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Energy Parameters of Dark Electric Current in Liquid

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ABSTRACT: *Measuring the voltage on the resistor linked to two cylindrical aluminum electrodes immersed in distilled water enables to determine electromotive force and internal resistance of such a source of electric current. This electric current flows in the circuit with no external optical influence. Chemical reactions of aluminum with water do not play role in creating this current. The internal resistance is found to be of order of* $k\Omega$

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

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I. INTRODUCTION

In studying the electric conductivity of liquids, experiments frequently encounter deviations from the known photocurrent-illuminance characteristics: the voltage is found to be proportional to neither the luminosity nor the temperature of the liquid. Sometimes with no external optical and other influences, such *dark* electric current flows in a liquid with two immersed metallic electrodes [1]. Behavior of such a source of electric current is easily enough understood if it is know of what it consists. If metal is aluminum and water is clean that a thin layer of aluminum oxide on its surface suppresses chemical reactions of the aluminum electrodes with water. On the other side, 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 [2]. Although this might seem strange at first, it is easily justified experimentally.

II. ELECTROMOTIVE FORCE, INTERNAL RESISTANCE AND TEMPERATURE

Laboratory device including the measuring circuit is shown in Fig. 2. It consists of small inner (1) and large outward (2) cylindrical electrodes with diameters 2 cm and 30 cm, respectively, immersed in the distilled water (3) in a cell (4). The cell is placed in a thermostat (5) filled with usual water (6). It enables to provide homogeneous heating of the distilled water changing the temperature of the water in the thermostat.

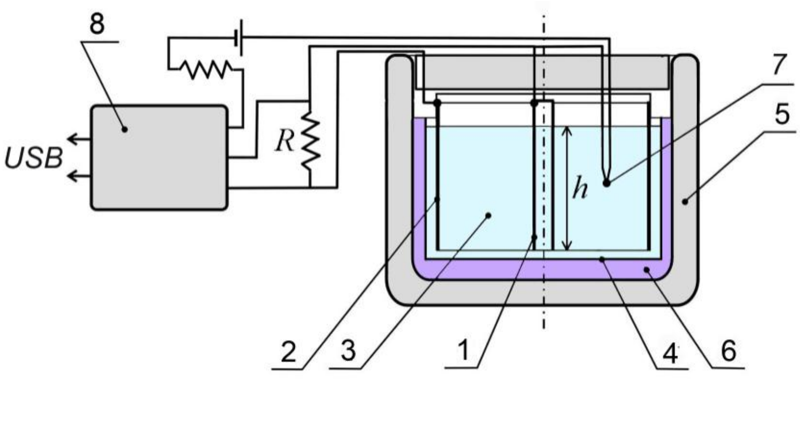

Fig. 1. Experimental setup

Electrically insulated temperature-sensitive resistor (7) is placed into the distilled water. Voltage U_R on the load resistance R simultaneously with the temperature t of the liquid are measured using a memory oscilloscope (8). Even for homogeneous heating, the temperatures of the electrodes (1) and (2) can be different, therefore appearance of a thermoelectromotive force does not violating the second law of thermodynamics, since the system is not equilibrium [3]. On the other side, this is an occasion to study the influence of the liquid temperature t on the voltages U_R.

