

IX.—*On the Balance Magnetometer, and its Temperature Corrections* By J. A. BROWN, Esq. Communicated by SIR T. M. BRISBANE, Bart.

(Read 21st April, 1845.)

1. THE Balance Magnetometer was imagined by Dr H. LLOYD, of Dublin, for the purpose of observing the variations of the vertical component of the earth's magnetic intensity. It consists simply of a balanced magnetic needle, with a knife-edged axle, resting on agate planes, at right angles to the plane of the magnetic meridian. In the instrument from which the results in this paper are deduced, the position of the needle is observed by means of micrometer microscopes.*

2. If m be the moment of free magnetism of the needle, Y the vertical component of the earth's magnetic force, W the weight of the needle, g the distance of the centre of gravity from the centre of motion, ϵ the angle contained by the line joining these two centres, and the magnetic axis of the needle when horizontal; the equation of equilibrium will evidently be

$$m Y = W g \cos \epsilon \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

By differentiation and division

$$\frac{\Delta Y}{Y} = \tan \epsilon \Delta \epsilon - \frac{\Delta m}{m} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

The differences $\Delta \epsilon$ are obtained by means of the micrometers, and the differences of Y in terms of Y will be obtained, if we can determine ϵ and $\frac{\Delta m}{m}$, the latter being the variation of the magnetic moment, due to temperature.

3. There are great practical difficulties in the way of rendering the needle capable of giving ϵ accurately by inversion, but Dr LLOYD has shewn† that

$$\tan \epsilon = \cot^2 \theta \frac{T'^2}{T^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

where θ is the magnetic dip, T' and T the times of one vibration of the balance needle in a horizontal and in a vertical plane. We have thus, instead of one, three unknown quantities to determine; and it becomes a matter of importance to shew with what degree of accuracy this may be done.

The dip and time of vibration in a horizontal plane can be obtained with sufficient truth for the purposes of this factor.

* See the Introduction to the Makerstoun Magnetical Observations for 1841-2.

† In his "Account of the Magnetical Observatory of Dublin," where the complete investigation will be found.

Observations of the time of vibration in a horizontal plane ranging through a period of three years, agree within 0.06, and this difference must be to a considerable extent due to alterations in the condition of the needle between the different observations.

4. The time of vibration in a vertical plane is in widely different circumstances.

These differences I shall proceed to point out.

1st, The time of vibration in a vertical plane is found increased *after* the needle has been, by any means, vibrated through a large arc.

The strongest evidences of this are contained in the following table; they were obtained either by iron having been brought accidentally near to the magnet, or by the necessary removal of the box which covers it. In the latter case, the magnet was vibrated through large arcs by currents of air.

One or two observations for the time of vibration are given for the periods immediately before and after the disturbance of the magnet.

The last column contains the times of vibration corrected to 50° Fahr.; for reasons that will be shewn, it is only these that are strictly comparable.

The observed time of vibration is generally the mean of two series, which rarely differ one-tenth of a second.

Additional evidence of the above conclusion is furnished by Table II.

TABLE I.

Observations for the Time of Vibration of the Balance Needle in a Vertical Plane, before and after excessive Vibrations.

