GOVERNMENT NOTIFICATION.—No. 200.

The following Report of the Director of the Observatory on the Verification of the Unifilar Magnetometer Elliott Brothers, No. 55, is published for general information.

By Command,

FREDERICK STEWART,
Acting Colonial Secretary.

Colonial Secretary's Office, Hongkong, 29th May, 1886.

ON THE VERIFICATION OF THE UNIFILAR MAGNETOMETER ELLIOTT BROTHERS, No. 55.

T_o = Observed time of one vibration of the magnet expressed in seconds.
T_1 = T_o corrected for rate of chronometer and arc of vibration.
T = T_1 corrected for torsion and induction and reduced to O° cent.
T_w = Observed and corrected time of one vibration with inertia cylinder in position.
ρ = Daily rate of chronometer in seconds.
a = Semi-arc of vibration at the beginning of the observation in parts of radius.
a' = " " " end " " " "
$\frac{H}{F}$ = Ratio of the force of torsion of the suspending thread to the magnetic directive force.
t = Temperature in degrees centigrade.
$qt + q' t^2$ = Reduction to O° of the magnetic moment of the magnet.
K = Moment of inertia of the magnet with its appendages.
m = Magnetic moment " " " "
W = Weight of the inertia-cylinder in grammes.
l = Length " " " centimeters.
d = Diameter " " " "
π = 3.14159.
μ = Increase in the magnetic moment produced by the inducing action of a magnetic force equal to one C. G. S. unit.
r_o = Observed distance between centres of deflecting and deflected magnets.
r = $r_o (1 + 0.000\ 018\ t)$ = r_o reduced to O°.
u_o = Observed angle of deflection.
P = A constant depending upon the distribution of magnetism in the two magnets.
X = Horizontal component of the earths magnetic force in C. G. S. Units.
$\frac{m_o}{X_o} = \frac{1}{2} r^3 \sin u_o$.
$\frac{m_1}{X_1} = \frac{m_o}{X_o}$ corrected for induction and reduced to O°.
$\frac{m}{X} = \frac{m_1}{X_1} (1 - \frac{P}{r_o^2})$.
A = Mean value of $\frac{m_1}{x_1}$ from deflections at 30 centimeters made during the year.
A_1 = " " " " 40 " " "

The formulæ for the calculation of the value of the horizontal component of the earth's magnetic force and of the value of the magnetic moment of a magnet are:—

$$T_1 = T_o (1 \mp \frac{\rho}{86400} - \frac{aa'}{16})$$

where the upper sign is used, when the chronometer is gaining, and the lower, when it is losing.

$$T^2 = T_1^2 (1 + \frac{H}{F} - qt - q' t^2 + \mu \frac{X_o}{m_o})$$

$$mX = \frac{\pi^2 K}{T^2} \qquad \frac{m_o}{X_o} = \frac{1}{2} r^3 \sin u_o$$

$$\frac{m_1}{X_1} = \frac{m_o}{X_o} (1 + \frac{2\mu}{r_o^3} + qt + q' t^2) \qquad \frac{m}{X} = \frac{m_1}{X_1} (1 - \frac{P}{r_o^2})$$

$$K = W (\frac{l^2}{12} + \frac{d^2}{16}) \frac{T^2}{T_w^2 - T^2} \qquad P = \frac{100 (A - A_1)}{\frac{A}{9} - \frac{A_1}{16}}$$

I compared the deflection bar with the standard at Kew and found it correct. At the same time e following constants were determined:—

W = 62.63 grammes, l = 9.4214 centimeters, d = 1.0006 centimeters.

The angular value of one scale division of the vibrating magnet = 110″.66.

„ „ „ „ „ „ „ deflection apparatus = 60″.46.

When the scale reading is above the middle of the scale, the correction to the circle reading is dditive, and when below it is subtractive.

The induction coefficient in C. G. S. Units adopted is $\mu = 4.917$ (Log. $\mu = 0.6917$) being the ean of the following determinations:—

Vertical induction: 1886, January 1, $\mu = 5.04$ Horizontal induction: 1886, January 8, $\mu = 4.68$

„ „ 5, = 5.07 „ „ 9, = 4.74

„ „ 8, = 5.26

The value of $1 + \frac{2\mu}{r_o^3}$ is = 1.000 364 for r = 30 and = 1.000 154 for r = 40 centimeters.

The reduction to O° is = 0.000 260t + 0.000 002 44 t^2

This is the mean of the following determinations:—

Date.	*Temperatures of testing.*	*Reduction.*
1885, December 28,	10°, 25°, 40°	+ 0.000 241t + 0.000 002 81 t^2
„ „ 30,	0 , 20 , 40	+ 0.000 254t + 0.000 002 44 t^2
1886, January 11,	5 , 20 , 35	+ 0.000 285t + 0.000 002 07 t^2

This formula evidently depends to some extent upon the temperatures, at which the magnet is ested, as the coefficient of the cube of the temperature is not taken into account.

