III. "Magnetic Observations at Kerguelen." By the Rev. S. J. Perry, S.J., F.R.S. Received March 15, 1877.

The Government expedition to Kerguelen Island for the observation of the Transit of Venus on December 8th, 1874, presented a very favourable opportunity for the accurate determination of the magnetic elements of an important station in the South-Indian Ocean, and one which will at most be visited only at distant intervals for the purpose of scientific investigations. When, therefore, I heard of my appointment to that station, I at once brought the question of terrestrial magnetism under the notice of the Astronomer Royal, and he readily agreed to my proposal of taking a complete set of magnetic instruments to Kerguelen, and of making any observations that would not interfere with the main object of our expedition.

Being in charge of the whole Kerguelen party of observers, I could not expect to be able to devote much time personally to the magnetic work; but the Rev. W. Sidgreaves, whom long experience, both at the Stonyhurst Observatory and during our magnetic survey of France in 1868 and 1869, had made perfectly conversant with all the details both of instruments and observations connected with terrestrial magnetism, had already been placed on the staff of astronomical observers for Kerguelen. The assistance of a very efficient observer being thus secured, the next step was to procure the necessary instruments. Fortunately I experienced no difficulty in this matter, as the authorities at Kew immediately placed at my disposal a Jones unifilar and a Barrow dip-circle. There was no question of the want of a good chronometer, as the astronomers were to be supplied with nine of these, besides the eight reserved exclusively for longitude connexions, which remained always undisturbed in their quiet berth on shipboard.

It was at first proposed by Sir Edward Sabine that we should take a series of magnetic observations at sea during our voyage from England to the Cape of Good Hope and thence to Kerguelen, and a special instrument was ready for the purpose; but as it was finally arranged that we should perform the first part of our journey in the mail-steamer, it was thought advisable by the Hydrographer of the Admiralty to relinquish all idea of taking magnetic observations at sea.

The land instruments were made use of on almost every available occasion, both at Kerguelen and during our journey; but I will confine myself in this paper to the Kerguelen results, reserving the other observations for a separate communication.

The constants for the temperature-correction, and for other data regarding the magnets employed, were kindly determined for me by Mr. Whipple at Kew.

No correction for error of graduation of deflection-bar was found necessary.

The angular value of one division of the scale of the vibration-magnet No. 3 $=2'\cdot3$. This was again tested at the Cape of Good Hope, and found to be $2'\,16''\cdot7$. The same magnet had for its induction-coefficient 0·0002204, and its dimensions of inertia were the following:—Length 0·31736 foot, diameter 0·032681 foot, and weight 979·127 grains.

The correction to 35° Fahr. was

$$0\cdot0001583\,(t-35^\circ)+0\cdot000000465\,(t-35^\circ)^2;$$

and log π^2k at 60° Fahr. $=1\cdot675300$.

Our chief astronomical station at Kerguelen was Observatory Bay, a little to the south of the north-west corner of Royal Sound, its approximate latitude being 49° 25′ 11″·9 S., and its longitude $4^h\,39^m\,34^s\cdot3$ E. of Greenwich. At this station a long series of observations of the dip, horizontal force, and declination were taken during our four months' stay. The trips undertaken for the establishment of our two secondary stations at Swain's Haulover and at Thumb Peak, and also for the longitude connexions, afforded opportunities of observing the magnetic elements at the second and third British stations, as well as at that of the Americans at Molloy Point. The existence of a magnetic observatory at the German station rendered unnecessary any further observations at Betsy Cove. A brick pier was erected on a solid foundation at Observatory Bay for the magnetic instruments, and most of the observations were made on this spot.

The Magnetic Dip.

The dip observations were taken with three needles, and the results obtained on different days are all entered in the following Table:—

	1874–75.	No. 1.	No. 2.	No. 3.	Mean.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″
Observatory Bay ...	November 13...	......	72 4 1	72 5 15	72 4 38
Swain's Haulover ...	December 13 ...	70 59 58	71 3 2	70 57 10	71 0 3
Thumb Peak	December 21 ...	......	71 6 38	......	71 6 38
Observatory Bay .	December 23 ...	......	71 57 6	71 54 30	71 55 48
	January 13 ...	......	71 52 40	71 56 54	71 54 47
	January 30 ...	71 58 30	71 54 21	72 3 34	71 58 48
	February 18 ...	......	71 42 6	......	71 42 6

