Laboratory work 3.31

Measure electromotive force by compensation method

Appliances and accessories: 1) the model of laboratory apparatus; 2) the power supply source.

Destination of this work: 1) to study the laws of direct current; 2) measure electromotive force by compensation method.

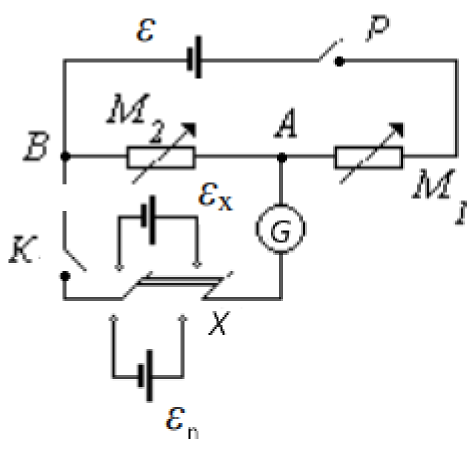
Description the appliance and theoretical statement:

Moving electric charge in the electrostatic field the force of this field do a work. The value that equal the work of electrostatic force by moving the unit of positive charge (specific work) from one point of field to another point is *differential of potentials* between these points.

Positive charge moves from one point with a high potential to the point with a low potential by act of electrostatics forces. Electrical charges can move not only by electrostatics forces but also by extraneous forces. These forces act, for example, in a galvanic cell, batteries, dynamo machines. Positive charges move from one point with a low potential to the point with a high potential by extraneous forces. The value that equal the specific work of extraneous forces that act in anything circuit calls *electromotive force*.

The compensation method is used for high quality measurements of EMF. The main theme of this method is:

1. Construct the plan (pic. 1) where ε_x is a studying galvanic cell with an unknowing value EMF; ε is a battery with EMF value that more than in ε_x; ε_n is normal element that EMF value is known. *K* is a button ; *P* is a key ; *X* is a switch.
2. When chose in stores M1 and M2 some resisters *R1* and *R2* and complete the circuit by the key *P* then the current will flow in the lower closed part of the plan. And accordin the Ohm's law:



Pic. 1

$$\varepsilon = IR_1 + IR_2 + Ir . \quad (1)$$

When plug in a studying galvanic cell ε_x into the circuit by switch *X*, that gives the current towards in galvanic circuit to the battery current and the value of current in the galvanometer will be depended by the falling of voltage *U2* = *IR2* in the part of the circuit (AB). Changing resistance R2 in this part of the circuit we can chose the value that the falling of voltage *U2* will be equal EMF of a studying galvanic cell.

$$U_2 = \varepsilon_x . \qquad (2)$$

The current through the galvanometer will not be leaking because of EMF source will offset by the counter potential difference *U2* on the site AB. From equations (1) and (2) the EMF studied source can be written as:

(3)

To include in the scheme the normal element instead of and don't change the resistance *R1*, to pick up a new resistance *R'2*, in which the current through the galvanometer won't leak. Base on reasoning similar to the previous one, you can write: ε_x

$$\varepsilon_x = \frac{R_2}{R_1 + R_2 + r}\varepsilon . \qquad (4)$$

From equations (3) and (4) to exclude the EMF battery ε_n and to find: ε_x

(5)

$$\varepsilon_n = \frac{R'_2}{R_1 + R'_2 + r}\varepsilon .$$

If the internal resistance of the battery *r* < *R1* + *R2* , it can be ignored and the formula (5) takes the form:

ε

$$\varepsilon_x = \frac{R_2\left(R_1 + R'_2 + r\right)}{R'_2\left(R_1 + R_2 + r\right)}\varepsilon_n . \qquad (6)$$

We will calculate by this formula. As a normal element use Weston mercury-cadmium element that characterized by a great constancy of EMF values and the dependence on temperature is small enough, V. *Shake and flip Weston element is barred. It couldn't be taken currents more than* $10^{-6} - 10^{-5}$ *A and to turn it on for a long period of time.* Everything of these can damage it !

$$\varepsilon_x = \frac{R_2\left(R_1 + R'_2\right)}{R'_2\left(R_1 + R_2\right)}\varepsilon_n .$$

The measurements were found for five values of resistance *R1* , begin with the value 800 ohm .

Found results put write down the table:

ε_x

The final result writes as: $\varepsilon_n = 1{,}0183$

$\varepsilon_{real} = \left(\langle\varepsilon\rangle \pm \Delta\varepsilon\right)B$ and $\alpha =$

mesur. №	R_1 ohm	R_2 ohm	R'_2 ohm	ε_{x_i} V	$\langle\varepsilon_x\rangle$ V	$\Delta\varepsilon_{x_i}$ V	$\Delta\varepsilon^2_{x_i}$ V	$S\langle\varepsilon\rangle$ V	α	$t_{\alpha,n}$	$\Delta\varepsilon_x$ V	E %
1												
2												
3												