Laboratory work №3.38
Determination of Earth Magnetic Field Strength Horizontal Component

Devices and materials: 1)tangent-galvanometer; 2)source of direct current; 3)switch; 4)ammeter; 5)conducting wires.

Purpose of the work: determination of the Earth magnetic field strength horizontal component.

Description of the instrument and theoretical information

Freely suspended magnetic needle by its middle in the Earth magnetic field is situated along a tangent of Earth magnetic field force line. The direction of tangent to magnetic force line at every point coincides with one of the Earth magnetic field strength vector.

Earth magnetic field is represented by a picture of the power lines (see figure 1).
As it is seen from the figure Earth surface under different angles at all points of considered surface.

In given point of the Earth surface the magnetic field strength vector $\vec{H}$ is located in the magnetic meridian plane and may be decomposed into horizontal $\vec{H}_h$ and vertical $\vec{H}_v$ components. Thus, if magnetic needle may free rotate around a vertical axis, it disposes in the magnetic meridian plane.

Magnetic needle which is put in the center of a circle with current, tends to dispose along a magnetic force lines of the current magnetic field, or perpendicular to the contour plane.

The magnetic field strength of the current in the contour center is determined by the formula

$$H_c = \frac{I}{2R}N, \tag{1}$$

Where I is a current strength in the contour, R is radius of the circle, N – number of the turns in the contour.

In our work the device, which is called a tangent-galvanometer, is used. The main part of them consists from some conductor turns, which are connected in series and which are disposed in the same plane. In the center of the turns a magnetic needle is secured(see figure 3).

Two magnetic fields act on the magnetic needle simultaneously: magnetic field of the current and

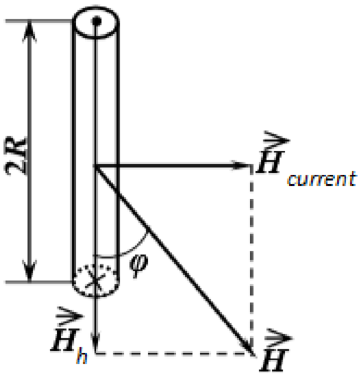

Figure 2

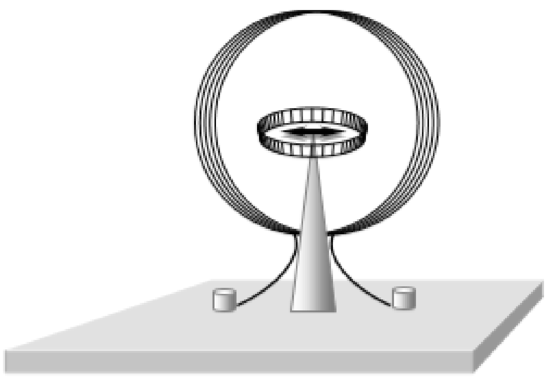
Figure 3

magnetic field of Earth. If one disposes the plane of tangent-galvanometer turns in the magnetic meridian plane, field strengths $\vec{H}_h$ and $\vec{H}_c$ become mutual perpendicular, and their resulting vector is $\vec{H} = \vec{H}_h + \vec{H}_c$ .Then, when the current flows along the tangent-galvanometer turns, the magnetic needle will be disposed in a direction of the vector $\vec{H}$ (see figure 2).

Let ϕ is an angle between the settled state and plane of magnetic meridian. Then from figure 2 it is seen, that $\vec{H}_h = \vec{H}c / tg\ \phi$.(2)

Substituting into formula (2) the circle current magnetic field strength value (1), we get

$$H_h = \frac{IN}{2R * tg\,\phi}. \tag{3}$$

From the expression (3) it follows, that the magnitude of the current, that flows along the turns of tangent-galvanometer is equal to

$$I = 2H_h * R * tg\phi \,/N = C * tg\,, \tag{4}$$

Where $C = H_h * R/N$ is a tangent-galvanometer constant.

Thus, given device allows measuring a magnitude of the current strength in the quantities H_h, R and N are known.

The name of given device is connected with proportionality of the current strength magnitude to the angle tangent of the device needle deviation.

A measurement of the angles is performed upon the tangent-galvanometer compass limb.

