II. "On the Temperature-correction and Induction-coefficients of Magnets." By G. M. Whipple, B.Sc., Superintendent of Kew Observatory. Communicated by Robert H. Scott, F.R.S. Received April 12, 1877.

It has been the practice at the Kew Observatory since 1856 to determine, for the use of persons about to make observations upon terrestrial magnetism, the various constants of the magnets and instruments with which they intend to observe; and a considerable number of these constants are now recorded in the books of the Observatory.

Having been frequently applied to for information respecting the constants of magnets and the method of determining them, I have extracted from our registers the values of the two most important constants, viz. that of the variation of the power of the magnet under changes of temperature, and that showing the effect of the inductive action of the earth upon the magnets, as found by experiment. The results are given in the following paper.

The magnets experimented upon may be classed under six heads (approximate dimensions):—

a. Solid cylinders, 3·6 inches long, 0·3 inch diameter.
b. Hollow cylinders (collimators), 3·65 inches long, 0·28 inch internal diameter.
c. Parallelopipeds (bars), 5·4 inches long, 0·8 inch wide, 0·12 inch thick.
d. Rhomboidal plates (dip-needles), 5·7 inches long, 0·05 inch thick.
e. Thin cylinders (enclosed in brass tubes, deflectors), 3·75 inches long, 0·30 inch diameter.
f. Various.

All of the magnets were made of the best steel, and rendered as hard as possible before magnetization, which operation has been in every case carried to saturation.

The method employed in determining the temperature-coefficient is as follows:—The magnet being firmly fixed in a water-tight wooden box, provided with a thermometer, is placed upon a frame in such a manner that its axis shall lie in the same horizontal plane with the needle of a unifilar magnetometer, at a short distance away, and adjusted until the axes of the two needles are approximately at right angles to each other, the position of the deflecting magnet being that which is designated by the Astronomer Royal as end on. Warm water at 85° F. is then poured into the box, and as soon as the magnet has become heated to this temperature the unifilar magnet is brought to rest and its position accurately read off. The water at 85° F. is then removed, and the apparatus being cooled down to 60° F., water of that temperature is placed in the box; another observation of deflection is then made, and finally the experiment is repeated with water at 35° F. After this another series of observations is commenced with water at 85° F., 60° F., and 35° F., and this is again repeated once or twice.

The observations are first corrected for changes of the earth's magnetic force during the experiment by means of simultaneous readings of the curves given by the self-recording magnetometers of the Observatory; and the reduction is performed according to the method given by the following formula, due to Prof. B. Stewart, the coefficients determined being q and q', which represent the decrease of the magnetic moment of the magnet produced by an increase of temperature of 1° F.

Demonstration of the Formula for finding Temperature-correction.

Let $\frac{m}{X}=\frac{1}{2}r^3 \sin u$ be the normal equation of equilibrium at temp. t_0, then $m\{1-q(t-t_0)-q'(t-t_0)^2\}=\frac{1}{2}Xr^3 \sin(u-du)$ is the altered equation.

Hence $$\tfrac{1}{2}r^3 X \sin u\{1-\&c.\}=\tfrac{1}{2}Xr^3 \sin(u-du);$$

$$\therefore \sin u-\sin uq(t-t_0)-\sin uq'(t-t_0)^2=\sin(u-du).$$

Let $\sin u(q)=x$, $\sin u(q')=y$; then

$$x(t-t_0)+y(t-t_0)^2=\sin u-\sin(u-du).$$

Demonstration of the method of using the Self-recording Magnetographs in eliminating the effects of disturbance in ascertaining Temperature-correction.

(1) Let the Horizontal Force alter;

let $$\frac{m}{X}=\tfrac{1}{2}r^3 \sin u \text{ be the normal equation,}$$

and $$\frac{m}{X+\Delta X}=\tfrac{1}{2}r^3 \sin(u-du) \text{ the altered one.}$$

Hence $$\frac{m}{X}\frac{\Delta X}{X}=\tfrac{1}{2}r^3 \cos u\, du;$$

hence $$du=\frac{\Delta X}{X}\tan u.$$

(2) Let the Declination alter; the equation is still $\frac{m}{X}=\frac{1}{2}r^3 \sin u$; hence the angle of deflection remains the same, or the deflected magnet makes the same angular change as the declination magnetograph.

