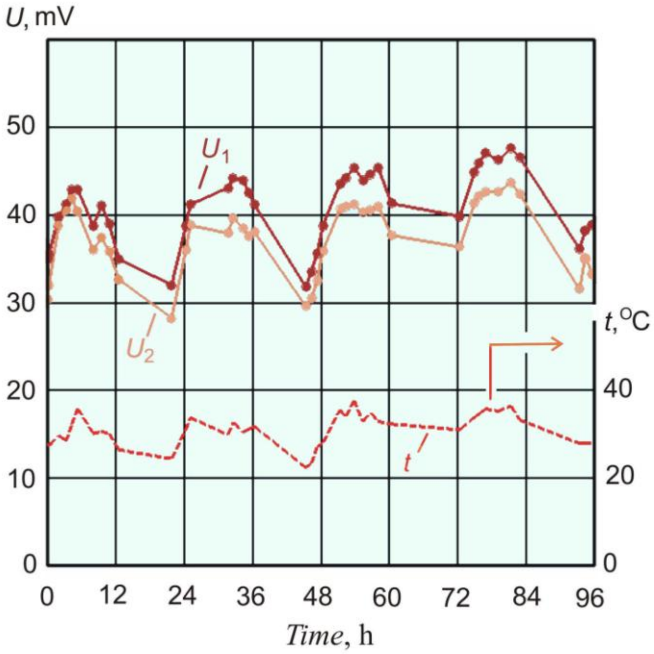


**Fig. 2. Time dependencies of voltages *U* and temperature *t***

Weak chemical reactions occur even when aluminum comes into contact with even distilled water. Ordinary water, not only sea water, reacts quite intensively with aluminum. However, the intensity of chemical reactions decreases over time, rather than increases. By the way, the measurements, the results of which are shown in Fig. 2, started a week after loading the water into the cells. In any case, how the voltage drops are correlated needs to be studied. It is not a dependence of one voltage drop on another. The influence of one source on another is excluded.

## III. CORRELATION AND DISSIPATED ENERGY

Ideally, the values of $U_1$ and $U_2$ should be proportional to each other if they are generated by the same source. For example, two lamps connected to one even chemical source of electrical energy at each moment of time shine the same even if the current in the circuit changes over time. It's another matter if the lamps are connected to two, even almost identical, chemical current sources. Chemical processes in current sources proceed in different ways. In this case, the proportionality between the luminosities of the lamps will be violated. Checking the proportionality between $U_1$ and $U_2$ allows, therefore, to evaluate the role of chemical processes that occur when aluminum comes into contact with water for the sources shown in Fig. 1. The 99correlation shown in fig. 3 allows us to assert that the role of chemical processes in such sources of electrical energy is minimized.

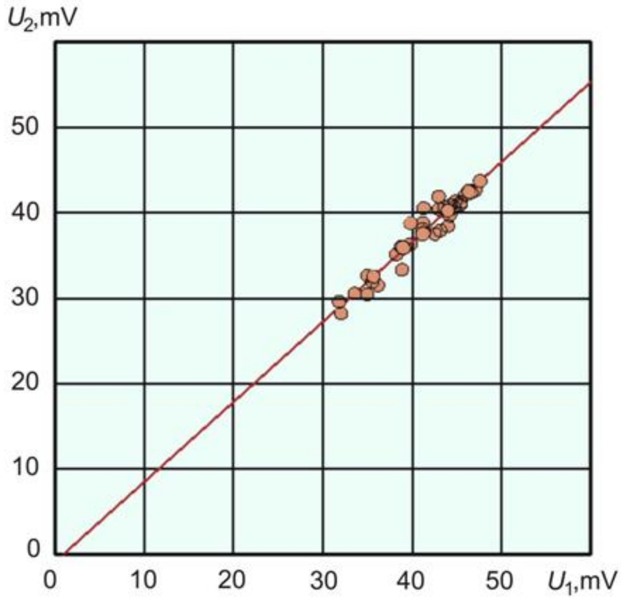


**Fig. 3. Correlation between voltages $U_1$ and $U_2$**

It can also be recalled that over 96 hours of exposure, the average current value per day did not decrease, but rather increased. The reason for this, apparently, is the increase in ambient temperature. Shown in fig. 5, the dependence of one of the voltage drops on the water temperature in the third cell also confirms this result. It turns out that a change in the ambient temperature by 1 degree leads to a change in the voltage drop by about 1 mV, but for a given volume of water and specific dimensions of the source electrodes shown in Fig. 1. Unfortunately, the limited range of experimental data does not allow us to accurately determine the temperature at which energy extraction stops.