DATE.	CAUSE OF DISTURBANCE.	Observed Time of one Vibration.	Temperature of Needle.	Time of one Vibration corrected to 50°.
1842.		s.	°	s.
March 19.	Balance magnet vibrated excessively.	10.14	45.5	10.48
... 22.				
April 2.		11.02	42.5	11.59
... 9.		10.94	44.0	11.40
Oct. 31.	{ A pair of compasses brought inadvertently near the balance needle.	10.05	55.9	9.60
Nov. 10.				
... 11.		10.34	51.0	10.26
... 19.		10.02	50.8	9.96
1843.				
Sept. 18.	{ The box of the magnetometer removed, and the needle exposed to currents of air.	10.60	65.0	9.46
... 22.		10.62	63.7	9.58
... 26.				
... 27.		11.20	51.9	11.06
... 29.		10.95	46.1	11.40
1844.				
April 29 ^h 22	{ Box lifted for the purpose of removing an insect, and replaced immediately afterwards; vibration not excessive.	9.04	50.2	9.02
... 30 7		9.50	60.5	8.70
... 30 7+				
... 30 8		10.03	60.5	9.23
... 30 22	{ Box lifted, and insect removed from beside the needle.	8.97	50.5	8.93
July 22 0		8.23	62.3	7.30
... 23 22		9.10	68.0	7.73
... 24 18				
... 25 0	The magnet vibrated by steel.	9.80	67.2	8.49
... 25 23		9.67	64.5	8.57
... 26 3				
... 26 23		10.04	65.4	8.87
... 29 22		9.45	58.5	8.80
Oct. 30 22		6.97	47.9	7.13
Nov. 3 22		6.72	43.9	7.18
... 3 ^d —7 ^d	{ Workmen in observatory, who had probably been near the magnet with a hammer.			
... 7 23		7.30	42.5	7.87
... 8 21				
... 9 1		8.24	46.8	8.48
... 10 23	{ Workmen brought a hammer near the magnet. After the vibration thus produced, the needle rested in a position differing 1'.6 from its previous position.*	8.03	43.7	8.51

5. 2*d*, The time of vibration in a vertical plane depends, to a considerable extent, on the magnitude of the arc of vibration.

3*d*, For the same arc, the time of vibration is greater, if it belong to a series

* This is the only case in which I determined, at the instant, the effect of excessive vibration on the position of the needle; the effect, though small, is considerable, when compared with the hourly changes; for several hours before this vibration, the magnet had not changed its position.

commencing with a large arc, than if it belong to a series commencing with a small one.

These conclusions I had arrived at nearly two years ago, and accordingly only small arcs were used in determining the time of vibration, seldom above 5'.0 commencing.

The following series of observations was made in January 1844, before removing the needle for the purpose of determining its temperature correction. Many other series made previously give the same result; but the following will be sufficient to prove the facts stated above.

TABLE II.

Observations for the Time of Vibration of the Balance Needle in the Vertical Plane, for different Arcs.

Time at the commencement of each Series.	Semi-arc of Vibration.		Number of Vibrations.	Means.	
	Beginning.	Ending.		Partial.	Of the Series.
Jan. ^d 26 ^h 22 ^m 15	1.8	0.4	14		9.58
22 25	1.4	0.4	14		9.58
22 40	25.0	18.6	6	11.15	
	18.6	6.5	6	10.98	10.95
	6.5	0.5	8	10.71	
22 53	1.3	0.4	16		9.78
23 20	1.6	0.4	16		9.70
23 32	45.5	25.0	6	11.36	
	25.0	11.3	8	11.20	
	11.3	6.5	6	11.07	11.07
	6.5	2.1	6	10.95	
	2.1	0.5	6	10.78	
23 50	1.7	0.4	14		10.17
Jan. 27 0 5	55.0	40.0	6	11.72	
	40.0	30.0	6	11.60	
	30.0	22.0	6	11.57	
	22.0	17.0	6	11.45	
	17.0	12.3	6	11.37	11.35
	12.3	5.8	6	11.33	
	5.8	5.5	6	11.22	
	5.5	4.5	6	11.09	
	4.5	0.7	6	10.80	
0 20	1.7	0.4	18		10.60

The semi-arcs were observed by my assistant Mr WELSH, at one microscope, while the times of each vibration were observed by myself at the other.

It is not my intention, in the present communication, to enter into any examination of the causes of these peculiarities; my object is simply to point them out as sources of error. I shall therefore merely state my conclusions, with their evidences.

6. 4th, The time of vibration in a vertical plane depends, to a considerable extent, on the temperature of the needle.

The following short series, taken at random from a great number of observations, at once prove the truth of this conclusion. From a comparison of a few of the observations, it was found that an increase of 1° Fahr. was equivalent to an increase of 0.076 in the time of vibration.

The last column for each series gives the times corrected by this quantity to 50° Fahr. That the correction obtained is only approximate, will, together with errors of observation, account for much of the discrepancies in the corrected quantities.

TABLE III.

Observations for the Time of Vibration of the Balance Needle in the Vertical Plane at different Temperatures.