The station at Swain's Haulover was six or seven miles to the south of Observatory Bay, and Thumb Peak about the same distance due east of the Haulover. At Thumb Peak there was only time to observe with a single needle; the weather, too, was bad, and the spot chosen not very favourable, being on the shingle near the water's edge. The readings on January 30th were taken on the rocks near the landing cove. The last observation at Observatory Bay was made near the top of the rock overhanging the dwelling, and in a rather unsteady position; it is therefore less reliable than the others. The true dip for January 1st, 1875, at Observatory Bay will probably be a little in excess of 71° 55′ 13″·4, which is the mean of the observed values.

The Magnetic Intensity.

The horizontal component of the intensity was determined in the usual way by observations of vibration and deflection. Only one set of observations was taken at a distance from the chief station, viz. that on December 13th, at Swain's Haulover.

Vibration Observations.

Station.	1874–75.	Temperature.	Time of one vibration.	Log m X.	Value of m.
Observatory Bay	November 13...	44°·4	5·47797	0·19703	0·45548
	„ 24...	59·6	5·48405	0·19724	0·45559
	December 10...	50·7	5·48567	0·19618	0·45476
Swain's Haulover...	„ 13...	49·9	5·57271	0·18250	0·45450
Observatory Bay	January 6	55·7	5·49071	0·19605	0·45372
	„ 16	47·9	5·48535	0·19621	0·45527
	„ 25	48·8	5·48425	0·19650	0·45569
	February 9 ...	58·5	5·49062	0·19629	0·45546

Deflection Observations.

Station.	1874–75.	Distances of centres of magnets.	Temperature.	Observed Deflection.	Log $\frac{m}{X}$.
		ft.			
Observatory Bay	November 13...	1·0	38°·3	15° 11′ 50″	9·12003
		1·3	38·3	6 52 1	9·11980
	December 10...	1·0	42·7	15 9 16	9·11920
		1·3	43·2	6 51 23	9·11955
Swain's Haulover...	„ 13...	1·0	44·9	15 38 14	9·13267
		1·3	45·7	7 3 39	9·13246
Observatory Bay	January 6	1·0	52·2	15 3 59	9·11755
		1·3	50·0	6 48 53	9·11750
	„ 16	1·0	46·5	15 10 49	9·12032
	„ 29	1·0	41·5	15 13 0	9·12084
	February 9......	1·0	51·3	15 10 41	9·12060

In the above Tables m represents the magnetic moment of the vibration-needle, and X the earth's horizontal magnetic intensity.

In deducing the vertical component and the total intensity from the horizontal force, I have made use of the dip obtained on the same day as the vibrations and deflections, or on the nearest day possible. As, however, the observation of February 18th is far from reliable, I have adopted for February 9th the mean value of the dip deduced from the December and January observations taken at Observatory Bay, viz. 71° 56′ 28″.

Station.	H. F.	V. F.	T. F.
Observatory Bay	3·4559	10·6852	11·2327
	3·4567	10·6876	11·2353
	3·4547	10·5884	11·1378
Swain's Haulover	3·3494	9·7278	10·2883
Observatory Bay	3·4615	10·5986	11·1496
	3·4510	10·5665	11·1158
	3·4501	10·5952	11·1428
	3·4502	10·5816	11·1299

If, now, we combine each determination of the horizontal force with the mean value of the dip for December and January, we obtain the following results at Observatory Bay for the Vertical Force and the Total Intensity:—

V. F.	T. F.
10·5991	11·1483
10·6015	11·1509
10·5954	11·1444
10·6163	11·1663
10·5841	11·1325
10·5813	11·1296
10·5816	11·1299

The probable error of the mean value of the intensity is thus reduced from $\pm 0{\cdot}0126$ to $\pm 0{\cdot}0035$; we may therefore consider 11·1431 as the adopted value of the total force for January 1st, 1875.

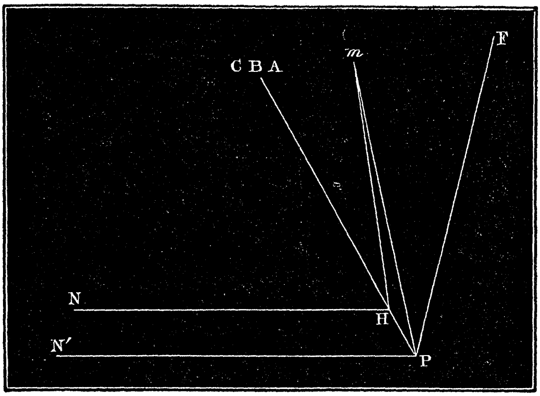
The Magnetic Declination.