Work performing order

1. Make sure that there are no ferromagnetic materials near the tangent-galvanometer. Rheostat, ammeter, switch must be disposed as far as possible from device.
2. To assemble the scheme in agree with the figure 4.
3. To settle the tangent-galvanometer turns plane in the plane of magnetic meridian.
4. After checking the scheme by the teacher close the electrical scheme of the device by the key.
5. To establish by the rheostat a magnitude of the current strength 0,1; 0,2; 0,3; 0,4; 0,5 ***A***. In every case determine the angles of the magnetic needle deviation ϕ_1 and ϕ_2.
6. Repeat the measurement for the same current strength, but for opposite current direction angles ϕ_3 and ϕ_4 again.
7. For every given current strength calculate meaning of the horizontal component of Earth magnetic

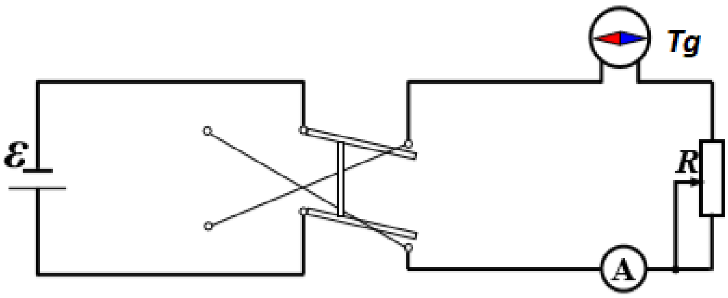

Figure 4

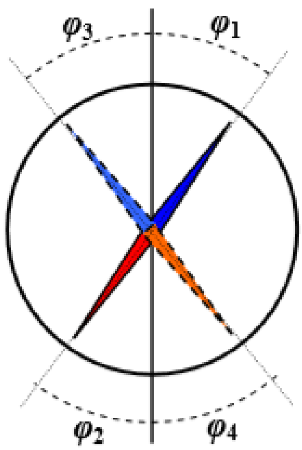

Figure 5

field. The magnetic needle deviation angle is determined upon the formula

$$\phi = \frac{\phi 1 + \phi 2 + \phi 3 + \phi 4}{4}.$$

8. Average meaning of the turns diameter is shown on the tangent-galvanometer.
9. Calculate meaning H_h upon the formula (3).

10. For every current strength meaning determine the constant C upon the formula (4) and its average meaning $\langle C \rangle$.
11. Results of measurings and calculations note down into the table.
12. Plot a graphic of dependence $tg\ \phi$ from I and determine constant for tangent-galvanometer.

№ of measurement	I, A	φ1	φ2	φ3	φ4	<φ>	tg φ	R, m	Hh, A/m	<H>, A/m	C, A	⟨C⟩, A	ΔC, A
1													
2													
3													
4													
5													

13. The final result represent in the form

$$H_h = (\langle H_h \rangle \pm \Delta H_h)\ A/m \text{ at } \alpha =$$
$$C = (\langle C \rangle \pm \Delta C)\ A \text{ at } \alpha =$$

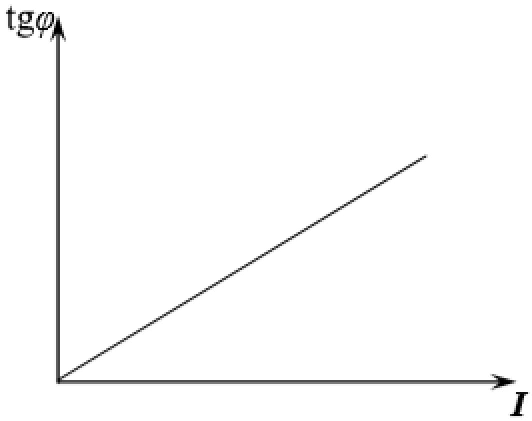

Figure 6

Control task

1. Formulate the Bio-Savart-Laplace law.
2. Why it is necessary to dispose a tangent-galvanometer so far from the ferromagnetic objects and magnetic fields sources as it possible?
3. Why measuring of the quantities H_h and C are performed under different current directions?
4. Is a tangent-galvanometer may be used for measuring of the current strength?

Literature:

1. I. Kucheruk, I. Gorbachuk, P. Lutsik General Physics Course. – C.: Engineering, 2001. – T.2, Section 2.
2. I. Savelyev General Physics Course. – M.: Science, 1997. – T.2, 4.1, Chapter 5.