TABLE I.

Value of $\frac{\rho}{86400}$

ρ	$\frac{\rho}{86400}$
1 sec.	0.00001
2	2
3	3
4	5
5	6
6	7
7	8
8	9
9	10
10	0.00012

TABLE II.

Value of $\frac{aa'}{16}$

Semi-arc at commencement.	Semi-arc at end of observation in scale divisions.				
	35d	30d	25d	20d	15d
40d	.00003	.00002	.00002	.00001	.00001
35	...	.00002	.00002	.00001	.00001
30	...	...	.00002	.00001	.00001
25	...	...	...	.00001	.00001

TABLE III.

Value of $1 + \frac{H}{F}$ for different values of the deflection produced by a twist of 90° of the suspending thread.

Effect of 90° torsion.	$1+\frac{H}{F}$
0.25 div.	1.00008
0.50	1.00017
0.75	1.00025
1.00	1.00034
1.25	1.00043
1.50	1.00052
1.75	1.00060
2.00	1.00068
2.25	1.00077
2.50	1.00086
2.75	1.00094
3.00	1.00103

TABLE IV.

Reduction to 0°

t	$qt + q' t^2$	t	$qt + q' t^2$
+ 14°	+.00412	+ 27°	+.00881
15	.00446	28	.00920
16	.00480	29	.00960
17	.00514	30	.01001
18	.00549	31	.01042
19	.00584	32	.01084
20	.00619	33	.01126
21	.00655	34	.01168
22	.00692	35	.01211
23	.00729	36	.01254
24	.00766	37	.01297
25	.00804	38	.01341
26	.00842	39	.01385
+ 27	.00881	+ 40	.01430

TABLE V.

Value of log $\frac{1}{2} r^3$ at different temperatures.

t	$r_o = 30$	$r_o = 40$
0°	4.13033	4.50515
5	4.13045	4.50527
10	4.13057	4.50538
15	4.13069	4.50550
20	4.13080	4.50562
25	4.13092	4.50574
30	4.13104	4.50585
35	4.13116	4.50597
40	4.13127	4.50609

On the determination of the declination.

The zero or true north point on the horizontal circle of the magnetometer is ascertained as follows from observations of Polaris. The horizontality of the axis of the speculum having been verified, the speculum is placed vertically and revolved round its vertical axis till the image of the wires, which are illuminated by a lamp held beside the collimating eye-piece of the telescope, appears in the field. The speculum is turned by its slow motion screw till the image of the vertical wire is covered by the latter itself. The instrument is then revolved round its vertical and the speculum round its horizontal axis till the image of Polaris is bisected by the wires, and both verniers of the circle are then read. This operation is repeated after reversing the mirror on its pivots. The speculum is then turned half a circumference round its vertical axis and the operation repeated directly and again after reversing the mirror on its pivots. The image of the vertical wire is therefore four times covered by the wire.

The mean of the eight readings and the corresponding four times indicated by the chronometer, whose error is known, are respectively taken. The azimuth of Polaris: A, counted from true north, corresponding to the mean of the times is calculated by the equations:—

$$\tan M = \tan \delta \sec t \qquad \tan A = \cos M \tan t \operatorname{cosec} (\phi - M)$$

where δ is the declination, t the hour angle of Polaris, and ϕ the latitude.

On the determination of the temperature correction.

The deflecting magnet was fixed in the middle of a water-tight wooden box placed on a bar fixed like the deflection bar, and the magnetometer was revolved till the two magnets were at right angles to each other. The magnetometer was then clamped and the circle read off. The difference between this reading (magnet placed) and the reading before the deflector was placed (magnet away) being $=u$. Water at the highest of the three temperatures chosen was now poured into the box, and a thermometer, whose error had been previously determined, moved about therein. As soon as the temperature, t_3, became constant, the scale was read, the angle of deflection being now $=u_3$. Water at the next temperature, t_2, was then substituted, and the corresponding angle of deflection, u_2, determined. Water at the lowest temperature, t_1, was then substituted, the corresponding deflection being $=u_1$. The magnet, whose ends were of course left open, was found to assume the temperature of the water as soon as this became uniform.

