Philosophical Magazine Series 5

ISSN: 1941-5982 (Print) 1941-5990 (Online) Journal homepage: http://www.tandfonline.com/loi/tphm16

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To cite this article: A.P. Chattock (1887) IX. On a magnetic potentiometer , Philosophical Magazine Series 5, 24:146, 94-96, DOI: 10.1080/14786448708628063

To link to this article: http://dx.doi.org/10.1080/14786448708628063

Published online: 29 Apr 2009.

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IX. *On a Magnetic Potentiometer.* *By* A. P. CHATTOCK *.

IN arranging some experiments on the magnetic resistances (so-called) of certain air and iron fields with a view to the more satisfactory designing of dynamos, I have been led, by the familiar analogy between magnetic and electrical circuits, to adopt the following method of measurement; which I venture to describe, partly on account of its convenience, partly because the measurement of magnetic resistances seems likely to play an important part in the practical application of electromagnetism.

The resistance between two points on a magnetic circuit may be expressed as the ratio of their potential difference to the total induction passing from one to the other (provided there is no reverse magnetomotive force between them).

The measurement of the total induction is of course a simple matter; but, so far as I am aware, no method of directly measuring differences of potential has yet been suggested.

Let A and B be two points in a magnetic field connected by any line of length l; and let H represent magnetic force resolved along l.

Then, if V be the difference of potential between A and B,

$$V=\int H . dl.$$

If, instead of points, A and B represent two equal plane surfaces of area a, and $\overline{V}$ be their average difference of potential,

$$a\overline{V}=\int V . da=\int H . dv,$$

v being the volume of a tube of constant cross section, a, connecting A and B by *any* path.

Now let a wire helix be wound uniformly upon such a tube, with n turns per unit length, and allow H to vary with time, t. Provided there be no magnetic substance inside the helix, an electromotive force, E, will be set up in the latter, such that

$$E=\frac{d}{dt}\iint H . da . dn=\frac{d}{dt}\,n\int H . dv=na\frac{d\overline{V}}{dt}.$$

The value of E is thus proportional to the rate of change of $\overline{V}$; and to this *alone*, if external inductive effects are guarded against by winding the wire in an even number of layers (n and a being constant). Hence, if the wire be connected with a ballistic galvanometer, and $\overline{V}$ be altered suddenly from V_1 to V_2, the needle of the galvanometer will be thrown through

* Communicated by the Physical Society: read May 14, 1887.

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the angle θ such that

$$V_1 - V_2 = K \sin \frac{\theta}{2},$$

and the combination forms what may be called a magnetic potentiometer.

In exploring a permanent field with such an apparatus, the best way is, perhaps, to fix one end of the helix in a clip, thereby keeping its potential constant, and to move the other end from point to point in the field. For this purpose the wire should be wound upon a flexible core, the average length of which, whether bent or straight, must be constant (otherwise $da \,.\, dn$ will not be equal to $n \,.\, dv$ in the last equation).

I have therefore constructed a helix by winding wire uniformly on to a piece of solid indiarubber, of constant cross section (in my case 37 centim. long and about 1 centim. diameter), leaving a small space between one turn and the next to allow the indiarubber to bend without elongating.

With this apparatus I made the following measurements of the potential difference between the ends of a permanent bar-magnet, in order to test the accuracy of the method. In the first set of readings the free end of the helix was moved at one leap from end to end of the magnet, giving a mean reading of 6·017; in the two other sets it was moved between the same two points in two and four leaps respectively, the resulting readings being added together in each case. The means of these were 6·047 and 6·048. The final mean was thus 6·037; and from this the most discordant reading differed by about 1 per cent. The close agreement between the second and third values was, no doubt, accidental; but the difference between them and the first may have been due to the difficulty of moving quickly from end to end of the magnet, a distance of over 40 centim.

In order to reduce these results to absolute measure, the helix (still connected with the galvanometer) was subjected to a known magnetomotive force by passing it through a coil of n turns and bringing its ends close together outside the coil, a current C being then started or stopped in the latter. The magnetomotive force due to this was of course equal to $4\pi n C$, and this being substituted for $V_1 - V_2$ in the last equation determined the value of K. In my case these values were $n = 20$, $C = 0·182$ C.G.S., and galvanometer throw $= 0·34$. The difference of potential between the ends of the magnet was thus

$$\frac{4\pi \times 20 \times 0·182}{0·34} \times 6·037 = 810 \text{ C.G.S.}$$

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A more suitable core for the helix than indiarubber is the flexible gas-tubing made of plaited and varnished canvas. It is very uniform in cross section; and by withdrawing the metal spiral upon which it is woven and mounting it on a spindle in a screw-cutting lathe, it is easy to wind the wire uniformly upon it.

The use of the lathe is the more desirable, as measurements of potential by the helix depend very much for their accuracy upon the uniformity with which it is wound; this being especially the case if its position in the field does not happen to coincide with the direction of the lines of force.

To keep the turns in place the small spaces between them may be filled with soft cotton-thread.

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X. *On the "Dimensions" of Temperature in Length, Mass, and Time; and on an Absolute C.G.S. Unit of Temperature.* *By* Charles V. Burton, *B.Sc.* (*Lond.*).*

SIR W. THOMSON'S second absolute scale gives us the means of finding the *ratio* between two temperatures, independently of any arbitrary convention as to the size of degrees. We are therefore bound to consider temperature as a physical quantity capable of exact measurement. Now every such quantity has certain dimensions in length, mass, and time; and I here propose to find the dimensions of temperature.

Let temperatures be represented on Sir W. Thomson's absolute scale, so that nothing remains arbitrary except the size of the degrees. Consider an absolutely perfect gas whose temperature on this scale $= t$. Let the mean kinetic energy of a molecule of the gas $=$ E. Then we have

$$\mathrm{E}=kt, \quad \ldots \ldots \quad (1)$$

where k is the same for all temperatures and for all *perfect* gases; being independent of the mass per molecule of the gas, and determined solely by the size of the degrees on our scale of temperature.

If we write (1) in the form

$$t=\frac{\mathrm{E}}{k}, \quad \ldots \ldots \quad (2)$$

we see that a temperature (t) is completely determined by the average-kinetic-energy-per-molecule (E) of a perfect gas

* Communicated by the Author.