The advantage of a fixed observatory enabled us to determine with great exactness the direction of the astronomical meridian, and to connect the position of the magnetic pier with the sites of the astronomical instruments. On January 28th and on February 5th observations of the sun were taken with an excellent transit theodolite made expressly for the expedition by Messrs. Troughton and Simms. The results give the following values for the azimuth of a well-defined point on the Prince of Wales's Foreland, some ten miles distant:—

	Circle right.	Circle left.
	° ′ ″	° ′ ″
January 28th	95 17 10	95 18 27
February 5th	95 19 30·5	95 18 18
	95 18 20·25	95 18 22·5

The resulting azimuth of the Foreland would therefore be 95° 18′ 21″·38 E. of the north point. The correctness of this angle, on which all the declinations depend, was tested by a series of measurements connecting the azimuth of the Foreland (F) with the azimuth mark (*m*) of the great theodolite, a most accurate instrument, especially designed by Sir G. B. Airy for the lunar longitude observations at Kerguelen. As the Fore-

land was not visible from the altazimuth hut (H), which stood, however, not far from the magnetic pier (P), the two marks were connected as



follows:—Let N, N′ be the true north, and A, B, C distant points on a mountain seen over H from P. By careful readings of A, B, C, and *m* from P and H the following values of the angle *m* were found—7′ 18″, 7′ 26″, 7′ 20″, 7′ 37″, 7′ 28″, 7′ 14″, giving as a mean 7′ 25″. This, applied to the azimuth of *m* from H (which was accurately known from daily readings to be 55° 41′ 12″), made the azimuth of *m* from P =55° 33′ 47″. The angle *m* P F was then found by repeated measures to be 39° 44′ 22″, which gave as a final result the angle F P N =95° 18′ 9″. As this is almost identical with the value obtained above from direct solar observations, we can adopt the mean of the two, viz. 95° 18′ 15″, as the azimuth of the Foreland; and thus we have only to take the bearing of the magnet with respect to this point in order to obtain the results included in the subjoined Table.

Observed Declinations.

1874–75.	L.M.T.	Circle reading of Magnet.	Scale correction.	Circle reading of Foreland.	Bearing of magnet south of Foreland.	W. Declination.	Daily means.
	h m	° ′ ″	′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
Nov. 13 ...	3 50 P.M.	175 43 55	−32 21	126 13 55	48 57 39	35 44 6	35 44 6
Nov. 24 ...	10 40 A.M.	182 34 20	,, ,,	133 12 50	49 9	52 36	52 36
	10 50	,, ,,	,, ,,	,, ,,	,, ,,	,, ,,	
Dec. 3......	6 0 P.M.	236 44 15	,, ,,	187 19 35	51 19	50 26	50 26
Dec. 10 ...	4 0	233 44 15	,, ,,	184 20 20	51 34	50 11	50 11
Jan. 6......	4 5	193 45 5	,, ,,	144 16 0	56 44	45 1	45 1
	4 40	,, ,,	,, ,,	,, ,,	,, ,,	,, ,,	
Jan. 13 ...	12 0	260 23 50	,, ,,	210 58 50	52 39	49 6	48 8
	2 15 P.M.	,, ,,	−31 54	,, ,,	53 6	48 39	
	3 15	,, ,,	−30 45	,, ,,	54 15	47 30	
	3 40	,, ,,	−29 37	,, ,,	55 23	46 22	
	4 15	,, ,,	−29 10	,, ,,	55 50	45 55	

Observed Declinations (*continued*).