The temperature co-efficients q and q′ were then calculated from Balfour Stewart's equations (Comp. G. M. WHIPPLE: "On the Temperature-correction and Induction-coefficients of Magnets," in proceedings of the Royal Society, No. 181, 1877):—

$$x\,(t_3 - t_1) + y\,(t_3 - t_1)^2 = \sin u_3 - \sin u_1$$
$$x\,(t_2 - t_1) + y\,(t_2 - t_1)^2 = \sin u_2 - \sin u_1$$
$$q = x \operatorname{cosec} u \qquad q' = y \operatorname{cosec} u$$

The operation was repeated and the readings corrected for change of declination. The correction being obtained in the form: $q\,(t - t_1) + q'\,(t - t_1)^2$ suitable for reducing the magnetic moment to t_1 degrees was converted to the form: $q\,t + q't^2$, for reducing to 0°, by aid of the corrections corresponding to 0°, 20° and 40° calculated from the former formula.

Specimen of observations; 11th January, 1886.

Magnet away (at commencement),	64°	58′	35″	u=18° 56′ 30″
,, placed,	46	2	5	Decl. increasing.
,, away (at end),	64	59	20	45″ in one hour.

Scale d.	Temp. Fahr. °	Scale d.	Temp. Fahr. °	
204.8	94.8	205.5	95.4	u_1=18° 56′ 30″ at 5°.0 Cent.
204.7	95.2	205.4	94.9	u_2=18 50 30 at 20°.0 ,,
204.75	95.1	205.2	94.7	u_3=18 43 30 at 35°.0 ,,
197.8	67.8	198.0	67.6	
197.9	67.9	198.4	67.8	
197.8	68.1	198.4	68.2	
197.9	68.2	198.3	68.4	
191.1	40.5	192.4	40.6	
191.8	41.2	192.4	40.9	
191.85	41.4	192.5	41.3	

Reduction to 5°.0: + ·000 305 9 (t−5°) + ·000 002 06 (t−5°)²
,, to 0°.0: + ·000 285 t + ·000 002 07 t²

On the determination of the Induction-coefficient.

The induction coefficient is, after Lamont's method, determined from deflections, the magnet being placed with its N-pole alternately upwards and downwards at the same distance from the suspended needle. But as the vertical force is small in Hongkong, the apparatus was arranged for also observing horizontal induction, the magnet being then placed with its N-pole alternately northwards and southwards.

Let m be the magnet moment of the magnet
,, X ,, ,, horizontal force.
,, i ,, ,, dip.
,, ϕ ,, ,, deflection, N-pole of magnet respectively downwards or northwards.
,, ϕ' ,, ,, deflection, N-pole of magnet respectively upwards or southwards.

The formulæ for calculating μ, the increase of the moment of the magnet by the action of an inducing force equal to a C. G. S. unity are then, for vertical induction :—

$$\mu = \frac{m}{\tan i \, X} \cdot \frac{\tan \frac{1}{2}(\phi - \phi')}{\tan \frac{1}{2}(\phi + \phi')}$$

and for horizontal induction :—

$$\mu = \tan i \cdot \frac{m \tan \frac{1}{2}(\phi - \phi')}{X \tan \frac{1}{2}(\phi + \phi')}$$

A short bar is fixed on the magnetometer in the same manner as the bar used in the deflections. There is at the end of this bar a pivot at about the same height as the deflected needle. The latter is if necessary raised or lowered by aid of the suspending thread. On the pivot the deflection bar is firmly fixed, so as to remain vertical to the short bar when turned on the pivot. On the deflection bar slides a carriage, that can be firmly screwed at any distance from the pivot. The deflecting magnet is fixed on this carriage and may be turned round its centre in a plane vertical to the fixed bar.

In order to investigate the vertical induction the deflection bar is placed vertical and the magnet above with its N-pole upwards. The magnetometer is then turned, till the central division on the scale appears near the middle of the field in the telescope. The verniers and also the scale are read. The deflection bar is then revolved half a circumference till the magnet is below with its N pole downwards. The scale is read and the operation repeated. Then the magnet is turned half a circumference on its axis, the magnetometer revolved till the central division appears in the middle of the field and the analogous operation performed. The short bar (with the deflection bar and magnet, which are not disturbed) is then reversed and the operations performed on the opposite side of the deflected needle.

In order to investigate the horizontal induction the deflection bar is placed horizontal and the analogous operations performed on both sides of the needle. As the horizontal force is so much greater than the vertical force in Hongkong, the latter method is more accurate than the former, although the needle is found to tremble more when the deflection bar is horizontal, than when it is vertical. It is assumed, that the induced magnetism is distributed in the same manner as the permanent magnetism, and the small difference between the values of the coefficient derived from the vertical and horizontal inductions respectively, is no doubt due to the want of perfect accuracy of this assumption, but the difference is almost insensible.

Specimen of Observations, 8th January, 1886.