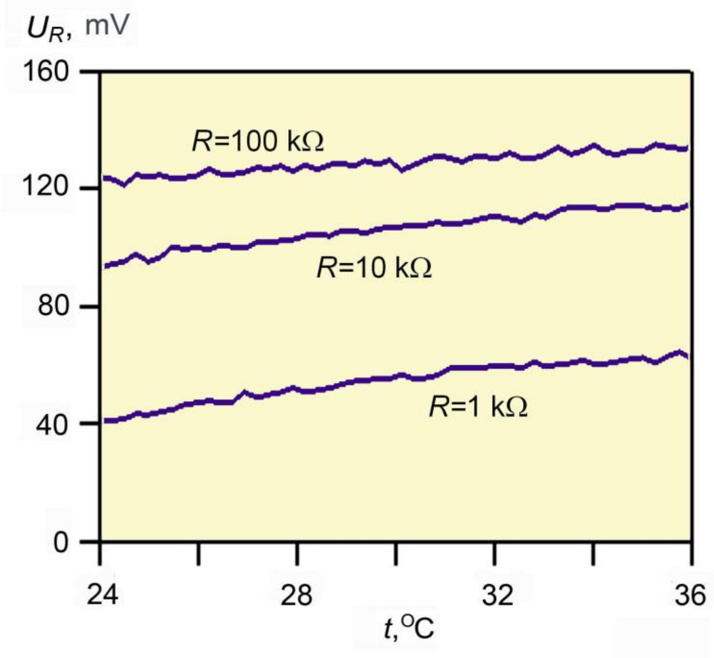

Fig. 2. Temperature dependences of the voltage at various load resistance *R*

The voltages shown in Fig. 2 have in common that they increase with temperature t, but at large values of resistance R, the voltage grows with temperature more weakly in comparison with that at 1 kΩ. This means that the internal resistance of such a source of electric current depends on the temperature t.

In fact, the temperature dependences shown in Fig. 2 were measured not only for three values of R but for ten at least. Since the resistance dependence of voltage U_R can be described by a relation $U_R=ER/(r+R)$, that having approximated inverse experimental values of voltages $1/U_R$ versus conductivity of the load resistance $1/R$, one may determine not only the internal resistance r but also the electromotive force (e.m.f.).

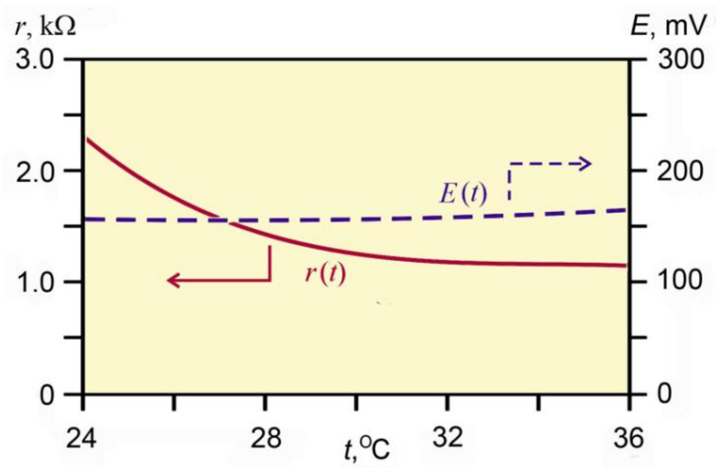

Fig. 3. Internal resistances *r* and e.m.f. *E* as a function of temperature

The results of such calculations shown in Fig. 3 are found to be quite unexpected. As the temperature of the liquid increases by 10 degrees, the internal resistance r decreases at least two times, but the electromotive force varies weakly. This means that the thermoelectricity is not a dominant process producing the dark electric current in the water with two asymmetrical aluminum electrodes. One should pay attention to small values of internal resistance shown in fig. 3. This is not a resistance of water, this is the equivalent resistance of the still weak source of electric energy. The growth of the voltage occurs due to the decrease of the internal resistance but not due to an alteration of the e.m.f.

III. DARK ELECTRIC CURRENT AND VOLUME OF LIQUID

Apparently in comparison with previous results [4], such small values of internal resistance are due to large volume of the clean water placed between aluminum electrodes. Slow evacuation of the liquid out of cylindrical vessel changes the area of cylindrical electrodes conducting with the liquid. By this manner, one may know how the high of immersion of electrodes in the liquid *h* affects energy parameters of this liquid source of electric current.