1874–75.	L.M.T.	Circle reading of Magnet.	Scale correction.	Circle reading of Foreland.	Bearing of magnet south of Foreland.	W. Declination.	Daily means.
	h m	° ′ ″	′ ″	° ′ ″	° ′ ″	° ′ ″	
Jan. 13 …	4 35 P.M.	260 23 50	−32 35	210 58 50	48 52 25	35 49 20	Moved magnet before observation.
	5 15	,, ,,	−32 21	,, ,,	52 39	49 6	
	6 15	,, ,,	,, ,,	,, ,,	,, ,,	,, ,,	
Jan. 16 …	12 15	195 25 40	,, ,,	146 3 20	49 59	51 46	35° 51′ 39″
	12 45	,, ,,	−32 7	,, ,,	50 13	51 32	
Jan. 21 …	10 30 A.M.	241 27 20	−32 21	192 3 25	51 34	50 11	47 54
	11 15	,, ,,	−27 20	,, ,,	56 35	45 10	
	11 45	,, ,,	−25 58	,, ,,	57 57	43 48	
	12 15 P.M.	,, ,,	−27 20	,, ,,	56 35	45 10	
	12 45	,, ,,	−26 26	,, ,,	57 29	44 16	
	4 25	144 52 10	−32 21	95 30 0	49 49	51 56	
	5 0	,, ,,	−32 7	,, ,,	50 3	51 42	
	6 30	,, ,,	−31 26	,, ,,	50 44	51 1	
Jan. 25 …	4 42	214 12 40	−32 21	164 46 10	54 9	47 36	48 10
	5 5	,, ,,	−33 29	,, ,,	53 1	48 44	
Feb. 6……	10 0 A.M.	192 51 15	−32 21	143 31 45	57 9	44 36	43 43
	10 35	,, ,,	−28 56	,, ,,	49 0 34	41 11	
	11 10	,, ,,	−28 1	,, ,,	1 29	40 16	
	11 40	,, ,,	−27 20	,, ,,	2 10	39 35	
	2 45 P.M.	193 2 0	−31 54	143 27 0	2 12	39 33	New suspension-thread.
	4 15	193 24 0	−32 21	143 59 10	48 52 29	49 16	
	6 15	,, ,,	−34 38	,, ,,	50 12	51 33	
Feb. 8……	10 0 A.M.	254 25 0	−32 35	205 5 10	47 15	54 30	35 49 2
	10 30	,, ,,	−32 21	,, ,,	47 29	54 16	
	11 0	,, ,,	−31 54	,, ,,	47 56	53 49	
	11 30	,, ,,	,, ,,	,, ,,	,, ,,	,, ,,	
	12 0	,, ,,	−31 26	,, ,,	48 24	53 21	
	12 30 P.M.	,, ,,	−28 29	,, ,,	51 21	50 24	Magnet vibrating considerably.
	1 30	,, ,,	−25 58	,, ,,	53 52	47 53	
	2 30	,, ,,	−22 20	,, ,,	57 30	44 15	
	3 0	,, ,,	−20 44	,, ,,	59 6	42 39	
	3 50	,, ,,	−20 17	,, ,,	59 33	42 12	
	5 30	,, ,,	−23 28	,, ,,	56 22	45 23	
	6 0	,, ,,	−24 23	,, ,,	55 27	46 18	
	6 45	,, ,,	−26 26	,, ,,	53 24	48 21	
	7 0	,, ,,	−27 20	,, ,,	52 30	49 15	
Feb. 9……	3 0	182 53 40	−32 21	133 24 5	57 14	44 31	35 43 55
	3 30	,, ,,	−29 37	,, ,,	59 58	41 47	
	4 0	,, ,,	−33 16	,, ,,	56 19	45 26	
Feb. 11…	9 45 A.M.	185 48 40	−32 21	136 30 10	46 9	55 36	54 18
	10 0	,, ,,	−34 24	,, ,,	44 6	57 39	
	10 30	,, ,,	−33 57	,, ,,	44 33	57 12	Magnet oscillating violently.
	11 0	,, ,,	−32 21	,, ,,	46 9	55 36	
	11 30	,, ,,	−33 16	,, ,,	47 4	54 41	
	12 15 P.M.	,, ,,	−38 2	,, ,,	51 50	49 55	
	12 30	,, ,,	−38 31	,, ,,	52 19	49 26	

Adopted mean ………… 35° 48′ 24″ W.

The declination magnet used throughout these observations was incapable of rapid reversion; and therefore the zero of the scale was tested carefully by several reversions previous to our departure from the island, and it was found to be 53·9. A very favourable series of reversions at Cape-Town Observatory had previously given 54·2 as the zero division.