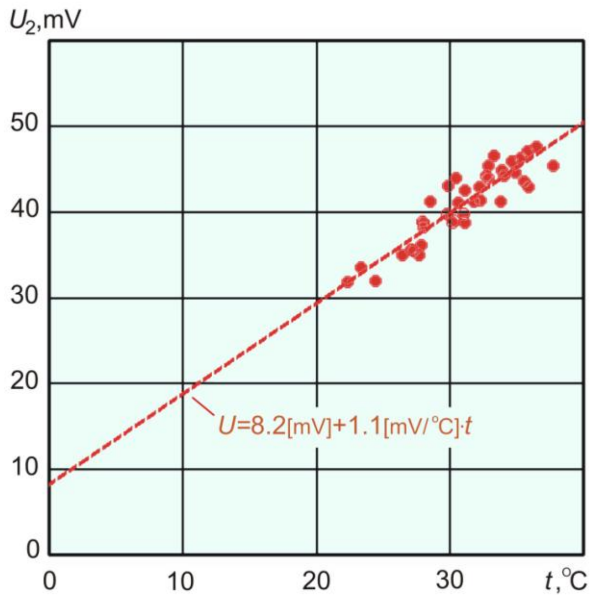


**Fig. 4. Temperature dependence of voltages**

It remains to estimate the amount of energy that is released on the resistor during the time interval t. For this, it is necessary to calculate the sum

$$W = \sum (U_{j+1}^2 + U_j^2)(t_{j+1} - t_j)/2R$$

for all experimental results shown in Fig. 2.

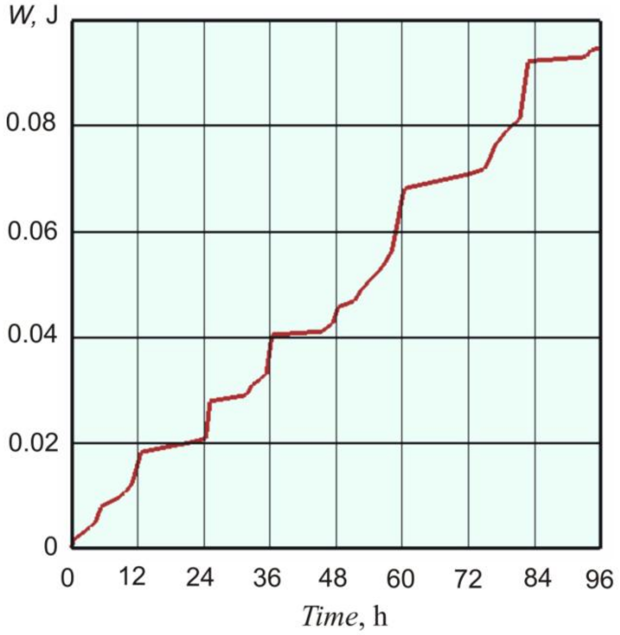


**Fig. 5. Dissipated energy as a function of time**

For 96 hours, the energy of about 0.1 J is released on the resistor with resistance $R$=6 kΩ (Fig. 5). Of course, this is small and only enough to lift a body weighing 100 g to a height of about 0.1 m. The electrodes are too small, their placement and design are far from optimal. A large number of such sources connected in parallel and in series can significantly increase this figure [6].

## IV. CONCLUSION

In the present work, small sources were used only to prove that the dark current energy is extracted from the environment. At least this is evidenced by the experimental results. No other explanation has yet been found. Most likely it is not. It remains to find ways to significantly increase the efficiency of dark sources of electrical energy. A large number of examples are known when a seemingly weak phenomenon became the basis for progress, including in the energy sector. There is every reason to believe that the same will happen with the dark current in the liquid.

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