Vertical Induction :—

Deflector East.				Deflector West.			
N-pole.	Magnet.	Circle.	Scale.	N-pole.	Magnet.	Circle.	Scale.
up	above	74° 31′ 30″	200.1	up	above	55° 27′ 35″	200.0
down	below		204.1	down	below		195.7
up	above		200.0	up	above		200.0
down	below		204.2	down	below		196.0
up	above		200.1	up	above		200.1
down	below		204.4	down	below		195.9
down	above	55° 20′ 45″	199.9	down	above	74° 40′ 0″	199.8
up	below		200.2	up	below		200.0
down	above		200.1	down	above		199.6
up	below		200.3	up	below		200.1
down	above		200.3	down	above		199.8
up	below		200.45	up	below		200.05

Horizontal Induction :—

Deflector East.				Deflector West.			
N-pole.	Magnet.	Circle.	Scale.	N-pole.	Magnet.	Circle.	Scale.
s	s	74° 30′ 40″	200.0	n	s	74° 42′ 20″	194.0
n	n		200.3	s	n		197.0
s	s		199.6	n	s		194.1
n	n		200.0	s	n		196.9
s	s		199.6	n	s		194.1
n	n		200.2	s	n		197.1
n	s	55° 33′ 40″	186.0	s	s	55° 33′ 45″	200.0
s	n		192.55	n	n		190.9
n	s		186.0	s	s		199.7
s	n		192.7	n	n		190.8
n	s		186.05	s	s		199.5
s	n		192.5	n	n		190.0

Vertical Induction:—

Deflector	East,	N-pole	up,	magnet	above: 74° 31′ 26″
,,	,,	,,	down,	,,	below: 74° 27′ 14″
,,	,,	,,	down,	,,	above: 55° 20′ 39″
,,	,,	,,	up,	,,	below: 55° 20′ 25″
,,	West,	,,	up,	,,	above: 55° 27′ 33″
,,	,,	,,	down,	,,	below: 55° 31′ 45″
,,	,,	,,	down,	,,	above: 74° 40′ 17″
,,	,,	,,	up,	,,	below: 74° 39′ 57″

$\frac{1}{2}(\phi + \phi') = 9° 34' 49''$ $\frac{1}{2}(\phi - \phi') = 0° 1' 3''.75$ $\mu = 5.265$.

Horizontal Induction:—

Deflector	East,	N-pole	south,	magnet	south 74° 30′ 57″
,,	,,	,,	north,	,,	north 74° 30′ 42″
,,	,,	,,	south,	,,	north 55° 41′ 9″
,,	,,	,,	north,	,,	south 55° 47′ 45″
,,	West,	,,	south,	,,	south 55° 34′ 2″
,,	,,	,,	north,	,,	north 55° 43′ 15″
,,	,,	,,	south,	,,	north 74° 45′ 21″
,,	,,	,,	north,	,,	south 74° 48′ 18″

$\frac{1}{2}(\phi + \phi') = 9° 28' 38''$ $\frac{1}{2}(\phi - \phi') = 0° 2' 18''.9$ $\mu = 4.68$.

The values of tan i and $\frac{m}{X}$ adopted were the means of the preceding and the following monthly, determinations.

W. DOBERCK,
Government Astronomer.

Hongkong Observatory, *25th January*, 1886.

GOVERNMENT NOTIFICATION.—No. 201.

The following Hydrographic Notice is published for general information.

By Command,

FREDERICK STEWART,
Acting Colonial Secretary.

Colonial Secretary's Office, Hongkong, 29th May, 1886.

Audacious, at Hongkong,
10th May, 1886.

HYDROGRAPHICAL MEMO., No. 9.

The following positions on S.E. coast of China have been determined by H.M.S. *Rambler*:—

Chelang Point Boulder,	Lat.	22°	39′	39″ N.
	Long.	115	34	15 E.
Chino Peak,	Lat.	22	45	22 N.
	Long.	115	48	11 E.
Turtle Rock,	Lat.	22	47	58 N.
	Long.	116	5	40 E.
Breaker Point Light House,	Lat.	22	56	24 N.
	Long.	116	29	43 E.

This notice affects Admiralty Charts No. 1962, 1963, 811, and 1262.

KOBE LIGHT.

With reference to my Hydrographical Memo. No. 8 of 8th March 1886, the Navigating Officer of *Champion* reports that his remark respecting Kobe Green Light no longer applies, the present light being as described in the Light List.

SATANOMISAKI LIGHT.

My Hydrographical Memo. No. 3 of 22nd December 1885 is cancelled, the Japanese Government having given notice that the first Order Fixed White Light on Satanomisaki (Cape Chichakoff) is now exhibited as heretofore, and the Temporary Light is discontinued.

R. VESEY HAMILTON,
Vice-Admiral, Commander-in-Chief.

To the Commodore and the respective Captains, Commanders, and Officers Commanding Her Majesty's Ships and Vessels employed on the China Station.