The above readings of the declination show an absolute maximum of 35° 57′ 12″ at 10 A.M. on February 11th, and a minimum of 35° 39′ 33″ at 2.45 P.M. on February 6th; the range, therefore, for the month, as far as observed, is 17′ 39″, and the mean declination =35° 48′ 22″·5. The daily means give a slightly larger W. declination, with a range of only 10′ 12″ for the whole series of observations.

Nothing more of course than the very roughest idea can be formed of the diurnal range from the few observations taken; but there is some evidence at least of an easterly movement of the needle between 10 A.M. and 3 P.M., followed by a westerly motion that continued till 7 P.M. The greatest mean velocity of the magnet was about 3′ 40″ per hour at 2 P.M.; but the velocity once reached 8′ an hour, viz. at 10 A.M., during the disturbance on February 11th. As there are many disturbing causes that probably affect the earth's magnetism as a whole, it may not be irrelevant to remark that an examination of the Stonyhurst magnetograms on all the days occurring in the above Table of Declinations shows that February 11th was the only disturbed day in England, and that, with the exception of a slight tremulous motion of the needle on November 13th and 14th, on December 10th, and on February 8th, the observing days were remarkably quiet.

Besides the series of observations taken at Observatory Bay, other determinations of the declination were made at Swain's Haulover, at Thumb Peak, and at Molloy Point; but as some doubt still remains to be cleared up respecting the errors and rates of the chronometers employed in the sun observations, I will defer the publication of the results until this essential point is satisfactorily settled.

Previous to these observations, taken in connexion with the Government Transit-of-Venus Expedition, the only magnetic observations at Kerguelen on record, if we except any possible results obtained by Captain Cook in the last century, are those of Sir J. Ross in 1840 and of H.M.S. 'Challenger' in 1874. The values contained in Sir Edward Sabine's "Contributions to Terrestrial Magnestism, No. XI." (Phil. Trans. 1868), furnish the data necessary for a comparison with our present work.

Adopting 71° 56′ 28″ for the dip of the south end of the needle at Observatory Bay on January 1st, 1875, and comparing this value with the observation of Sir J. Ross in 1840, after correcting the dip of −70°·0 at Christmas Harbour by −0°·4 for change of station to Royal Sound, we find a secular variation of about −2′·7. But if we consult the Table of numerical coefficients deduced from all the collected observations, and take the value of the dip in 1840 for the station whose longitude is 70° E.

and latitude 50° S., which was approximately our position at Observatory Bay, we obtain a secular variation of $-2'\cdot 3$. We may therefore fairly conclude that $-2'\cdot 5$ represents the annual change with considerable accuracy.

