Philosophical Magazine Series 5

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

On magnetization

M. Mascart

To cite this article: M. Mascart (1886) On magnetization, Philosophical Magazine Series 5, 21:133, 515-518, DOI: [10.1080/14786448608627887](https://doi.org/10.1080/14786448608627887)

To link to this article: <http://dx.doi.org/10.1080/14786448608627887>

Published online: 29 Apr 2009.

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

Article views: 3

View related articles [↗](#)

LXXII. *Intelligence and Miscellaneous Articles.*

ON MAGNETIZATION. BY M. MASCART.

WHEN an isotropic and feebly magnetic substance is placed in a uniform field, it acquires a magnetization parallel to the field, and its coefficient of magnetization is the ratio of the magnetic moment for unit volume, or intensity of magnetization, to the intensity of the field.

With highly magnetic substances, on the contrary, such as iron, nickel, cobalt, the reaction due to the induced magnetism must be allowed for, and the preceding definition is only applicable for infinitely long cylinders magnetized longitudinally or for closed rings.

The calculation of the magnetizing force as a function of the external field is very simple in the case of the sphere or the ellipsoid, or of an infinitely long cylinder magnetized transversely; but except in the case of very elongated ellipsoids, the coefficient of magnetization may vary within very extensive limits without the magnetic moment of the body being sensibly modified. The slightest want of homogeneity has in that case a considerable influence.

The coefficient of magnetization is often determined by using cylinders arranged parallel to the field, and which are assimilated to infinite cylinders, or to ellipsoids of the same length and the same median section; the magnetic moment is then measured, or the discharge, induced in a coil surrounding the central section, when the magnetization is reversed. With rings, induced charges can alone be used, and the coefficients of magnetization are generally found too high. It may then be asked if one of the methods is at fault; and if, for instance, a special phenomenon is produced in the case of closed rings which exaggerates the effects of induction. In order to solve this question, I used with the same metal closed rings, and a series of cylinders in which the ratio of the length to the diameter varied within very wide limits.

The cylinders were placed in the axis of a cylindrical coil of 1.20 metre in length, and 0.03 metre in diameter, so that the internal field of the current may be considered as sensibly uniform over a length of more than 0.80 metre. This coil was at right angles to the magnetic meridian, and its action on an adjacent declinometer was compensated by that of an external coil. The magnetic moment of the cylinder is deduced from the deflection produced in the declinometer. Further, a coil of several turns, wound on the mean portion of the magnetized cylinder, was connected with a ballistic galvanometer, and the induced charge produced by the inversion of the magnetization, eliminating the effect produced by the field itself.

The measurement of the magnetic moment by the deflection of the declinometer requires in strictness that the position of the poles be known, or at any rate that the experiments be made at two different distances so as to eliminate the factor of correction; but with very narrow cylinders, Coulomb's rules furnish a sufficient approximation for the degree of exactitude I had in view. Finally, the field F of the magnetizing coil is determined by the intensity I of the current, and the number n of turns of the wire for unit length,

$$F = 4\pi n_1 I.$$

The quotient of the magnetic moment M of the cylinder by its volume V gives the mean intensity of magnetization A , and we may denote as the mean coefficient of magnetization,

$$f = \frac{A}{F} = \frac{M}{4\pi n_1 IV}.$$

On the other hand, if S is the section of the cylinder, A the intensity of magnetization in the median region, F the action of the magnetism induced in this region, p the number of turns of the small coil, R the resistance of the circuit of which it forms part, and Q the discharge induced by the reversal of the magnetization, we have

$$QR = 2pS(4\pi A_1 - F_1) = 8p\pi S\left(A - \frac{F_1}{4\pi}\right).$$

Putting

$$f_1 = \frac{1}{F_1}\left(A_1 - \frac{F_1}{4\pi}\right),$$

we shall obtain by experiment two mean coefficients f and f_1 which have slightly different significations.

Experiment shows in the first place that we have always $f_1 > f$. These two quantities, which are very different for short cylinders, approximate more and more, and this ratio tends to unity as the length of the cylinder increases. At the same time, the greatest values of the coefficients f and f_1 correspond to fields which are gradually weaker. Lastly, the values of f and of f_1 furnished by very long cylinders are equal to the coefficient k given by closed rings.

With the iron which I used, when the ratio of the length to the diameter varied from 40 to 500 or 600, the maximum value of the coefficients f or f_1 varied from 25 to 190, or from 40 to 220, while the corresponding fields diminished from 20 to 25 C.G.S. units to 3 units; the same wires used as rings gave for the maximum of the coefficient k , a value of about 200 with a field of 3 units. The agreement of these results is sufficient, if we allow for the difficulty of obtaining specimens which are identical.

