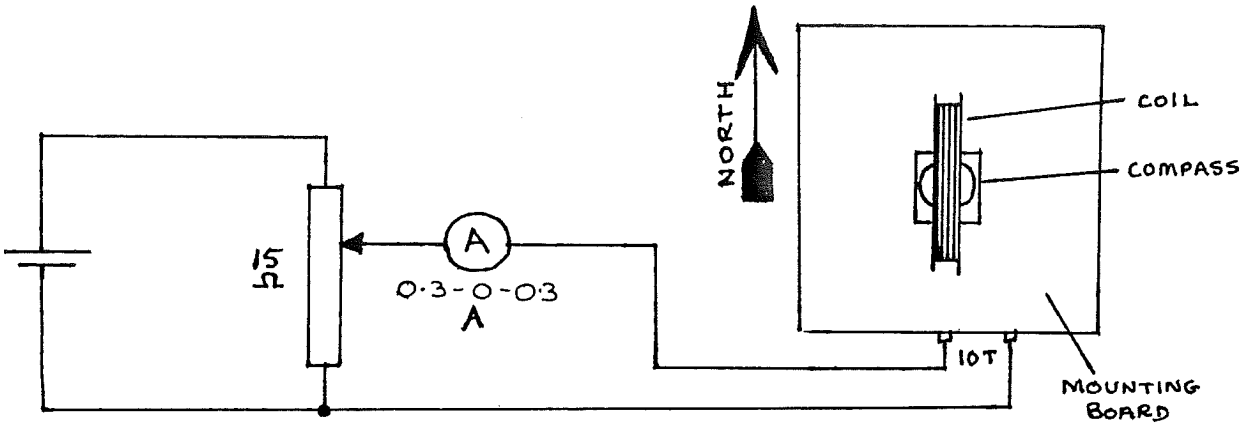
F5-2: Measurement of the Horizontal Component of Earth's Magnetic Field.

Apparatus

1.5V Cell; 15Ω rheostat (approximate); galvanometer with shunt for 0.3–0–0.3 A; mounted coil; magnetic compass; 5 wires (3 long, 2 short); 0.5m ruler.



Procedure

1. Set up the apparatus as above, but do not connect the battery. To avoid errors due to extra magnetic fields, the wires from the coil to the ammeter & rheostat should be long and twisted together. Arrange the compass accurately at the centre of the coil.
2. Turn the plane of the coil so that it lies accurately North–South (magnetic).
3. Connect the battery and adjust the rheostat until the compass needle points NW or NE (at exactly 45° to North). Read the ammeter.
4. Reverse the battery, and repeat step 3. Average the two readings of current.

5. Measure the coil across several diameters. Average these readings and thus find the average radius of the coil.

Theory

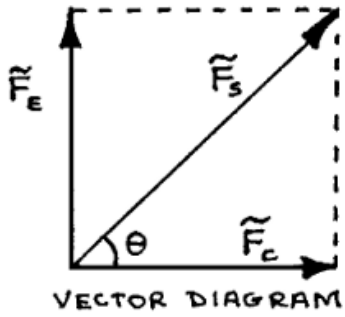
There are two forces acting on the compass needle:

$\tilde{F}_E$ due to the Earth's magnetic field
$\tilde{F}_C$ due to the magnetic field of the current

The compass needle points along the direction of the vector sum of these two forces.

When $\tilde{F}_C = 0$, the needle points North, along $\tilde{F}_E$;

When $\tilde{F}_C \neq 0$, then the needle points along the sum $\tilde{F}_S$, as shown on the vector diagram:



From the diagram, when $\theta = 45°$, $\tilde{F}_E = \tilde{F}_C$. In this case, the magnetic fields of the coil current and the Earth are equal. The field produced by the coil current can be calculated from:

$$B = \frac{\mu_0 NI}{2r}$$

Where:

$B =$ magnetic field (tesla -τ)
$\mu_0 = 4\pi \times 10^{-7} \mathrm{Hm}^{-1}$
$N =$ number of coil turns
$I =$ current (A)
$r =$ coil radius (m)

In the experiment the magnitude of the field produces by the coil has the same value as the horizontal component of the Earth's magnetic field.

Analysis

1. Calculate the horizontal component of the Earth's magnetic field.
2. Draw a diagram of the Earth showing the magnetic lines of force.
3. Use the diagram to explain why the experiment measures the **horizontal** component of the field. (Hint: consider the difference if the experiment is done first in Tanzania, then in Iceland).
4. If in the experiment, the electric current is doubled, calculate the angle (from magnetic North) along which the compass needle points.