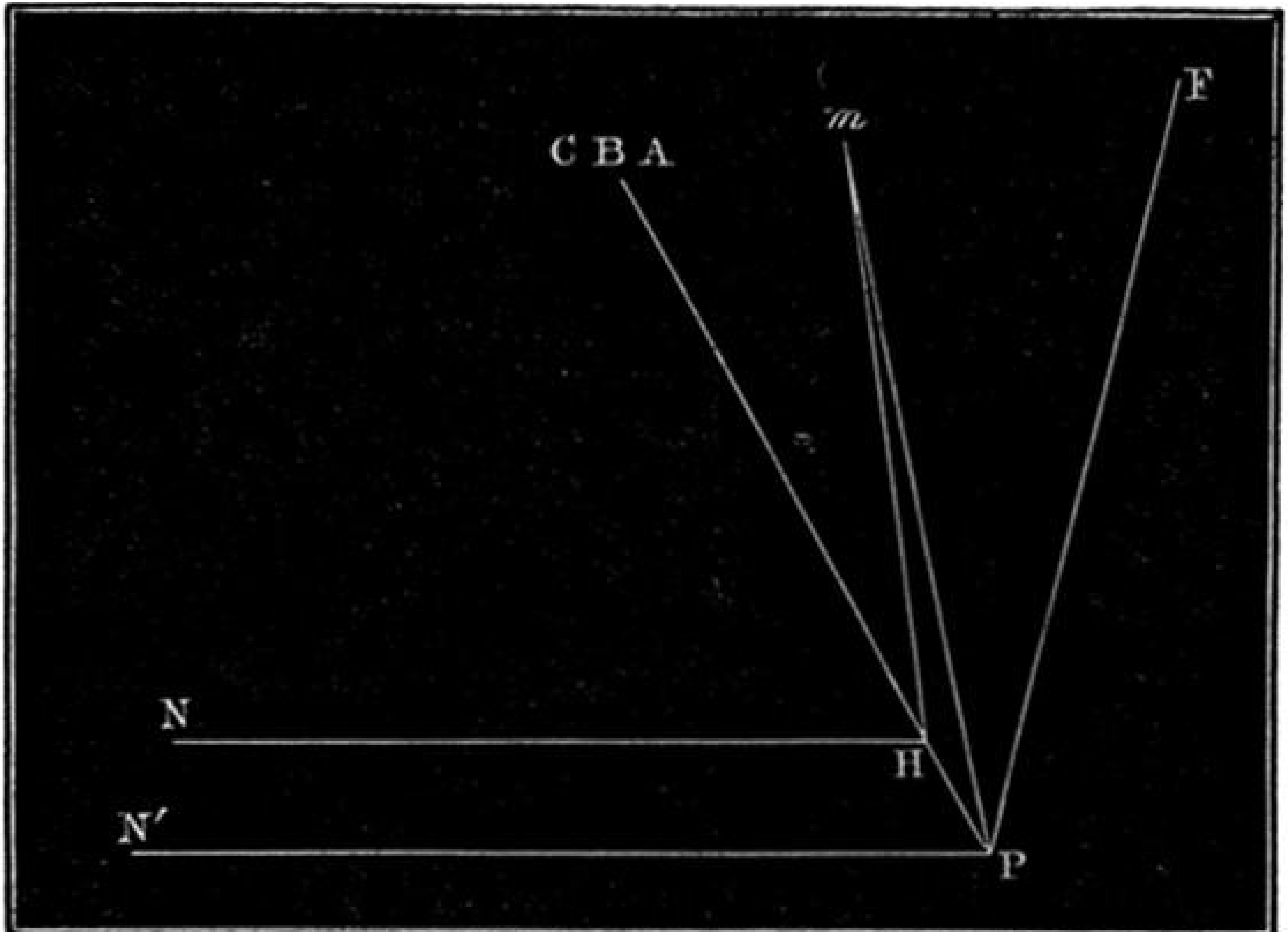
Passing from the dip to the total force we find 11·323 to be in British units the mean of three determinations from observations made on shore by H.M.S. 'Erebus' and 'Terror.' If, now, we apply the correction +0·1 for the change from Christmas Harbour to Royal Sound, the result is still somewhat less than the mean of the observations taken near the eastern extremity of Kerguelen during the epoch 1840–45. Adopting 11·423 as the mean value for 1842–45, and 11·143 for 1875, we obtain a secular diminution of 0·0086 in this element of terrestrial magnetism.

The annual increase of the declination will be $+7'\cdot 0$, if we take the approximate value of 32·0 W. from the map of Sir E. Sabine as representing the declination for the epoch 1842–45.

IV. "On the Variations of the Daily Range of the Magnetic Declination as recorded at the Kew Observatory." By BALFOUR STEWART, LL.D., F.R.S., Professor of Natural Philosophy at the Owens College, Manchester. Received February 28, 1877.

1. The daily range of the magnetic declination at any station may perhaps be regarded as a convenient representative of the magnetic activity of the place. For while a thorough discussion of the diurnal magnetic changes must embrace along with the declination the two components of the force, yet, as regards such daily ranges, the declination gives results which are not only more prominent but also more easily procurable and subject to fewer uncertainties than similar ones for the other two elements.

In estimating the daily range of the magnetic declination, as recorded at the Kew Observatory, I have excluded the disturbed observations, conceiving that by so doing a better indication of the true magnetical activity of the place would be obtained than by including them, inasmuch as they follow a very different set of laws from that of the well-known diurnal declination-range. The disturbed observations have been separated by the method of Sir E. Sabine, those being rejected as disturbed for which the measurements on the photographic curve are 0·150 inch either above or below the mean value for that month and hour, one inch denoting $22'\cdot 04$ of angular change. The daily ranges are here given in inches, and they denote the differences between the greatest and least values of each day's hourly tabulations from the curve, disturbances being excluded. I am indebted to the kindness of the Kew Committee for giving me the daily ranges herein discussed, extending from the beginning of 1858 to the end of 1873, thus embracing in all sixteen years' observations.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