Of the temperature-coefficients of 109 magnets which have been examined, the value of q' has only been determined for 79. Taking the whole series we find the following:—

	Mean value.	Average difference from mean.	Maximum.	Minimum.
q	0·000161	±0·000060	0·000762	0·000044
q'	0·00000048	±0·00000023	0·00000398	0·00000001

Subdividing them into classes we have, for

Class A. Solid cylinders. 20 magnets examined.

q	0·000178	±0·000048	0·000368	0·000104
q'	0·00000057	±0·00000027	0·00000129	0·00000011

Class B. Collimators. 46 magnets examined.

q	0·000161	±0·000043	0·000399	0·000093
q'	0·00000043	±0·00000016	0·00000082	0·00000004

Class C. Bars. 7 magnets examined.

q	0·000171	±0·000068	0·000286	0·000103
q'	0·00000064			

Class D. Dip-needles. 11 magnets examined.

q	0·000073	±0·000027	0·000132	0·000044
q'	0·00000023	±0·00000018	0·00000054	0·00000001

Class D. (Between temperatures 10° and 60° F.)

q	0·000095	±0·000038	0·000164	0·000054

Class E. Deflectors.				
q	0·000197	±0·000044	0·000254	0·000111
Class E. Deflectors (between temperatures 10° and 60° F.).				
q	0·000161	±0·000054	0·000323	0·000091
Class F. Various magnets.				
q	0·000418		0·000762	0·000193
q'	0·00000157		0·00000398	0·00000020

Induction-coefficients.

The induction-coefficient is determined from observations of deflection made after the well-known method of Lamont, the magnet being alternately placed with its north pole upwards and downwards, but at the same distance from a suspended needle, the difference in the amount of deflection of the latter in the two positions determining the effect of the earth's inductive action upon the magnet.

The formula, differing slightly from Lamont's, employed in the reduction, and of which the following is a demonstration, is due to the late Mr. John Welsh, F.R.S. :—

(1) It is assumed that the induction produced by the inducing action of the earth's magnetic force is distributed in the same manner throughout the bar experimented upon as its permanent magnetism.

Let μ=the increase of the moment of the magnetic bar produced by the action of an inducing force = unity.

M=the magnetic moment of the permanent magnetism of the bar.

X=horizontal component of the earth's force.

Y=vertical component of the earth's force.

ϕ=angle of deflection, north end of bar downwards.

ϕ'=angle of deflection, north end of bar upwards.

u=angle of deflection when the bar is used as an ordinary deflector at 1 foot distance.

i=magnetic dip.

(2) If c be a constant, and m the magnetic moment of the suspended needle, $c\text{M}m$ may be taken to represent the attraction of the bar (disre-

garding induced magnetism) upon the suspended needle; then, as the line joining the centres of the two magnets is in every part of the observation approximately at right angles to the suspended needle, it follows from (1) *that the attraction of the bar will be proportional to its magnetism.* Hence in the north end downwards the equation of equilibrium will be

$$c(\mathrm{M}+\mathrm{Y}\mu)=\mathrm{X}\sin\phi,$$

and with the north end upwards

$$c(\mathrm{M}-\mathrm{Y}\mu)=\mathrm{X}\sin\phi'.$$

Hence

$$2c\mathrm{Y}\mu=\mathrm{X}(\sin\phi-\sin\phi'),$$

$$2c\mathrm{M}=\mathrm{X}(\sin\phi+\sin\phi').$$

Hence

$$\frac{\mathrm{Y}}{\mathrm{M}}\mu=\frac{\sin\phi-\sin\phi'}{\sin\phi+\sin\phi'}=\frac{\tan\frac{1}{2}(\phi-\phi')}{\tan\frac{1}{2}(\phi+\phi')};$$

and since $\mathrm{Y}=\mathrm{X}\tan i$,

$$\mu=\frac{\mathrm{M}}{\tan i\,\mathrm{X}}\frac{\tan\frac{1}{2}(\phi-\phi')}{\tan\frac{1}{2}(\phi+\phi')}=\frac{\sin u\tan\frac{1}{2}(\phi-\phi')}{2\tan i\tan\frac{1}{2}(\phi+\phi')}.$$

From the values of observations made at the Observatory with 66 magnets, all belonging to Classes A and B, we find—

	Mean value.	Average difference from mean.	Maximum.	Minimum.
μ	0·000207	±0·000035	0·000420	0·000080

III. "Distribution of the Radicals of Electrolytes upon an Insulated Metallic Conductor." By Alfred Tribe, Lecturer on Chemistry in Dulwich College. Communicated by Dr. Gladstone, F.R.S. Received April 19, 1877.

Among other facts demonstrated in my communication to the Royal Society in January 1876 (Proc. Roy. Soc. vol. xxiv. p. 308), it was shown that a rigid conductor, when placed lengthwise between the electrodes in a fluid in the act of electrolysis, becomes, with sufficient battery-power, endowed with the power of doing chemical work similar in kind to the battery-electrodes themselves. This phenomenon, it was contended, was explicable on the view which regards an electrolyte as a dielectric, with the additional function of being capable of mutually exchanging its constituents in the act of depolarization—a conception which induced the quantitative experiments detailed below.