Time of Observation.	Observed time of one Vibration.	Temperature of the Magnet.	Time of one Vibration corrected to 50° Fahr.	Time of Observation.	Observed time of one Vibration.	Temperature of the Magnet.	Time of one Vibration corrected to 50° Fahr.
1844.				1845.			
Jan. d h	s	°	s	Jan. d h	s	°	s
2 22	8.91	31.4	10.32	20 23	7.21	35.4	8.32
3 2	9.48	40.0	10.24	23 23	8.38	46.3	8.66
3 4	9.80	43.5	10.29	26 22	7.42	35.9	8.49
3 5	9.96	45.2	10.32	30 2	6.72	27.0	8.47
3 22	9.74	41.4	10.39	31 2	6.42	21.5	8.59
				Feb. 4 22	7.64	38.7	8.50
April 30 22	8.97	50.6	8.92	12 2	6.93	32.6	8.25
May 1 8	9.77	64.1	8.70	16 23	7.49	38.9	8.33
1 22	9.28	56.3	8.80				
2 21	9.13	55.2	8.73	Mar. 9 22	7.43	41.0	8.11
3 8	9.81	64.4	8.72	12 23	6.87	31.6	8.27
3 23	9.02	53.6	8.75	13 22	7.08	31.9	8.46
				16 22	6.82	31.2	8.25
				23 23	8.07	45.6	8.40
				April 1 11	8.10	48.7	8.20

It should be remarked, that the series for January 1844 is not comparable with the following series, as an adjustment of the instrument occurred in that month; neither, indeed, are the other series comparable with each other, from the circumstances given in Table I.

7. To take one of the most marked cases from this table, it will be seen that the observed times of vibration on January 23d and 31st 1845, differ nearly two seconds, while the corrected times do not differ one-tenth of a second.

8. While an inequality in the expansion of some parts of the needle would alter its sensibility by elevating the centre of gravity, it seems very doubtful if there is any thing in the form of the needle which is at all likely to render this supposition sufficient. An alteration in the position of the centre of motion would produce a like effect; and as the position of the needle depends, to some extent, on its temperature, it is necessary to shew whether position or temperature only is the cause of the differences in the times of vibration. Had the readings for the position of the needle been given with Table III., it would have been evident from these alone that the differences were *not* due to differences of posi-

tion. The following series of observations made during a magnetic disturbance, will, however, prove it more distinctly.

TABLE IV.

Observations for the Time of Vibration of the Balance Needle in a Vertical Plane, the position of rest varying.

Gottingen Mean Time of Observation.				Balance Magnetometer.		Time of one Vibration.	
				Reading.	Thermometer.	Observed.	Corrected to 50° Fahr.
	d	h	m	Mic. Div.	°	s	s
April	15	22	52	—148	47.7	8.84	9.01
	17	1	50	+ 101	52.5	9.21	9.02
		2	20	+ 4	53.2	9.46	9.22
		3	15	+ 25	54.2	9.46	9.14
		3	25	+ 23	54.7	9.36	9.00
		5	15	— 18	56.4	9.62	9.13
		7	45	— 10	56.3	9.66	9.18
		8	45	— 90	56.0	9.68	9.22
		10	20	—190	55.2	9.42	9.02
		10	30	—176	55.2	9.62	9.22
		13	40	—310	54.3	9.23	8.90
		13	50	—293	54.3	9.35	9.02
		22	15	—185	51.1	9.28	9.20
		22	25	—185	51.1	9.38	9.30
	18	22	30	—134	50.3	9.01	8.99

The positive and negative signs indicate that the north pole of the needle was below or above the horizontal. It would have required a change of 50° Fahr. to have produced *alone* a difference of 400 micrometer divisions. Such a change of temperature, according to § 6, would have been equivalent to a change of 3.8 in the time of vibration. The observed times differ only a few tenths, and the times corrected for temperature agree within the limit of the errors of observation.*

9. It results from these facts, that the time of vibration in a vertical plane cannot be used at present in the reduction of the observations, as theory takes no account of them. The theoretical corrections for differences of arc or the variation of the moment of inertia due to temperature would, in the examples given, be inappreciable.