The method of cylinders, provided their length is at least 500

times the diameter, is then equivalent to that of the rings; it has this advantage, that we can ascertain at any moment the real magnetic condition of the metal, and demagnetize it so as to subject it to fresh tests.

The mean coefficient of magnetization diminishes very rapidly with the ratio λ of the length of the cylinder to its diameter, and soon becomes of the same order as the coefficient f_1 , relative to the transverse magnetization. Further, the magnetization is proportional to the intensity of the external field, within much more extended limits.

By forming short cylinders with packets of the same iron wire as before, we have obtained as mean values in fields of 1 to 10 units:

λ .	f .	f_1
12.3	3.40	0.13
7.5	1.90	0.14
5.0	1.20	0.14
3.3	0.73	0.14

Rectangular bars of soft iron gave in like manner for the mean coefficients of magnetization f, f_1, f_2 , parallel to the three edges:—

Dimensions.				f .	f_1 .	f_2 .
c.	c.	c.				
9	1	1		2.0	0.15	..
9	2	1		1.34	0.22	0.10
9	2	2		0.88	0.15	..
9	3	2		0.72	0.20	0.13

Theory shows that in the case of infinitely long cylinders the coefficient f for transverse magnetization is expressed by

$$\frac{k}{1+2\pi k} = \frac{1}{2\pi\left(1+\frac{1}{2\pi k}\right)} = \frac{0.159}{1+\frac{1}{2\pi k}},$$

and should be below 0.159; it will be seen that experiment gives values near this limit, even with very short cylinders.

A knowledge of these coefficients of magnetization is of particular interest, as furnishing a correct means of calculating the effect of the magnetization induced by the Earth in a magnetized bar, in observations relative to the absolute measurement of the terrestrial field.

More generally, when a body is isotropic and of any given form, there are three rectangular directions for which the magnetization is parallel to the external field, with different coefficients f, f_1 , and f_2 ; these coefficients have the same properties as the coefficients of magnetization of a feebly magnetic anisotropic substance.

Suppose, for instance, that $f > f_1$ and that the body is movable about an axis parallel to the direction f_2 in a field whose component

perpendicular to this axis is H . If V is the volume of the body and the angle of the field with the direction f , the moment of the couple due to the action of the field is

$$C = V (f - f_1) H^2 \sin \alpha \cos \alpha.$$

It is readily seen that magnetization may be regarded as the superposition of two other magnetizations—the one constant, $f_1 H_1$, parallel to the field and producing no couple; the other, $(f - f_1) H \cos \alpha$, connected with the body, and parallel to the direction of greatest magnetization. This latter is sensibly constant for feeble deflections.

This is the case of a magnet which oscillates under the influence of the Earth. If we take into account the induced magnetization, we should strictly add to the rigid magnetization a magnetization in the same direction $(f - f_1) H$ proportional to the difference of the longitudinal and transverse coefficients.

We may add that for steel the mean coefficient of longitudinal magnetization is much weaker than for soft iron, which greatly tends to increase the importance of transverse magnetization.—*Comptes Rendus*, May 5, 1886.

ON AN INSTRUMENT FOR REPRODUCING AN INVARIABLE QUANTITY OF ELECTRICITY. BY M. MARCEL DEPREZ.

The object of this instrument is to reproduce readily and under any given conditions of temperature and pressure the unit quantity of electricity which is known as a *Coulomb*.

It consists of a U-tube the two limbs of which end in glass bulbs the volume of which is far greater than that of the cylindrical parts, the whole being hermetically sealed. One of the bulbs and the corresponding limb is completely filled with water acidulated by phosphoric acid; in the other limb it is filled with air at a definite pressure as well as the bulb in which it ends. In the branch filled with liquid are four platinum wires facing each other in pairs, two at the top of the bulb and two others in the cylindrical part a little below the lowest point of the bulb. If an electrical current is passed through these latter, water is decomposed, and the detonating gas arising from this decomposition accumulates in the upper bulb, while the liquid driven into the second limb ascends in this, compressing the air in the second bulb. If we take care to note the point of departure of the column of liquid in the second limb, which is divided into parts of equal capacity, as well as the point at which it stops when the current is suppressed, we have all the elements necessary for knowing the quantity of electricity expended in producing the detonating mixture. It is readily seen that, if the volume of this liquid measured by the rise of the liquid in the second limb is constantly the same, the quantity of electricity