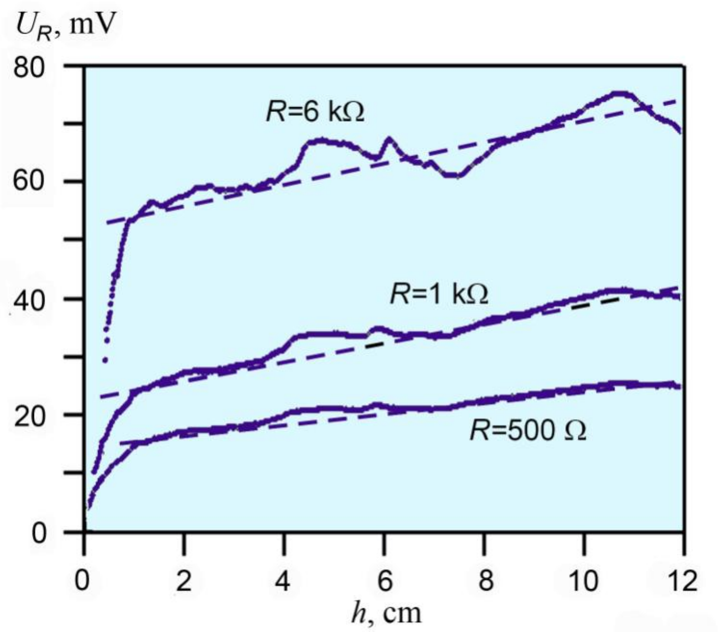

Fig. 4. Influence of the depth of immersion on the voltage

Typical dependences of the voltage U_R on the depth of immersion *h* are shown in Fig. 4. In an intermediate range of depths of immersion these dependences are approximately linear (dashed lines in the Fig. 4), that enables to act with them as it was done in previous section with the dependences of the voltage versus temperature, that is to say, to know how volume of the liquid in the vessel affects the internal resistance and the e.m.f.

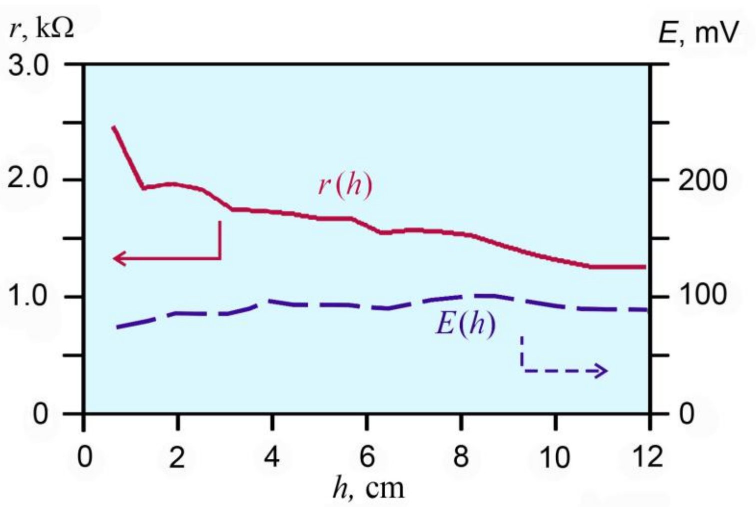

Fig. 5. Influence of the depth of immersion on the internal resistance and e.m.f.

Results of such calculations plotted in Fig. 5 show that in the intermediate range of depths from *h*=1 cm up to *h*=12 cm the electromotive force does not depend on *h* (Fig. 5). At the same time the internal resistance decreases with the magnitude of *h*. The electromotive force would be proportional to the depth of immersion if chemical reactions play dominant role in creation of this dark electric current in a liquid. This is not true for these experimental results. Weak chemical reactions really take place only at the beginning of measurements: in a few hours after charging the clean water into the vessel, the electric current decreases to zero, changes its direction and tends to a saturation called the dark electric current.

IV. CONCLUSION

There were problems in attempts to improve energy parameters of source based on the use of the dark electric current [5]. Source of energy with internal resistance of order of 100 kΩ is out of practical interest. Another thing if this value is a hundred times smaller. It is easily to estimate the power developed in the load with the resistance equal to the internal one. This is about 10^{-5} W. Appropriate to remember that the source with the parameters described above, within 24 hours liberates the energy sufficient to lift a body of mass of 0.1 kg through the high 1 m.

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