10. I shall now consider $\frac{\Delta m}{m}$, the temperature correction for the position of the needle.

The method which has been adopted for its determination is as follows:—

The magnet, whose temperature correction is to be obtained, is placed at right angles to a magnet freely suspended, which is thus deflected by an angle u from the magnetic meridian. If m be the magnetic moment of the deflecting magnet,

* The time of vibration throughout the year varies from other causes. The law which regulates these variations I have not yet determined.

and X the horizontal component of the earth's magnetic force, the equation of equilibrium is

$$m = X \sin u \quad . \quad . \quad . \quad . \quad . \quad (4.)$$

The variations of u are observed, while the deflecting magnet has its temperature altered 30° or 40° Fahr., by means of hot or cold water; by differentiating equation (4) and dividing by it, these variations are connected with $\frac{\Delta m}{m}$ by the equation.

$$\frac{\Delta m}{m} = \cot u \Delta u \quad . \quad . \quad . \quad . \quad . \quad (5.)$$

X and the magnetic declination being constant.

11. The chief objections to this method are the following :—

1st, The circumstances under which the magnet is placed are considerably different from its usual condition. It is necessary to raise or lower the temperature 30° or 40° in water, within a few minutes, to obtain satisfactory results, whereas the most rapid changes in the magnetometer-box will probably be under 2° in an hour. It seems doubtful to me whether it has been proved that the changes of magnetic moment occur as rapidly as those of temperature in all cases.

2d, In the event of there being any other source of error due to temperature, it is altogether omitted by this method.

3d, If the correction has not been determined before adjusting the instrument, the series of observations is broken up by the necessity of removing the needle.

12. As it is desirable that the observations of the balance magnetometer should be made as valuable as possible, I shall proceed to consider how this may be best done, as it is my opinion that they will be found ultimately capable of giving diurnal and annual changes with considerable fidelity.

13. The observations of $\Delta \epsilon$, the varying angle formed by the needle and the horizontal, will at present obviously give comparative observations for the variations of vertical force, without reference to the value of the coefficient $\tan \epsilon$, until a good approximate value of the latter can be obtained, *if* the observations in micrometer divisions can be corrected for temperature. In order to do this, it would be necessary to convert the value of $\frac{\Delta m}{m}$, obtained by deflection experiments into micrometer divisions, if this value be q .

$$q = \frac{\Delta m}{m} \tan^2 \theta \frac{T^2}{T'^2} \quad . \quad . \quad . \quad . \quad . \quad (6.)$$

We cannot, however, use T , and therefore the method of deflections is, in this way, insufficient; besides, if the alterations in the value of T from temperature should be caused by changes in the position of the centre of gravity, this change

would probably not be altogether in the vertical, the portion resolvable to the horizontal would affect the *position* of the needle.

14. From these considerations I was induced, about two years ago, to endeavour to obtain the temperature correction from the usual daily observations of the instrument. To most persons acquainted with the irregularities in the magnetical variations, from the changes of the magnetic intensity or its direction, this might appear to some extent chimerical, and as at best only capable of giving a rough approximation to, or verification of, the determinations by deflection. It will, however, I think, be shewn, that a better coincidence of partial results, and a better correction, may be obtained from this than from the usual method.

It will not be necessary to point out the methods which were at first tried; I shall proceed at once to those which have been ultimately adopted.

15. Having selected a series of days during which the readings of the instrument seem regular, and in which the changes of temperature from day to day are considerable, rejecting any day of marked disturbance, the hourly or two-hourly readings for the position of the needle and for its temperature are summed for each day. Let us designate the sum of the micrometer readings for the first day of the series y_1 , for the second day y_2 , and so on to y_{2n+1} ; the corresponding sums of the thermometer readings being $t_1, t_2, \dots, t_{2n+1}$, the number of the days, from the beginning to the end of the period, being $2n+1$.

The most simple and probable hypothesis that can be formed, is, that the mean vertical force increases or diminishes gradually throughout the period; let the mean daily change be α .

