XXXVI. The magnetic field of any cylindrical coil

W. H. Everett B.A.

To cite this article: W. H. Everett B.A. (1896) XXXVI. The magnetic field of any cylindrical coil , Philosophical Magazine Series 5, 41:251, 367-368, DOI: [10.1080/14786449608620851](https://doi.org/10.1080/14786449608620851)

To link to this article: <http://dx.doi.org/10.1080/14786449608620851>

Published online: 08 May 2009.

Submit your article to this journal [↗](#)

Article views: 5

View related articles [↗](#)

of necessity be a small uncertainty, as there is no datum-point between 339° and 1052° ; but this cannot amount to more than a very few degrees.

In conclusion, we may point out that plotting our melder-meter-readings against other observers' melting-points does not give a smooth curve.

University College, London.

XXXVI. *The Magnetic Field of any Cylindrical Coil.*

By W. H. EVERETT, B.A.*

APPLYING Ampère's formula for the magnetic force at any point due to an element of current, the force perpendicular to any plane circuit, carrying a current i , is found to be, at any point P,

$$Z' = i \int \frac{rd^2\theta}{(r^2 + h^2)^{\frac{3}{2}}};$$

h being the distance of P from the plane of the circuit, and r, θ the polar co-ordinates of any point of the circuit referred to the projection of P as origin.

The longitudinal force at any point due to a current in a cylindrical coil, or solenoid, is given by a second integration. It is the sum or difference of two terms, each of the form

$$Z = inh \int \frac{d\theta}{\sqrt{r^2 + h^2}};$$

where h denotes the distance of the point from an end plane of the solenoid, and n the number of turns per unit length of h . The depth of the coil, normal to the cylindrical surface, is assumed to be inconsiderable. The limits of integration are 0 and 2π for any point whose projection, taken parallel to the axis, falls within the solenoid.

Similarly, the transverse force at any point, due to a solenoid, is found to be

$$R = in \Sigma \left(\frac{1}{\sqrt{r^2 + h_1^2}} - \frac{1}{\sqrt{r^2 + h_2^2}} \right) ds,$$

the summation being vectorial.

The latter two formulæ can be readily applied, for approximate calculation, to a cylindrical coil of any cross-section,

* Communicated by the Physical Society, being abstract of paper read November 8, 1895.

368 *The Magnetic Field of any Cylindrical Coil.*

including coils of circular and rectangular sections. But in the case of rectangular coils the formulæ become integrable.

Let p be the perpendicular distance of any point P from one of the faces of the rectangular coil, and a one of the two parts into which the corresponding side of a cross-section is divided by the perpendicular from P . Then the longitudinal force at P is given by the algebraic sum of sixteen terms, each of the form

$$\begin{aligned} Z &= inh p \int_0^a \frac{dx}{(x^2 + p^2) \sqrt{x^2 + p^2 + h^2}}, \\ &= in \sin^{-1} \frac{ah}{\sqrt{(a^2 + p^2)(h^2 + p^2)}}. \end{aligned}$$

And the transverse force at P is the resultant of eight terms, each of the form

$$\begin{aligned} R &= in \int_0^a \left(\frac{1}{\sqrt{x^2 + p^2 + h_1^2}} - \frac{1}{\sqrt{x^2 + p^2 + h_2^2}} \right) dx, \\ &= \frac{in}{2} \log \left(\frac{p^2 + h_2^2}{p^2 + h_1^2} \cdot \frac{a + \sqrt{a^2 + p^2 + h_1^2}}{a + \sqrt{a^2 + p^2 + h_2^2}} \right). \end{aligned}$$

The first formula in the paper can be used to find an expression for the force due to a circular current, at any point P in the plane bounded by the circle. Draw any chord through P , and call its segments r , r' . Write c for the distance of P from the centre, b for half the minimum chord through P , and a for the radius. Then for the force at P the formula reduces to

$$\begin{aligned} F &= i \int_0^{2\pi} \frac{d\theta}{r}, \\ &= i \int_0^\pi \left(\frac{1}{r} + \frac{1}{r'} \right) d\theta, \\ &= \frac{2i}{b^2} \int_0^\pi \sqrt{a^2 - c^2 \sin^2 \theta} \cdot d\theta. \end{aligned}$$

This can be written

$$F = i \frac{s}{b^2},$$

s being the perimeter of the ellipse with a and b as semi-axes, and having some value between $2\pi a$ and $4a$, according to the position of the point considered.