Laboratory work Nr. 2.5

Measurement of the horizontal component of Earth's magnetic field induction by tangensgalvanometer

In each point the Earth's magnetic field is directed in any defined angle with respect to the horizontal plane and meridian, therefore the induction vector of Earth's magnetic field usually is splitted into two components: horizontal and vertical one. The magnetic arrow with vertical axis then will oriented by horizontal component of magnetic field. This property is used in devices called tangensgalvenometres (TG). By TG is possible to define either the horizontal component of Earth magnetic field B_0, or to measure current, if the value of this is known at any specific place. For Riga $B_0 = 0.168 \times 10^{-4}\ T$.

TG consists of vertically placed loop with one or more turns of wire (1 on fig.1). In the center of this loop the magnetic arrow (2 on fig.1) or compass is placed which is able to turn around the vertical axis in horizontal plane.

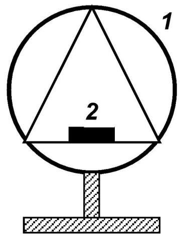

Fig.1. The schematic view of the tangensgalvanometer.

If there is no current in TG, than arrow is positioned along the meridian of the Earth magnetic field.

The loops of wire should be oriented also in this direction. If the current flows through the wire, the induction vector B_I of generated magnetic field is perpendicular both to the wire plane and Earth's magnetic field vector B_0. Vectors of discussed fields are shown on fig.2 (top view).

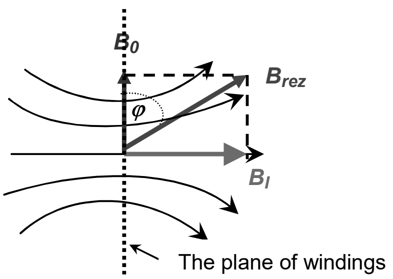

Fig.2. The scheme of Earth's and current magnetic fields inside TG (top view).

Under the action of these two fields magnetic arrow will be oriented along the resultant field $\boldsymbol{B}_{rez}$ and is deflected on angle φ from the original direction. The value of this angle can be derived from following equation (see Fig.2):

$$tg\varphi = \frac{B_I}{B_0} \qquad (1)$$

The induction B_I of current loop magnetic field in the center of it according to the Bio-Sawart law is:

$$B_I = \frac{\mu_0 In}{2R} \tag{2}$$

where B_I – induction of magnetic field (T); μ_0 – magnetic permeability constant ($1,2566\times10^{-6}$ H/m); I - current (A); n – the number of turns; r – the radius of the loop (m).

From (2) the current I can be expressed and, using (1), recorded as

$$I = \frac{2B_0R}{\mu_0 n} tg\varphi = ktg\varphi \text{ , \quad where} \tag{3}$$

$k = \dfrac{2B_0R}{\mu_0 n}$ is a TG constant. From last expression we have got

$$B_0 = \frac{\mu_0 kn}{2R} \tag{4}$$

and

$$B_0 = \frac{\mu_0 nI}{2Rtg\varphi} \tag{5}$$

that is, the horizontal component of the Earth's magnetic field induction B_0 can be defined, if the current in the TG is measured, or the constant of the TG is known.

If the constant k of the TG is known, than the TG can be used also for current measurement. To calculate k B_0 must be given. The constant can be defined also experimentally, by measuring of the angle of deflection of magnetic arrow and corresponding current.

The scheme of used circuit is shown on Fig.3. Before the beginning of measurement the loop of wire should be placed parallel to the meridian of Earth's magnetic field. The magnetic arrow should be placed very precisely in the center of the TG. The current in the loop is measured by ammeter A. The six-pole switch S is used to change the direction of the current on the opposite one. For precise definition of the angle φ, current of both directions is used and corresponding angles of deflection are defined (φ_1 and φ_2). The mean value of φ should be taken for calculations:

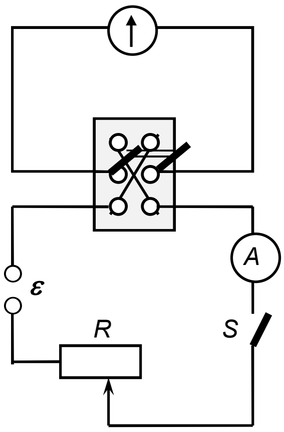

Fig.3. Electrical scheme for definition of the horizontal component of Earth's magnetic field induction by using the tangensgalvanometer.

$$\varphi = \frac{\varphi_1 + \varphi_2}{2} \tag{6}$$

Measurements should be performed by different currents, which can be changed by variable resistor R, and B_0 should be calculated by using (5).

The readings of the TG can be disturbed by neighbourhood magnetic field, therefore it should be placed as far as possible from other parts of the circuit (resistor, source of current), connecting wires and ferromagnetic objects.

Possible appointments for the work.

1. To determine the horizontal component of the Earth's magnetic field induction at specific place.
2. To construct the graph tgφ=$f(I)$ and define the constant of the tangensgalvanometer.

Protocol for laboratory work 2.5.

Measurement of the horizontal component of Earth's magnetic field induction by tangensgalvanometer

Students: 1.

2.

Appointments:

1. Define the deflection angles φ when the current is: ______________________________ flowing in both directions.

2. Determine the horizontal component of the Earth's magnetic field induction at specific place.

3. Calculate the absolute error of B_0 for I = _________ .

Used measuring devices:

Nr.	***Device***	***Type, number***	***Current type***	***Precision class***	***Measuring diapason***	***The value of smallest scale***
1.	Ammeter					
2.	Compass					

Data table

Nr.	$I \pm \delta I$, *A*	$\varphi_1 \pm \delta\varphi_1$, ^{o}	$\varphi_2 \pm \delta\varphi_2$, ^{o}	$\varphi \pm \delta\varphi$, ^{o}
1.				
2.				
3.				
4.				
5.				

n = *R* = (±) *cm*

Example of calculations:

$$\varphi = \frac{\varphi_1 + \varphi_2}{2} =$$

$$B_0 = \frac{\mu_0 n I}{2 R tg\varphi} =$$