If q be the temperature correction for 1° Fahr. in micrometer divisions, we may form the following series of equations:

$$\begin{array}{rcl}
 y_1 = y_2 + \alpha + (t_1 - t_2) q & y_2 = y_3 + \alpha + (t_2 - t_3) q & \\
 y_1 = y_3 + 2\alpha + (t_1 - t_3) q & y_2 = y_4 + 2\alpha + (t_2 - t_4) q & \\
 \dots & \dots & \\
 y_1 = y_{n+1} + n\alpha + (t_1 - t_{n+1}) q & y_2 = y_{n+2} + n\alpha + (t_2 - t_{n+1}) q & \\
 \dots & \dots & \\
 y_{n+2} = y_{n+3} + \alpha + (t_{n+2} - t_{n+3}) q & & \\
 \dots & &
 \end{array} \quad \left. \vphantom{\begin{array}{rcl} y_1 = y_2 + \alpha + (t_1 - t_2) q \\ y_2 = y_3 + \alpha + (t_2 - t_3) q \\ \dots \\ y_1 = y_{n+1} + n\alpha + (t_1 - t_{n+1}) q \\ y_2 = y_{n+2} + n\alpha + (t_2 - t_{n+1}) q \\ \dots \\ y_{n+2} = y_{n+3} + \alpha + (t_{n+2} - t_{n+3}) q \\ \dots \end{array}} \right\} (7.)$$

There will be breaks in each series, as there are no sums for the Sundays. As t_2 may be greater than t_1 and t_3 , the result of the comparison of y_1 with y_3 is not equivalent to the comparison of y_1 with y_2 and y_2 with y_3 .

From these equations the most probable values of α and q might be obtained by the usual methods; but the labour which they demand is probably much beyond the greater accuracy to be attained. The following, it is conceived, will be found sufficient.

First classing the equations in which $t_p >$ or $< t_{p+r}$, and considering each class separately.

Placing the equations in the form

$$\frac{y_p - y_{p+r}}{t_p - t_{p+r}} = \frac{r \alpha}{t_p - t_{p+r}} + q \quad . \quad . \quad . \quad . \quad . \quad (8.)$$

Naming the differences in which $r = 1$, Δy_1 , and Δt_1 , in which $r = 2$, Δy_2 , and $\Delta t_2 \dots \Delta y_n$, Δt_n . Summing separately all the equations for Δ_1 , all those for $\Delta_2 \dots$. It will simplify the investigation, and be sufficiently accurate to take for the divisor of $r \alpha$, the mean of all the values of Δt , naming this Δt_0 .

We obtain the following equations:

$$\left. \begin{aligned} \frac{\Sigma \Delta y_1}{\Sigma \Delta t_1} &= q + \frac{\alpha}{\Delta t_0} \\ \frac{\Sigma \Delta y_2}{\Sigma \Delta t_2} &= q + \frac{2 \alpha}{\Delta t_0} \\ . \quad . \quad . \quad . \quad . \\ \frac{\Sigma \Delta y_n}{\Sigma \Delta t_n} &= q + \frac{n \alpha}{\Delta t_0} \end{aligned} \right\} \quad (9.)$$

If the difference of each equation be taken with every one following it, another series of equations of the following form will be produced.

$$\frac{\Sigma \Delta y_p}{\Sigma \Delta t_p} - \frac{\Sigma \Delta y_{p+r}}{\Sigma \Delta t_{p+r}} = \frac{r \alpha}{\Delta t_0} \quad . \quad . \quad . \quad (10.)$$

Summing the equations thus formed, we obtain an equation which may be put as follows:

$$\overline{n-1} \left(\frac{\Sigma \Delta y_1}{\Sigma \Delta t_1} - \frac{\Sigma \Delta y_n}{\Sigma \Delta t_n} \right) + \overline{n-3} \left(\frac{\Sigma \Delta y_2}{\Sigma \Delta t_2} - \frac{\Sigma \Delta y_{n-1}}{\Sigma \Delta t_{n-1}} \right) + \dots = -\frac{\overline{n+1} \cdot \overline{n} \cdot \overline{n-1}}{6} \cdot \frac{\alpha}{\Delta t_0} \quad (11.)$$

Summing equations (9.)

$$q = \frac{1}{n} \Sigma \frac{\Sigma \Delta (y)}{\Sigma \Delta (t)} - \frac{n+1}{2} \frac{\alpha}{\Delta t_0} \quad . \quad . \quad . \quad . \quad . \quad (12.)$$

16. The following example, from the Makerstoun observations, will shew the method found most convenient in practice for the summations.

