Measurement of Earth's Magnetic Field

Purpose: To measure the horizontal component of the earth's magnetic field.

Equipment: Tangent galvanometer, 6 volts power supply, milliammeter, reversing switch, connecting wires.

Introduction: As Oersted showed in the 19th century, a magnetic field is produced whenever a current flows through a wire. The magnitude and direction of the field at points near the wire depends on the shape of the wire as well as the amount of current flowing through the wire. One particularly useful geometry that commonly occurs is a single circular loop of wire. The magnetic field, B, at the center of such a loop is given by

$$B = \frac{\mu_o I}{2R} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where $\mu_o = 4\pi \times 10^{-7}$ Tesla-m/amp, I is the current in amps and R is the radius of the loop in meters. The direction of $\vec{B}$ is given by the right hand rule.

On the surface of the earth, the magnetic field at the center of such a current loop is the resultant of two fields: that due to the current in the loop and that due to the magnetic field from the earth as shown in figure 1. By determining the direction of the resultant magnetic field we can, using equation 2 and vector addition, determine the horizontal component of the earth's magnetic field.

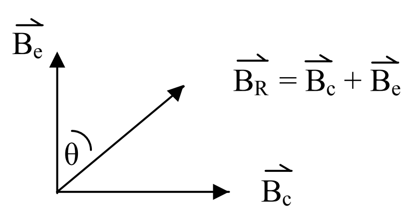

Figure 1

The direction of the magnetic field can be determined at any point by observing the direction of a compass needle at that point. Therefore by placing a compass needle at the center of a circular wire loop we can determine the direction of the magnetic field at that location. With no current flowing the compass will be aligned with the direction of the horizontal component of the earth's magnetic field, B_e.
When the current is turned on, the compass needle will deflect through an angle θ to realize itself with the new resultant field. The angle of

deflection will of course depend on the size of the magnetic field B_c caused by the current in the wire loop. By measuring θ one can calculate B_e from the equation (see figure 1).

$$B_e = B_c/\text{Tan}\ \theta \quad \ldots\ldots\ldots\ldots\ldots\ldots.. \quad (2)$$

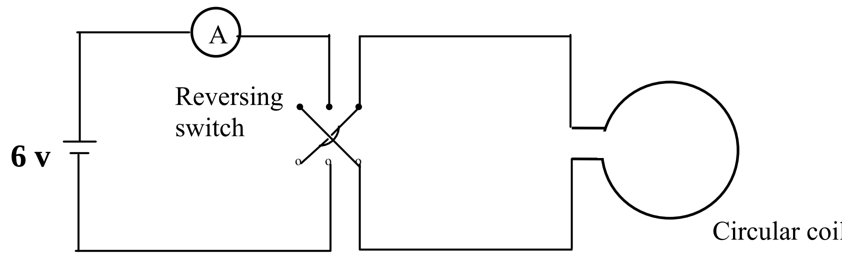

Figure 2

Procedure:

1. Choose a location in the room as far as possible from any magnetic materials (iron, pipes, etc). Align the plane of the current coil of the tangent galvanometer as closely as possible with direction of the earth's magnetic field as shown by the compass at the center of the coil.

2. Set up the circuit shown in figure 2 and carefully increases the voltage on the power supply until the current through the coil causes a deflection of approximately 35°. Record the value of the current. Read the deflection angle, θ_1, as closely as possible, then throw the reversing switch to reverse the direction of the current and carefully measure the new angle, θ_2. By measuring the deflection for both current directions the error introduced by inexact alignment of the coil with the earth's magnetic field is reduced.

3. Using equations 1 and 2, find the average Be (from forward and reverse currents) for approximate deflection angles of 35°, 40°, 45°, 50°, and 55°. Find the percent difference from the mean for each of the five values obtained for B_e. If possible, obtain a local value for B_e and compare with your results.