A period of 52 days, from June 1 till July 22. 1843, having been selected as nearly free from disturbances, and containing considerable changes of temperature, the 3d and 7th June being rejected on account of disturbances; the sums for each day of the micrometer and thermometer readings were entered into columns titled Σy and Σt . Each sum was then compared with all the sums up to the 27th day after, and the differences entered into columns titled $\Delta y_1, \Delta t_1; \Delta y_2, \Delta t_2; \dots \Delta y_{26}, \Delta t_{26}$. Those differences, the fewest in number, in which $t_p > t_{p+r}$ were marked out, the others summed for each column, and the divisions $\frac{\Sigma \Delta y_1}{\Sigma \Delta t_1} \dots \frac{\Sigma \Delta y_{26}}{\Sigma \Delta t_{26}}$ performed.

From these and equations (11), (12),

$$\Sigma \frac{\Sigma \Delta (y)}{\Sigma \Delta (t)} = 8.338; \quad \frac{\alpha}{\Delta t_0} = 0.0375; \quad \alpha = 2.05; \quad q = 7.832 \text{ Mic. div.}$$

The differences, when $t_p > t_{p+r}$ were too irregular and too few, on some days, to give a good value of α .

17. It is very rare that periods of such magnitude can be found free from considerable irregularities. In general, however, it is conceived that smaller periods will give equally good results, and by a shorter method.

If we consider the equations

$$q = \frac{y_p - y_{p+r}}{t_p - t_{p+r}} - \frac{r \alpha}{t_p - t_{p+r}}; \quad t_p > t_{p+r}$$

$$q = \frac{y_{p+r} - y_p}{t_{p+r} - t_p} + \frac{r \alpha}{t_{p+r} - t_p}; \quad t_p < t_{p+r}$$

it is obvious, that if the temperatures rise and fall considerably throughout the period selected, and no attention be paid to the sign of $t_p - t_{p+r}$ in the summations of the differences, the coefficients of α will nearly destroy each other.

18. In the following cases the sums for each day have been compared with the sums of all the days after it in the period selected. By this means irregularities in the force upon any day have their effect on the final result to a considerable extent destroyed, as it is probable that the results will be as much too great in some cases, as they are too small in others.

The whole differences have been summed without regard to days, and the signs of $t_p - t_{p+r}$ have been disregarded.

The equation is, therefore, simply

$$\frac{\Sigma \Delta (y)}{\Sigma \Delta (t)} = q$$

TABLE V.

Determinations of the Temperature Correction for the Balance Magnetometer, from comparisons of the Daily Observations at different periods.

PERIOD.	$\Sigma \Delta (t)$	$\Sigma \Delta (y)$	q	Time of Vibration corrected to 50° Fahr.	REMARKS.
1843.	°	Mic. Div.	Mic. Div.	s	
Jan. 16—21.	525.3	4315.3	8.21	9.20	In 1843, there were 9 daily observations made at two-hourly intervals, from 5 A.M. till 9 P.M.
23—28.	817.7	5723.5	6.99	9.20	
Jan. 30—Feb. 4.	576.0	4151.5	7.21	9.02	
Feb. 6—11.	609.9	4080.6	6.69	9.25	Sept. 2, the needle was removed, in order to determine its temperature correction by the method of deflections.
June 1—30.	14320.4	114646.9	8.006	9.28	
Sept. 6—16.	1083.7	8730.4	8.04	9.92	
1844.					
May 9—24.	8415.4	66621.7	7.93	8.38	In 1844, there were observations at every hour of the day. The needle was removed between September and February for temperature correction deflections.
Aug. 3—Sept. 6.	21696.9	171460.5	7.902	8.06	
For the series in 1843.	17933.0	141648.2	7.898		
For all,	48045.3	379730.4	7.903		

From the above table it would appear that neither the removal of the needle and readjustment, nor the alteration of the time of vibration, has affected the temperature correction.

The first values of q shew that periods of a week are insufficient for very accurate determinations.

The mean for 1843 is almost identical with that for 1844.

19. The differences for three periods were also summed without regard to days, but paying attention to the sign of $t - t_{p+r}$. The following table contains the results.

TABLE VI.

Determination of the Temperature Correction for the Balance Magnetometer, regard being paid to the signs of the differences of temperature.

PERIOD.	Preceding temperatures greater than the succeeding.			Preceding temperatures less than the succeeding.			Mean Value of q
	$\Sigma \Delta (t)$	$\Sigma \Delta (y)$	q	$\Sigma \Delta (t)$	$\Sigma \Delta (y)$	q	
1843.	°	Mic. Div.	Mic. Div.	°	Mic. Div.	Mic. Div.	Mic. Div.
June 1—30.	3350.2	29096.6	8.68	10970.2	85550.3	7.80	8.24
1844.							
May 9—24.	5404.3	37559.9	6.95	3011.1	29061.8	9.65	8.30
Aug. 3—Sept. 6.	4726.1	34249.3	6.68	16970.8	137211.2	8.09	7.39
For all the periods,	13480.6	100905.8	7.49	30952.1	251823.3	8.14	7.813

The result No. 16, and the mean results in Tables V. and VI., for the whole periods, agree very closely. As the value of one micrometer division, in parts of the whole vertical force, is about 0.00013, the greatest difference of the three final results, 7.83, 7.90, and 7.81, is 0.0000012.

The final results, from five days' observations, by the method of deflections, were .000085, .000077, .000079, .000062, .000073, differing 0.000023.

The results, from the comparison of daily observations, in parts of the whole vertical force, will be about .000134, the time of vibration being about 9 seconds; if 11 seconds were adopted, the result would be .000095; in either case considerably more than the result obtained by deflections.

20. The satisfactory determination of q for the Balance magnetometer, led me to determine the correction for the Bifilar magnetometer by the same method.

Besides the variation of the magnetic moment, temperature also affects the length and interval of the suspending silver wires; it probably also affects their elasticity.

The determination of the correction from the daily observations, at once sums up all the effects of temperature. When the suspending threads are of silk, these sources of error are avoided; but I conceive that much graver errors are introduced, due chiefly to varying humidity affecting the torsion of the thread.

I shall give simply the results of the comparisons of the daily observations for the Bifilar magnetometer.

TABLE VII.

Determination of the Temperature Correction for the Bifilar Magnetometer, from comparisons of the Daily Observations.

PERIOD.	Preceding temperatures greater than the succeeding.			Preceding temperatures less than the succeeding.			Mean of the two values of q in parts of force.	Value of q independent of the sign of $\Delta (t)$ in parts of force.
	$\Sigma \Delta (t)$	$\Sigma \Delta (x)$	q	$\Sigma \Delta$	$\Sigma \Delta (x)$	q		
1844.		Sc. Div.	Sc. Div.		Sc. Div.	Sc. Div.		
May 9—24.	5334.9	13066.8	2.45	2359.9	4033.0	1.71	0.000270	0.000289
May 29—June 28.	11938.2	24597.2	2.06	26719.2	45966.3	1.72	0.000246	0.000238
July 17—30.	1843.1	3004.0	1.63	4637.8	8470.4	1.83	0.000225	0.000230
Sept. 2—25.	27322.6	53684.3	1.96	622.1	1260.8	2.03	0.000259	0.000255
Nov. 26—Dec. 13	17855.4	36791.6	2.06	2143.7	3104.5	1.45	0.000229	0.000259
For all the periods,	64294.2	131143.9	2.04	36482.7	62835.0	1.72	0.000244	0.000250

When it is considered that the daily range of the Bifilar readings, in parts of the whole horizontal force, is to the daily range of the Balance readings, in parts of the whole vertical force, as 7 or 8 to 1, it will be seen that the results for the Bifilar magnetometer are equal to those for the Balance. It should also be remembered that the results for May and July are from short periods.

The results obtained by deflections on two days were 0.000291 and 0.000298, the partial results agreeing very well.

Taking into account the expansion of the wires, the total temperature correction is 0.000304.

It will be observed, in this case, that the results by deflections are greater than those from a comparison of the daily observations.

MAKERSTOUN, *April 18. 1845.*